

Capacity requirements for LNG terminals in Germany

Prepared for Hanseatic Energy Hub GmbH

June 2022



Executive Summary

This study was commissioned by the Hanseatic Energy Hub to show the potential contribution of LNG import terminals to security of supply in a stress event.

Two scenarios without Russian gas supply were modelled for 2025 and 2030 that are mainly differentiated by gas demand and called "Baseline" and "Optimistic" scenario.

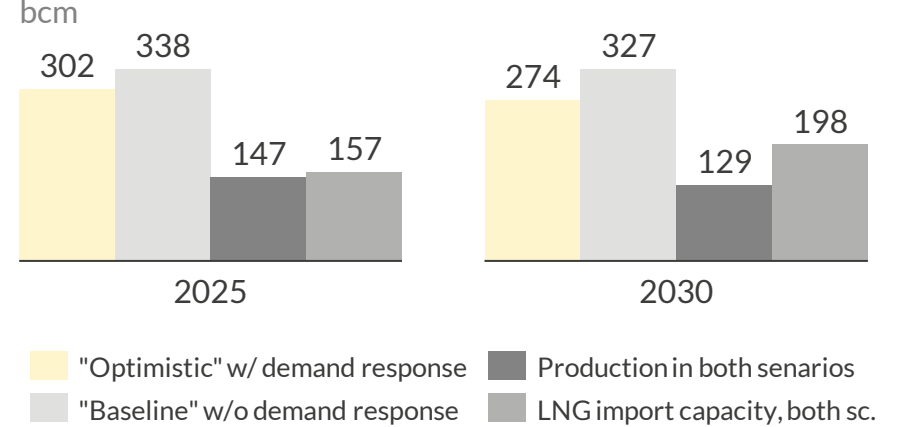
To assess security of supply, an N-1 case was calculated in which the largest pipeline supplying Germany is not available.

We found that all planned German LNG-import terminals would be required to meet German gas demand under the Baseline scenario in 2030.

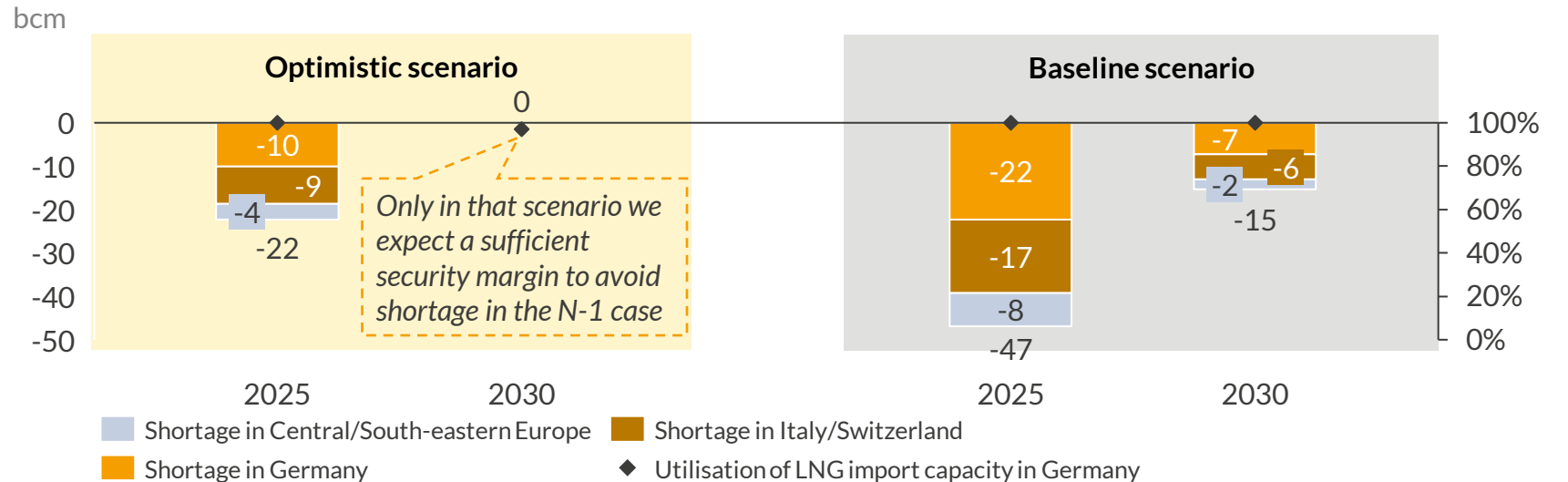
Scope and methodology

- We considered two scenarios that only differ with regards to the future gas demand as it depends on the speed of the energy transition and the scale of demand side response to elevated gas prices
- We analysed whether secure gas supply in Germany and Core Europe is met under an N-1 criterion where Europipe II, with 24 bcm/a of capacity is not available for one year
- All currently planned or announced LNG terminals were considered

Key assumptions for Core Europe¹ by scenario



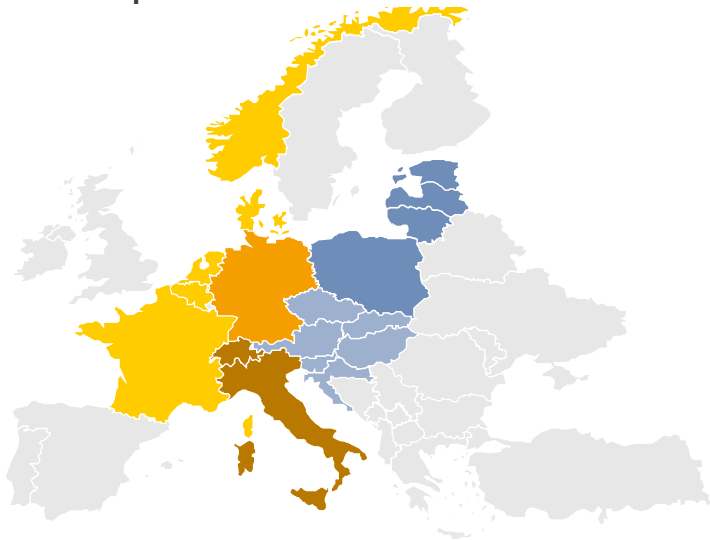
Key results: Supply shortages in two scenarios with the Europipe II not available in respective year



1) Germany and directly neighbouring regions, countries are listed on next slide

This study is based on two scenarios with the main differentiator of gas consumption and focuses on Germany and Neighbours

Regions considered for this study "Core Europe"



- Germany
- Additionally modelled countries
- Italy/Switzerland
- Central-Southeast Europe
- Northeast Europe

Gas scenarios used for this study in 2025 and 2030

1. "Baseline" scenario

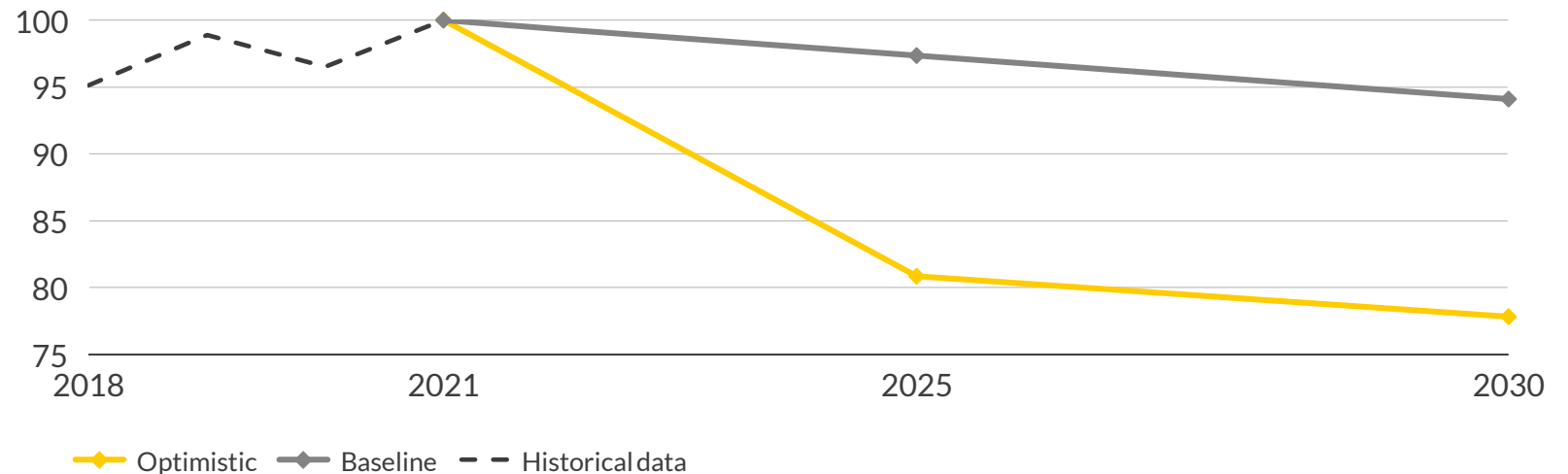
- We assume no reaction of gas demand in comparison to a business-as-usual scenario as published in Aurora's April 2022 commodity forecast
- Capacity additions of renewables remain below government targets

2. "Optimistic" scenario

- A significant reduction of gas demand in power sector is assumed due a strong expansion of renewables
- In response to the high prices and political effort, energy demand in industry, households and services decreases in that scenario

Gas demand, Germany

bcm



We stress-test Core Europe's gas supply and demand balance under an N-1 scenario by removing supply via Europipe II for one year

Methodology

- I Inputs from Aurora's global commodity model for the two scenarios
- II Calculation of base case for the scenarios by balancing of import and export gas flows considering physical constraints in gas pipeline infrastructure between countries
- III Calculation of the N-1 case with the loss of the single largest supply route by balancing of import and export gas flows considering physical constraints in gas pipeline infrastructure between countries¹
- IV Outcome: level of security of gas supply can be assessed

Key flow restrictions between regions

- Poland → Germany: 0bcm export capacity
- France → Germany: 1bcm export capacity
- Poland → Central-Southeast Europe: 0bcm export capacity from Poland to SVK/CZE

N-1 criterion

- For 2025 and 2030: unavailability of Europipe II, the largest pipeline connecting Germany and Norway with an annual capacity of ~24bcm
- Removal of the pipeline would impede Germany's ability to import pipeline gas due to:
 - Limited *additional* import potential from the Netherlands
 - Technical limitations for imports from Northeast Europe (Poland)

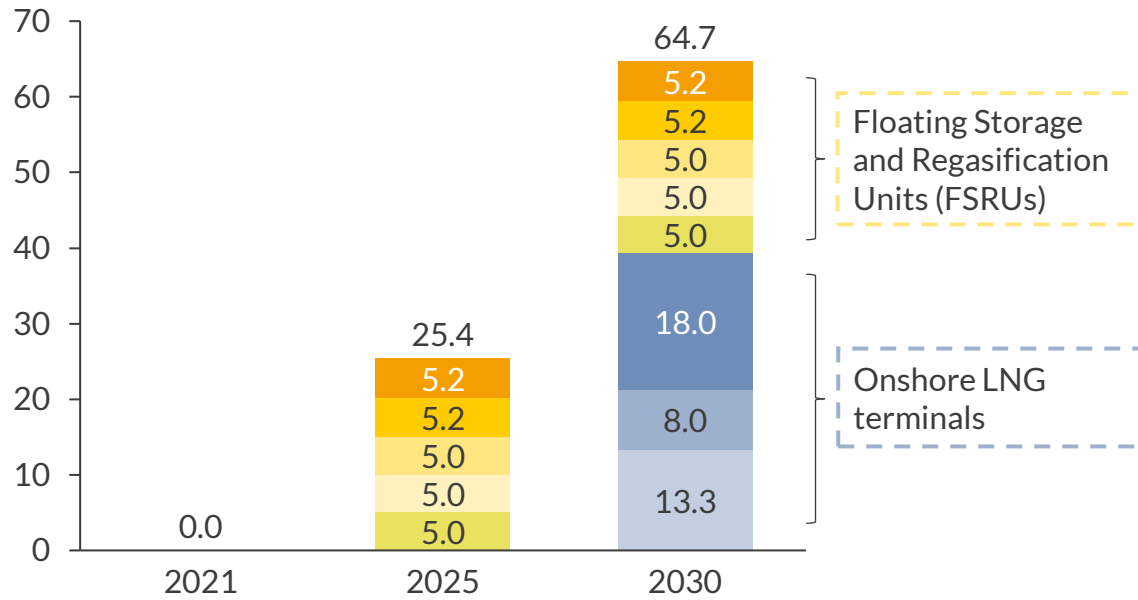


1) We optimised intra-EU gas flows such that the ratio between total demand and shortage was equivalent between the typically undersupplied markets: Germany, Italy/Switzerland, and Central-Southeast Europe

For Germany, we assume 25bcm LNG import capacities in 2025 increasing to 65bcm in 2030

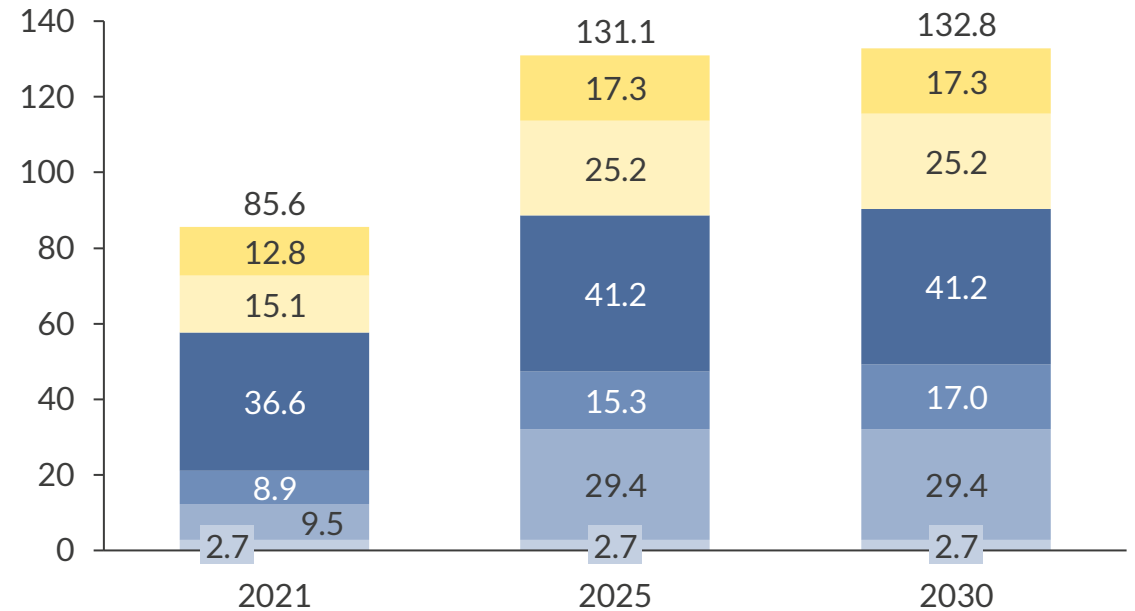
Assumed nominal LNG import capacities in Germany bcm

- Aurora assumes five FSRU units with a combined nominal capacity of 25.4bcm to come online until 2025
- For onshore LNG terminals, we assume COD at the end of 2026, bringing additional 39.3bcm of LNG import capacity to Germany
- LNG terminals are assumed to operate at 100% of their nominal capacity¹ unless the market is oversupplied or supply can be met via pipeline imports



Assumed nominal LNG import capacities in Core Europe excluding Germany bcm

- Nominal capacity in Core Europe markets is expected to grow almost two-fold by 2025, with limited growth expected thereafter
- Largest capacity additions are expected in Northeast Europe, France, Italy and the Netherlands



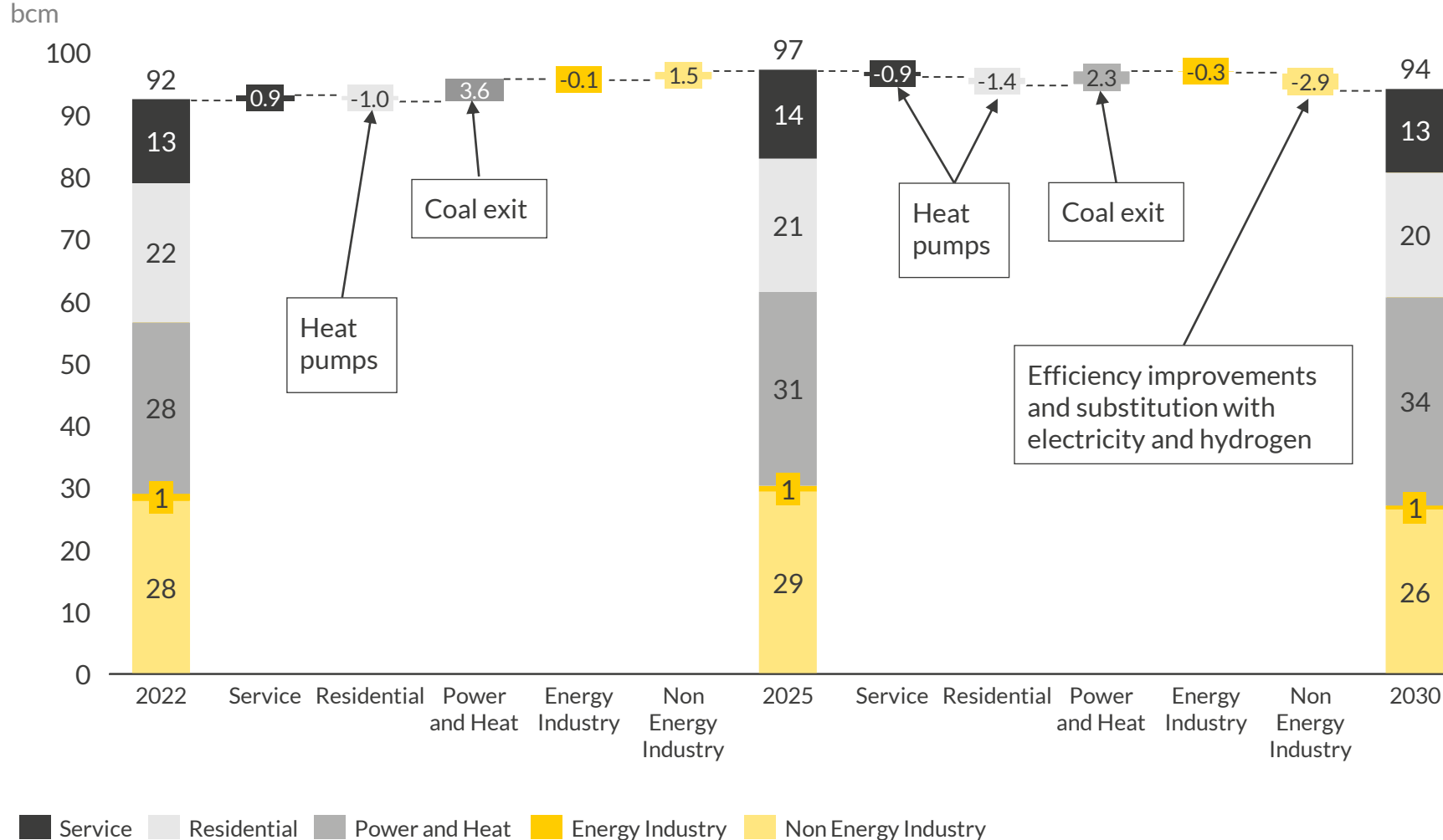
■ Trngas Force
 ■ Høegh Esperanza²
 ■ TES (FSRU)³
 ■ Brunsbüttel
■ Trngas Power
 ■ Høegh Galleon/Giant²
 ■ Wilhelmshaven
 ■ HEH - Stade

■ Netherlands
 ■ France
 ■ Northeast Europe
■ Italy
 ■ Belgium
 ■ Center-Southeast Europe

1) Temporarily the peak capacity can exceed the nominal capacity of LNG terminals 2) Two Høegh terminals are assumed, but they are not confirmed yet 3) Based on publicly available information; limited information on certainty of project materialisation

In the Baseline scenario without demand response gas demand is expected to persist rather stable till 2030

Natural gas demand in Germany, Baseline scenario (same demand as with continued imports from Russia)



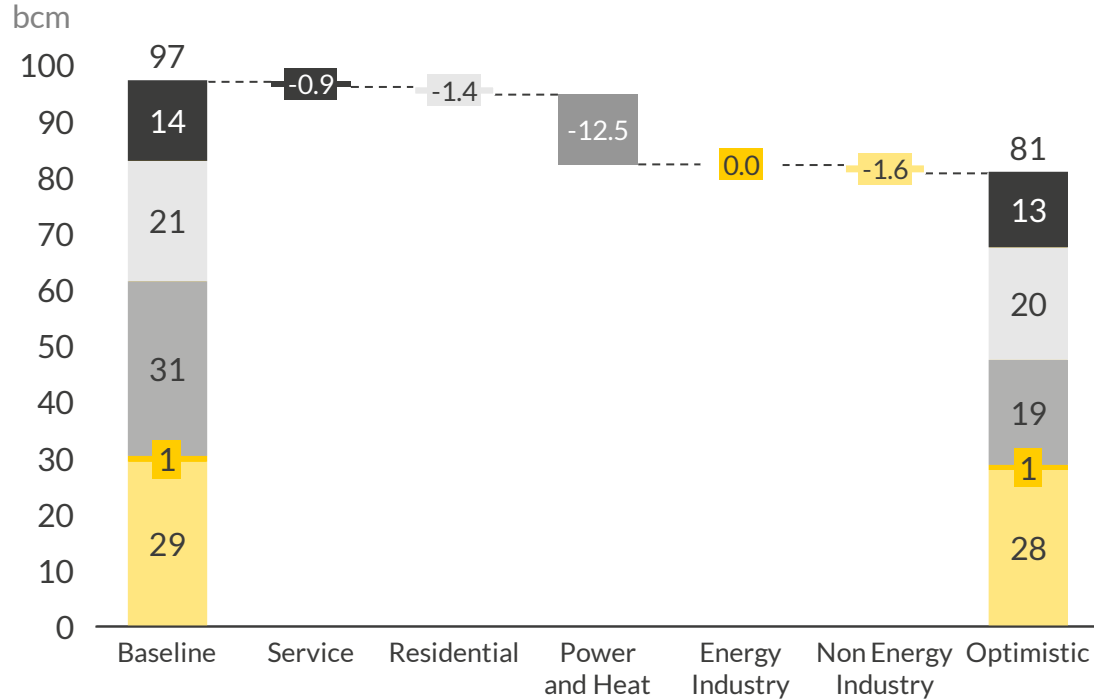
Comments

- We expect the gas demand to stay fairly stable till 2030 with a total growth of 2% in eight years
- The demand assumption of the scenario are based on Aurora’s Baseline scenario from April 2022
- The gas demand from the power sector assumed to rise till 2030 due to the coal exit and lower gas prices
- The expected coal exit is the main driver for increasing demand
- The installation of heat pumps in the residential and service sector is the main demand reducer

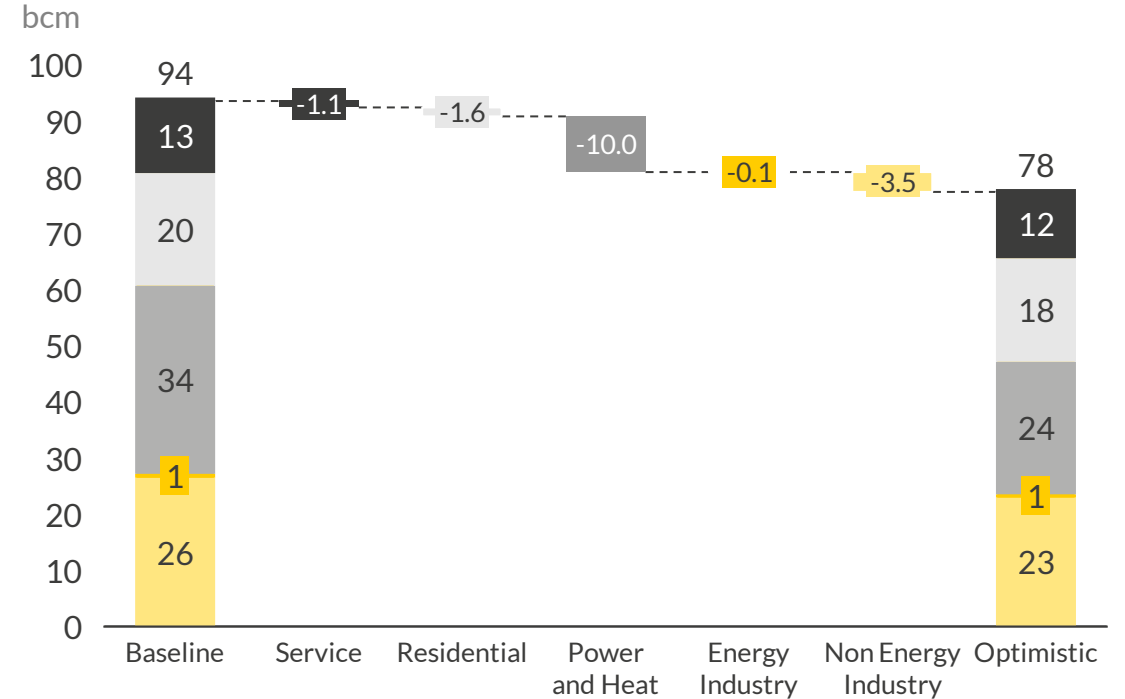
Demand in the Optimistic scenario with demand response is lower than in the other scenario which mainly driven by the power sector

Natural gas demand delta in Baseline vs Optimistic scenario, Germany

Gas demand 2025



Gas demand 2030



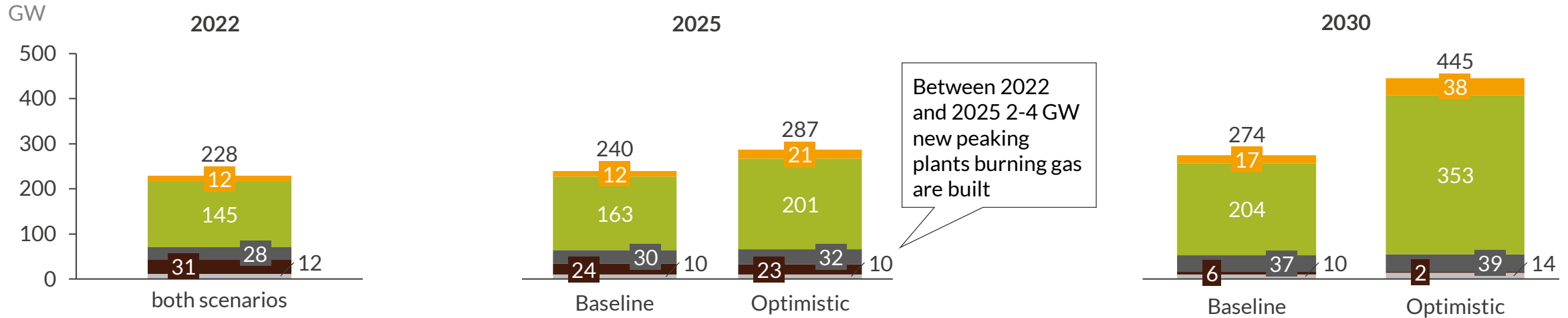
- The most important driver is the power market sector: in case of an import stop from Russia we would expect increased production of coal power plants in the short-term and more renewables in the mid-term
- Demand from other sectors is assumed to be rather inflexible

- In 2030 the power sector stays the main differentiator: more renewables, batteries and power-to-heat substitute gas fired CCGTs and CHPs
- The demand reduction in industry can be explained by fuel switching and sustainable loss of competitiveness of some energy intensive industries

■ Service ■ Residential ■ Power and Heat ■ Energy Industry ■ Non Energy Industry

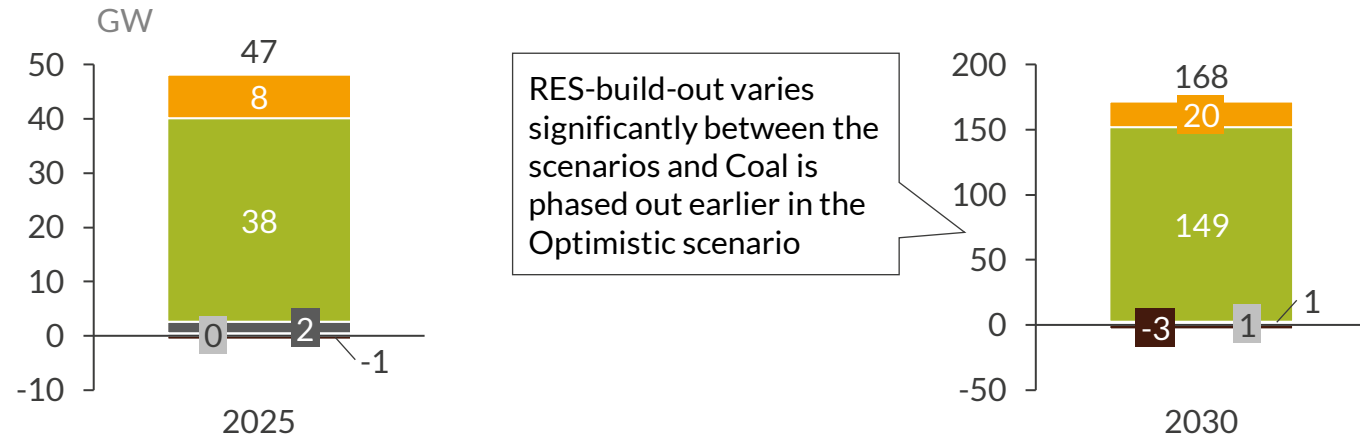
The Optimistic scenario expects 54 GW more PV build-out than the Baseline in 2030, as well as faster closure of coal

Installed capacity, Optimistic vs Baseline scenario, Germany



Between 2022 and 2025 2-4 GW new peaking plants burning gas are built

Difference in capacity, Optimistic minus Baseline, Germany



RES-build-out varies significantly between the scenarios and Coal is phased out earlier in the Optimistic scenario

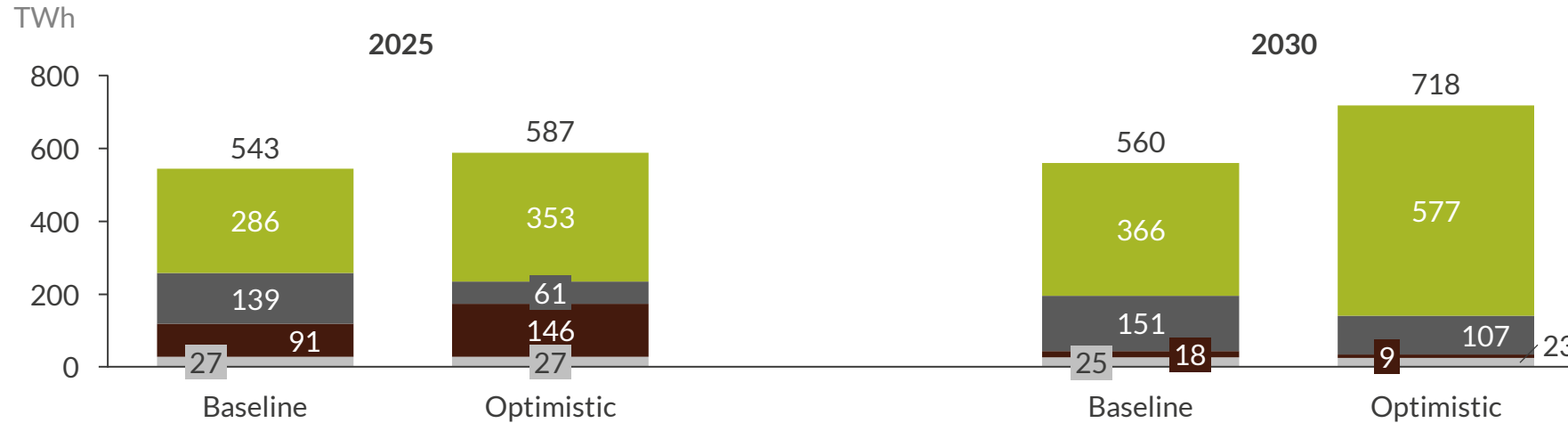
- Power generation capacities are compared between the Optimistic and the Baseline scenario
- The largest growth is expected for renewables, increasing by 59-208 GW from 2022 to 2030

Flexibilities¹ RES² Gas³ Lignite/Coal⁴ Other thermal⁵

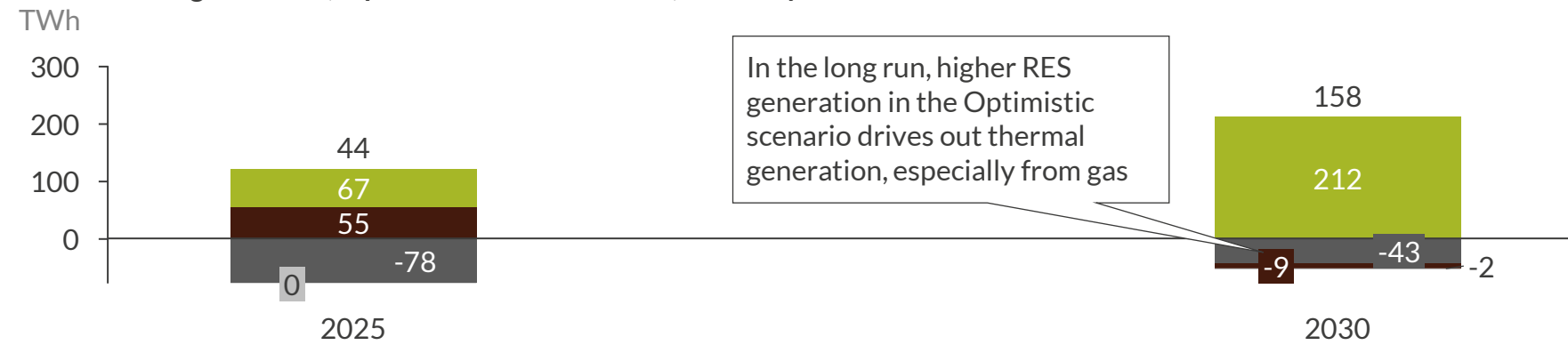
1) Flexibilities include DSR, pump storage and batteries; 2) RES is composed of Solar PV, onshore and offshore wind, biomass, other gas renewables, hydro and marine. 3) Gas ist CCGTs, OCGTs, and peaking plants 5) Other thermal consists of nuclear plants, waste and on-site industrial thermal power plants and oil peaker.

Power generation from renewables reaches 75%-80% in 2030, impacting gas demand

Power generation, Optimistic vs Baseline scenario, Germany



Difference in generation, Optimistic minus Baseline, Germany



Comments

- In the 2025, the Optimistic scenario less gas is used in the power sector with a generation of 43-78TWh less electricity than in the Baseline scenario
- In the 2025, unused coal and lignite capacities act as a replacement, generating 55 TWh more than in Baseline vs. Optimistic
- Towards 2030, renewables increasingly fill the gap, generating 80% of the electricity in the Optimistic scenario (557 TWh) and 65% (366 TWh) in the Baseline scenario

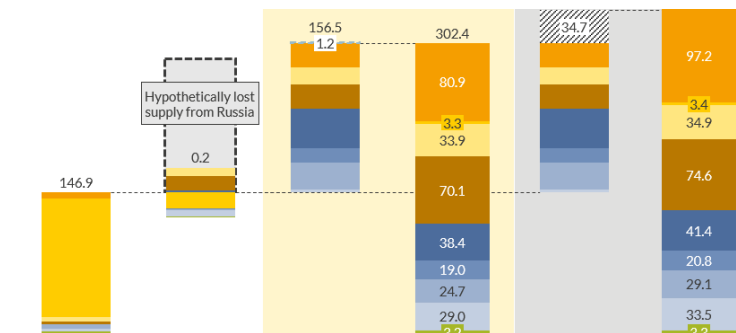
RES^{1,2} Gas³ Lignite/Coal⁴ Other thermal⁵

1) As generation from pump storage and batteries nets out over the year, this is not shown here; 2) RES is composed of Solar PV, onshore and offshore wind, biomass, other gas renewables, hydro and marine. 3) Gas ist CCGTs, OCGTs, and peaking plants 5) Other thermal consists of nuclear plants, waste and on-site industrial thermal power plants and oil peaker.

The key results of the study are shown in three steps

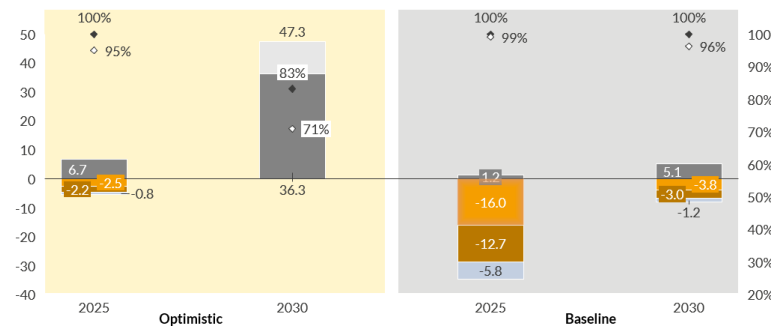
1. Aggregated Core European level

- Assumptions for production, net imports, demand and LNG imports are visualised for 2025 and 2030
- In 2025 security of supply is at risk in both scenarios on an aggregated level with either a high shortage or a low security margin
- In 2030 additional LNG capacities allow a security margin in Optimistic but in the Baseline scenario a net shortage of 8 bcm is expected



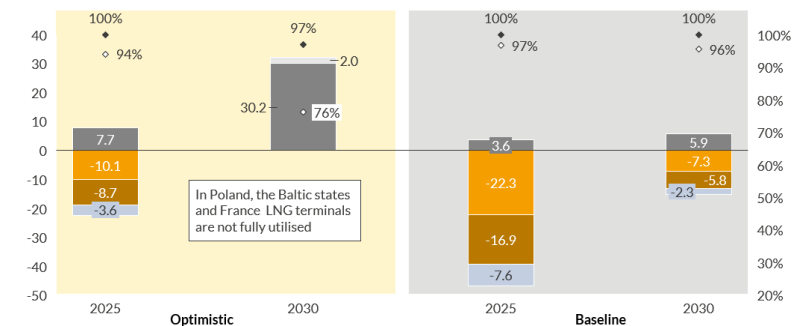
2. Base case: expected shortages by country

- While Core European markets are balanced on aggregate, intra-EU flow constraints can cause constraints in Germany and other markets
- For Germany, Italy/Switzerland, and Central-Southeast Europe in 2025 shortages are expected even with a strong demand response and a net zero path in the power sector
- LNG imports are expected to play a key role for supplying markets previously relying in Russian imports



3. N-1 case: expected shortages by country

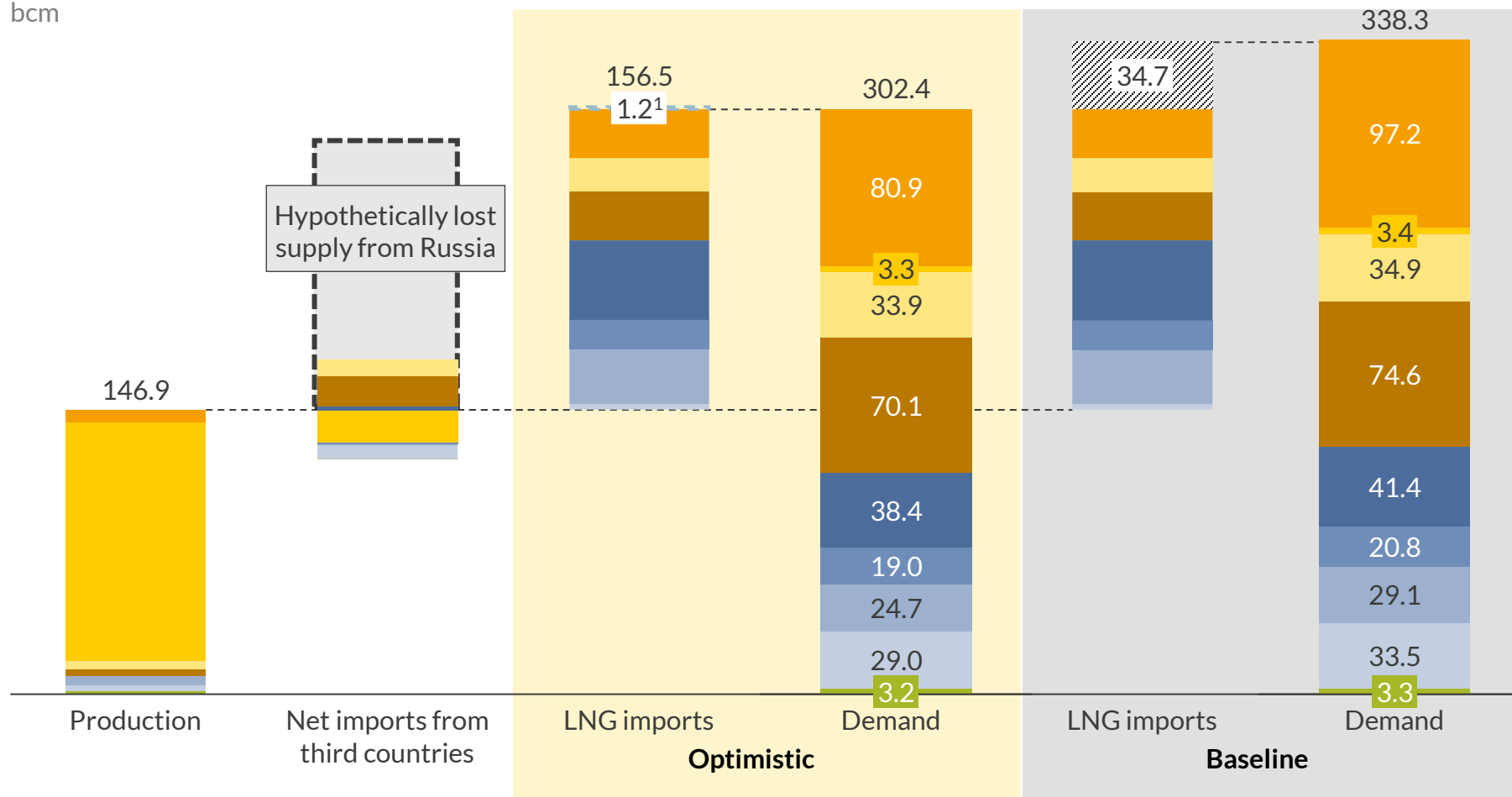
- A combination of Russian import halt and Europipe II fallout causes significant shortages in most scenarios
- Despite pan-European supply being relatively balanced, intra-European flow constraints can exacerbate shortages in some markets under an N-1 scenario
- Germany, Italy/Switzerland, and Central-Southeast Europe are expected to have shortages in case Europipe II pipeline flows stop in most scenarios



1. In 2025 security of supply is at risk in both scenarios on an aggregated level with either a shortage or a low security margin

Demand, production, and imports in Core European markets in 2025

bcm



Comments

- Under an Optimistic scenario, we expect Core European markets to have a minor security margin in 2025 in the absence of gas imports from Russia
- Absence of demand response can lead to a shortage of ~35 bcm per year (~10%) of total demand in the baseline scenario
- Shortages in individual markets can be exacerbated due to intra-European flow constraints

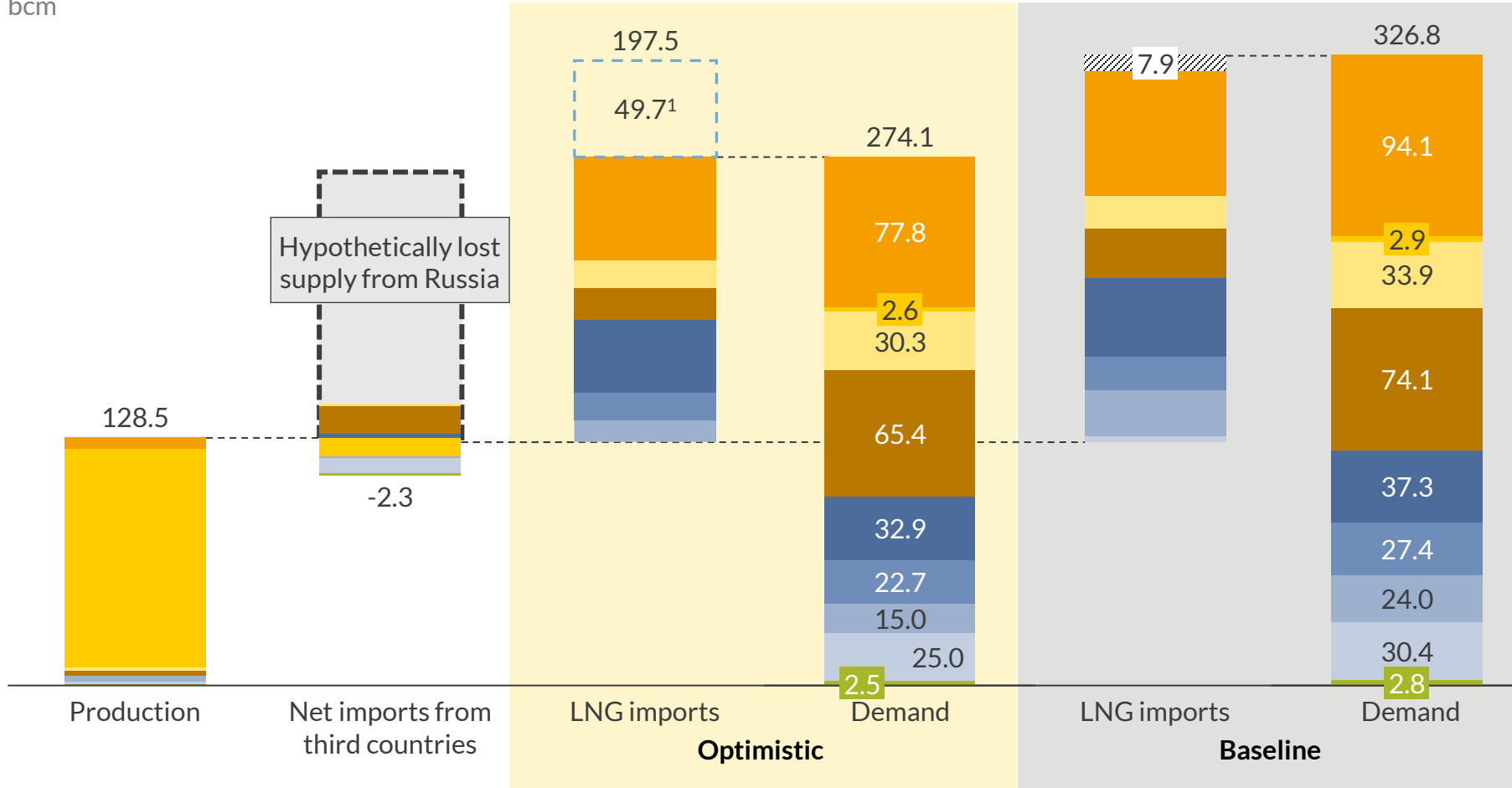
 Net security margin
 ■ Germany
 ■ Netherlands
 ■ France
 ■ Northeast Europe
 ■ Denmark
 Net shortage
 ■ Norway
 ■ Italy+Switzerland
 ■ Belgium+Luxembourg
 ■ Center-Southeast Europe

1) Security margin represents pan-European balance between demand and available additional supply from LNG terminals across Core European markets

1. In 2030 more LNG imports allow a security margin in Optimistic scenario but a 8 bcm shortage is expected for the Baseline

Demand, production, and imports in Core European markets in 2030

bcm



Comments

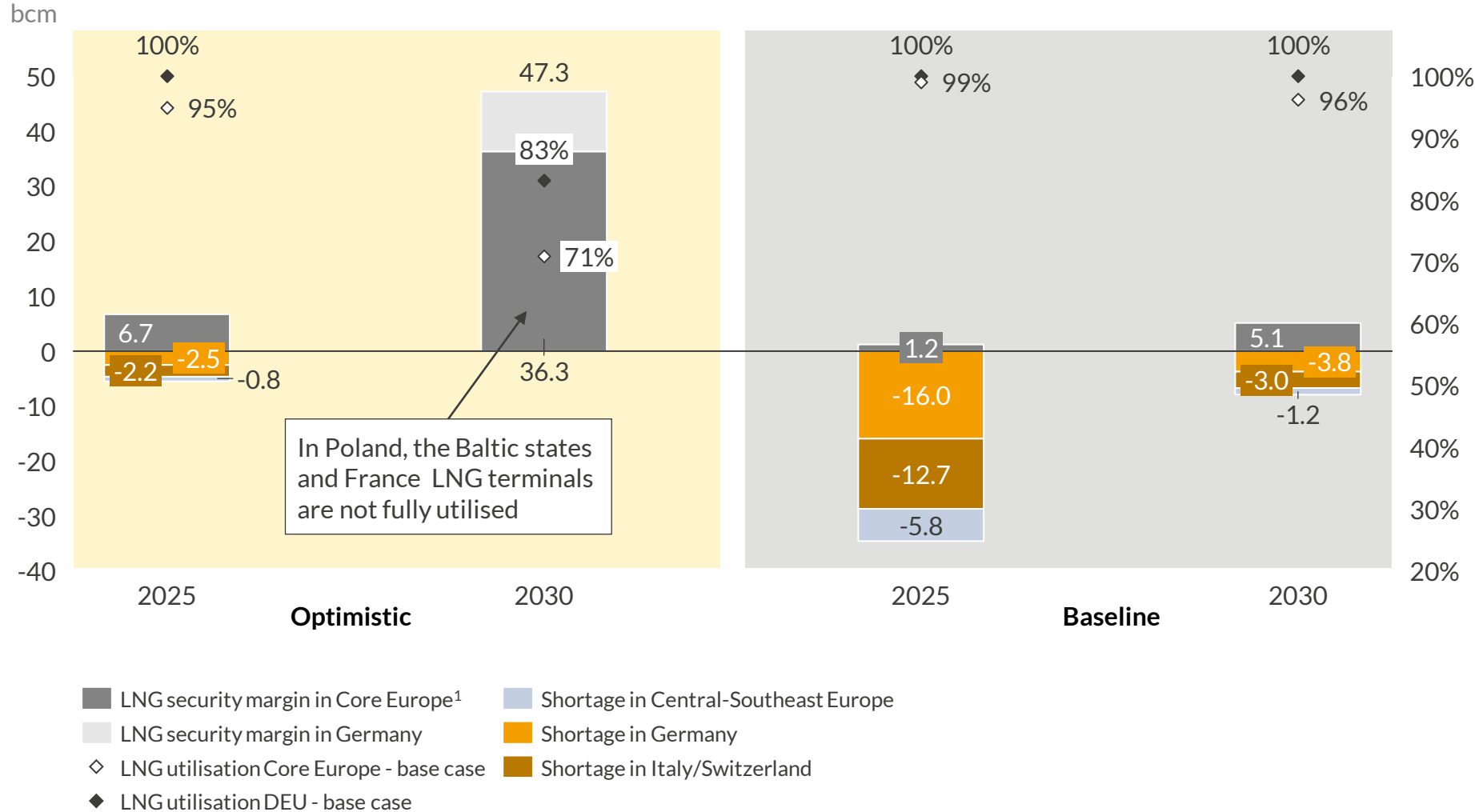
- In 2030 under the Optimistic scenario, we would expect oversupply of the Core European markets under an assumption of 100% utilisation of nominal LNG capacity
- Lagging demand response to missing Russian imports would lead to a shortage of ~8bcm (~3%) in the Baseline scenario
- Notably, intra-European flow constraints can further increase the shortage in importing markets, while driving oversupply in producing and LNG importing markets
- Consequently, we expect LNG imports to play a key role in supplying markets with limited pipeline import opportunities

Net security margin
 Germany
 Netherlands
 France
 Northeast Europe
 Denmark
 Norway
 Italy+Switzerland
 Belgium+Luxembourg
 Center-Southeast Europe

1) Security margin represents pan-European balance between demand and available additional supply from LNG terminals across Core European markets

2. While Core European markets are balanced on aggregate, intra-EU flow constrain supply in Germany and other markets

Balance in Core Europe markets and LNG utilisation under base case scenarios with optimised intra-EU flows



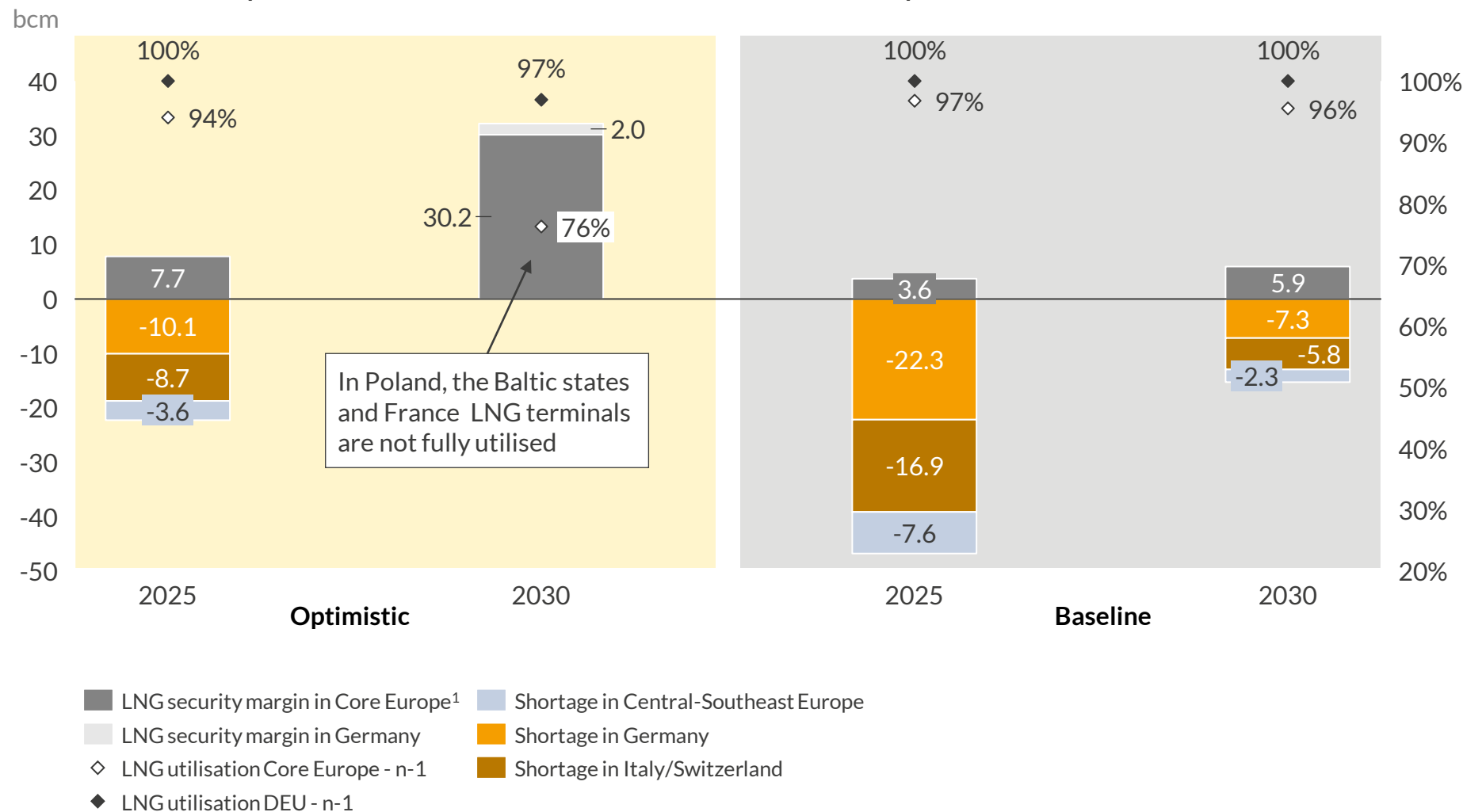
Comments

- For Germany, Italy/Switzerland, and Central-Southeast Europe shortages in 2025 are expected even with strong demand response
- This is primarily driven by intra-EU gas flow constraints (i.e. Poland having limited export capacity to pass all LNG imports to Germany and Central/SE Europe)
- Expected decrease in gas demand due to more systemic changes will alleviate the European shortage towards 2030
- Notably, German LNG import capacity utilisation is higher than the Core European markets' average even under excess supply, indicating importance of LNG for German gas security of supply

1) The security margin in Core Europe without Germany is not relevant for Germany since it would not be available due to gas grid constraints

3. Shortage caused by Russian import halt and Europe II fallout cause significant shortages in most scenarios

Balance in Core Europe markets and LNG utilisation under N-1 scenarios with optimised intra-EU flows



Comments

- Despite pan-European supply being relatively balanced, intra-European flow constraints can exacerbate shortages in some markets under an N-1 scenario
- Germany, Italy/Switzerland, and Central-Southeast Europe are expected to have shortages in case Europe II pipeline flows stop
- Germany's import capacity from Norway falls by ~50%; import capacities from France, Poland, and the Netherlands are restricted
- German LNG import capacity utilisation is close to 100% and significantly higher than in the other Core European markets' average even in the Optimistic scenario in 2030

1) The security margin in Core Europe without Germany is not relevant for Germany since it would not be available due to gas grid constraints

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