The Dutch Gas Market 2020-2030

VOLUME, CAPACITY AND FLEXIBILITY ANALYSIS

PREPARED FOR

Gasunie Transport Services

PREPARED BY

Dan Harris

Marcella Fantini

Matteo Coriglioni

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THE Brattle GROUP

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Introduction and Summary

1. The Dutch gas system is in transition. In March 2018 the Dutch Government decided to reduce the production of gas from the Groningen field progressively and to stop it by 2030. Following a new earthquake in May 2019, the Dutch government decided to aim at terminating production by 2022. However, the Groningen field is expected to be left in stand-by until 2026 to be able to supply additional capacity in case of a disruption or extreme cold weather. The decrease in gas production from the Groningen field has caused the Netherlands to become a net gas importer in 2018 for the first time in its history.

2. In the context of this transition, Gasunie Transport Services (GTS) has retained the Brattle Group (Brattle) to assess whether there will be sufficient gas volumes, infrastructure capacity and flexibility to meet forecast demand. We present our findings in this report.

3. The gas produced by the Groningen field is a low calorific gas ("L-gas"), and is mostly used in the Dutch residential and commercial sector for heating and exported to Germany, Belgium and France to supply their domestic sectors. The L-gas can also be produced from high calorific gas ("H-gas"), which is the gas from indigenous small fields or imported by the Netherlands, using conversion and blending facilities to increase concentration of nitrogen (pseudo L-Gas). L-gas and H-gas are transported and distributed through two separate infrastructures that are interconnected through the conversion and the blending facilities. Accordingly we conduct our analysis for the Dutch L-gas and H-gas markets separately, accounting for conversion capacity constraints. We focus on three reference years (2020, 2025 and 2030). For consideration of volumes, we consider demand both for average weather conditions and for cold weather conditions. For the analysis of capacity, we consider peak demand for 'design' conditions of -17 degrees Celsius. We also assess the use of Working Gas Volume (WGV), or flexibility, in both H-gas and L-gas storages.

4. We carried out our analysis based on historical data and projections provided by GTS on demand and supply. The volume and flexibility analysis is based on the balancing between total hourly demand and total hourly supply in the L-gas market and in the H-gas market in each hour of the year.

I.A. Volume Analysis

5. Our analysis shows that:

   a. Starting from 2025, when production of the Groningen field is close to zero, supply on the L-gas market depends on availability of H-gas and on conversion capabilities. L-gas storages are needed to provide the needed flexibility.

   b. In cold years import of H-gas additional to projected import will be needed to meet demand on both the L-gas market and the H-gas market. A marginal increase in import of H-gas is needed in 2030 even in the case of an average year to compensate for the significant expected decrease in production of small fields.

   c. Available import capacity can accommodate the required import volumes. The average load factor of the system in the average year (calculated based on capacity available at all entry points) is estimated to amount to 79% in 2020 and to decrease to 60% in 2025 following decrease in demand. The load factor is not expected to change in 2030 when, despite further decrease in gas demand, more import is needed to compensate for decrease in production of small fields. If we assume that gas import will flow only from Norway and Germany (in the latter case from the interconnection with the Gaspool area), the load factor of such points in the average year will amount to 94% in 2020, 79% in 2025 and 82% in 2030.

   d. In cold years load factors are higher as more import is needed to meet increase in gas demand. The average load factor of the system is estimated to amount to 79% in 2020 and to decrease to 69% in 2025 following decrease in demand. The load factor is expected to decrease marginally to 68% in 2030 when more import is needed to compensate decrease in production, as described above. If we assume that gas import will flow only from Norway and Germany (Gaspool), the load factor of such points in the average year will amount to 100% in 2020, therefore signaling the risk of congestions as import pipelines are used at full capacity, 93% in 2025 and 93% in 2030. When demand is particularly high, the interconnection point with the German NCG market area can be used as an additional entry point. In this case, the load factor of the three entry points mounts to 90% in 2020, 82% in 2025 and 83% in 2030.

   e. Storage facilities are essential to grant security of supply in case of cold winter weather conditions. In cold years, all available L-gas storage volume is needed until 2025. In following years, a decrease in demand reduces the need for flexibility and use of storage capacity. Capacity of H-gas storages will be crucial in cold years, when flexibility might be requested to accommodate imports.

I.B.Capacity Analysis

6. Our analysis shows that:

   a. With existing infrastructures, supply can meet peak capacity needs in the L-gas and H-gas markets in all years, even with the failure of the largest source of supply (a so-called N-1 scenario).

   b. If the Norg and Grijpskerk storages are unavailable, there could be a shortfall of peak capacity in the L-gas market in 2025. This implies that a choice might have to be made on whether to meet flexibility demand from the domestic market or from transit. In the same year, a shortfall in both L-gas and H-gas markets appears when Norg, Grijpskerk and imports from Norway are not available.

   c. In 2030, if Norg and Grijpskerk are not available peak capacity is met by a narrow margin in the L-gas market, thanks to decreasing demand compared to 2025. However, peak capacity in the H-gas market could not be met, as available capacity on the H-gas market is not sufficient to grant security of supply simultaneously on both markets. This is even more the case if import capacity from Norway is also unavailable. In this scenario, a choice might have to be made on whether to supply flexibility to the domestic market or to transit.

7. We conclude that supply can meet peak demand under design conditions for the next 10 years, as long as there are no retirements of the existing large gas storages.

8. Our report is organised as follows:

   a. Section II includes our volume and flexibility analysis, details methodology and assumptions and presents our assessment of results;

   b. Section III includes our capacity analysis under different infrastructure scenarios and presents our assessment of results;

   c. Appendices include details of the analysis and the whole set of charts summarising results.

II. Volume and Flexibility Analysis

9. Our volume and flexibility analysis aims at assessing whether over the next 10 years there will be sufficient capacity to make the gas flowing in the gas system and whether storage facilities are able to accommodate differences in seasonality of demand and supply (flexibility).

10. We assessed whether volume and flexibility available to the Dutch gas market are able to accommodate demand separately for the low-calorific gas ("L-gas") market and the high-calorific gas (H-gas) market.

II.A. Methodology

11. We start by building the hourly gas demand and the total hourly gas supply for years 2020, 2025 and 2030 separately for the L-gas and H-gas markets for both an average and a cold year.

12. Hourly L-gas demand is demand of L-gas for domestic consumption and for export. The supplier of "natural" L-gas is the Groningen field. Production from Groningen has to be minimised to reduce the risk of earthquakes in the Groningen area. Therefore, Groningen production is not sufficient to meet demand for L-gas, which is supplied according to the following merit order: first, "pseudo L-gas" is supplied, i.e. L-gas obtained from available conversion/enrichment capacity and available H-gas volumes. Second, L-gas from L-gas storages is supplied. If pseudo L-gas and L-gas from storages are not able to meet demand, "natural' L-gas is supplied by the Groningen field. The latter, therefore, will only be used in case the first two options are not sufficient to fulfil L-gas demand. In our modelling, gas demand on the L-gas market is always met and any excess or shortfall of gas supply is shown on the H-gas market.

13. Hourly H-gas demand is demand of H-gas for domestic consumption (mainly used in the industrial and thermal sectors), for quality conversion and for transit, being H-gas that is transported across the Netherlands for consumption in another country.

14. Clearly, gas that transits the Netherlands is 'volume neutral' in the sense that transit does not add to overall volume demand. However, we need to account for transit volumes, because they both use import capacity, and because transit volumes can also use flexibility in the Netherlands.

15. H-gas is sourced from indigenous small fields production and from import (piped gas and LNG). GTS provided us with projections on expected gas production from small fields and import in two scenarios (average and cold), one scenario where import flows are lower and another scenario where import flows are higher. As we considered the scenario with the highest demand, we have also considered the scenario where import flows are higher to assess whether available import capacity is sufficient to meet import demand when gas demand is high. When projected supply of H-gas is not sufficient to meet demand, as for example in cold years, we may need to add import to projected import volumes.

16. Differences in the hourly shape of total demand and total supply are accommodated by storage, which provides a Load Factor Conversion service to the system. Storages follow the typical yearly withdrawal/injection cycle, where withdrawal of gas from storage occurs from October to March ("winter") and injection of gas into storage occur from April to September ("summer"). During summer, hourly gas supply in excess of demand is sent to storage to be used in winter, when demand is higher.

17. In years when forecasted supply is not able to meet demand, additional gas import is added to forecasted supply. We do not know when additional gas will be sourced and from where. This implies that the estimated volume of storage space that is required to accommodate additional supply ranges from zero in a scenario where exit of additional gas is equal to entry of such gas to a higher value in a scenario where additional import is in summer and needs to be stored.

18. The next paragraphs will detail the specific assumptions on demand and supply components.

II.B. Demand Assumptions

19. Hourly L-gas demand and H-gas demand have been calculated based on historical profiles of hourly domestic L-gas and H-gas demand, L-gas export and H-gas transit that GTS provided to us for an average and a cold year. Historical demand data for the average year refer to years from 2015 to 2019. Historical data for the cold year refer to the gas year 2012/2013. Details are reported in Appendix A.

II.B.1. Domestic Demand Volumes

20. For the domestic demand we consider the scenario with the highest demand, based on the three scenarios GTS prepared for the 2020 Investment Plan ("IP2020") and provided to us. This scenario (the Alternative Transition Scenario or AT Scenario) is based on the assumption that transition to a decarbonised economy is slower than transition envisaged

in the Draft Climate Agreement that was presented in December 2018. Details on the three scenarios are reported in Appendix B.

Figure 1: Domestic L-gas Demand and H-gas Demand in 2020, 2025 and 2030

		2020	2025	2030
Demand Scenario	***AT***			
Average year, TWh		349.2	337.2	325.4
L-gas		237.1	206.5	202.5
H-gas		112.1	130.7	122.9
Cold year, TWh		396.9	380.8	367.4
L-gas		279.2	243.7	238.4
H-gas		117.7	137.2	129.1

II.B.2. L-gas Export Volumes

21. The Netherlands exports L-gas to Germany, Belgium and France. Following the decision of the Government of the Netherlands to phase-out natural gas production from the Groningen field, the gas infrastructure operators of importing countries have started making arrangements to progressively reduce the import of L-gas from the Netherlands.[1] Current estimations indicate that L-gas exports are expected to reduce by about 10% per year over the next 10 years, declining to zero in 2030 when L gas production is terminated. Figure 2 shows the projected export of L-gas in an average year and a cold year situation in the years covered by the analysis.

Figure 2: L-gas Export Demand in 2020, 2025 and 2030

	Export Demand	
	Average year, TWh	Cold year, TWh
2020	272.7	310.8
2025	91.1	103.9
2030	0.0	0.0

22. Based on indication provided by GTS, demand of L-gas exports in a cold year is obtained by increasing L-gas export by 14% from the levels forecasted in an average year. We believe this to be a reasonable approximation as in importing countries (i) climate conditions are similar to those in the Netherlands; and (ii) L-gas is predominantly

[1] IEA, EntsoG, GTS and Ministry of Economic Affairs ad Climate Policy, *L-Gas Market Conversion Review*, Winter report 2020.

consumed in the residential and commercial sectors and it is reasonable to expect consumption patterns similar to those in the Netherlands.

II.B.3. H-gas Transit Volumes

23. Figure 3 shows the projected transit of H-gas in an average year and a cold year in the years covered by the analysis.

Figure 3: H-gas Transit Demand in 2020, 2025 and 2030

	2020	2025	2030
Transit in average year, TWh	202	111	164
Transit in cold year, TWh	212	116	172

Source: data from GTS.

24. Based on indication from historical provided by GTS, demand of H-gas transits in a cold year is obtained by increasing H-gas transits by 5% from the levels forecasted in an average year.

II.B.4. Total Hourly Demand

25. We derived the total hourly gas demand, separately for the L-gas and H-gas markets, for an average and a cold year considering the assumptions on demand volumes described above and historical hourly data on demand:

a. To estimate the total hourly demand profile in an average year, we used data on hourly domestic demand, export demand and transit demand in years from 2015 to 2019. For each year, we sum domestic, export and transit demand in each hour. Then we rank hours from the hour when demand is the highest to the hour when demand is the lowest to obtain the so-called Load Duration Curve ("LDC"). We then averaged the LDCs of the years 2015-2019 to obtain the average LDC. The hourly profile we considered in our model applies this average LDC to the demand forecasts described above;

b. To estimate the hourly demand profile in a cold year, we used data on hourly domestic demand, export demand and transit demand for the gas year 2012/2013, and constructed the LDC using the same approach explained above. The hourly profile we considered in our model applies this cold year LDC to the demand forecasts described above.

26. Figure 4 below summarises total gas demand for the relevant years. Appendix A provides additional details on the calculation of the hourly demand.

Figure 4: Total Gas Demand in 2020, 2025 and 2030 in Average and Cold Year

		Average Year			Cold year		
		2020	2025	2030	2020	2025	2030
Domestic Demand, TWh	[1]	349	337	325	397	383	370
L-gas Export, TWh	[2]	273	91	0	311	104	0
H-gas Transit, TWh	[3]	202	111	164	212	117	172
Total	[4]	823	539	489	919	601	540

Sources and Notes:
[1] - [3]: GTS data
[4]= sum([1]: [3]). Discrepancies due to rounding

II.C. Supply Assumptions

27. Total gas supply volume (L-gas and H-gas) is the sum of domestic gas production, imports and regasified LNG volumes:

a. Domestic gas production is the production from the Groningen gas field (L-gas) and from small gas fields (H-gas);

b. Pipeline imports are imports of H-gas volumes from Norway, Belgium and Germany;

c. Re-gasified LNG is the LNG re-gasified at the Gate terminal.[2]

28. The following paragraphs detail the model's assumption on supply volumes and hourly profile.

II.C.1. Domestic Production

29. In our model of the Dutch gas system, there are two main sources of domestic gas production: the Groningen gas field, which produces L-gas, and the small gas fields, which produce H-gas.

30. Figure 5 shows the projected supply volumes and capacity from the Groningen gas field considered in our analysis, provided by GTS. Such volumes are estimated to reflect the fact that production from Groningen is minimised and that Groningen is used only if L-gas from conversion/enrichment of H-gas and L-gas available in storages are not able to meet L-gas demand.

2 In the capacity analysis below, we also consider the Maasvlakte LNG facility. However, since Massvlakte does not produce any net volumes, we do not consider it in the volume analysis.

Figure 5: Production from the Groningen field

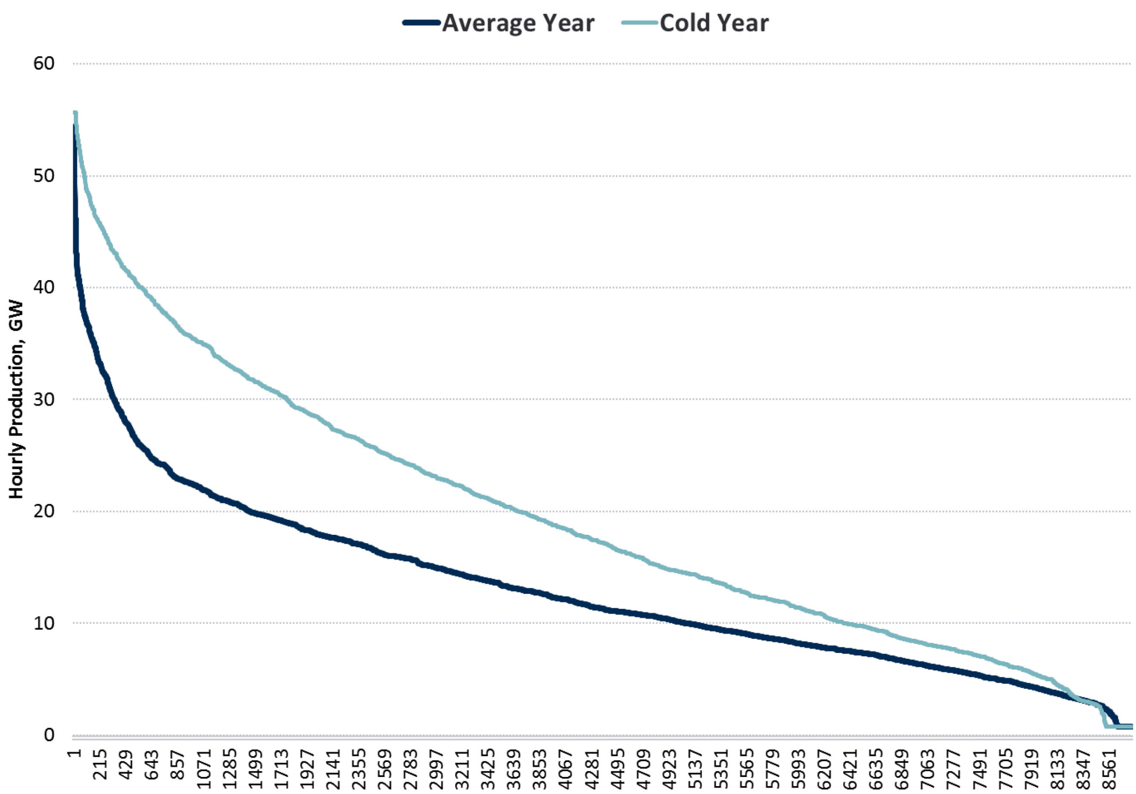
	Volumes, TWh	
	Average Year	Cold Year
2020	113.9	168.6
2025	0.3	1.2
2030	0	0

Source: data from GTS.

31. Production from Groningen is expected to become unavailable over the next few years. While the Groningen field is still technically open in 2025, it is expected at that point to be in "stand-by" and to produce only marginal amounts of gas.

32. The forecasted production capacity of the Groningen field is 56 GW in 2020, 10 GW in 2025 and 0 GW in 2030. The hourly profile of the Groningen production field is based on data provided by GTS on the expected use of the production capacity in 2020, both in case of a cold year and in case of an average year. The production profile of the Groningen field concentrates a larger share of the annual production in the hours of highest demand. Figure 6 shows the production profile of the Groningen field for the year 2020.

Figure 6: Groningen Production Profile in 2020



Source: Brattle analysis on data from GTS.

33. Projected volumes of small field production included in our analysis for both an average year and a cold year are:

a. 172 TWh in 2020

b. 107 TWh in 2025

c. 47 TWh in 2030

34. In contrast to the Groningen gas field, production from the small gas fields is assumed not to provide any flexibility to the system: we model small fields production as constant throughout the year, and it is assumed not to increase in a cold year.

II.C.2. Pipeline Import

35. Our analysis considers the following projected supply volumes from pipeline import, for both an average year and a cold year:

a. 491 TWh in 2020;

b. 371 TWh in 2025;

c. 373 TWh in 2030.

36. In order to determine the hourly import profile, we divide in each hour the import volumes in two components: the import of gas to meet requested H-gas for transit and the import to meet H-gas demand of the Dutch market:

a. The volume of H-gas for transit that enters into the system is assumed to be equal to the volume of H-gas that exits the system and is redelivered to other countries. The latter is the H-gas demand for transit that is included in the H-Gas hourly demand (see paragraph II.B.3). In other words, transit volumes are assumed to be a pass-through - the H-gas demand for transit volumes (transit exit) is always equal to the pipeline import reserved to transit (transit entry).

b. Gas imported to meet the H-gas demand of the Dutch market is assumed to follow an hourly profile that has been determined based on historical data provided by GTS. This data shows that imports for the Dutch market have a "reverse seasonality" – as it is higher in summer months than the winter months, when demand is higher. To account for this reverse seasonality in our model, we have constructed the hourly profile of import volumes destined to the Dutch market based on historical data:

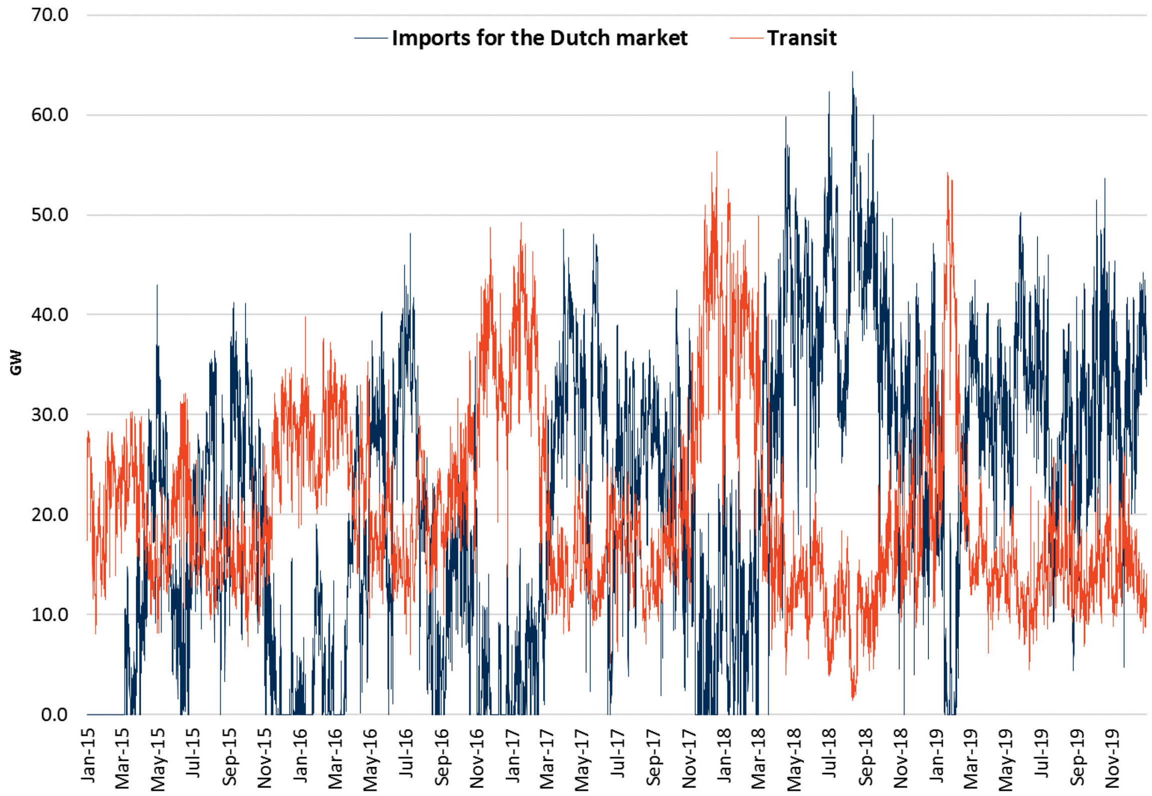
i. First, we calculated, over the period 2015-2019, the percentage of the annual import for the Dutch market that enters the market in each calendar month;

ii. Then, we ranked the months from the one with the lowest percentage of import to the one with the highest. In this way, we obtain a "reverse" monthly distribution of import;

iii. Finally, we modelled the hourly profile of import for the Dutch market in line with the estimated reverse monthly distribution.[3]

37. The two components – imports for internal demand and imports for transit – have opposite seasonal profiles. This emerges from the historical hourly profile of the two components of import over the years 2015-2019, shown in the figure below.

Figure 7: Hourly Profile of Pipeline Import, 2015-2019



38. The opposite seasonal profiles of pipeline import for the Dutch market and transit partially offset one another. However, the total import profile still displays a moderate reverse seasonality, as the Dutch market represents a larger share of the overall import volumes compared to transit.

3 We used a monthly distribution instead of hourly data for modelling reasons, as in some hours the import flow is equal to zero and does not allow the construction of a hourly LDC

II.C.3. LNG imports

39. Volumes from LNG regasification at the Gate terminal, for both an average year and a cold year are as follows:

    a. 59 TWh in 2020

    b. 61 TWh in 2025

    c. 68 TWh in 2030

40. The expected increase in use of LNG to partially replace decrease in production of Groningen implies an increase in use of existing regasification capacity. The load factor of the LNG entry point, calculated over 8,000 assumed hours of operation, therefore increases from 44% in 2020 to 52% in 2030.

41. We assume that the LNG volumes are supplied throughout the year with a constant hourly profile.

II.D. Role of Conversion and Storages

42. After having determined the hourly profile of each component of total demand and the supply of H-gas and Groningen L-gas, we assess the volume of H-gas that needs to be converted to meet the L-gas demand. We also assess the flexibility that the storages must provide.

43. H-gas is used to "produce" L-gas in two ways:

    a. nitrogen blending: nitrogen is added to the H-gas to lower the calorific value until it meets L-gas specifications; and

    b. enrichment: H-gas is added to the Groningen gas to meet the L-gas specifications.

44. The accelerated decrease in Groningen production has increased the demand of H-gas for conversion, tightening the relationship between the L-gas and the H-gas market. Following the increase in H-gas demand, the Netherlands has become an importer in 2018 for the first time. Conversion/enrichment capacity, therefore, is crucial to meet L-gas demand.

45. Storages have a key role in providing the flexibility required by the system. This role is expected to increase in the future to compensate for the decline in Groningen flexibility. In our analysis we relied on the Gas Storage Europe database to determine the working gas volume available to the Dutch gas transmission system. We consider both the storage facilities located in the Netherlands (EnergyStock, Grijpskerk, Norg, Bergermeer and

Alkmaar) and the German salt caverns connected to the Dutch system. Two of the three existing EPE storages are expected to be closed by 2025. Figure 8 summarizes the working gas volumes data used by the Volume Analysis.

Figure 8: Storages Working Gas Volumes

Working Gas, TWh		2019	2020	2025	2030
EnergyStock	L-gas	3	3	3	3
Grijpskerk	H-gas	28	28	28	28
Norg (Langelo)	L-gas	49	49	49	49
Bergermeer	H-gas	46	46	46	46
Alkmaar	L-gas	5	5	5	5
Jemgum, Astora	H-gas	7	7	7	7
Etzel, Crystal	H-gas	2	2	2	2
Etzel, EKB	H-gas	11	11	11	11
Jemgum, EWE	H-gas	4	4	4	4
Nuttermoor, EWE	H-gas	2	2	2	2
Etzel, OMV	H-gas	5	5	5	5
EPE	L-gas	7	7	1	1
Storage L-gas		64	64	58	58
Storage H-gas		105	105	105	105

Source: Gas Storage Europe database.

46. We first calculate, on an hourly basis, how much H-gas needs to be converted to match L-Gas demand (the "hourly conversion demand"). The hourly conversion demand is equal to the maximum conversion level.

47. The total volume of H-gas converted in a year equals the yearly conversion demand, which is calculated as the sum of hourly conversion demand over the year. Our base assumption is that the gas volume which is converted in each hour is constant over the year. That is, H-gas is converted at a constant rate.

48. This above implies that conversion demand and the volumes converted in the year have different hourly profiles. L-gas storages are, therefore, needed to allow match demand and availability of conversion (Load Factor Conversion):

    a. When hourly conversion demand is lower than volumes converted in the hour, the excess converted volumes are injected into L-gas storages.

    b. On the contrary, when hourly conversion demand is higher than volumes converted in the hour, the potential shortfall is met by gas withdrawn from L-gas storages.

c. We assume that there is no gas in storage at the beginning of the injection phase. Gas is injected in hours when demand is low (typically in summer) and used in hours when demand is high (typically in winter). In our modelling we assume that shippers have perfect foresight, i.e. they inject into storage exactly the gas volume that they will use to meet demand of their consumers. This assumption implies that no gas is left in storage at the end of the withdrawal phase and that only the working gas volume needed to meet demand is used.[4]

49. Our model maximises the use of gas storages as the main source of flexibility in the L-gas market. We assume that, in case the flexibility required by L-gas demand is more than the maximum flexibility that can be provided by storages, conversion profiles can be adjusted to provide additional flexibility, while still minimising use of Groningen. As data provided by GTS on Groningen production refer to minimised production (see par. 30), the difference between L-gas demand and the (minimised) production from Groningen represent the volume of gas and flexibility that need to be provided by conversion facilities and storages. We understand that conversion facilities run close to full capacity, however in cases when shippers foresee that availability of L-gas storages is constrained, they will be able to optimise use of conversion capacity and storages to meet demand.

50. After the L-Gas markets is balanced thanks to the use of conversion facilities and L-Gas storages, we assess the flexibility provided by storage facilities to balance the H-gas demand and supply. H-Gas storages are filled and emptied based on the hourly differences between demand and supply, as assumed for L-gas storages:

a. The available H-Gas hourly supply (small fields production, pipeline import and regasified LNG) is reduced by the volume of H-gas required for conversion;

b. When hourly H-gas demand is lower than remaining H-gas supply in the hour, the excess supply volumes are injected into H-gas storages;

c. On the contrary, when hourly H-gas demand is higher than remaining H-gas supply in the hour, gas is withdrawn from H-gas storages;

d. As for L-gas storages, we assume that there is no gas in the H-gas storage at the beginning of the injection phase and that shippers have perfect foresight, i.e. they inject into storage exactly the gas volume that they will use to meet demand of their consumers. This assumption implies that no gas is left in storage at the end of the withdrawal phase.

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[4] In other words, our assumptions implies that use of working gas space available from storage facilities could not be entirely used if demand is low.

51. There are cases when projected supply volumes are not sufficient to meet demand and additional import is needed. We do not know the import profile of the additional imports. Therefore we consider two cases:

a. A Low Flexibility Case, where additional import is assumed to be such that hourly exit volume equals hourly entry volume (pass-through). This implies that no additional working gas volume from storage facilities is needed;

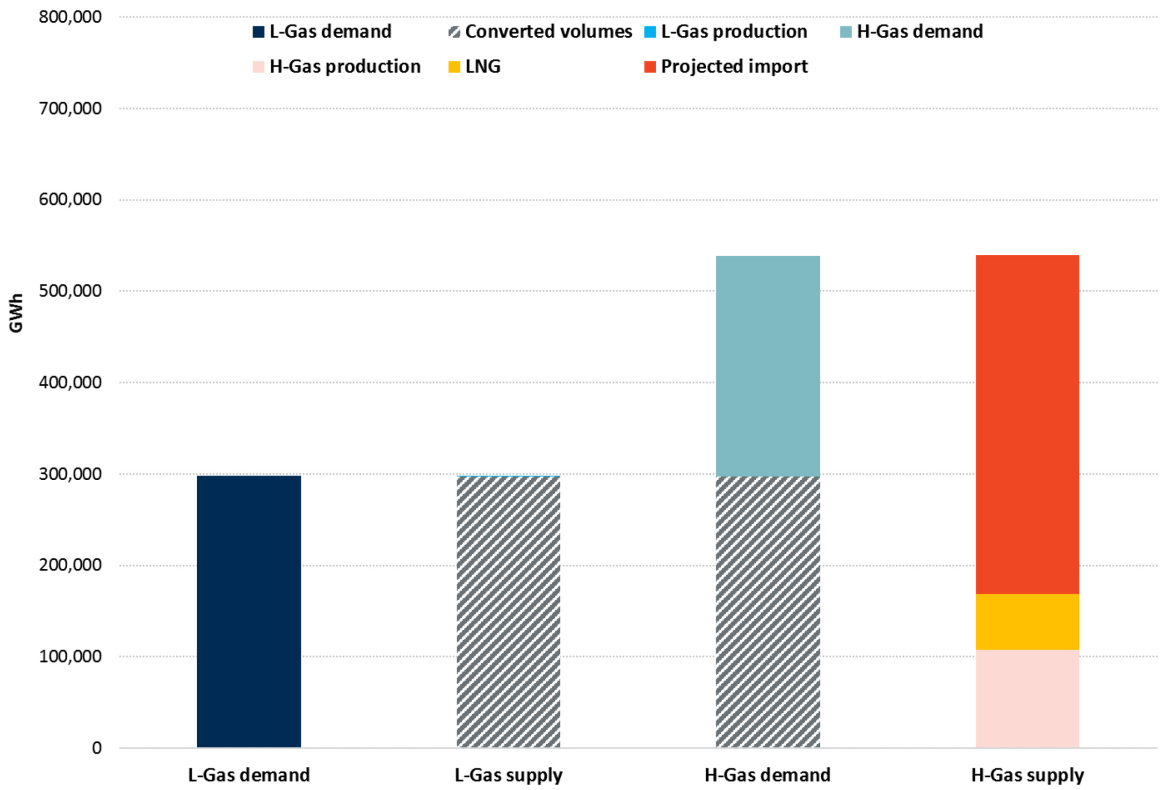
b. A Conservative Case, where additional import is in summer and a high mismatch between hourly supply and hourly demand exists, Hence, the required flexibility in terms of additional working gas volume from storage facilities is very high. This is the case we present in our results.

II.E. Results

52. For each reference year (2020, 2025 and 2030) and for each type of year (average, cold) we have assessed how demand is met in each market (L-gas and H-gas) and the flexibility provided by storage facilities (L-gas storage facilities and H-gas storage facilities).

53. Results for each market and each case are summarised in charts. Below we report and comment results for Year 2025 as an example. The complete set of charts for all reference years is included in Appendix C.

Figure 9: Volume Analysis – 2025, Average Year



54. Figure 9 shows that in 2025 projected supply volumes are sufficient to meet demand, without the need for any additional import:

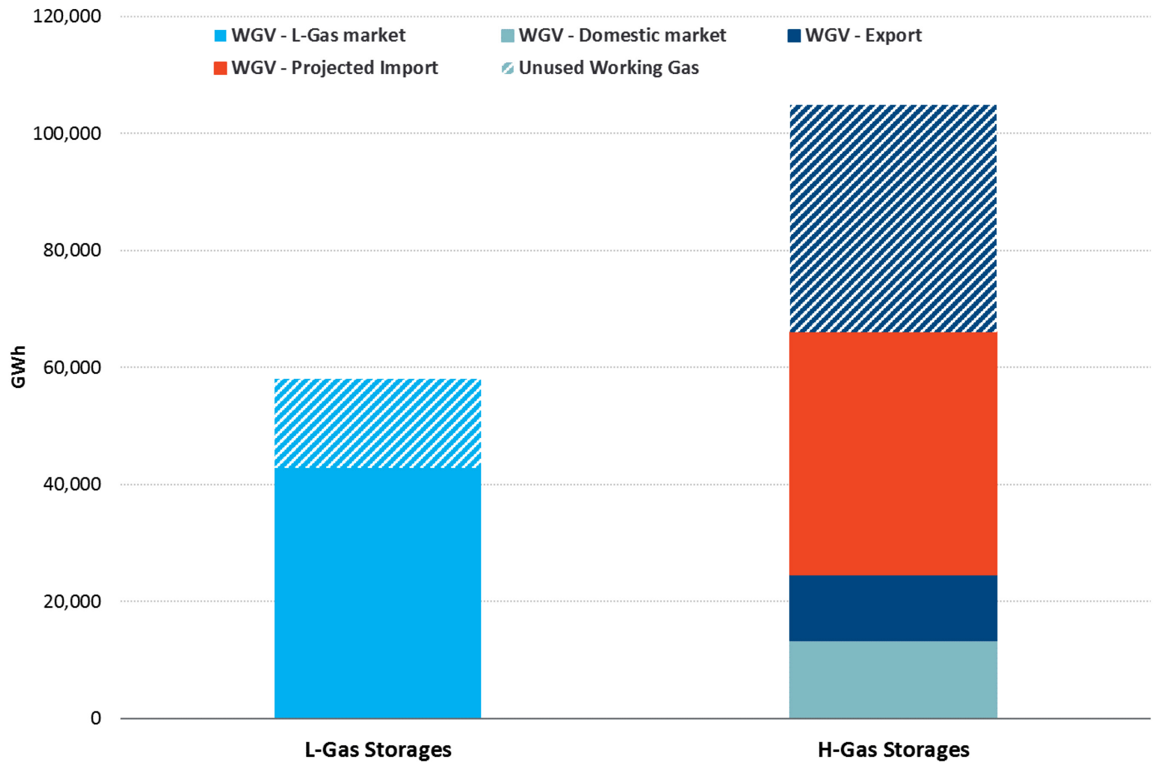
a. The first column represent total L-gas demand.

b. The second column represent total L-gas supply and details the share of L-gas supply from the Groningen field ("L-gas production") and the share of L-gas supply that result from conversion of H-gas ("converted volumes"). In 2025, converted H-gas supplies nearly all L-gas volumes.

c. The third column represents H-gas demand. More than 50% of H-gas demand is for H-gas to be converted to ensure supply to the L-gas market.

d. The fourth column represents H-gas supply and shows that import is the major source of supply. This implies that import of H-gas is crucial to ensure supply on both the H-gas and the L-gas market.

Figure 10: Flexibility Analysis – 2025, Average Year



55. Figure 10 shows the volume of working gas in the L-gas storage facilities (about 43 TWh of the 58 TWh available) and H-gas storage facilities (about 66 TWh of the 102 TWh available):

a. The first column reports the working gas used to accommodate seasonality of the L-gas supply and demand.

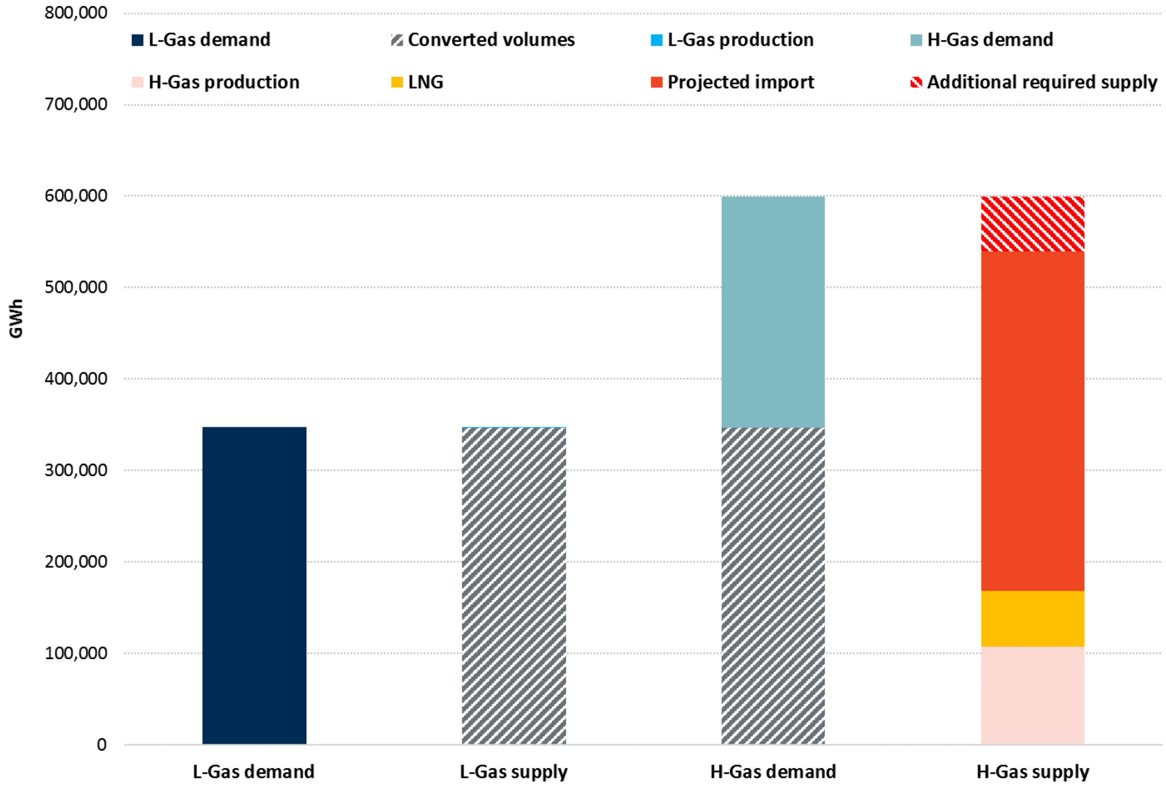
b. The second column reports the working gas in the H-gas storages and estimates the share of working gas which is needed to address seasonality of the different components of supply and demand:

i. WGV-Import: volume of working gas needed to accommodate reverse seasonality of import.

ii. WGV-Transit: volume of working gas needed to accommodate seasonality of transit.

iii. WGV-Domestic Market is the volume of working gas needed to provide flexibility to the domestic H-gas market.

Figure 11: Volume Analysis – 2025, Cold Year



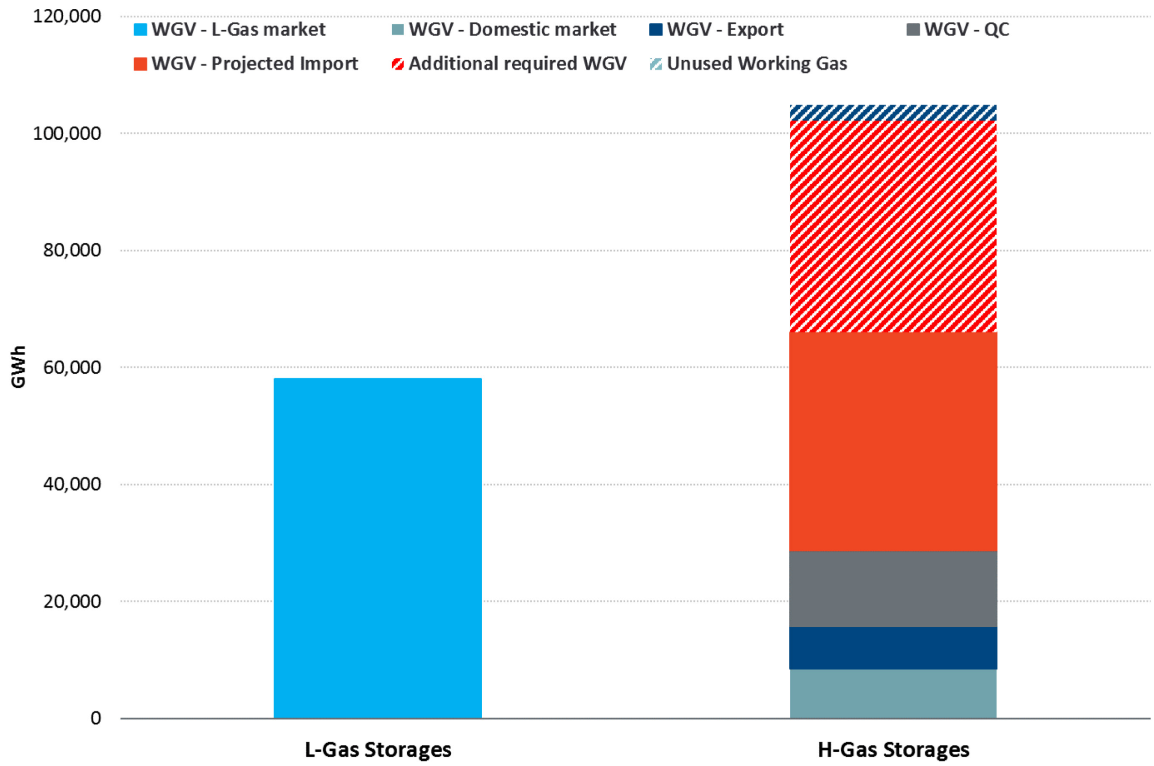
56. Figure 11 reports results for year 2025 in case of cold year. Projected supply is not sufficient to meet demand in case of cold year and additional H-gas import by about 61 TWh is needed (as shown in the fourth column). Available import capacity can accommodate additional supply:

a. The expected average load factor of the system would increase from 60% to 69%.[5]

b. If we assume that additional import will be met by only increasing imports from Norway and Germany (Gaspool) the load factor of those import points will increase from 79% to 93%. If also the NCG import point from Germany is used (in addition to the Gaspool import entry point), the total load factor of the three entry points is expected to be around 82%.

[5] The load factor is calculated assuming 8,000 hours of operating time. The estimation, therefore, already accounts for downtime (760 hours) required for maintenance.

Figure 12: Flexibility Analysis – 2025, Cold Year



57. Figure 12 shows that in case of cold year all available L-gas storage capacity is needed for a total of 58 TWh and working gas space is needed from H-gas storage facilities for a total of 102 TWh. This includes an additional 36 TWh compared to an average year to accommodate the additional imports assuming a Conservative Case (i.e. the additional import is mostly in summer and the required flexibility is high). Figure 13 summarises results for all cases.

Figure 13: Summary of Results

		Average Year 2020 [A]	Average Year 2025 [B]	Average Year 2030 [C]	Cold Year 2020 [D]	Cold Year 2025 [E]	Cold Year 2030 [F]
L-gas market							
L-gas demand, TWh	[1]	**510**	**298**	**203**	**590**	**348**	**238**
L-gas supply, TWh	[2]	**510**	**298**	**203**	**590**	**348**	**238**
Groningen production, TWh	[3]	*114*	*0*	*0*	*169*	*1*	*0*
Converted volumes, TWh	[4]	*396*	*297*	*203*	*421*	*346*	*238*
WGV in L-gas Storages, TWh	[5]	**47**	**43**	**29**	**64**	**58**	**50**
H-gas market							
H-gas demand, TWh	[6]	**709**	**539**	**489**	**751**	**600**	**540**
H-gas demand, TWh	[7]	*314*	*241*	*287*	*329*	*253*	*301*
H-gas conversion, TWh	[8]	*396*	*297*	*203*	*421*	*346*	*238*
H-gas supply, TWh	[9]	**722**	**539**	**489**	**751**	**600**	**540**
Import, TWh	[10]	*491*	*371*	*373*	*491*	*371*	*373*
LNG regasification, TWh	[11]	*59*	*61*	*68*	*59*	*61*	*68*
Small field production, TWh	[12]	*172*	*107*	*47*	*172*	*107*	*47*
Additional Import, TWh	[13]	*0*	*0*	*1*	*29*	*61*	*51*
Load factor of import pipelines (system), %	[14]	**79%**	**60%**	**60%**	**84%**	**69%**	**68%**
Load factor of import pipelines from Norway and Germany (only Gaspool), %	[15]	**94%**	**79%**	**82%**	**100%**	**93%**	**93%**
Load factor of import pipelines from Norway and Germany (Gaspool and NCG), %	[16]				**90%**	**82%**	**83%**
WGV in H-gas Storages, TWh	[17]	**77**	**66**	**55**	**94**	**102**	**72**
WGV for additional import (Conservative Case), TWh	[18]			*1*	16	36	*18*

Sources & Notes
Source: our estimation on GTS data.
[2]=[3]+[4]
[6]=[7]+[8]
[9]= sum([10]:[13])
[14]: Load factor calculated assuming 8000 hours of operations.
[15]: Load factor calculated assuming 8000 hours of operations.
[16][A]-[C]: NCG interconnection point is used to export in average years.
[16][D]-[F]: Load factor calculated assuming 8000 hours of operations.

58. Results show that:

a. Starting from 2025, when production of the Groningen field is close to zero, supply on the L-gas market depends on availability of H-gas and on conversion capabilities. L-gas storages are needed to provide the requested flexibility.[6]

b. In cold years additional imports of H-gas will be needed to meet demand on both the L-gas market and the H-gas market. A marginal increase in import of H-gas is needed in 2030 to compensate for the significant expected decrease in production of small fields.

c. Available import capacity can accommodate the requested increase in imports:

i. In average years, the average load factor of the system (which is calculated based on the capacity of all import entry points) decreases from 79% in 2020 to 60% in 2030,[7] following decrease in demand of H-gas from 709 TWh in 2020 to 489 TWh in 2030, which prompt for a decrease in import from 491 TWh in 2020 to 374 TWh in 2030.

---

6 The Groningen production will reduce to zero (or close to zero) in 2022, when the Zuidbroek nitrogen baseload installation will start operations. As our analysis considers year 2020, 2025 and 2030, year 2025 is the first year in our analysis when production from Groningen goes to zero.

7 The load factor for the system is calculated based on the total technical import capacity (equal to 78 GW) and 8,000 hours of operation.

ii. In cold years, the average load factor of the system is higher than in the average year as more import of H-gas is needed. As we observed for the average years, the expected decrease in demand between 2020 and 2030 and the consequent decrease in the volume of import causes the load factor to decrease from 84% in 2020 to 68% in 2030.

iii. If we assume that all additional import will be met by increasing import from Norway and Germany only, the system can accommodate additional supply but the risk of congestion increases. The Netherlands imports gas from Germany from the Gaspool market area. In cold years, when demand is high, imports from the NetConnect Germany ("NCG") market area can be added.[8] In case the only import point from Germany is the interconnection with the Gaspool market area, the load factor of import points from Norway and Germany taken together would increase to 100% (over 8,000 hours) in 2020 and import pipelines operates close to technical capacity. The load factor is expected to decrease to 93% in 2030 following decrease in demand (and in import to meet demand). If the interconnection with the NCG market area is added, the load factor in 2020 equals 90% and will decrease to 83% in 2030.

59. Storage facilities are essential to grant security of supply in case of severe weather conditions. In cold years, all available L-gas storage volume is needed until at least 2025. In following years, decrease in demand reduces the need for flexibility and use of storage capacity. Capacity of H-gas storages will be crucial in cold years, when additional flexibility might be requested to accommodate additional import.

II.F. Conclusions on Volume Analysis

60. Over the next 10 years, an increase of imported H-gas (either piped gas or LNG) is required for conversion to compensate decreasing domestic production, therefore increasing dependency on imports. Import infrastructures and storage facilities to provide the required flexibility will be crucial in the future to guarantee supply in both the L-gas and the H-gas market. According to current projections, no volume supply issue is expected to emerge over the next ten years as long as import infrastructures will be able to accommodate increase in import of H-gas and sufficient L-gas and H-gas (seasonal) storage volume will be available.

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8 The interconnection with the Gaspool area is usually the only import entry point from Germany and the interconnection with the NCG market area is used for export. As the latter is bi-directional, in cold years, when demand is high, it can be used as an additional import entry point.

61. Existing GTS infrastructures are able to accommodate the required increase in H-gas import (compared to import volumes currently projected) over the time horizon of the analysis and projected conversion/enrichment capacity appears to be sufficient to accommodate requested conversion volumes.

62. Existing storage capacity is able to provide the required flexibility to the Dutch system to meet total volume demand in hours when consumption is high. As dependency of the Netherlands from import will likely increase in the future, storage facilities will have a crucial role in providing the required load factor conversion services.

III. Capacity Analysis

63. The capacity analysis aims at assessing whether over the next 10 years there will be sufficient supply capacity to meet peak demand. We assessed this separately for the L-gas market and H-gas market, in the three key years (2020, 2025 and 2030) by calculating the "supply capacity margin" over demand in the peak hour, which is the difference between capacity available at peak from supply infrastructures and peak capacity demand.

64. Capacity data refer to capacity requested and available at a temperature of -17°C, which represent the cold weather conditions with frequency 1:50 years ("Design case") and have been provided by GTS, unless a different source is specified.

III.A. Methodology and Assumptions

III.A.1. Peak Demand

65. Peak capacity demand in the L-gas market in years 2020, 2025 and 2030 is calculated as the sum of the peak capacity required from domestic L-gas demand and peak capacity required from L-gas export. This is a conservative assumption as peak of different demands components do not necessarily occur at the same time. The rationale for such assumption is to assess whether capacity is available to meet peak demand in case of system stress:

a. The peak capacity domestic demand in the L-Gas market is equal to the peak demand in the domestic demand scenario with the highest expected peak demand (Scenario "AT").

b. The peak capacity required from the L-gas export in 2020 is equal to the capacity required in the hour with the highest L-gas export that we have estimated from

2020 yearly export volumes of L-gas exports and its historical hourly profile in a cold year. The peak L-gas export capacity for years 2025 and 2030 has been provided by GTS.

66. The same methodology applies to calculation of the peak capacity demand in the H-gas market, which is calculated as the sum of the peak capacity required from domestic H-gas demand and peak capacity required from transit of H-gas:

a. The peak capacity domestic demand in the H-Gas market is equal to the peak demand in the "Design Case" provided by GTS.

b. The peak capacity required from H-gas transit demand in 2020 is equal to the capacity required in the hour with the highest H-gas transit that we have estimated from 2020 yearly volumes of H-gas transit and its historical hourly profile in a cold year. The peak H-gas transit capacity for years 2025 and 2030 has been provided by GTS.

67. Figure 14 summarizes the peak capacity demand used in our Capacity Analysis.

Figure 14: Capacity Demand

	Capacity, GW		
	2020	2025	2030
Domestic Demand - Design Case			
L-gas	137	128	126
H-gas	27	32	28
Export Demand (L-Gas)	68	41	0
Transit Demand (H-Gas)	45	34	51
Peak demand - L-Gas	**205**	**169**	**126**
Peak demand - H-Gas	**73**	**66**	**79**

III.A.2. Peak Supply

68. Peak capacity available for supply in years 2020, 2025 and 2030 is equal to the maximum available supply of gas infrastructures.

69. Supply capacity available to the L-gas market in the peak hour depends on the maximum GTS quality conversion capacity, the maximum withdrawal capacity available from L-gas storages, maximum capacity offered by the Groningen field and a small amount of capacity made available from network buffering and the LNG peak shaver:

a. Maximum capacity for Groningen production is the capacity estimated by GTS taking into account EU Security of Supply regulation (2017/19238).

b. Maximum withdrawal capacity of L-gas storage facilities is the technical withdrawal capacity resulting from the Gas Storage Europe database. According to planned closure of storage facilities, we assume that capacity from EPE storages will decline by 2025.

c. Capacity from network buffering is the capacity made available from the linepack of the L-gas system and the LNG peak shaver is the capacity of the peak shaver in Maasvlakte estimated by GTS.

70. Peak capacity available for supply to the H-gas market depends on the maximum capacity for import of H-gas, the maximum LNG regasification capacity, production capacity of small fields and the withdrawal capacity of H-gas storages:

a. The maximum capacity of import pipelines is the maximum capacity that can be used at the interconnection points. Such capacity depends on capacity made available at interconnection by the interconnected country and by the Dutch system and is equal to the lower capacity made available ("lesser rule"). The rationale for such assumption is that in case of severe weather conditions, the interconnected TSOs will be able to increase capacity up to the technical limit that is compatible with security of the system.

b. Capacity available from the LNG regasification terminal is equal to the technical capacity at the entry point of the GTS network. The rationale for such assumption is that capacity at the interconnection point between the LNG regasification terminal (the Gate terminal) and the transmission system is consistent with the regasification capacity and can accommodate an increase of LNG regasification up to the maximum regasification capacity;

c. We estimated the capacity available from small fields by dividing the forecasted production for the assumed number of hours of production in a year (8,000);

d. Withdrawal capacity of storage facilities is the technical withdrawal capacity resulting from the Gas Storage Europe database.

71. Figure 15 summarizes the supply capacity used in our Capacity Analysis and details whether capacity is available for L-gas or H-gas supply.

Figure 15: Capacity Supply

Supply source	Type of Gas	Capacity, GW 2020	2025	2030
Production - Groningen	L-gas	55.7	9.8	0.0
Production - small fields	H-gas	21.5	13.4	5.9
Import	H-gas	77.6	77.6	77.6
LNG	H-gas	16.6	16.6	16.6
LNG peak shaver	L-gas	12.7	12.7	12.7
Storage				
EnergyStock	L-gas	17.6	17.6	17.6
Grijpskerk	H-gas	30.0	30.0	30.0
Norg (Langelo)	L-gas	30.9	30.9	30.9
Bergermeer	H-gas	23.1	23.1	23.1
Alkmaar	L-gas	14.7	14.7	14.7
Jemgum, Astora (H-gas)	H-gas	6.1	6.1	6.1
Etzel, Crystal (H-gas)	H-gas	3.9	3.9	3.9
Etzel, EKB (H-gas)	H-gas	9.0	9.0	9.0
Jemgum, EWE (H-gas)	H-gas	2.9	2.9	2.9
Nuttermoor, EWE (H-gas)	H-gas	2.9	2.9	2.9
Etzel, OMV (H-gas)	H-gas	4.5	4.5	4.5
EPE (L-gas)	L-gas	12.7	3.9	3.9
Network buffering	L-gas	2.0	2.0	2.0

72. To meet peak demand in the L-Gas market, we account for the capacity offered by conversion and enrichment facilities:

a. We calculate the maximum conversion capacity starting from the "theoretical conversion capacity" figures provided by GTS, expressed in terms of volumes that can be theoretically converted, which is equal to 451 TWh in 2020, to 640 TWh in 2025 and to 595 TWh in 2030. This theoretical conversion capacity reflects both increased capacity of the conversion facilities and market dynamics. Although the market requires less conversion volumes after 2025, the available conversion capacity increases between 2020 and 2025 and is not expected to decrease afterwards. As such, the conversion capacity used in the capacity analysis in 2020 and 2025 is equal to the theoretical conversion capacity divided by the assumed number of working hours of conversion facilities in a year (8,000), equal to 56.4 GW in 2020, to 79.9 GW in 2025, and in 2030 is kept equal to the 2025 level.

b. The maximum enrichment capacity has been provided by GTS and equals 26.4 GW in 2020, 10.4 GW in 2025 and 0 GW in 2030 as production from the Groningen field and the L-gas export is terminated.

73. Based on the data described above, we calculate the capacity margin at peak separately for the L-market and the H-market as the difference between all supply capacity available at peak and peak demand weighted for the relative size of the two markets. We express the margin as a percentage of peak demand. In order to stress test the capacity of the

Dutch gas system to grant supply, we have assessed the capacity margin under different infrastructure scenarios, as described in the next section.

III.B. Description of Scenarios

74. We have assessed whether gas infrastructure capacity available at peak is able to meet forecasted peak gas demand under different infrastructure scenarios, which differ based on expected availability of import and storage capacity:

a. Scenario 1 is the scenario where that all existing capacity (except a relatively small fraction of capacity from L-gas storages in Germany) will be available until 2030 and that conversion/enrichment facilities will increase their capacity as expected.

b. Scenario 2 is equal to Scenario 1 except for unavailability of import pipeline for Norway. This is the N-1 scenario that is considered in the assessment of security of supply.[9]

c. Scenario 3 is equal to Scenario 1 except for unavailability of the major L-gas storage (Norg) and of the major H-gas storage (Grijpskerk) starting from 2025. Following decrease in the gas price differential between summer and winter and progressive reduction in demand, available storage capacity in Europe decreased in latest years and we understand that there is an ongoing discussion in the Netherlands on remuneration of gas storages that are needed to grant security of supply.

d. Scenario 4 is the most challenging scenario, where import from Norway and the Norg and Grijpskerk storage facilities are not available.

75. Figure 16 summarises the four different scenarios used in the capacity analysis.

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[9] Ministry of Economic Affairs and Climate Policy, Preventive Action Plan 2019, The Netherlands.

Figure 16: Capacity Scenarios

Scenario	Description
Scenario 1 **(all infrastructures available)**	Capacity of gas infrastructures (import and export capacity, LNG regasification and storage) does not change over the period 2020-2030
Scenario 2 **(disruption of largest import capacity)**	The largest import capacity (entry from Norway) is not available starting from 2020
Scenario 3 **(closing of storage facilities)**	Norg and Grijpskerk storage fields are not available starting from 2025
Scenario 4 **(disruption of import capacity and closing of storage facilities)**	The largest import capacity (entry from Norway) and the Norg and Grijpskerk storage fields are not available starting from 2025

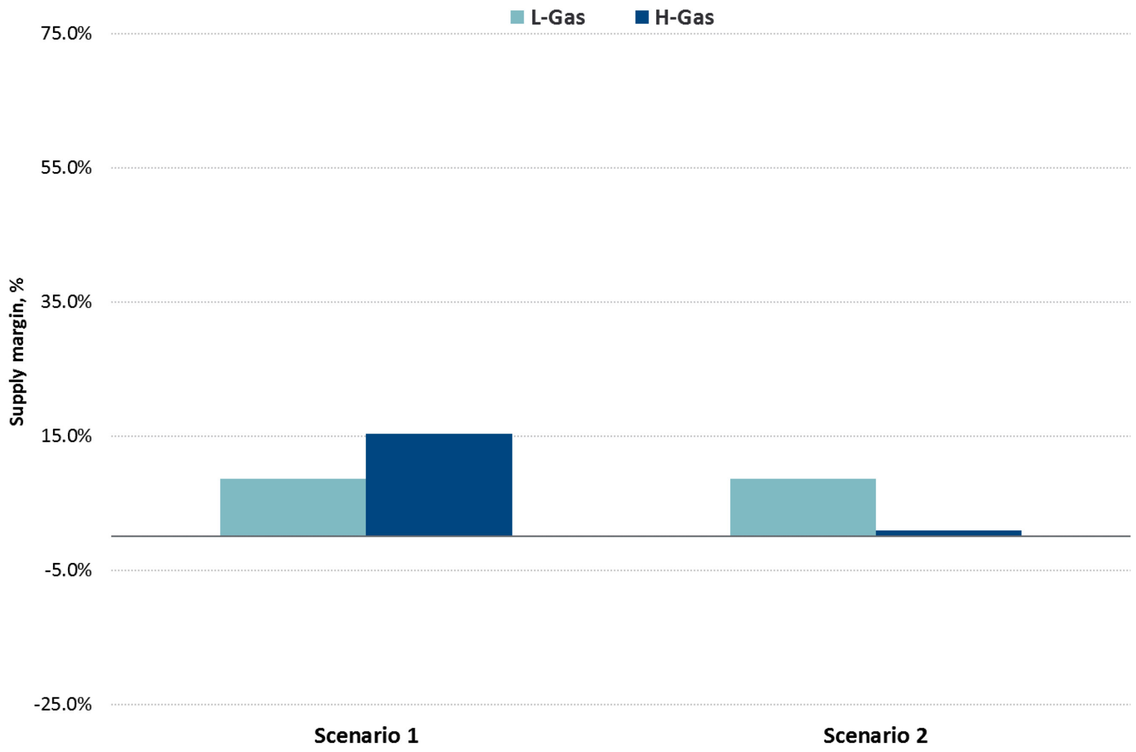
76. As the closing of the storage facilities in Scenarios 3 and 4 takes place by 2020, the capacity analysis for the year 2020 only considers the Scenarios 1 and 2.

III.C. Results

77. The following figures show the results of the capacity analysis for the years 2020, 2025 and 2030 in all infrastructure scenarios considered.

78. Figure 17 shows results for the reference year 2020. Capacity supply is enough to meet demand, both in the L-Gas and the H-Gas market (Scenario 1), even in case of disruption of the largest import, i.e. import from Norway (Scenario 2).

Figure 17: Capacity Analysis - 2020

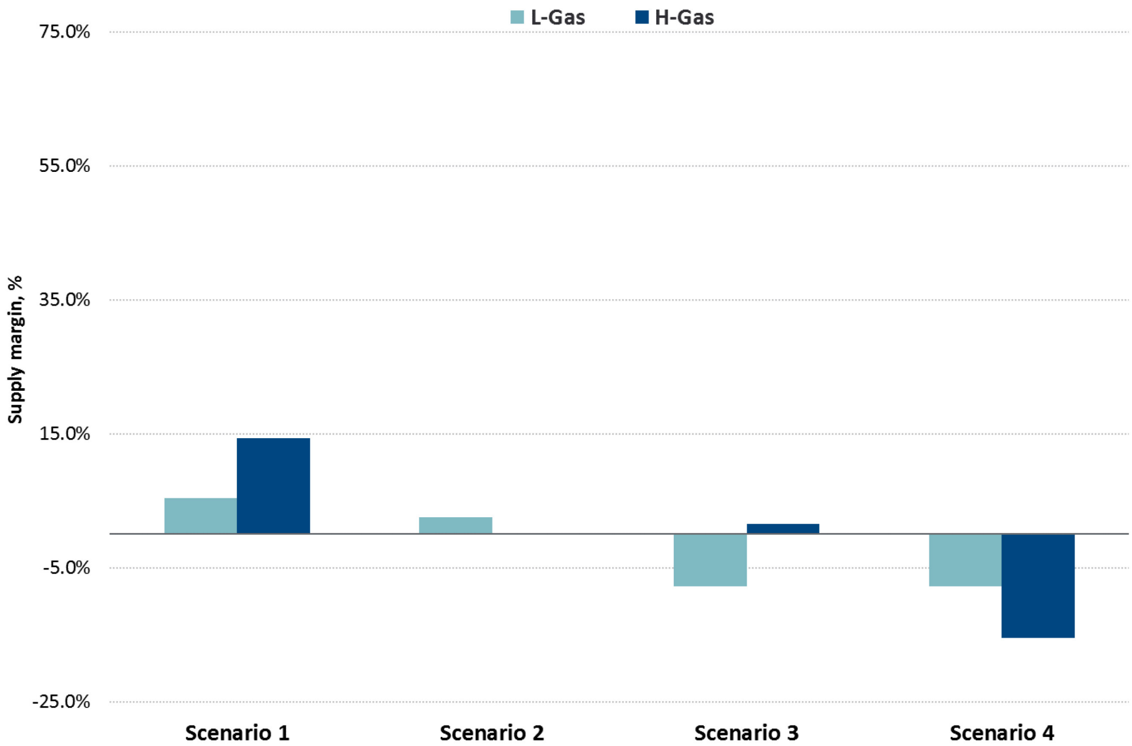


Source: Brattle analysis on data from Gasunie and Storage Europe database.

79. Figure 18 shows that in 2025, peak demand is met when all infrastructures are available (Scenario 1) and in case of disruption of import from Norway (Scenario 2). In Scenario 3, peak demand is not met in the L-gas market if Norg and Grijpskerk are both unavailable. The potential shortfall in the L-gas market in Scenario 3 compared to previous assessments from GTS in their advice concerning Groningen capacity can be explained by different assumptions in this study compared to the assumptions that GTS used.[10] A shortfall on both the L-gas market and the H-gas market appears when import from Norway is also disrupted (Scenario 4).

10 While the "Design Case" peak demand used in this analysis is the demand estimated at -17 C° conditions, GTS considered demand at -15,5 C° conditions in their advice concerning Groningen capacity.

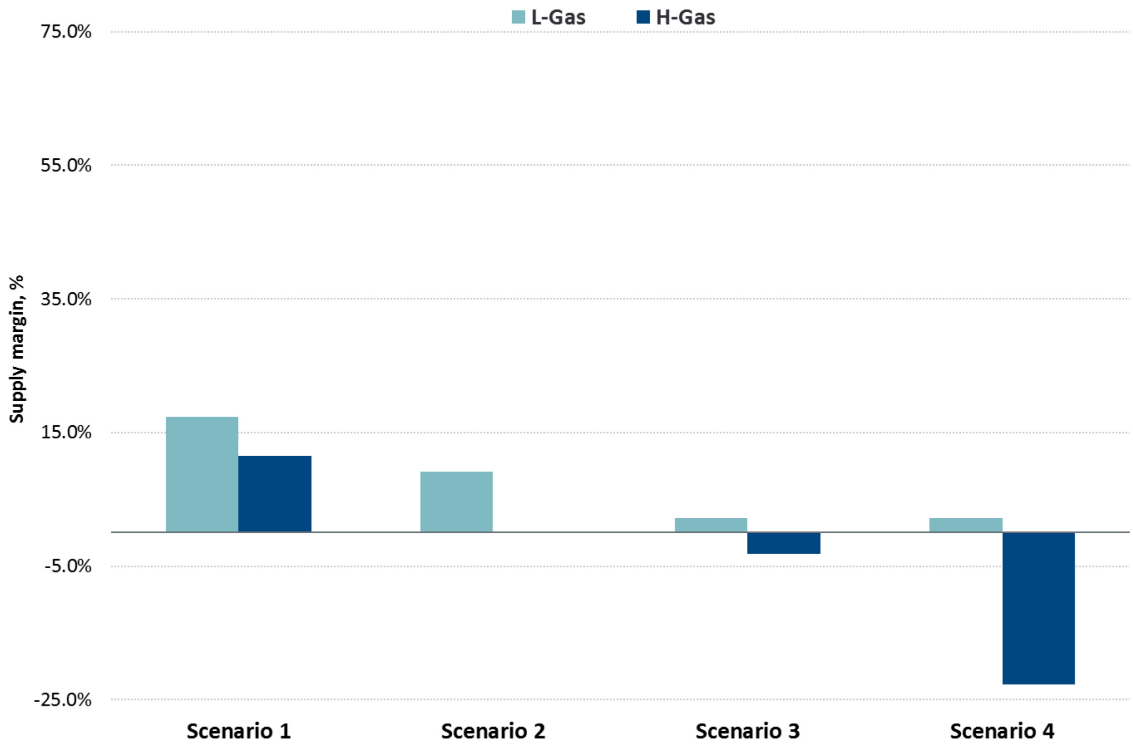
Figure 18: Capacity Analysis -2025



Source: Brattle analysis on data from Gasunie and Storage Europe database.

80. Figure 19 shows that in 2030 capacity supply is enough to meet peak demand, both in the L-Gas and the H-Gas market when all infrastructures are available (Scenario 1) and in case of disruption of import from Norway (Scenario 2). Decrease in gas demand compared to 2025 is such that peak capacity demand in the L-gas market can be met through conversions in Scenario 3. Peak demand is not met in the H-gas market in Scenarios 3 and 4 though, when largest import and storage infrastructures are not available and capacity supply on the H-gas market is not sufficient to grant security of supply in both markets.

Figure 19: Capacity Analysis - 2030



Source: Brattle analysis on data from Gasunie and Storage Europe database.

III.D. Conclusions on Capacity Analysis

81. Results show that in the Design Case:

  a. Supply can meet peak demand under the N-1 criteria (unavailability of import from Norway) in the L-gas and H-gas markets in all the years considered by the analysis, in the scenario with existing storage infrastructures (Scenario 2).

  b. In 2025, unavailability of Norg and Grijpskerk (Scenario 3) results in a shortfall of peak capacity in the L-gas market. This implies that a choice might have to be made on whether to meet flexibility demand from the domestic market or from transit. In the same year a shortfall appears in both the L-gas market and the H-gas market when Norg, Grijpskerk and import from Norway are not available (Scenario 4).

  c. In 2030, when Norg and Grijpskerk are not available (Scenario 3), peak capacity is met by a narrow margin in the L-gas, thanks to decreasing demand compared to 2025. However, peak capacity in the H-gas market is not met, as available capacity on the H-gas market is not sufficient to grant security of supply simultaneously on both markets. This is even more the case when Norg, Grijpskerk and import from Norway are not available (Scenario 4).

Appendix A. Calculation of Hourly Demand Profiles

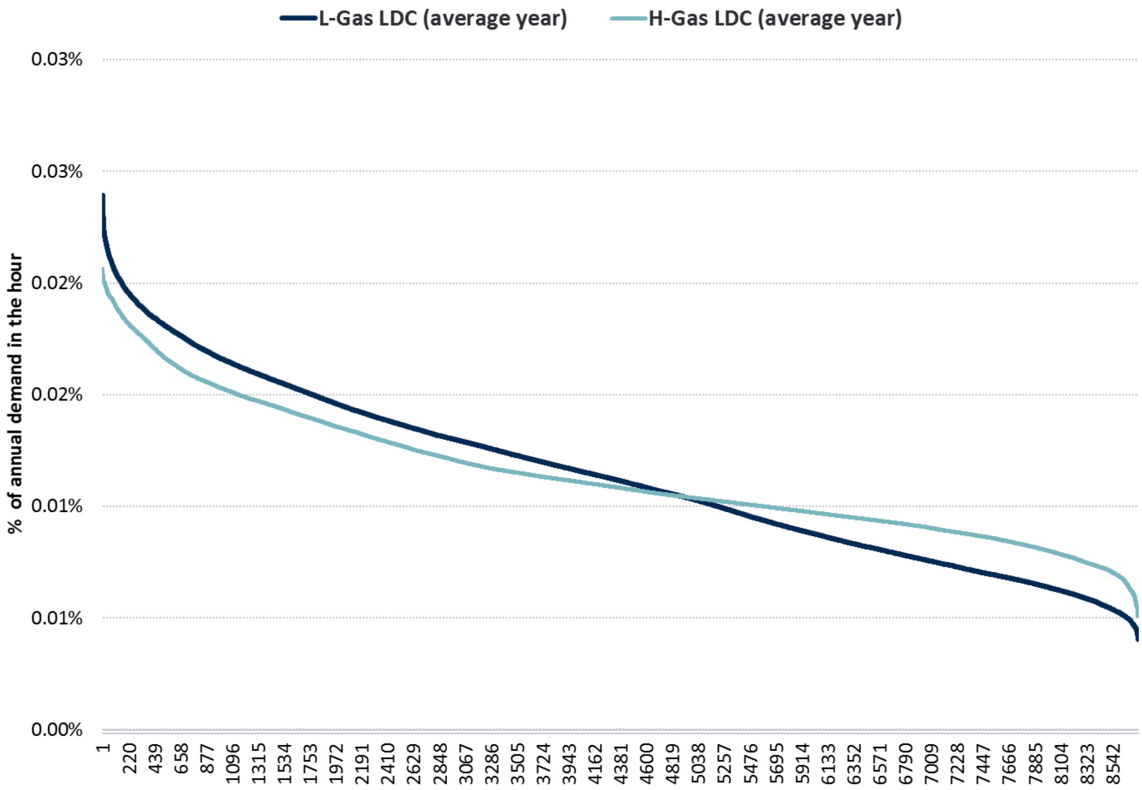
82. We calculated the hourly L-gas and H-gas demand profiles in the average year as follows:

    a. We calculated over the period 2015-2019 the total hourly L-gas demand in each hour as the sum of the domestic L-gas demand and L-gas export demand. For each year, total L-gas demand is then ranked from the hour when demand is the highest to the hour when demand is the lowest to obtain the so-called Load Duration Curves ("LDC") for the L-gas market. We then calculated an average historical LDC for the L-gas market, by averaging the LDCs of the period 2015-2019. The LDC provides a demand profile, as it can be used to determine how much of the total demand of the year is concentrated in each particular hour.

    b. We calculated over the period 2015-2019 the total hourly H-gas demand in each hour as the sum of the domestic H-gas demand and H-gas transit demand. For each year, total H-gas demand is then ranked from the hour when demand is the highest to the hour when demand is the lowest to obtain the LDCs for the H-gas market. We then calculated an average historical LDC for the H-gas market, by averaging the LDCs of the period 2015-2019.

83. Figure 20 shows the LDC profiles for the average year, calculated based on the description above. The hourly profile of demand in 2020, 2025 and 2030, in case of an average year, is obtained applying these profiles to the forecasted level of total demand.

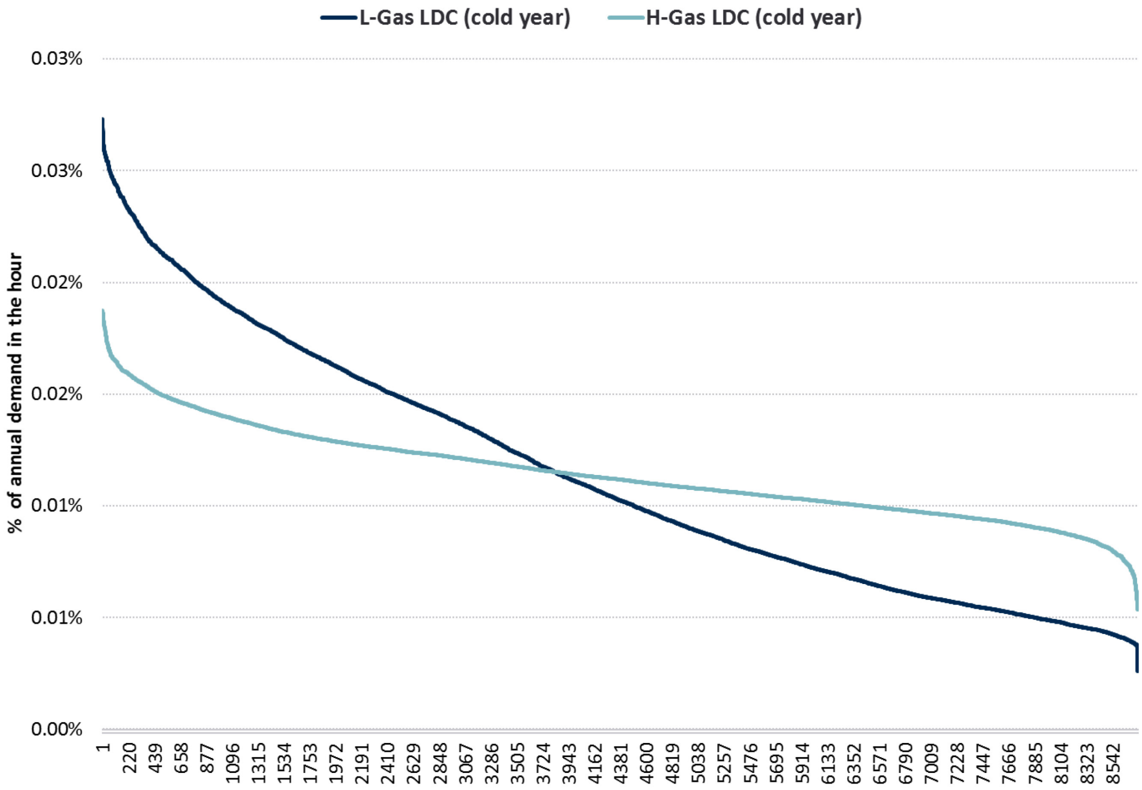
Figure 20: LDC Profile in the Average Year for the L-market and the H-market



Source: Brattle analysis on GTS data.

84. The same approach applies to calculation of the hourly L-gas and H-gas demand in the cold year. As historical data for the cold year refer only to one year, the hourly profile of L-gas demand is calculated by summing up domestic L-gas demand and L-gas export in each hour of the year and the H-gas demand by summing domestic H-gas and H-gas transit in each hour of the year.

Figure 21: LDC Profile in the Cold Year for the L-market and the H-market



Source: Brattle analysis on GTS data.

85. Figure 21 shows the LDC profiles for the cold year situation, calculated based on the description above. The hourly profile of demand in 2020, 2025 and 2030, in case of a cold year, is obtained applying these profiles to the forecasted level of total demand in a cold year.

Appendix B. Domestic Demand Scenarios

86. GTS drafted three scenarios for Dutch domestic demand:

a. The Climate Accord scenario ("KA Scenario"), which is based on measures and actions included the Draft Climate Agreement (the "Climate Agreement") presented in December 2018. All actions required to achieve the target of a maximum increase in warming of 1.5°C compared to pre-industrial era and a reduction of CO_2 emissions by 49% by 2030 are implemented.

b. The Alternative Transition Scenario ("AT Scenario"), where transition to a decarbonised economy is slower than in the KA scenario. Although green gas becomes a viable alternative, roll-out of wind and PV is slower than in the KA scenario.

c. The Foundation for System Integration scenario ("FSI Scenario"), where wind and PV generation increases faster than expected and use of blue hydrogen in gas-fired power stations and electric transport increases. In industry, Power-to-Heat technology becomes a viable option.

87. The AT Scenario is the scenario with the highest gas demand, as shown in Figure 22.

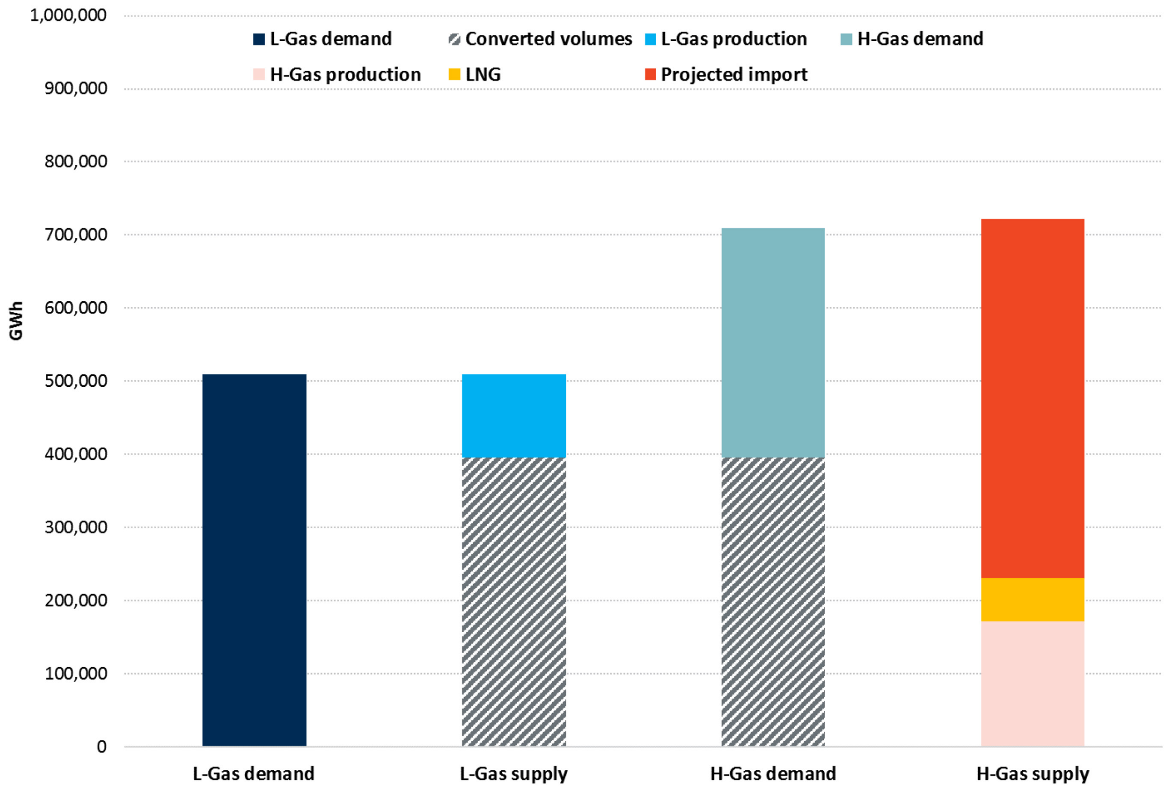
Figure 22: Domestic Gas Demand Scenarios

	Year volume [TWh]					
Scenario	Volumes Average Year (TWh)			Volumes Design Case (TWh)		
	2020	2025	2030	2020	2025	2030
KA Scenario						
L-Gas	237	206	200	279	243	235
H-gas	112	131	121	118	137	127
Total	349	337	321	397	383	365
AT Scenario						
L-Gas	237	207	203	279	244	238
H-gas	112	131	123	118	137	129
Total	349	337	325	397	383	370
FSI Scenario						
L-Gas	237	194	177	279	230	209
H-gas	112	126	105	118	132	110
Total	349	325	301	397	369	341

Source: GTS

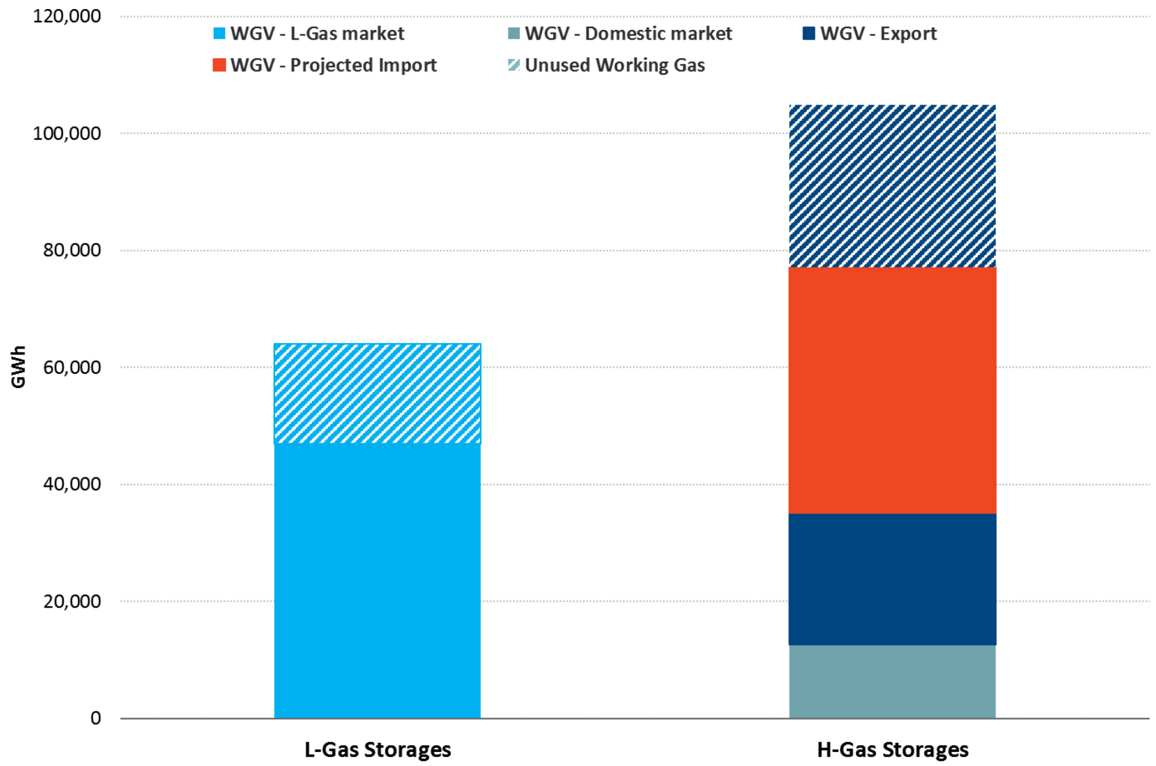
Appendix C. Results of Analysis for All Reference Years

Figure 23: Volume Analysis – 2020, Average Year



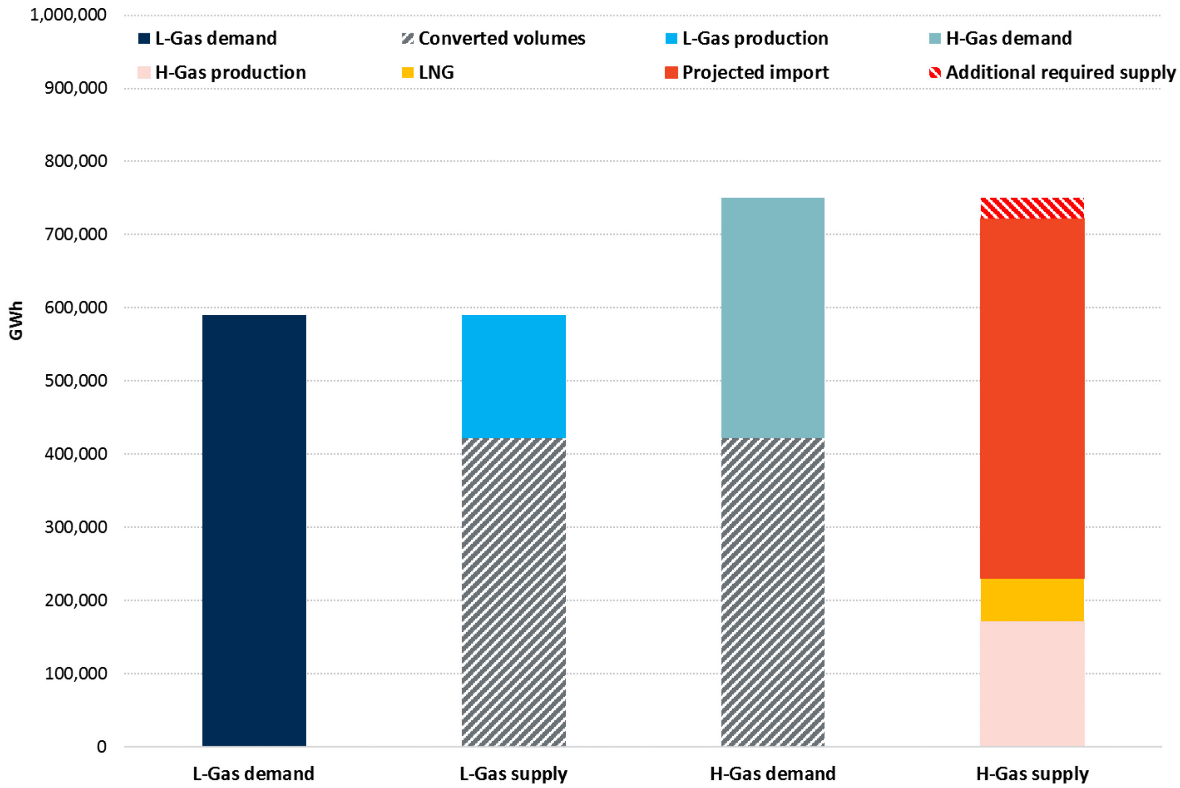
88. Figure 23 shows results for year 2020. Results show that forecasted supply volumes are sufficient to meet demand.

Figure 24: Flexibility Analysis – 2020, Average Year



89. Figure 24 shows the volume of working gas in the L-gas storage facilities (about 47 TWh) and H-gas storage facilities (about 77 TWh)

Figure 25: Volume Analysis – 2020, Cold Year

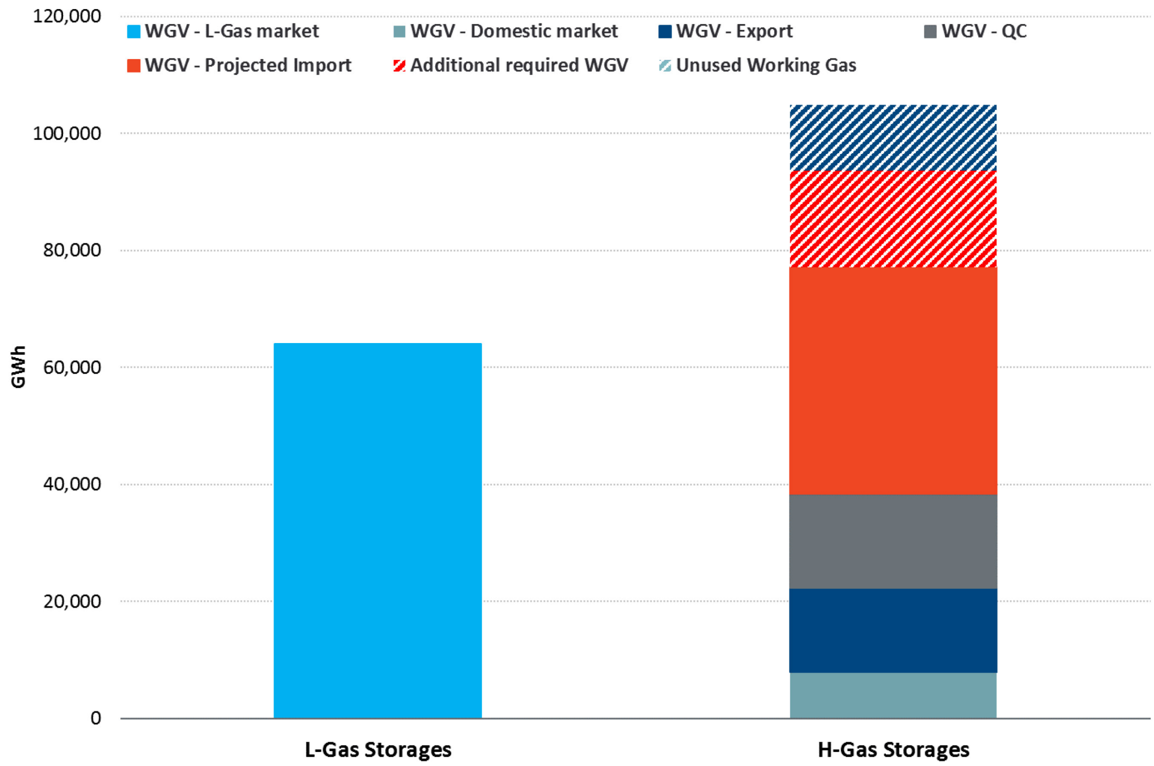


90. Figure 25 reports results for year 2020 in case of cold year. Projected supply is not sufficient to meet demand in case of cold year and additional H-gas import by about 28 TWh is needed (as shown in the fourth column). Available import capacity can accommodate additional supply:

a. Expected average load factor of the system would increase from 79% to 84%.

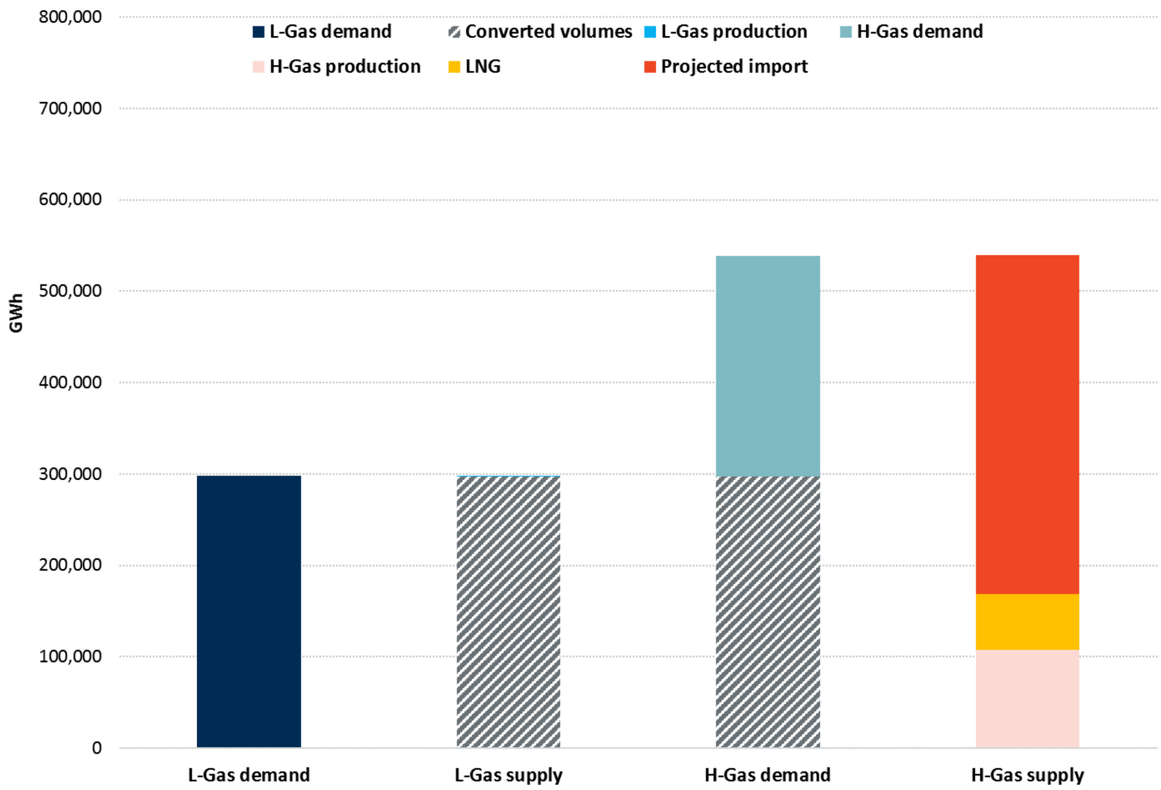
b. If we assume that all additional import will be met by increasing import from Norway and Germany (Gaspool) only, the system can accommodate additional supply but the risk of congestion increases as the load factor of those import points would increase to 100% (over 8,000 hours) and import pipelines operates close to technical capacity. If also the NCG import point from Germany is used (in addition to the Gaspool import entry point), the total load factor of the three entry points is expected to be around 90%.

Figure 26: Flexibility Analysis – 2020, Cold Year



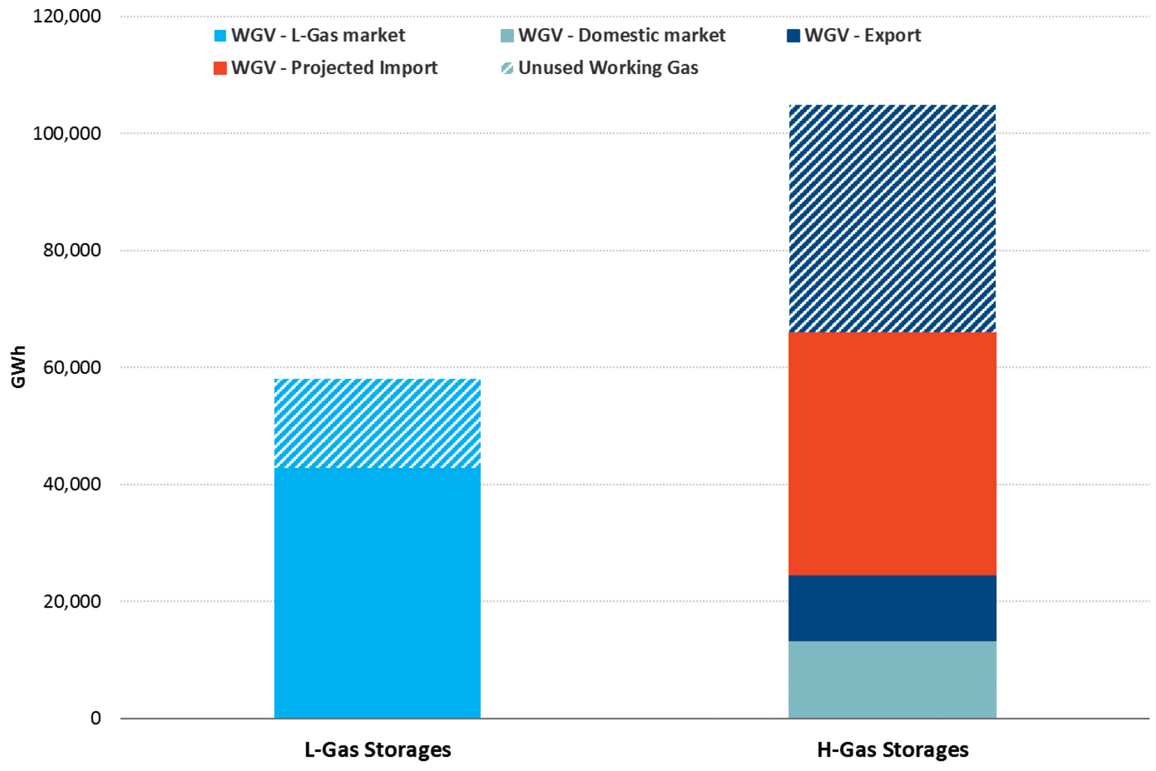
91. Figure 26 show that in case of cold year all available L-gas storage capacity is needed for a total of 64 TWh and working gas space is needed from H-gas storage facilities for a total of 93 TWh, including additional 16 TWh compared to an average year to accommodate additional the import assuming a Conservative Case (i.e. the additional import is mostly in summer and the required flexibility is high).

Figure 27: Volume Analysis – 2025, Average Year



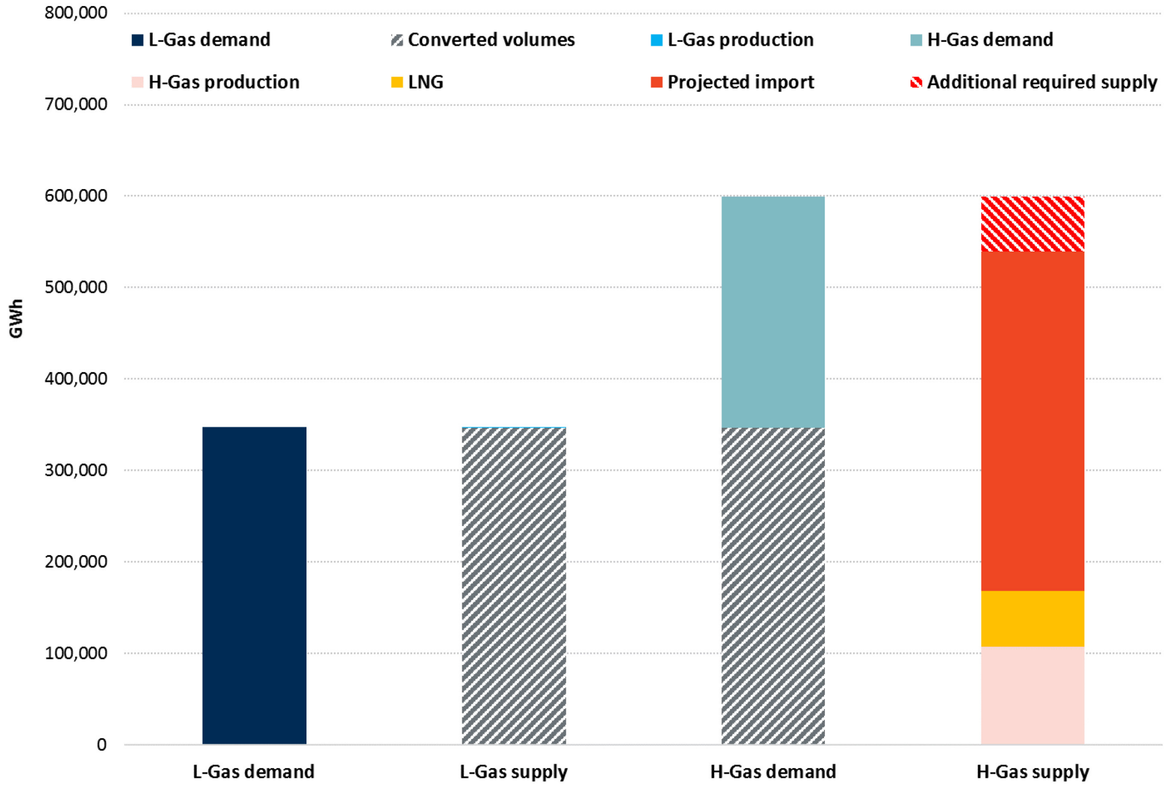
92. Figure 27 show that in 2025 average year, current projections of available supply meet volume demand in both the L-Market and the H-market.

Figure 28: Flexibility Analysis – 2025, Average Year



93. Figure 28 show that in 2025, L-gas Working Gas Volumes amount to about 43 TWh and H-gas Working Gas Volumes to about 66 TWh, lower than in 2020 because of decrease in demand.

Figure 29: Volume Analysis – 2025, Cold Year

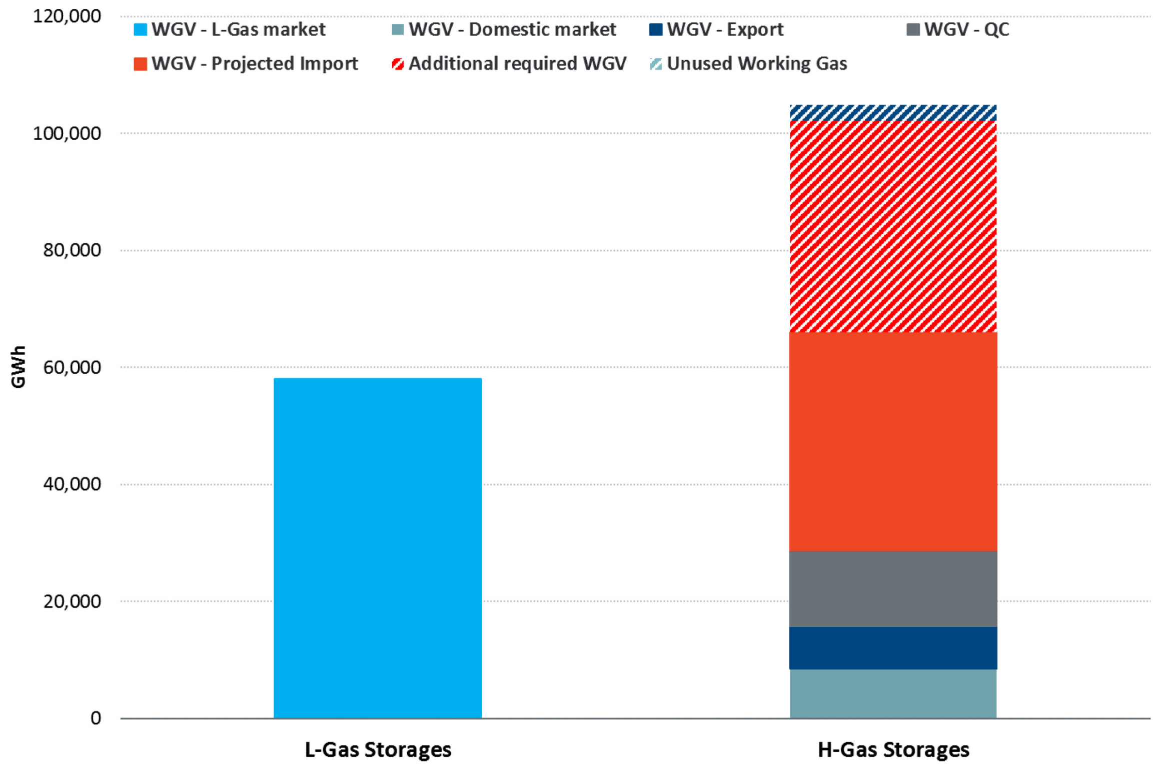


94. Figure 29 show that in 2025 cold year, additional gas import is required to meet demand (+ 61 TWh):

a. The expected average load factor of imports would increase from 60% to 69%

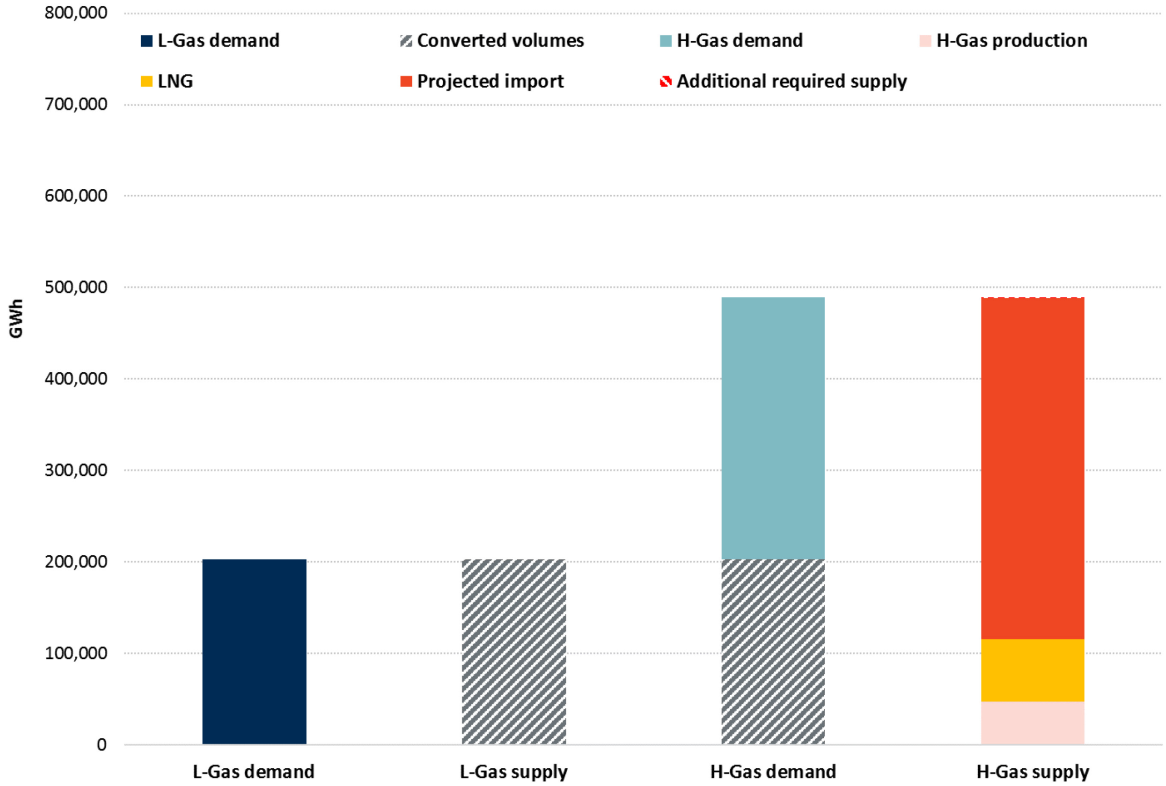
b. If we assume that additional import will be met by only by increasing imports from Norway and Germany (Gaspool) the load factor of those import points will increase from 79% to 93%. If also the NCG import point from Germany is used (in addition to the Gaspool import entry point), the total load factor of the three entry points is expected to be around 82%.

Figure 30: Flexibility Analysis – 2025, Cold Year



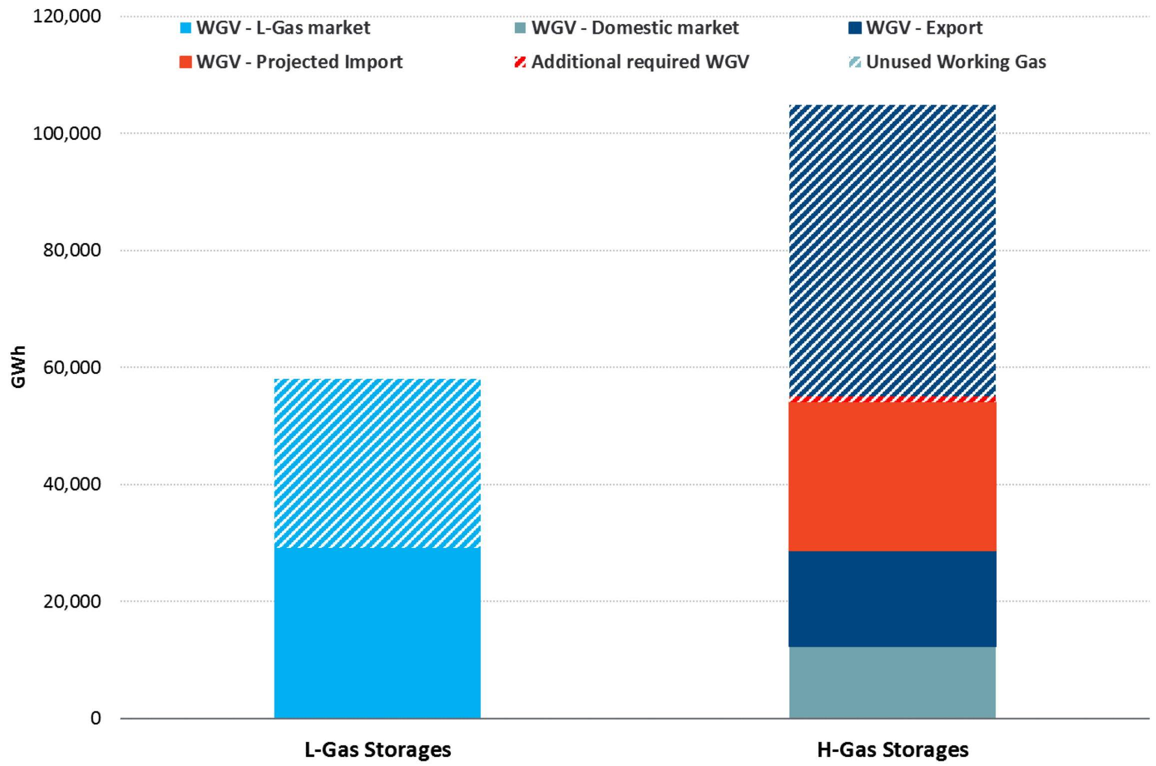
95. Figure 30 shows that in 2025 cold year, all the total available working gas volume of L-gas storage facilities is needed, for a total of 58 TWh. The additional import required to meet demand needs additional working gas volume compared to an average year of around 36 TWh in H-gas storage facilities, for a total of 102 TWh (Conservative Case).

Figure 31: Volume Analysis – 2030, Average Year



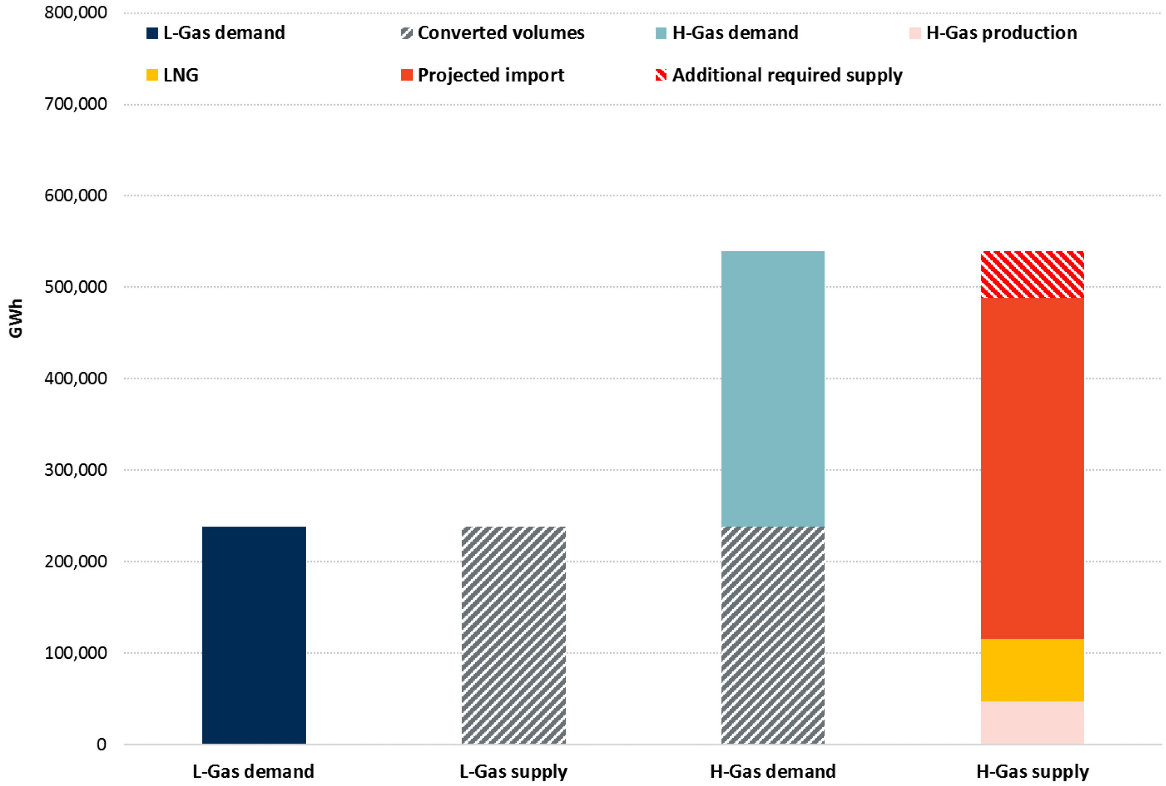
96. Figure 31 shows that in 2030, forecasted demand in the L-Market and the H-market in the average year is 1 TWh higher than current supply projections. This increase has no material impact on the average load factor of import pipelines (60%)

Figure 32: Flexibility Analysis – 2030, Average Year



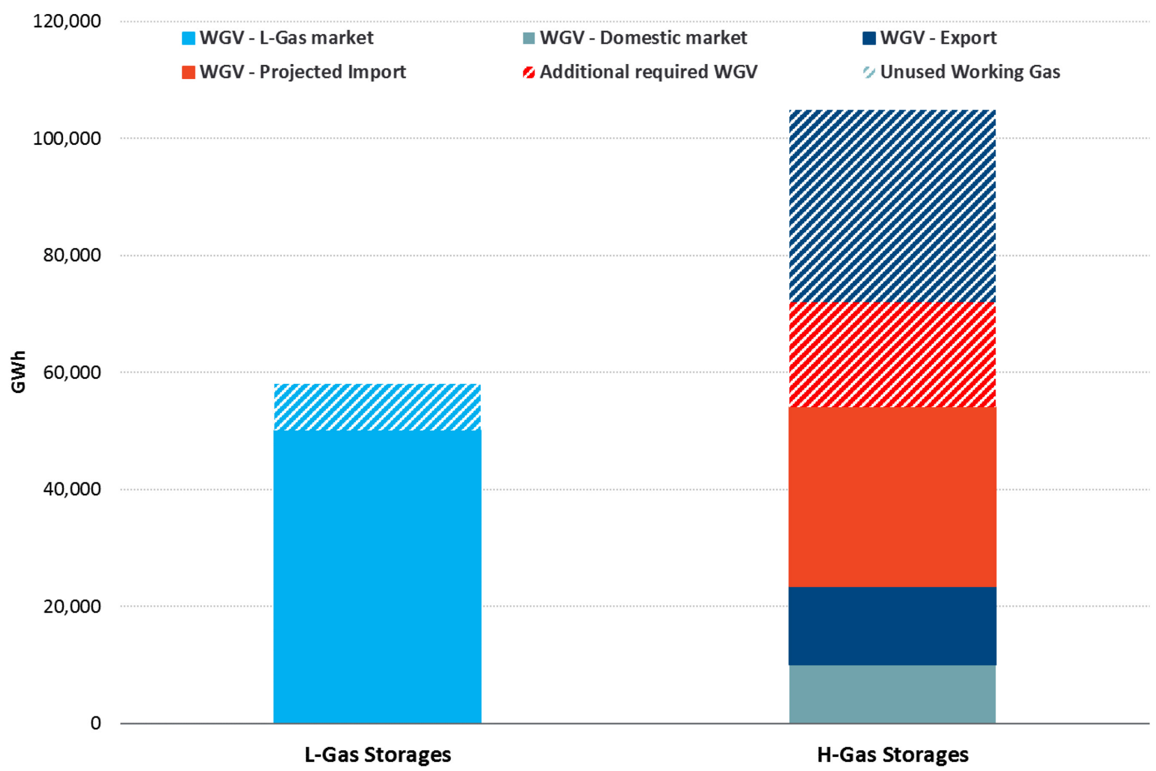
97. Figure 32 shows that in 2030, L-gas Working Gas Volumes from storages amount to about 29 TWh and H-gas Working Gas Volumes amount to about 54 TWh. The additional import required to meet demand requires additional H-gas Working Gas Volumes of 1 TWh (Conservative Case).

Figure 33: Volume Analysis – 2030, Cold Year



98. Figure 33 shows that in 2030, forecast demand in the L-Market and the H-market in the cold year is 51 TWh higher than current supply projections. This will Increase the expected average load factor of import pipelines from 60% to 68%. If we assume that additional import will be met by increasing import from Norway and Germany (Gaspool), the load factor of those import points will increase from 82% to 93%. If also the NCG import point from Germany is used (in addition to the Gaspool import entry point), the total load factor of the three entry points is expected to be around 83%.

Figure 34: Flexibility Analysis – 2030, Cold Year



99. Figure 34 shows that in 2030, in case of a cold year, the working gas volume required in L-gas storage facilities increase by 21 TWh, for a total of 50 TWh. The additional import required to meet demand requires availability of additional working gas volume compared to an average year of around 18 TWh in H-gas storage facilities, for a total of 72 TWh (Conservative Case).

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