

Seasonal Flexibility in the European Natural Gas Market

Online Supplementary Material

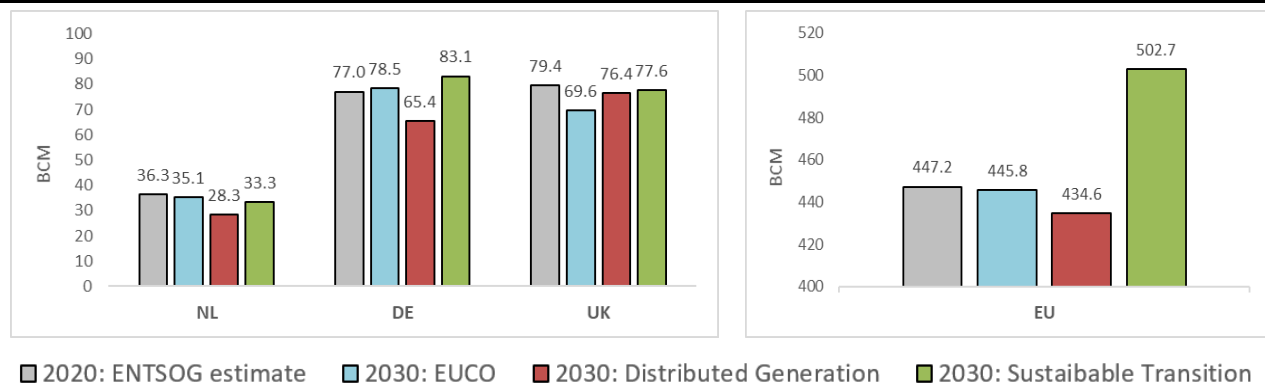
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While we rely on **EUCO30** scenario projections from ENTSG TYNDP (2018) report to base our assumptions on gas demand developments until 2030, we acknowledge that these inputs are subject to uncertainty. Such uncertainty impacts the model outputs, and thus the resulting estimates (e.g. the scaled coefficient of variation) carry also uncertainty.

This online appendix shows the results when we base our assumptions on different demand scenarios from the same source. The results provide robustness checks to the estimated effects in the main paper. The online appendix also includes supplementary materials to the discussion of the main text, such as the short-term effect that Nord Stream 2 pipeline has on storage utilization in Germany.

The two additionally modelled scenarios for the gas demand are **Sustainable transition scenario** and **Distributed generation scenario**. These represent the high demand and the low demand scenarios on the EU scale accordingly; however, on the country scale, the order varies (see Figure 1).

Figure 1: Annual gas demand in three selected countries (left) and EU*(right) per scenario.



*here we refer to the modelled EU area (see Appendix B of the manuscript)

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MODEL OUTPUTS: SUSTAINABLE TRANSITION

Figure 2: Quantitative gas supply contributions for selected countries in bcm per month. Time axis depicts calendar years. Sustainable transition scenario.

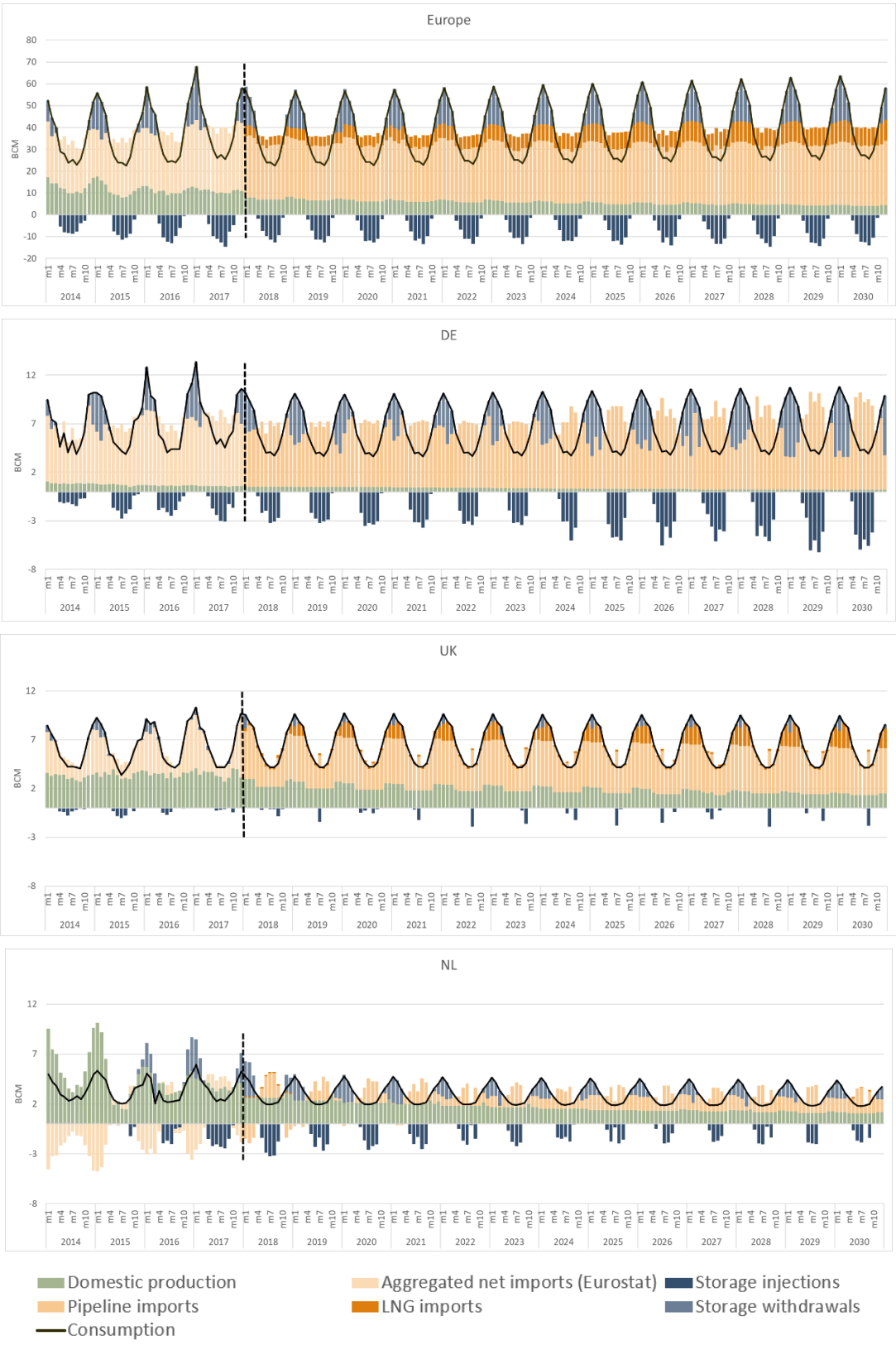


Figure 3: Annual load duration curves for selected countries in bcm per month. Time axis depicts calendar years. Values are sorted by gas consumption levels. Sustainable transition scenario.

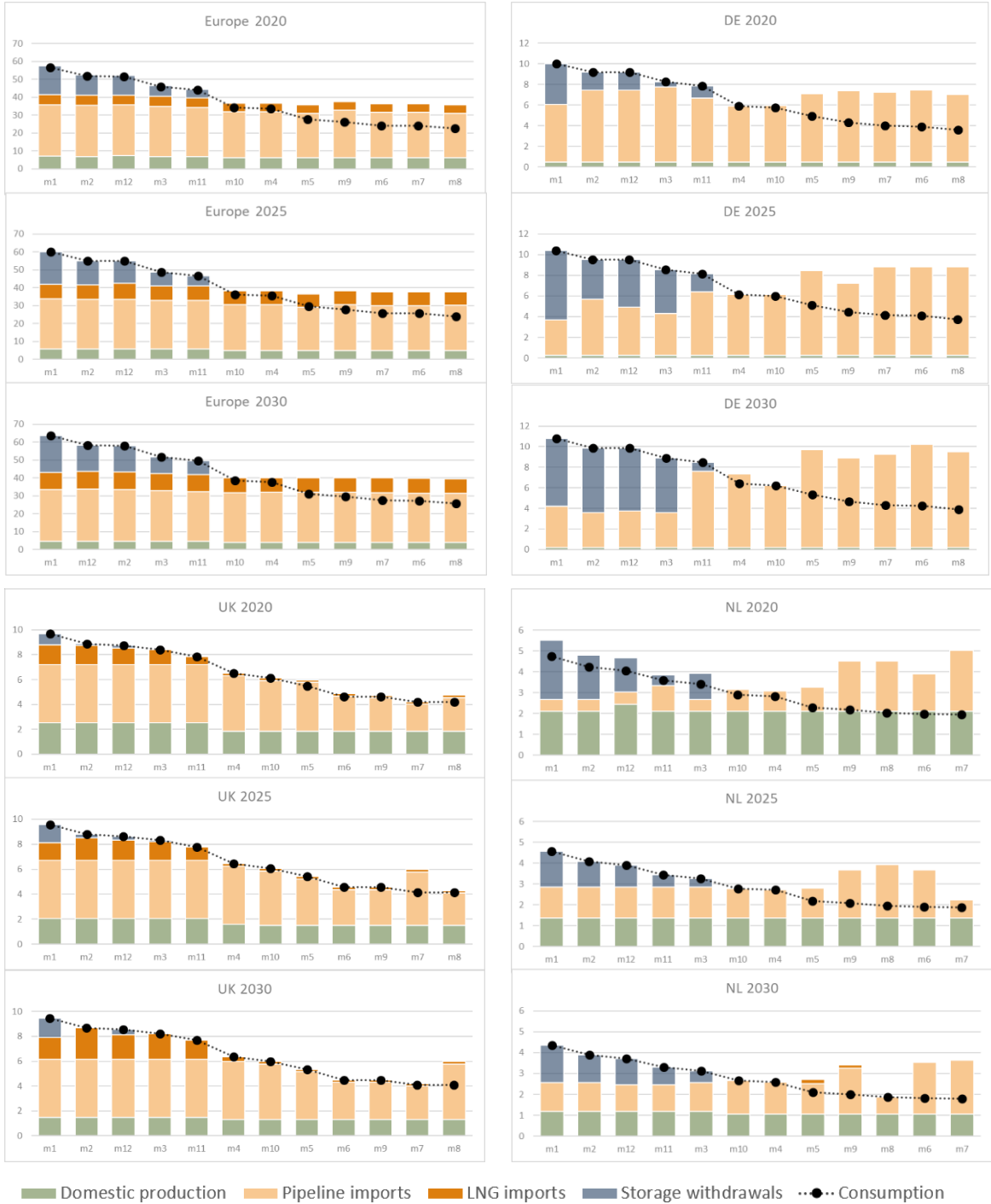
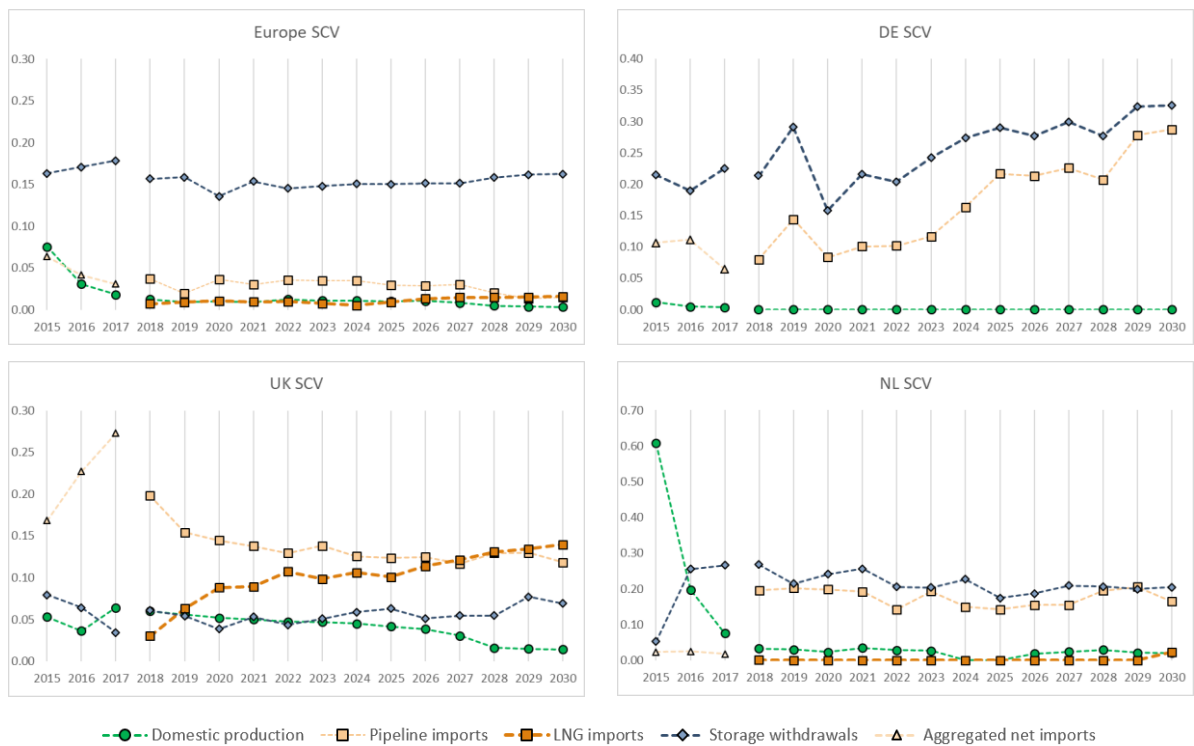


Figure 4: Annual SCVs for selected countries. Sustainable transition scenario.



MODEL OUTPUTS: DISTRIBUTED GENERATION

Figure 5: Quantitative gas supply contributions for selected countries in bcm per month. Time axis depicts calendar years. Distributed generation scenario.

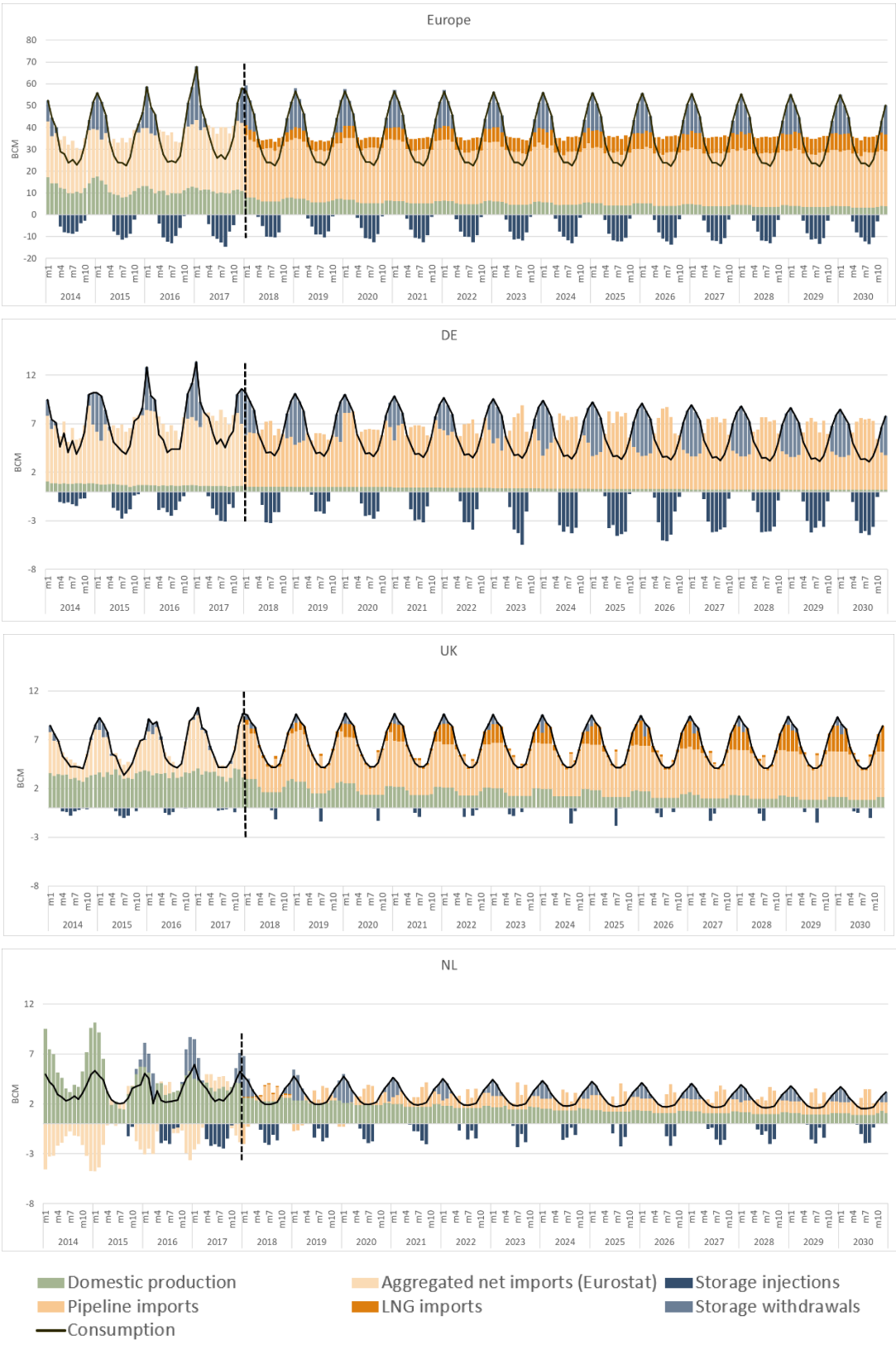


Figure 6: Annual load duration curves for selected countries in bcm per month. Time axis depicts calendar years. Values are sorted by gas consumption levels. **Distributed generation scenario.**

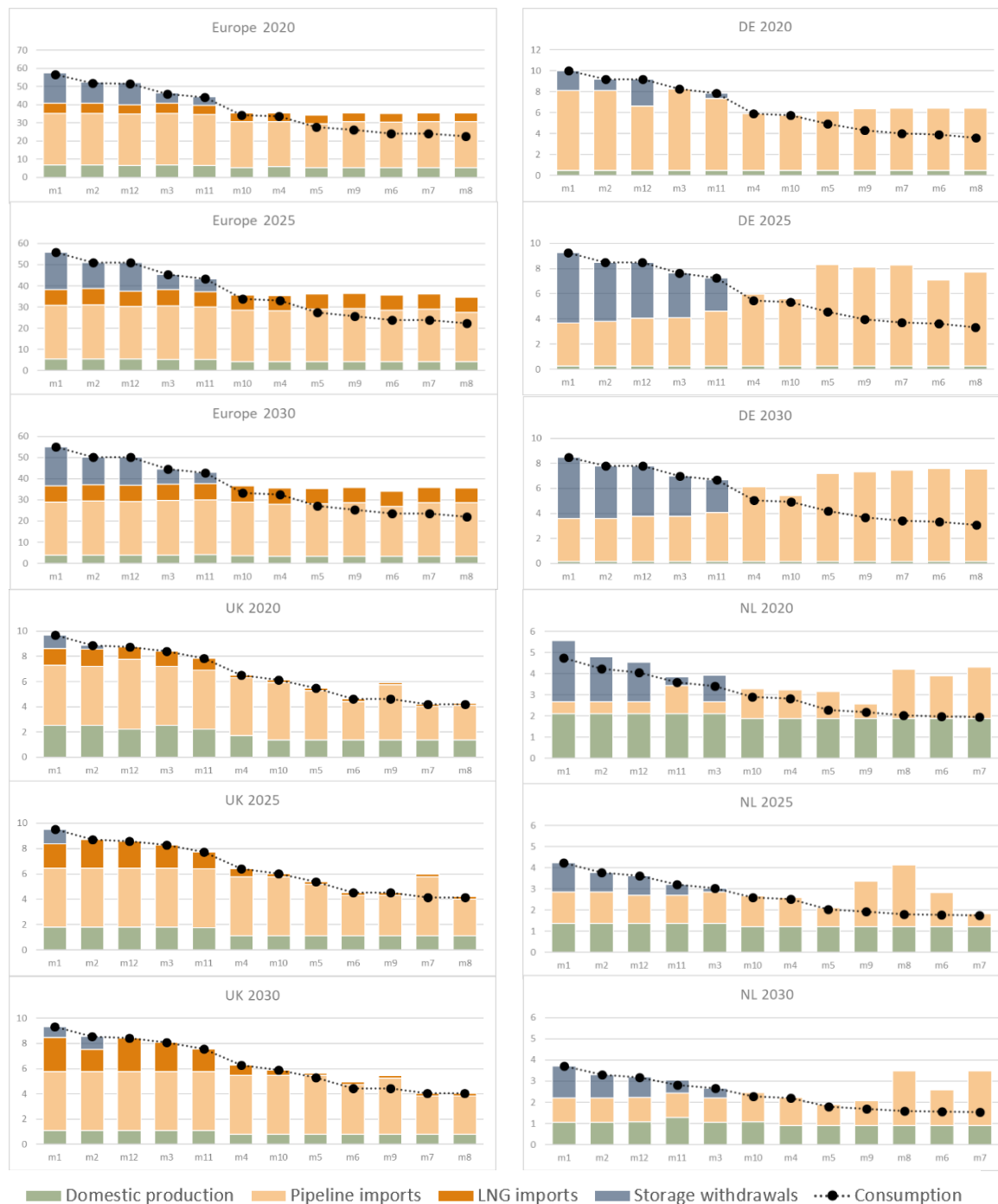
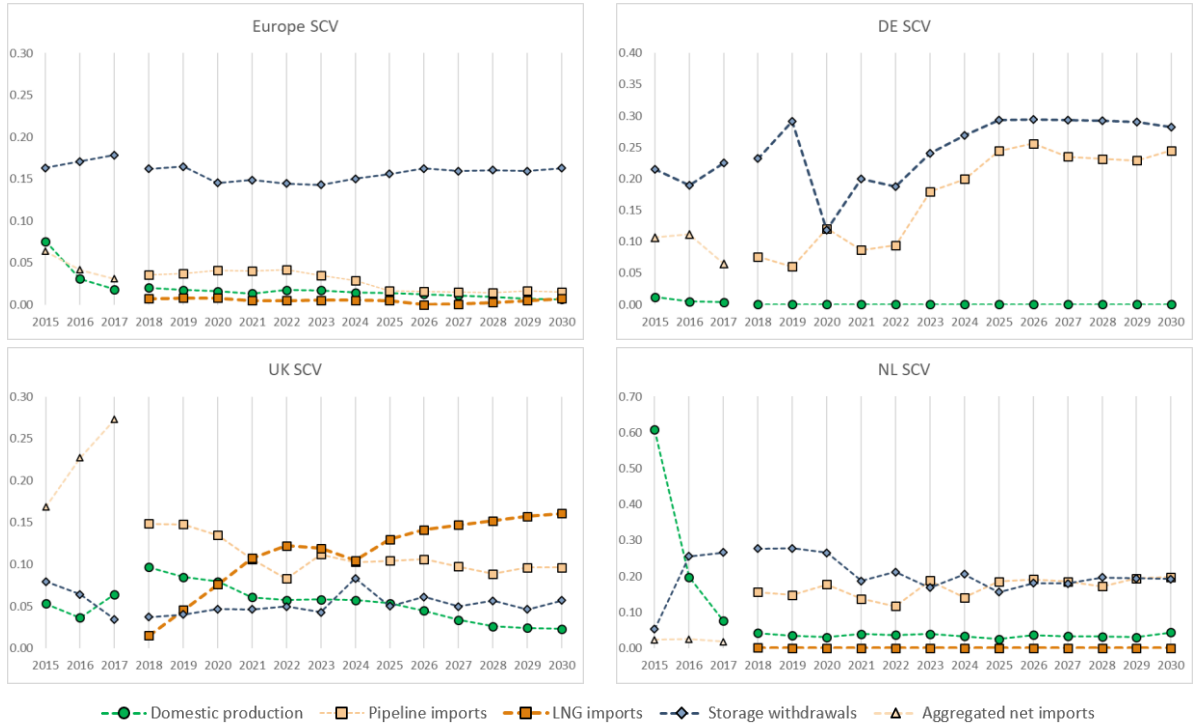


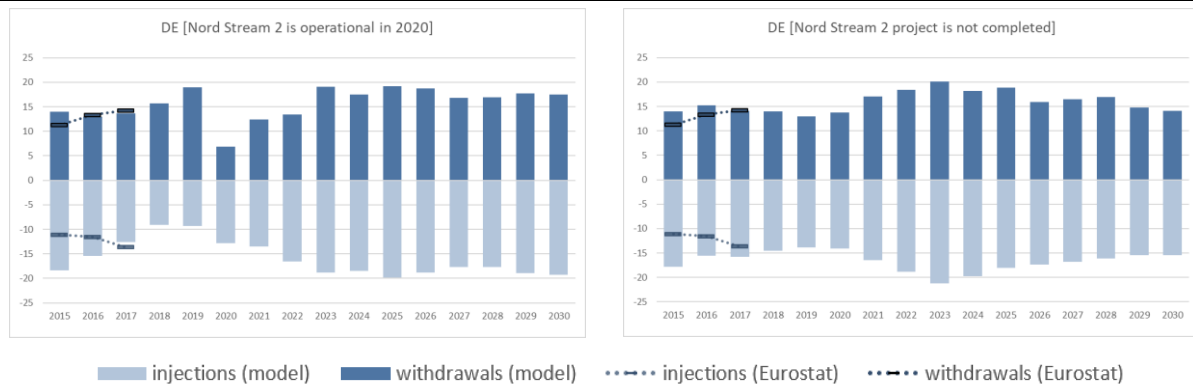
Figure 7: Annual SCVs for selected countries. Distributed generation scenario.



SUPPLEMENTARY MATERIAL FOR SECTION 3.1

Figure 8: illustrates net annual storage injections and withdrawals in Germany for the reference scenario (left) and for a scenario in which Nord Stream 2 is not realized and all other market settings remain the same (right). The results suggest that gas imports via the Nord Stream 2 pipeline aimed at substituting storage withdrawals in 2020 will have a short-term effect—storage utilization recovers the following calendar year. Furthermore, the fact that injection and withdrawal volumes in preceding years are greatly affected can be explained by the perfect information assumption in a cost-minimization problem.

Figure 8: Utilization of German gas storage under different market settings—the Nord Stream 2 pipeline is completed by 2020 (left) and the Nord Stream 2 pipeline is not completed (right). EUCO30 Scenario. All values are in bcm per year.



REFERENCES

ENTSOG TYNDP. The Ten-Year Network Development Plan (2018). Available at: <https://www.entsog.eu/tyndp>.