

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

3 Sebastian Zwickl-Bernhard^{a,b,*}

4 ^a*Energy Economics Group (EEG), Technische Universität Wien, Gusshausstrasse*
5 *25-29/E370-3, 1040 Wien, Austria*

6 ^b*Department of Industrial Economics and Technology Management,*
7 *The Norwegian University of Science and Technology, Trondheim, Norway*

8 **Abstract**

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

9 *Keywords:*

*Corresponding author

Email address: zwickl@eeg.tuwien.ac.at (Sebastian Zwickl-Bernhard)

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 planning¹. 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

¹For 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 **Declaration of interests**

92 None.

93 **Declaration of Competing Interest**

94 The authors report no declarations of interest.

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