

Response to reviewers

To the editor and reviewers,

Thank you for taking the time to review our paper submitted to *Energy*. The criticism and recommendations from Reviewer #2 have been carefully considered in the revised version of the manuscript. Changes to the manuscript have been made visible in blue color. We believe that the reliability of our results has improved the paper. We would again thank Reviewer #1 for the constructive criticism in the first round.

Before delving into the specifics of the two remaining issues, we would like to express our appreciation for the reviewer's and editor's patience and thoroughness in considering our manuscript. We understand the importance of integrating feedback effectively while maintaining the integrity of our original intent. Balancing these aspects has been a challenge, but we believe the current version of the manuscript strikes a balanced compromise between our central arguments and the critiques provided by Reviewer #2. After having addressed all points in our first response we provide a detailed explanation of how we addressed the two (remaining) core issues in the revised manuscript:

- 1. Regarding the uncertainty analysis of parameters, the revised draft of the article only proposes that "future work should solve the uncertainty of key parameters through probability and statistical methods", but it has not been revised in the current research.*
- 2. In the original study, the research period was only 2040. It is suggested to adjust the model to a dynamic simulation year by year to reflect the temporal trend of the global LNG market. However, the revised draft did not make any adjustments to the model.*

First, we note that Reviewer #2 suggests a fundamentally different choice of method. We will argue that for the purpose of our contribution this is not required and elaborate as follows:

Ad 1) In response to the reviewer's feedback, we have included a dedicated section in the revised manuscript to examine the impact of parameter uncertainty on the outcomes. This new section, titled "Section 4.3 Sensitivity analysis," features a comprehensive Monte Carlo simulation comprising 10 000 iterations. Our objective is to thoroughly assess the sensitivity of the modeling results, with a particular emphasis on key results such as the average and marginal cost of supply to Europe, as well as the proportion of European domestic production equipped with CCS, across the *Net Zero* and *Persisting Fossil Demand* scenarios.

Throughout this analysis, we have tailored the stochastic parameter sampling for each Monte Carlo simulation model run to align with the previously examined cases. For instance, in the case labeled *High price Middle East*, we stochastically vary the delivered ex-ship costs from the Middle East between zero and one quarter. Similarly, in the case

denoted as *No export from Africa*, we amplify the delivered ex-ship costs of African exporters up to fourfold.

Furthermore, we have introduced five new result figures (Figure 10a-b, Figure 11a-b, and Figure 12) in the revised manuscript to visually depict the outcomes of our sensitivity analysis. We are confident that by incorporating both the previously analyzed cases and the Monte Carlo simulations, our study ensures the reliability and robustness of the obtained results.

Despite the efforts made to address uncertainties in input parameters through the Monte Carlo simulation, we acknowledge that there is still room for improvement in this aspect. We appreciate the recommendation for future work to further explore the impact of parameter uncertainties on modeling results. This suggests that despite the steps taken in our current analysis, there may be additional avenues to consider regarding the handling of uncertainties in input parameters.

Ad 2) In response to the reviewer's feedback, we have included a dedicated section in the revised manuscript to examine the temporal trend of results. This new section, titled "Section 4.4 Temporal trend of supply costs to Europe until 2040," includes as suggested a dynamic simulation year by year to reflect the temporal trend of the global LNG market. Since the focus of our analysis lies on the role of Europe, we present the average and marginal supply costs to Europe from 2030 to 2040, respectively. The values are derived by running the model on an annual basis (i.e., year by year). In the modeling approach, it is assumed that the demand remains consistent across both scenarios in 2030, following which it diverges. This explains why the values are identical for the two scenarios in 2030. As a simplification, gasification and liquefaction capacities are presumed to remain consistent across all yearly model iterations. We have introduced two new result figures (Figure 13a-b) in the revised manuscript to visually depict the outcomes of the temporal trend.

We have deliberately chosen to only consider developments until 2040. This is mainly due to the unclear role of Europe in an international context at this point in time. Whereas it is clear that to achieve committed decarbonization goals by 2050 will result in negligible amounts of LNG imported to Europe, this is less clear for the year 2040. With the current surge in LNG activities globally and the securing of European energy imports against the phasing out of imports of Russian natural gas it seems relevant to assess the role of Europe in such a context.

We believe that investment decisions need to be taken in the very short-to-mid-term to achieve the committed decarbonization goals by 2050. Our paper aims to contribute to the debate on if and how important Europe and its demand for natural gas is in an international context.

We hope that revised manuscript and the elaborations above have clarified the points of misunderstanding and can now be considered for publication.

Best regards, Sebastian Zwickl-Bernhard and Anne Neumann