

LNG Shipping via the Northeast Passage

BY MICHAEL SCHACH AND REINHARD MADLENER

Abstract

The increasingly ice-free Northeast Passage is a game changer for global LNG trading and shipping routes, and especially relevant for the Russian federation with its recently completed Yamal LNG terminal and the upcoming Arctic LNG 2 sister terminal – making Russia the fourth-largest LNG producer globally. The ongoing War in Ukraine has also changed the game, with still largely unpredictable consequences depending on its outcome.

Introduction

In our research, undertaken before the outbreak of the War in Ukraine and the Covid-19 pandemic, we examine the economic and geopolitical relevance of an ice-free Northeast Passage (NEP) as a shipping route, with a particular view on the major LNG-supplying and LNG-consuming countries, and expected changes in LNG trade flows. Several key aspects are considered in-depth, such as the developments in natural gas production in the Russian Arctic, important trends and strategies of major Asian LNG-consuming countries, and the geographical and climatic particularities of the Arctic.

In our study we also aim at examining the significance and the impacts of the NEP on LNG shipping. First, the major trends in LNG supply and demand and the specific role of the NEP are analyzed. Next, a hybrid algorithmic model is applied, considering these insights to optimize the global LNG flows and capacities with regard to an ice-free NEP. In addition to the model, the effects on spatial price arbitrage are investigated. The three research questions raised are: (1) What are the impacts of an ice-free Northeast Passage on LNG transport routes and transport capacities? (2) To which extent is an ice-free NEP a competitive advantage for Russian LNG producers? (3) How does the emergence of additional LNG capacities originating in Russia impact the global pricing of LNG?

Methods Used

The impacts of a second wave of LNG supplies on the market balance are demonstrated in four distinct scenarios: Scenario 1 “The second wave fails to materialize and no new capacities are constructed”; Scenario 2 “A moderate expansion of supplies occurs by 2025”; Scenario 3 “A moderate expansion of supplies occurs by 2025, but faces heightened natural gas demand in Asia”; and Scenario 4 “A massive expansion of supplies occurs by 2025”. The constituents of the ‘moderate’ and ‘massive’ expan-

sion of supplies directly result from the prior analysis of pre-FID (projects before the final investment decision) LNG projects in the US and Russia. The assessment of these liquefaction terminals, considering stakeholders such as government and competitors, forms the very basis for reasonable assumptions needed for the modeling. Also the segments of the LNG value chain, as well as corresponding costs, are examined. As an outcome of the LNG routing optimization research, recommendations for action are formulated concerning the optimal extent and pace of the next LNG supply expansion.

In order to find the optimal solution for a specific LNG shipping problem, various algorithms can be applied. However, before such an application a definition of ‘optimal’ is needed: What is the shortest or fastest path between multiple locations? Which bottlenecks have what impacts on the capacity planning? What is the most cost-effective route? In our research, several algorithms are applied for evaluating the relevance of the NEP for LNG shipping. Specifically, the applicability of the interpretation of the LNG transport routes network as (1) a Shortest Path Problem, (2) a Max-Flow Problem, and (3) a Min-Cost Flow Problem is evaluated. More specifically, the Dijkstra Algorithm, the Ford-Fulkerson Algorithm, and the Cycle-Cancelling Algorithm were used and the results obtained compared with each other. The analysis of various scenarios reveals the relative competitive-

Michael Schach is a graduate of RWTH Aachen University. **Reinhard Madlener** is Full Professor of Energy Economics and Management, Adjunct Professor at the Norwegian University of Science and Technology (NTNU), Vice-President of the Swiss Association for Energy Economics (SAEE), and Director of the Institute for Future Energy Consumer Needs and Behavior (FCN) at RWTH Aachen University's E.ON Energy Research Center. Dr. Madlener may be reached at RMadlener@eonerc.rwth-aachen.de.

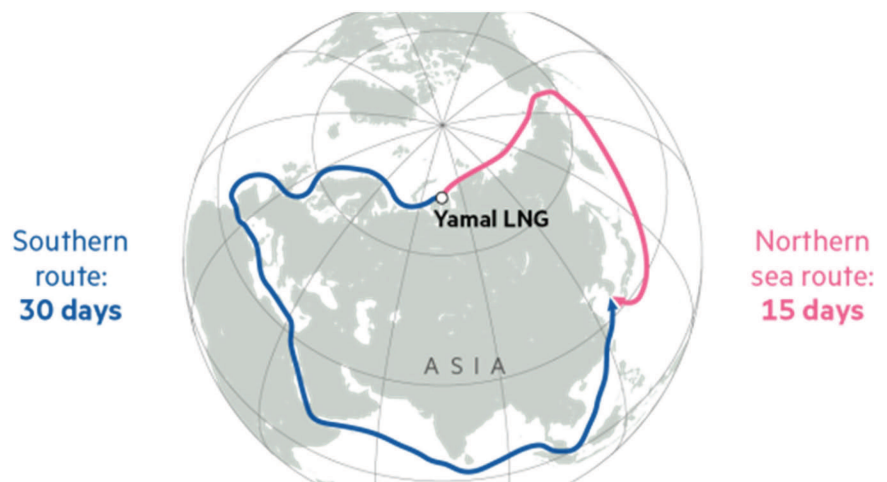


Fig. 1: Shipping scenarios of the Yamal LNG project
Source: Foy (2017)

ness of different LNG producers. Furthermore, the impacts of a sudden shutdown of one of the depicted chokepoints, in the case of a terrorist attack, a natural catastrophe, or regarding the NEP of an extensive freeze, are analyzed.

Results

The analysis reveals the competitiveness of Russian LNG exports along the Northeast Passage due to Yamal LNG and Arctic LNG 2, with the NEP as a potential game-changer for global LNG supplies. We further find that an ice-free NEP is primarily relevant for maritime bulk (and particularly LNG) shipping, and thus of great geopolitical importance and strategic interest, especially for Russia and the US on the supply side, and China, Japan, and South Korea on the demand side.

Three major insights are found with the algorithmic model. First, the Suez Canal Route (SCR) is not used at all in the regular scenario with all chokepoints intact. While the US LNG is transported through the Panama Canal Route (PCR), the Russian exports take place along the NEP, and Qatari tankers pass through the Strait of Hormuz (SOH), the other considered producers can ship their cargo directly to Asia. However, it should be kept in mind that the model used is simplistic, taking into account only the Asian consumer market and only the major LNG producers. Second, the demand variation scenarios depict a supply-side competition, considering the costs of transportation and production. The results show that the Australian and US LNG exports are the least competitive, primarily due to the high production costs. Again, the model is highly simplified and, for instance, does not fully consider the sunk costs of the producers. Third, a shutdown of the NEP, as it occurs during the winter months, shifts all Russian exports through the SCR and almost triples the transportation costs. Nonetheless, the Russian exports remain competitive, if compared to the US or Australia. A shutdown of the SOH, resulting in a cut-off of Qatari supplies, benefits the other market participants who occupy Qatar's market share. There is no imminent threat to the LNG supply security. If the PCR closes down, the US exports would be rerouted through the NEP and SCR with only a slight cost increase.

The dynamics in the global LNG market are likely to evolve in the next decade, due to significant developments both on the supply and demand side: The wave of new upstream investments in the early 2010s generated abundant LNG volumes on the market upon completion of the projects. On the contrary, the demand of the mostly Asian LNG consumers is expected to increase insufficiently in order to absorb the oversupply. As a result, the Japanese and Chinese consumers will increasingly find themselves in an advantageous position to enforce their requirements concerning short-term contracts or the abolishment of destination clauses. The greater availability of LNG volumes and the liberalization of regulations on gas infrastructure can facilitate an integrated, possibly virtual trading hub in Asia and progressively integrated prices in the region. Considerations about energy supply security

and the diversification of supply sources strengthen the position of LNG in the energy mix of most Asian countries. In order to pursue these considerations, numerous investments in hydrocarbon production, amongst others in assets in the Russian Arctic, have been made. Therefore, it can be concluded that the LNG-consuming states have economic, political and strategic interests in the Arctic as a prospective hydrocarbon province and the NEP as a prospectively crucial future shipping route.

Conclusions

The political relevance of the Arctic is becoming more lucid, because the retreating ice creates possibilities for the development of hydrocarbons and new shipping routes, but also fosters strategic and military considerations of the littoral countries.

In this research, it turned out to be very difficult to determine whether the NEP impacts the LNG market or vice versa. Undoubtedly, the ice-free NEP will impact the Asian markets to some extent by facilitating Russian LNG exports from the vast gas fields in North-Western Siberia within the Arctic Circle. The completion of the Yamal LNG project increased the Russian LNG export capacity by 165%. Russian LNG exports to Europe increased by 13.5% in 2022 (compared to 2021), totaling to 14.65 million tons. This represents almost the full annual capacity of Yamal LNG, amounting to 16.5 million tons (Staalesen, 2023). On the one hand, any further large-scale LNG export aspirations in Russia are ultimately correlated with the usage of the NEP as a uniquely competitive shipping route to the Asian markets. On the other hand, all further aspirations will primarily be driven by the LNG market conditions and prices. In the end, aside from strategic political interventions, the demand and corresponding investments will determine the prospects for any Arctic hydrocarbon developments, and therefore for any extensive Arctic shipping activities.

The geographical location of the leading LNG producers and consumers makes the NEP mainly relevant for Russian LNG suppliers, if all other global chokepoints remain intact. However, for Russia's ambitions as a major LNG supplier, the NEP is of ultimate significance. Still, no significant LNG shipping between Europe and Asia has taken place yet, since both regions are primarily consumers. The scale of the exports of Russian hydrocarbons from Arctic regions will determine the scale of any Arctic shipping activity along the NEP in the near future. However, the prospects for destinational bulk shipping remain significant in the long term. Until then, the use of the NEP will remain a crucial competitive advantage for the producers and exporters of Arctic natural resources. Naturally, future shipping along the NEP will be of national significance for the Russian federation. Firstly, the development of infrastructure along the NEP can be a substantial factor of growth for the country's most remote regions, and will thus also be relevant from a regional development policy perspective. Secondly, an ice-free Arctic ocean creates multiple perspectives not only for E&P activities

and trade, but also for politico-military applications. Again, a common policy approach by the Arctic Council, involving both the US, Russia and the other members is necessary, in order to limit the conflict potential and to create statutory foundation for future commercial and governmental activities. Obviously, in light of the waging War in Ukraine, this is all questionable now.

Nevertheless, Russia's entry in the LNG supply competition will probably exacerbate the political tensions between Russia and the US. Since the shale gas revolution, the US has permanently challenged the dominant Russian market position in Europe. Now, it will find itself competing against considerable volumes of highly competitive Russian LNG in the mid-term future. A comparative economic analysis of Russian and US LNG supplies and a systematic analysis of the political risks and opportunities that examines these considerations in a broader manner, would provide useful but had to be left for future research.

The developments in the Asian LNG market and the facilitation of a trading hub are of great interest from both a scientific and corporate perspective. Especially the interdependencies between the currently advantaged LNG consumers and the producers with regard to, e.g., contract conditions and market power could be examined in more detail. Another truly absorbing thought is a joint global reduction of LNG exports. The Gas Exporting Countries Forum (GECF) was established as an effigy of OPEC but for natural gas production (exports). But unlike OPEC, which mainly consists of Arab states, the members of the gas cartel are very heterogeneous and pursue different political agendas. In addition, the significantly varying costs of the leading LNG producers enhance the potential gains from finding a Pareto-efficient joint solution. In this respect, and in light of the forecasted oversupply in the next decade, a study that examines possible reduction measures and the corresponding effects appears very useful.

The NEP is a crucial element in the supply chain of Russian LNG producers. It opens up a shorter and less expensive alternative to the SCR for Russian LNG producers. Because most of the Russian gas fields are

located in North-West Siberia, such a sea route is a necessity for any large-scale LNG export aspirations. A shutdown of the NEP nearly triples the transportation costs to the Asian markets when using the SCR instead. However, the NEP is hardly relevant for other LNG-producing countries for exports to Asia. Since the expansion of the Panama Canal in 2016, all North- and South-American producers will prefer the usage of the PCR as the shortest and most cost-efficient route to Asia. Nevertheless, the crucial element for the competitiveness of various worldwide projects remains the projects' break-even costs. Further, a more detailed assessment of the parameters might facilitate a more accurate forecast on achievable cost savings with regard to the NEP. However, the objective of the modeling in this study was to initially demonstrate the usefulness of applying various methods to LNG shipping routes with regard to a temporally ice-free NEP, and to pave the way for further research. Finally, it can be stated that, although there are other factors to consider, Russia's market entry, largely enabled through ice-free shipping along the NEP, does affect both global LNG prices as well as competition and geopolitics.

References

- Staalesen A. (2023). Russian Arctic LNG advances in European market, *The Barents Observer*; URL: <https://thebarentsobserver.com/en/2023/01/russian-arctic-lng-advances-european-market> <https://thebarentsobserver.com/en/2023/01/russian-arctic-lng-advances-european-market> (accessed January 18, 2023).
- Foy (2017). Russia's Yamal gas project navigates ice and sanctions, *Financial Times*, [Online] URL: <https://www.ft.com/content/8412ba8c-6ace-11e7-b9c7-15af748b60d0> [last accessed Jan 15, 2023].
- Schach M., Madlener R. (2018). Impacts of an Ice-Free Northeast Passage on LNG Markets and Geopolitics, *Energy Policy*, 122: 438-448.
- Schach M., Madlener R. (2018). Economic and Geopolitical Impacts of the LNG Supply-Side Competition Between the USA and Russia, *FCN Working Paper No. 10/2018*, Institute for Future Energy Consumer Needs and Behavior, RWTH Aachen University, July.
- Schach M., Madlener R. (2017). Impacts of an Ice-Free Northeast Passage on LNG Trading: Transport Routes and Optimal Capacity Planning, *FCN Working Paper No. 12/2017*, Institute for Future Energy Consumer Needs and Behavior, RWTH Aachen University, September.