

1 Exploring the Role of Europe in the global LNG  
2 Market Equilibrium until 2040

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8 **Abstract**

The present paper embodies a study of the global liquified natural gas (LNG) market until 2040.

9 *Keywords:*

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## 10 **1. Introduction**

11 The world is committed to achieving carbon neutrality by mid-century. Undis-  
12 puted thereby are measures that increase the share of renewable energy in the  
13 energy system and thus replace fossil energy sources [1]. However, the speed  
14 on the way there and the specific target year in which net zero emissions are  
15 emitted vary between regions. China, for example, has defined 2060 as the tar-  
16 get year [2], while Europe aims to achieve climate neutrality in 2050 [3]. For  
17 these regions and all others, the question arises of how this sustainable energy  
18 transition is shaped in concrete terms [4]. The consensus is that transitional  
19 solutions and so-called bridge technologies (or bridge fuels) are necessary if re-  
20 newable energy cannot fully supply the energy system [5]. A pillar of these  
21 bridge technologies, namely liquified natural gas (LNG), is the subject of this  
22 paper.

23 So far, the role of LNG in energy systems has differed significantly among global  
24 regions. Traditionally, the Asian market, particularly the Japanese one, firmly  
25 focused on LNG. Other countries, for example, China and South Korea, have  
26 shifted to LNG and increased their demand partly significantly in the past  
27 decades [6]. Today, as China has become the largest LNG importer worldwide,  
28 more than half of China's overall natural gas imports are LNG [7]. On the  
29 contrary, LNG's imports to Europe were minor since Europe has been supplied  
30 with piped gas in the last decades. The leading supply country for Europe's  
31 gas demand was Russia. Traditionally, about 40% of Europe's total natural  
32 gas imports were Russian piped gas. In some European countries, such as  
33 Germany, to name one of them, dependence on Russian piped gas was even  
34 more significant. In 2020, more than 65% of natural gas demands were covered  
35 by imports from Russia [8]. The geographical proximity between Russia and  
36 Europe and the generally low price of Russian piped gas in the past was the  
37 main reason why Europe as an LNG market has been unattractive until now.  
38 However, this situation has changed fundamentally as a result of the invasion  
39 of Ukraine by Russia in February 2022. In response to Russian aggression and

40 the resulting war in Ukraine, Europe has imposed sanctions on Russia. These  
41 have led to the collapse of Russian piped gas imports to Europe in 2022 and,  
42 consequently, a rethinking of natural gas in Europe. On the one hand, measures  
43 were taken to reduce energy and, thus, gas consumption. On the other hand,  
44 Europe had to look for alternatives to replace the lack of imports from Russia.  
45 In addition to (limited) increased piped gas imports from Norway and other  
46 reactions, the main consequence is that LNG is on Europe's agenda now.

47 In the short term, LNG is essential for the supply security of Europe's energy  
48 systems. That is why Europe was willing to pay high prices in 2022, facing  
49 the risk of not being able to meet all the natural gas demands otherwise. In  
50 order to bring the procured quantities of LNG to Europe and the countries,  
51 new LNG terminals across Europe were also built. For example, Germany,  
52 Poland, but also Italy and Greece have already built or are currently in the  
53 process to built LNG terminals [9]. In view of the above, it can be expected  
54 that LNG will play an important role in Europe's energy supply not only in  
55 the crisis mode of 2022, but also in the medium term. Although European  
56 countries have attempted to negotiate short-term supply contracts for LNG, the  
57 investments made in LNG terminals and related transport infrastructure point  
58 to longer-term planning<sup>1</sup>. However, many questions are unclear in this context  
59 so far. In addition to uncertainties regarding how far LNG can contribute to  
60 the achievement of European and global climate targets and what quantities  
61 will be demanded regionally, there is also the significant issue of how a market  
62 equilibrium for LNG will develop in the medium to long term. Particularly,  
63 the current market situation in 2022 is not representative for future market  
64 equilibrium projections as China's LNG demand is considerably low due to  
65 effects of Covid measures there.

66 Against this background, the core objective of this work is to investigate the

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<sup>1</sup>For example, the LNG terminal in Poland mentioned above will not start operations until 2025.

67 global LNG market equilibrium until 2040. Thereby, exchanged LNG quanti-  
 68 ties between the most relevant import and export countries to meet expected  
 69 demands and resulting regional LNG prices are in the foreground of the anal-  
 70 ysis. We focus on the European market and its most relevant export countries  
 71 to cover Europe’s demand until 2040. The analysis furthermore allows esti-  
 72 mating future LNG price developments until 2040. Latter is not only a main  
 73 novelty of the present work but can also be seen as a relevant contribution to  
 74 the literature. LNG prices are often needed for modeling energy systems and  
 75 are, in those predominantly, an exogenous input parameter. The present values  
 76 for LNG price trends, especially for those in Europe that consider the absence  
 77 of Russian pipeline gas, may therefore be of great importance for future work  
 78 of the scientific community analyzing the trajectory of the European energy  
 79 system toward carbon neutrality.

80 The method applied is the development of a linear optimization model. The  
 81 objective function is to minimize the total LNG import costs (i.e., the sum of  
 82 all import countries) while fulfilling all importer’s exogenously predefined LNG  
 83 demands. Import and export countries are represented by nodes in the model.  
 84 Optimality of the model finds, among others, optimal LNG flows from each ex-  
 85 port to each import country. Input parameters encompass LNG import volumes  
 86 (i.e., demands) with a monthly or yearly resolution, LNG export capacities, and  
 87 LNG break-even prices. Additionally, spatial and further techno-economic data  
 88 is used to calculate LNG transportation between each export and each import  
 89 country. The data is available under a Zenodo license. The optimization model  
 90 is implemented in Python, solved with Gurobi, and available on GitHub.

91 The paper is organized as follows. Section 2 summarizes the current state-of-the-  
 92 art in literature and outlines the own contribution of this work beyond existing  
 93 research. Section 3 presents the materials and methods developed in this work,  
 94 including the mathematical formulation of the model, input data, and scenarios.  
 95 Section 4 presents the results of this work, including sensitivity analyses of key

determining parameters. Section 5 discusses the results, concludes the work,  
and outlines possible future research.

## **2. Literature survey and own contribution**

## **3. Materials and methods**

## **4. Results and sensitivity analysis**

### *4.1. Sensitivity analysis*

## **5. Conclusions and outlook**

### **Declaration of interests**

None.

### **Declaration of Competing Interest**

The authors report no declarations of interest.

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