

Preliminary Estimates of Economic Implications of Small-Scale LNG Airship Transportation to Remote Areas

M.S. Gaivoronskaya^{1,*}, V.V. Semikashev¹

¹ Institute of Economic Forecasting, Russian Academy of Sciences, Moscow, Russia

Abstract — The paper is concerned with preliminary estimates regarding the impact of transporting small-scale LNG to remote locations via airship on the power output. The main production sites, assumed as sources of small-scale LNG supplies, are presented and the leading airship manufacturers in Russia are identified. The study involves estimating the cost of different options for energy supply to remote areas, including the use of petroleum products and coal. Thus, the effects for the consumer are estimated and the economic implications are assessed with a detailed description of inter-industry links. The study reveals that the manufacturing industry and the energy sector are impacted to the greatest extent. The results of the calculations are however debatable. The success of the project heavily depends on the redirection of currently used petroleum products, whose production makes a significant contribution to the economy and the budget, to other markets. On the other hand, a considerable share of the cost of petroleum products is subsidized, which in the case of switching to natural gas will free up the state's financial resources. Given the ambiguity of the conclusions for the project of small-scale LNG airship transportation to remote areas, other domains of airship use are proposed and described. These

include transportation and logistics, the oil and gas sector, forestry, the electric power industry, as well as the social initiatives and housing construction. The paper concludes with future objectives in continuation of the current study.

Index Terms: Cargo airships, small-scale LNG, inter-industry links, manufacturing industry, subsidies, energy sector, remote areas.

I. INTRODUCTION

The energy supply to the northern and isolated territories of Russia is characterized by the high cost of energy resources (primarily petroleum products - diesel fuel) due to expensive transportation, as well as its complexity, duration, and unpredictability that stem from severe and changeable weather conditions. The use of hydrocarbons from the deposits situated in these territories is possible only if they are industrially developed and exploited. Even in this case, however, the cost of fuel can also be extremely high, even if the fuel is cheaper than imported energy resources.

One of the solutions to this problem is the use of cargo unmanned aerial vehicles - specifically, cargo airships – for the delivery of small-scale LNG (SSLNG), as proposed in [1].

According to estimates [1], airship transportation to northern and isolated areas will allow the delivery of SSLNG cargoes, weighing from several tons to 60 tons, in a few hours over a distance of about thousands of kilometers. These flights can be executed in 1 to 2 days, significantly reducing the current multi-week fuel delivery time. This can make fuel supplies more accessible, safer, and predictable.

SSLNG can be produced at small-scale LNG plants.

* Corresponding author.

E-mail: ms.gayvoronskaya@yandex.ru

<http://dx.doi.org/10.25729/esr.2024.04.0011>

Received October 1, 2024. Acc. December 24, 2024. Available online December 28, 2024.

This is an open-access article under a Creative Commons Attribution-NonCommercial 4.0 International License.

© 2024 ESI SB RAS and authors. All rights reserved.

Currently, there are about 20 such plants operating in Russia [2]. Their activities are aimed at expanding gas engine market, as well as ensuring gas supply to the population and individual facilities. In particular, they can act as a source of LNG for the proposed scheme. Provided there are available gas volumes for supply to remote areas, we can consider the following operating small-scale LNG plants: Tobolsk LNG complex (LNGC) in the Tyumen Region, Sakhalin PCC LNGC in the Sakhalin Region, Pervouralsk LNGC and Nevyansk LNGC in the Sverdlovsk Region, Gazprom Helium Service LNGC in the Amur Region and Primorsky Territory, Nizhny Bestyakh LNGC in the Republic of Sakha (Yakutia), Sibir-Energo LNGC in the Kemerovo Region, and other facilities, either under construction or newly built.

The main use of SSLNG in remote areas will be energy supply to the population, the public utilities sector, generation facilities, industrial consumers, and others.

The cost of such an energy supply option remains an open question, especially given the need to develop the production of airships, their launch, along with creation and maintenance of their fleet for these and other purposes. When addressing the energy supply problem, a significant part of the costs will be associated with airships and changes in the load of other enterprises engaged in fuel production and transportation, and the corresponding financial flows. Therefore, the economic assessment of the project for the SSLNG delivery by airship should also consider these flows and factor in possible multiplier effects, which is the focus of this paper. The estimates produced are preliminary and just enable us to understand whether it is worth further investigating this issue and refining the estimates already obtained. In addition, the experience of assessment will be useful for considering other areas of airship use.

II. COMPARISON OF ENERGY SUPPLY OPTIONS FOR REMOTE COMMUNITIES

Current energy supply, along with electric and thermal energy production in remote communities, relies largely on delivered diesel fuel and coal. In 2016–2017, the cost of liquid fuel, depending on the area, ranged from 50 to 100 thousand RUB/t [3]. As a result, the electricity cost was estimated in the range of 22–68 RUB/kWh in different areas, which is 5–15 times higher than the Russian average [3]. At the same time, prices and tariffs for energy

resources for the population and the public utilities sector are several times lower, that is, the cost of fuel, electricity, and heat is subsidized. The share of local budget expenditures in paying for energy supply in the areas of the Far North exceeds 30%, and in some of them, it is more than 60%, while the Russian average is about 20% [3]. In addition, a substantial portion of the Northern Delivery budget, amounting to RUB 99.7 billion in 2022 [4], is allocated to the expenses for fuel and energy resources.

The economically justified price for producing and regasifying SSLNG, not including its delivery, starts at 15 RUB/m³. Given transportation services, the cost of gas in remote areas can reach nearly 25 RUB/m³.

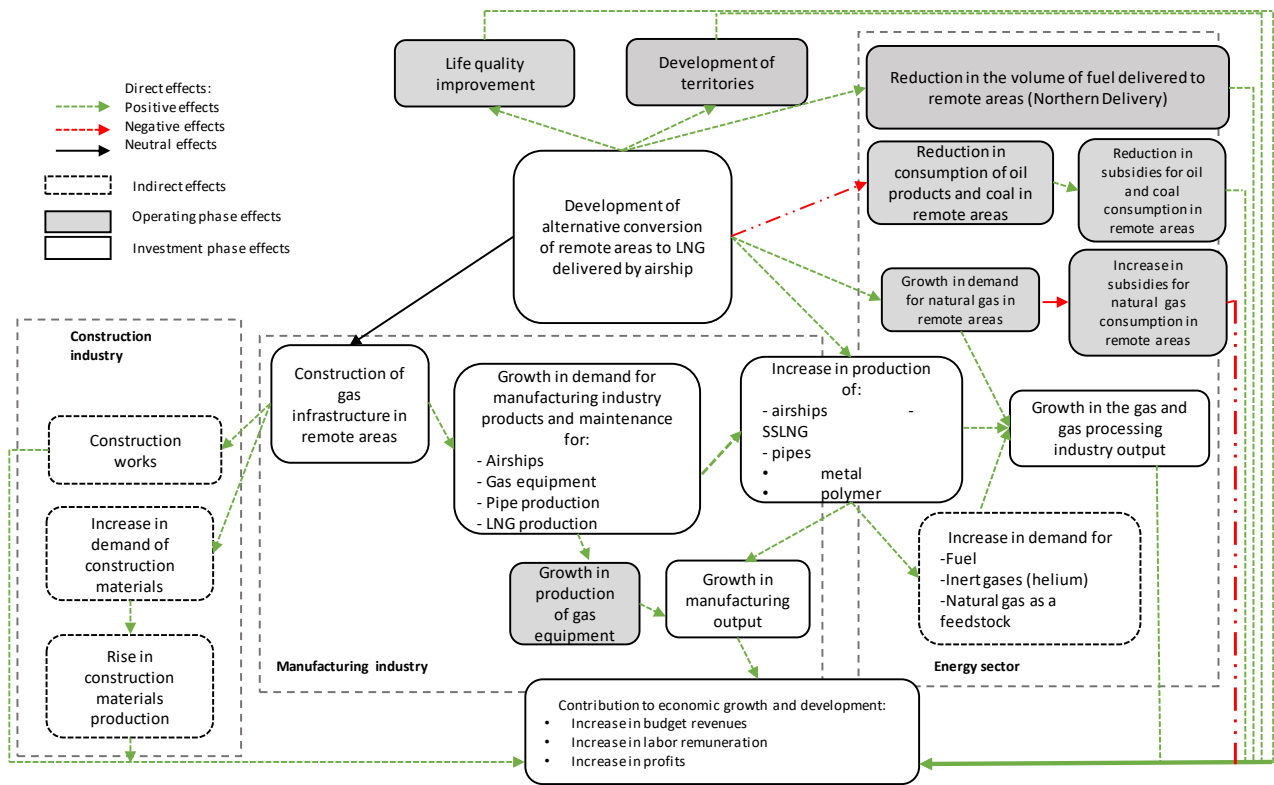
Under various conditions (the ratio between thermal and electrical energy, capacity utilization factor, regional conditions, and others), the electricity price can be about 12–20 RUB/kWh [5]. This is higher than the average Russian indicators, but lower than the current electricity cost in remote areas, i.e., this energy supply option is more economical and will require smaller subsidies. Thus, the use of LNG can lower the cost of electricity, therefore, it is important to evaluate other effects (multiplier, economic, investment, environmental, and others).

Currently, several research and production groups are involved in the development of airships in Russia:

- The company “Aerostatika” has already built several experimental airships and has eight years of experience in their operation [11].
- The Foundation for Advanced Research is developing a wind-resistant airship called “Skipper,” the use of which may be relevant for the Northern Delivery [12,13].
- The company “Augur” produces the airship “Atlant,” which is considered for the coal transportation in Kuzbass [14] and
- Others.

III. DESIGNING THE PROJECT AND ASSESSING ITS ECONOMIC COMPONENTS

To assess all the economic effects of switching to LNG with its delivery by airships to remote areas with subsequent regasification and further use of natural gas by consumers, it is necessary to examine the impact of all processes arising in this regard. At the same time, it is assumed that new production facilities will make significant advancements, while existing ones will be loaded for both fuel extraction and transportation.



Source: Generated by the authors

Fig. 1. Scheme of macroeconomic effects of conversion to SSLNG delivered by airships.

Consideration is also given to manufacturing and servicing airships, as well as to establishing the infrastructure for the on-site use of SSLNG. The main changes in connection with the proposed project are shown in Fig. 1.

Let us formulate the indicators of this project for the SSLNG delivery to remote areas via airships.

1. Manufacturing airships, tank containers, and cryogenic tanks for the SSLNG transportation.
2. Converting the energy infrastructure in remote communities to gas (construction of gas infrastructure, providing buildings with gas equipment, modernization of generation facilities).
3. Organizing and maintaining SSLNG transportation by airships.
4. Increasing the production of SSLNG and helium for fueling airships for these purposes.
5. Reducing liquid fuel and coal production or redirecting them for export.
6. Minimizing transportation within the traditional scheme of fuel delivery to remote settlements.

The SSLNG transportation requires the production of not just airships but also tank containers and cryogenic

tanks. This demand will enhance the production output in the manufacturing industry. To supply energy to the first 500–600 remote communities, it is proposed to produce 15 airships and about 1 600 tank containers with deliveries planned roughly every two months.

The production of helium to fuel airships will increase the demand for it, creating additional orders for the petrochemical industry. Additional helium production of approximately 0.1 million m³ per year is expected.

The proposed option for using LNG involves the construction of gas infrastructure in remote territories. This will increase demand for distribution gas pipelines, gas distribution points, and the necessary gas pumping equipment. In addition, consumers will need new gas equipment: gas boilers, stoves, and water heaters for households and other buildings; generating equipment running on natural gas – for boiler houses and power plants. A comprehensive plan encompasses the construction of about 1.7 thousand km of gas networks and installation of 166 thousand units of gas equipment, including gas pumping systems and in-house plants. Additionally, about 0.5 thousand MW of electric power

TABLE 1. Performance of the Project for the SSLNG Delivery to Remote Areas Using Airships After Their Launch

	Quantity
1. Manufacturing industry, including construction	
<i>for 10 years</i>	
Production of tank containers and cryogenic tanks	1 660 pcs.
Airship production	15 pcs.
Production of pipes for local gas networks and gas equipment, including that at consumers' end	1 700 km of pipes and 166 thousand units of equipment
Modernization of generating equipment	0.5 thousand MW, 1 thousand Gcal/h
2. Energy sector, including transportation	
<i>for 1 year</i>	
Production, transportation, and consumption of SSLNG for remote power supply	2.5 billion m ³
Production and consumption of helium for airships	0.1 million m ³
Production, transportation, and consumption of petroleum products (diesel fuel)	-1.5 million t
Production, transportation, and consumption of coal	-0.7 million tons

Source: Authors' estimates

generation capacity and up to 1 thousand Gcal/h of thermal power generation capacity will be modernized to facilitate gas usage. All this will generate additional output in the manufacturing sector.

Conversion to gas will increase the consumption of natural gas, which will replace the currently used liquid fuel, coal, and other fuels. The annual consumption of 1.5 million tons of liquid fuel and 0.7 million tons of coal will be replaced by approximately 2.5 billion m³ of natural gas. This will change the demand for products from the extractive industries. Thus, the main industries that will be affected by the use of SSLNG transported by airships will be the manufacturing industry and the energy sector (Table 1).

In addition, flows in the construction and transportation sectors will change. According to our estimates, however, these changes are significantly smaller than those indicated above. Moreover, neither the maintenance of new gas infrastructure, equipment, and airships, nor the maintenance of the previous energy supply system are considered in this analysis. These indicators prove comparable in size.

I. PRELIMINARY ESTIMATES OF THE PROJECT EFFECTS GIVEN INTER-INDUSTRY LINKS

The initial assessment involved calculating changes in the output for economic sectors (activities) driven by the proposed project. The calculation was conducted within the assessment of the effects over a one-year period, assuming the project operates at full capacity. To this end, flows associated with fuel supply were calculated for the conventional year 2035, and flows constituting the airship transportation system and the new LNG-based energy

supply system were calculated as 1/10 of the total costs for 10 years (Table 2).

The presented calculation is preliminary and illustrative.

The total estimate of the change in output from the energy sector and the manufacturing industry during the implementation of the project aimed at switching to SSLNG delivered by airships will amount to RUB 58.76 billion per year (Table 2). That is, the costs will be reduced.

Let us consider the economic impact components.

The effect on the manufacturing industry output is positive and will amount to RUB 19.04 billion in 2035. The effect for the LNG industry will be RUB 29.90 billion. This project will also boost the output of the gas processing industry (helium production) and will enhance the airship transportation services in the transportation sector.

As a result of the proposed measures, natural gas consumption in remote areas will go up, and the consumption of petroleum products and coal, as well as the costs for their transportation and logistics, will go down.

The transition from liquid fuel and coal to natural gas will significantly reduce the output of the energy sector. On the one hand, we can expect a significant reduction in the output in the oil refining and transportation industries (particularly regarding Northern Delivery). On the other hand, a large share of current costs can be viewed as subsidies from the budget, which can be reallocated for other purposes. Consequently, the expenses for the population and the housing and utilities sector will not increase, but decrease (in some cases they may decline, while in others, they may remain at the same level).

Another important factor to consider is how many years it will take to pay for the project if the only source of funding is the reduction in subsidies. This issue will be

discussed in subsequent papers.

In addition, it is worth noting that the calculations do not factor in the investment phase, which involves developing new related industries for the airship production or loading existing ones.

Calculation of multiplier effects for the project under consideration poses a separate issue, since the airship construction, alongside the SSLNG production and transportation are specialized industries, and generalized industry multipliers [6] are not suitable for their assessment. Moreover, with changes in the structure of the economy, multipliers can also change over time, which should also be considered when assessing long-term projects relying on the products of new sub-industries.

II. OTHER USES OF AIRSHIPS

By exemplifying the use of airships for transporting SSLNG, it is shown that under certain conditions, the proposed types of transportation can be both cost-effective and highly sought for. Therefore, it is worth paying attention to other airship application areas.

Further, the ideas of A. A. Konoplyanik and V. V. Voroshilov on the use of airships are partially presented [7].

The two main valuable features of airships lie in their capacity to be transformed into a transport-and-infrastructure vehicle, which makes it possible to transport any cargo to any territory without infrastructure and

associated costs, as well as their ability to transport fully-assembled equipment and various other objects, thus reducing the construction and assembly time, and enhancing quality.

The production of airships generates benefits for both producers (new industries and production are created) and consumers, that receive the service cheaper than before. This contributes to the expansion of demand for airship transportation services.

The proposed solutions have the potential to benefit several sectors, including transportation and logistics, oil and gas, forestry, electric power, as well as social and housing construction.

1. A. Use of airships in mining

Oil-gas and mining companies could use airships to deliver assembled equipment for geological exploration, drilling, development and maintenance of mineral deposits, and construction of oil and gas processing plants. Deliveries of already assembled equipment will save time and speed up project launches, which means greater economic efficiency. Only commissioning work will be required on site. The same principle could be used to build remote power plants (nuclear power plants, renewable energy sources, thermal power plants) – airships could be used to deliver large blocks assembled at factories to construction sites when they cannot be delivered by other means of transportation. Here, the use is similar to the solution generated by Novatek to manufacture modules for

TABLE 2. Estimated Output Given Inter-Industry Links for Alternative Conversion of Remote Areas to SSLNG, In 2024 Prices

	Unit of measurement	Quantity	Output, billion RUB
1. Manufacturing industry, including construction			
Production of tank containers and cryogenic tanks	pcs.	166	0.08
Airship production	pcs.	1.5	3.75
Production of pipes for local gas networks and gas equipment, including that for consumers			6.46
Maintenance of gas infrastructure and equipment			3.20
Modernization of generating equipment			2.00
Construction and installation works for SSLNG and airship infrastructure			3.55
2. Energy sector, including transportation			
SSLNG production	billion m ³	2.5	29.90
Helium production	million m ³	0.1	0.50
SSLNG transportation	billion m ³	2.5	25.00
Production of petroleum products (diesel fuel)	million t	-1.5	-89.50
Coal production	million t	-0.7	-3.70
Transportation of oil products and coal (part of the Northern Delivery)*			-30.00
Maintenance of current energy supply			-10.00
Total			-58.76

* Excluding the construction of winter roads

Source: Authors' estimates

the LNG plant in Murmansk. Instead of transporting and assembling modules on-site, they manufacture them off-site, and then deliver to the work location. According to their estimates, this provides savings in costs and time [8].

2. B. Use of airships in the forest industry

The use of airships in the forest industry can significantly enhance the efficiency of technological processes by enabling much of the wood pulp processing, including waste management, directly at the felling site. Thus, it is possible to achieve 100% utilization of wood pulp instead of the current 40–50%. This will allow preserving the soil cover of the forest, which is usually severely damaged by logging equipment and haulage vehicles. Technological schemes and mathematical models for the use of airships in the forest industry have already been developed, as evidenced by scientific works [9, 10].

3. C. Use of airships in the supply sector

Beyond their specialized application, such as transporting SSLNG, or serving individual industries, airships have potential to deliver essential life support services to remote communities. They can transport not only fuel, water, medicine, mail, and other goods, but also components of socio-cultural and housing infrastructure such as schools, kindergartens, stores, medical, and other institutions of full readiness, which, owing to their block-container design, can reduce the cost and increase the speed of construction. This option can be convenient for both temporary mobile (for example, mobile clinics) and stationary facilities.

4. D. Specialized use of airships

A separate strand for the advancement of unmanned cargo airships may be their specialized use, and the unmanned control function will play a key role here. Airships hold significant potential across various sectors, including the space industry, the Internet, communications and radar-location systems, agriculture, and firefighting. In the space industry, unmanned cargo airships could be used to deliver finished products, to assemble products for multiple launches (search and return of the first and second stages of rockets and descent spacecraft), rescue crew, monitor flight trajectory, establish radar systems, and others.

Many remote areas, such as the Northern Sea Route, suffer from inadequate communication infrastructure,

including the Internet and radar services. Using airships could contribute to its enhancement in this region, improving emergency response times.

Moreover, airships could be instrumental in firefighting, which is currently carried out by helicopters.

Flying airships with a smaller payload (for example, 2 tons) could be used in agriculture for spraying and applying fertilizers. They can also be utilized for fishing in the northern regions and hunting game in Siberia. In the USSR, An-2 aircraft and Ka-26 helicopters were used for such purposes, but currently unmanned aerial vehicles are an alternative, but they are designed for short-term flights.

III. CONCLUSIONS

The use of cargo airships represents a promising opportunity for advancing the transportation industry. Using the example of small-scale LNG, the study has revealed the effects of replacing Northern Delivery with airship transportation of fuel to remote and inaccessible areas. Other applications of the considered aircraft are also proposed and described. To evaluate all the main effects of airship production and use in Russia, it is essential to analyze the demand for airship services across other industries, estimate the costs associated with their production and maintenance, and assess the benefits of using airships in other sectors, factoring in multiplier effects. These elements outline the focus for future research.

REFERENCES

- [1] V. V. Voroshilov, A. A. Konoplyanik, "From transition to gas in the Russian Trans-Urals and Arctic zone to the energy consolidation of Eurasia (part 1)," *ECO*, vol. 54, no. 2, pp. 236–260, 2024. (In Russian)
- [2] Map of the Russian LNG industry 2023. Reference materials. [Online]. Available: <http://nasslng.ru/assets/files/spravochnye-materialy-spg-karta-2023.pdf>. Accessed on: Sep. 15, 2024. (In Russian)
- [3] I. A. Bashmakov, M. G. Dzedzicek, "Assessment of energy supply costs in the regions of the Far North," *Energoberezhenie*, no. 4, pp. 40–51, 2017. (In Russian)
- [4] The Northern Delivery: Life support system for the Far North areas. [Online]. Available: https://vostokgosplan.ru/wp-content/uploads/sevzavoz_digest.pdf. Accessed on: Sep. 15, 2024. (In Russian)

- [5] V. V. Molodyuk, "Method for calculating tariffs for CHP plants in the regional market of electric and thermal energy provided the maximum balance profit of all market participants is achieved," *Energosovet*, no. 48, pp. 29–36, 2017. (In Russian)
- [6] M. Yu. Ksenofontov, A. A. Shirov, D. A. Polzikov, A. A. Yantovsky, "Estimation of multiplier effects in the Russian economy based on input-output tables," *Studies on Russian Economic Development*, no. 2, pp. 3–13, 2018. (In Russian)
- [7] V. V. Voroshilov, A.A. Konoplyanik, "From transition to gas in the Russian Trans-Urals and Arctic zone to the energy consolidation of Eurasia (part 2)," *ECO*, vol. 54, no. 3, pp. 205–233, 2024. (In Russian)
- [8] A. Ivanter, "Arctic front of NovaTEK: Cold to the rescue," *Expert*, no. 4, pp. 38–49, 2023. (In Russian)
- [9] G. V. Bernotas, "Mathematical model of the performance of aerostatic transportation systems in the development of inaccessible forest areas," *Engineering Bulletin of the Don*, no. 3, p. 154, 2015. Available: <https://cyberleninka.ru/article/n/matematicheskaya-model-proizvoditelnosti-aerostaticeskikh-transportnyh-sistem-pri-osvoenii-trudnodostupnyh-lesnyh-territoriy>. Accessed on: Sep. 10, 2024. (In Russian)
- [10] M. E. Akim, E. L. Akim, "Wood and decarbonization under sanctions," *NG-Energy*, Nov. 09, 2023. [Online]. Available: https://www.ng.ru/ng_energiya/2023-09-11/13_8823_wood.html. Accessed on: Sep. 10, 2024. (In Russian)
- [11] Feasibility study on new generation airships in various sectors of the Russian economy / Available: <https://anav.ru/news/tpost/l4timf6la1-tehniko-ekonomicheskoe-obosnovanie-ispol>
- [12] <https://tass.ru/ekonomika/18574551>
- [13] <https://goarctic.ru/news/ozvucheno-nachalo-razrabotki-dirizhabley-dlya-severnogo-zavoza-no-dirizhabli-yakutii-zanimayutsya-et/>
- [14] <https://www.kommersant.ru/doc/6787620>



M.S. Gaivoronskaya, a Ph.D. in Economics, is a graduate of Moscow Institute of Physics and Technology. Currently, she is a research fellow at the Laboratory for the Energy Sector Forecasting at the Institute of Economic Forecasting of the Russian Academy of Sciences. Her research interests include energy economics, conversion to gas, and the advancement of the Russian gas industry.



V.V. Semikashev, a Ph.D. in Economics, serves as the Head of the Laboratory for the Energy Sector Forecasting at the Institute of Economic Forecasting of the Russian Academy of Sciences. His research interests include economics of the energy sector industries, forecasting the development of these industries in Russia, and energy policy.