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Shaking Dutch Grounds Won't Shatter the European Gas Market

Franziska Holz*+, Hanna Brauers*°, Philipp M. Richter˜*, Thorsten Roobeek+

Abstract:

The Netherlands have been a pivotal supplier in Western European natural gas markets in the last decades. Recent analyses show that the Netherlands would play an important role in replacing Russian supplies in Germany and France in case of Russian export disruption (Richter & Holz, 2015). However, the Netherlands have suffered from regular earthquakes in recent years that are related to the natural gas production in the major Groningen field. Natural gas production rates – that are politically mandated in the Netherlands – have consequently been substantially reduced, with an estimated annual production 30% below the 2013 level. We implement a realistically low production path for the next decades in the Global Gas Model and analyze the geopolitical impacts. We find that the diversification of the European natural gas imports allows spreading the replacement of Dutch gas over many alternative sources, with diverse pipeline and LNG supplies. There will be hardly any price or demand reduction effect. Even if Russia fails to supply Europe, the additional impact of the lower Dutch production is moderate. Again, alternative suppliers from various sources are able to replace the Dutch volumes. Hence, the European consumers need not to worry about the declining Dutch natural gas production and their security of supplies.

Keywords: Natural gas, supply security, Europe, equilibrium modeling

JEL codes: C69, L71, Q34

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1. Introduction

Since the winter 2013/2014, consumers in the European Union have worried about the security of their natural gas supplies. The difficult geopolitical situation with Russia that was triggered by the conflict over Crimea and Ukraine has cast doubts about the reliability of the Russian natural gas exports to Europe. Several 2014 analyses of the supply situation showed that European supplies – that rely on domestic production as well as on imports from various sources – are diversified enough to sustain a disruption of Russian exports in the short and in the long run (Richter and Holz 2015, Hecking et al. 2014, ENTSO-G 2014a).

One important part of the supply portfolio of Europe – and in particular Northwest Europe – is the indigenous natural gas production in the Netherlands. In 2013, total Dutch natural gas production reached 86 billion cubic meters (bcm), of which 67 bcm were exported to other EU countries (IEA, 2014a). Dutch natural gas production in 2013 was almost 20 % of the total EU consumption (IEA, 2015).

However, since 2013 an unprecedented series of earthquakes has rattled the country's Northeastern provinces. Because the seismic activity is related to the natural gas extraction in the largest Dutch gas field – the Groningen field – there has been increasing public opposition to the resource extraction in the Netherlands. Consequently, the Dutch Minister of Economics had to lower the production ceilings for Groningen gas in 2014 and 2015, so that no more than 70 bcm (2014) respectively 60 bcm (2015) are produced in total in the Netherlands.

In this paper, we want to analyze the impact of the reduction of Dutch production capacities on the European natural gas market. The Dutch production problems add up to the geopolitical risk on Russian supplies and we therefore analyze them jointly using a natural gas sector model. However, Dutch natural gas production was already scheduled to go down in the next decades prior to the current earthquake problems that shake the Dutch society.[1] The Groningen reserves are limited, as are the small fields, and the densely populated country is unlikely to pursue shale gas production. Hence, a decrease of the future production path was already forecasted in the past and our long run results are likely to diverge less from the Base Case results for the future European natural gas market than the 2013 share of the Dutch natural gas production leads to presume.

The remainder of this paper is organized as follows. Section 2 describes the Dutch natural gas market and the decision process on the production cap in detail. In Section 3, the Global Gas Model is explained, the dataset is presented and the scenario definitions are laid out. Section 4 discusses our main results, while Section 5 concludes.

[1] Dutch natural gas production is said to have peaked already in the 1970s (IEA, 2014b). New discoveries were small in scale.

2. The Dutch natural gas market: Setup and recent developments

Natural gas production in the Netherland started in the 1960s and the market setup created back then is still in place in its main traits. There are three main actors in the Dutch gas market:

- The central state (government)
- Shell
- Exxonmobil

Through a composition of organisations and institutions, these three actors have established a public-private partnership that develops and sells most of the Dutch natural gas (Correljé and Odell, 2000). The revenues from gas sales have been significant both for the state as well as the private parties.[2] How does this public-private partnership, that is called the 'gas building', work and who takes which decisions? In the following, we focus on the organisation of the production from the Groningen field since this is the largest field and the source for uncertainty of the Dutch natural gas production.

The Ministry of Economic Affairs is the most important player since it is prohibited to explore and extract raw minerals or geothermal heat without a license from the Minister of Economic Affairs.[3] In addition, the Ministry plays a crucial role through the state participant EBN (*Energie Beheer Nederland* – Energy Management Netherlands), which engages with operators and takes a 40% share in all gas and oil projects. EBN is an instrument to ensure public interest. Finally, the Ministry has to approve production plans of operators and can exercise power by adjusting or rejecting these plans. In the last decades, the Ministry approved a rather flexible production plan for the Groningen field with a cap for a multi-year period (425 bcm maximum production between 2006 and 2015, and 425 bcm maximum production between 2011 and 2020; IEA, 2014b).

Shell and Exxonmobil, the other two important actors, together formed the *Nederlandse Aardolie Maatschappij* (Netherlands Petroleum Partnership, NAM) in 1947. NAM obtained an eternal license for the Groningen field after consenting to sign an agreement of cooperation with EBN. Together, NAM and EBN form the *Maatschap Groningen* (Partnership Groningen), which manages the production of Groningen gas. NAM holds 60% of the shares and EBN 40%, but the vote ratio is 50:50. The Groningen gas is extracted on account of the *Maatschap*, but GasTerra is responsible for sales and NAM is the operator of the Groningen gas field. GasTerra is owned by the state (10%), EBN (40%), Shell (25%) and Exxonmobil (25%). Decisions concerning the strategy are taken by an assembly of the most important shareholders of GasTerra and the *Maatschap*. This assembly has a double role since it both sets the strategy for the *Maatschap* (production), as well as the strategy for GasTerra (sales). Although there are formally two assemblies, the *College van Gedelegeerd Comissarissen* (Assembly of the Delegated Commissioners) and *College van Beheer van de Maatschap* (Management Assembly of the Partnership), they are formed by the same people: the Director-general of Ministry of Economic Affairs, an independent representative of EBN, the Chief executive of EBN, the President-

[2] IEA (2014b) reports government revenues of € 13 billion in 2013 from the natural gas sector.
[3] Article 6 of the Mining Act of the Netherlands.

Director of Exxonmobil Benelux and the President-Director of Shell Netherlands. These five people are at the core of the Dutch gas market.[4]

Although the general strategy is discussed beforehand in this assembly of shareholders, the official procedure for final production is as depicted in Figure 1: The NAM, as the operator, sends its production plan to the Minister of Economic Affairs. State Supervision of Mines (SSM) advises and the Minister of Economic Affairs makes the final decision on whether to approve the production plan. The Minister is also authorized to intervene in case of safety concerns.

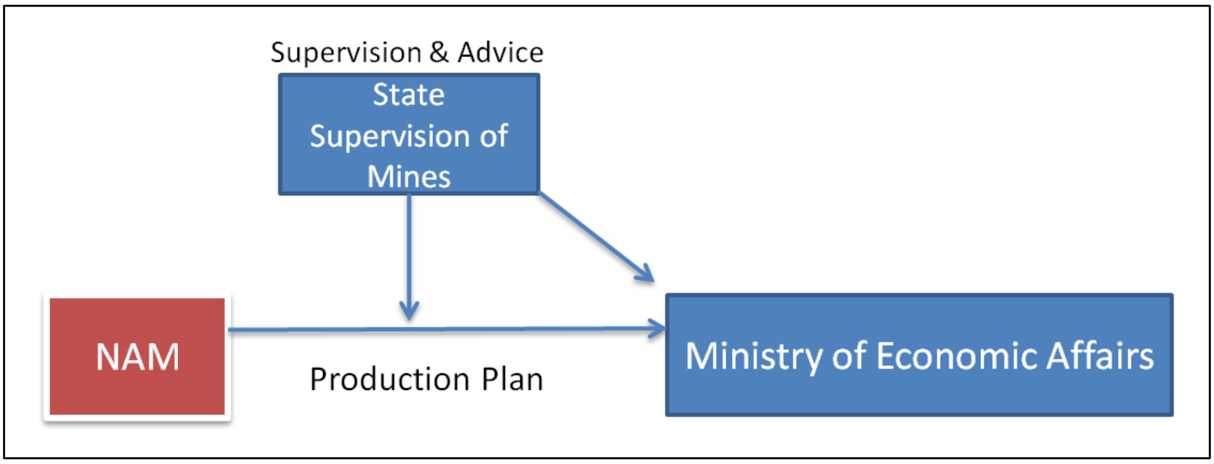

Figure 1: Final decision-making procedure on Dutch natural gas production

State Supervision of Mines therefore plays an important role as the state's watchdog on mining activities. It is a subordinated authority of the Ministry of Economic Affairs and has the technical knowhow and expertise to assess effects of mining on the environment and on subsidence. It advises the Minister on its decisions regarding licensing and approval of production plans. The Minister usually follows the advice given by this authority. SSM's advice in 2013 to reduce gas production from the Groningen field as quickly and reasonably as possible has also been the trigger for the Economic Minister to reduce the Groningen production plan in 2014 and further decrease it to 30 bcm in 2015.[5]

It is expected that steering of production volumes from Groningen through the legal framework of the Mining Act (approval of production plans) will continue in the coming years.[6] A consequence of this is that the Minister will be able to set the maximum volume of production for Groningen. It will thus be a political decision whether to increase or decrease the future caps. However, the minister is not only influenced by public opinion, but also by information provided by experts and research institutes. This shall ensure that the minister arrives at a

[4] Dutch Safety Board (2015): Aardbevingsrisico's in Groningen 18-02-2015: p.70. (Earthquake risks in Groningen).
[5] Ministry of Economic Affairs (2015): Kamerbrief Besluit Gaswinning Groningen in 2015. Letter to Parliament, June 23, 2015.
[6] Ministry of Economic Affairs (2015): Jaarverslag 2013 Delfstoffen en Aardwarmte in Nederland en Jaarverslag 2013 EBN. B.V. Letter to Parliament, January 21, 2015.

weighted judgement based on public opinion as well as on advice from experts at SSM, EBN, NAM, GasTerra, TNO, and the Technical Commission for Subsidence.

Provinces and Municipalities do not play an official role in the decision-making process, except that they can advise the Minister on potential decisions. With the current public opinion in the Groningen province being strongly opposed to gas extraction and tensions rising, there are already first signs that the Ministry of Economic Affairs is increasing the involvement of local authorities in the debate. New dialogue fora between all stakeholders and the appointment of the national coordinator to improve liveability and safety have been the first steps in a changing policy by the government.[7] Figure 2 provides a schematic overview of the parties involved.

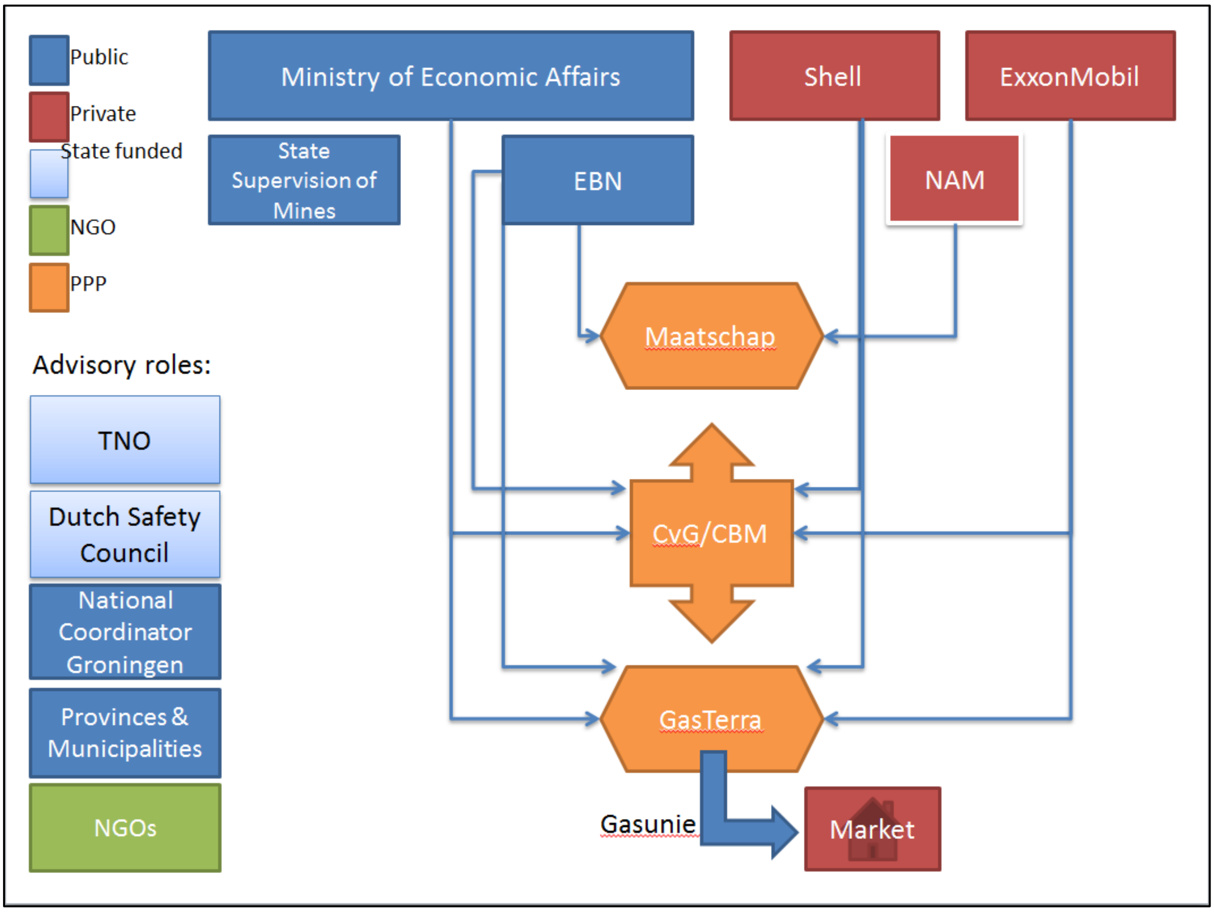

Figure 2: Schematic overview of most important players in Dutch gas market and strategy setting

Most natural gas produced in the Netherlands is so-called L-gas ("low-calorific gas") with a Wobbe index lower than 46.5 MJ/m^3.[8] In contrast, most – if not all – other large international natural gas suppliers produce so-called H-gas ("high-calorific gas") with a Wobbe index higher

[7] Ministry of Economic Affairs (2015): Kamerbrief over aanstelling Nationaal Coordinator Groningen. Letter to Parliament, May 1, 2015.

[8] The Wobbe index is a measure of gases that combines heating value and specific gravity (density).

than 46.5 MJ/m^3.[9] Groningen gas, also called G-gas in the Netherlands, is a variant of L-gas. L-gas contains lower proportions of higher hydrocarbons and therefore has less energy per m^3 than H-gas. As a result, both types of gas cannot be used interchangeably; gas-firing appliances are set to a specific range of qualities of gas.

In the Netherlands, L-gas is used predominantly. The state-owned pipeline operator Gasunie was given the statutory duty to convert H-gas to L-gas. Since Gasunie has this responsibility, shippers and traders do not have to purchase quality conversion services and a single market for gas was created (L-gas). With lower future production of Groningen, there will be more demand for quality conversion facilities from H- to L-gas.

Quality conversion can be used to sustain a reduction of production from the Groningen field and still meet domestic demand in the Netherlands. Quality conversion essentially consists of blending H-gas with nitrogen to obtain L-gas. More H-gas is then needed to be supplied to Gasunie. However, conversion from H-gas to L-gas comes at a cost and the installations are limited in volume and capacity. Gasunie reports that it can cost up to tens of millions of euros per year of additional operational costs, with the costs depending on the characteristics of the H-gas to be blended (Gasunie, 2013). The current maximum amount of quality conversion is between 19-23 bcm. This capacity remains constant until the new conversion plant is to be opened in 2019. This plant would increase the total capacity to 20-29 bcm.

Interestingly, the conversion problem is exactly opposite for the importers of Dutch L-gas: Germany, France and Belgium have started converting their local L-gas pipeline networks to H-gas networks.[10] They plan to use only H-gas at the latest by 2030. We abstract from the L-gas and H-gas distinction in the following – and in particular – in the modelling and use standard calorific value equivalents.[11] Kuper and Mulder (forthcoming) empirically confirm that the regulations in place since 2009 have made the distinction between L-gas and H-gas negligible in natural gas trade in the Netherlands and between the Netherlands and Germany.

The Netherlands represent an important natural gas source for various EU member states (Figure 3). In general, we observed a rising trend in EU imports from the Netherlands in the last years. Germany represents the biggest importer, with Belgium, France and the United Kingdom following. While the United Kingdom rapidly gained importance since 2007, Italy's shares of Dutch imports have been declining.

[9] The only other significant production region of L-gas is (Northern) Germany which shares the geological properties with the Netherlands. However, some Dutch fields also supply H-gas. The average Wobbe index of Norwegian H-gas is 52-53 MJ/m^3, of Russian gas it is 52-54 MJ/m^3, and of LNG imports to the Netherlands it is 53-55 MJ/m^3 (cf. Gasunie, 2013).

[10] See, for example, the respective network development plans: in Germany, FNB Gas (2015) "Netzentwicklungsplan Gas 2014"; in France, GRTgaz "2014/2023 Ten Year Development Plan for the GRTgaz Transmission Network"; in Belgium, Fluxys "Fluxys Indicative Investment Programme 2010-2019 for the Development of Natural Gas Infrastructure in Belgium".

[11] According to the IEA definition, this is "data in million cubic metres […] measured at 15°C and at 760 mm Hg, i.e. standard conditions." (IEA, 2014a).

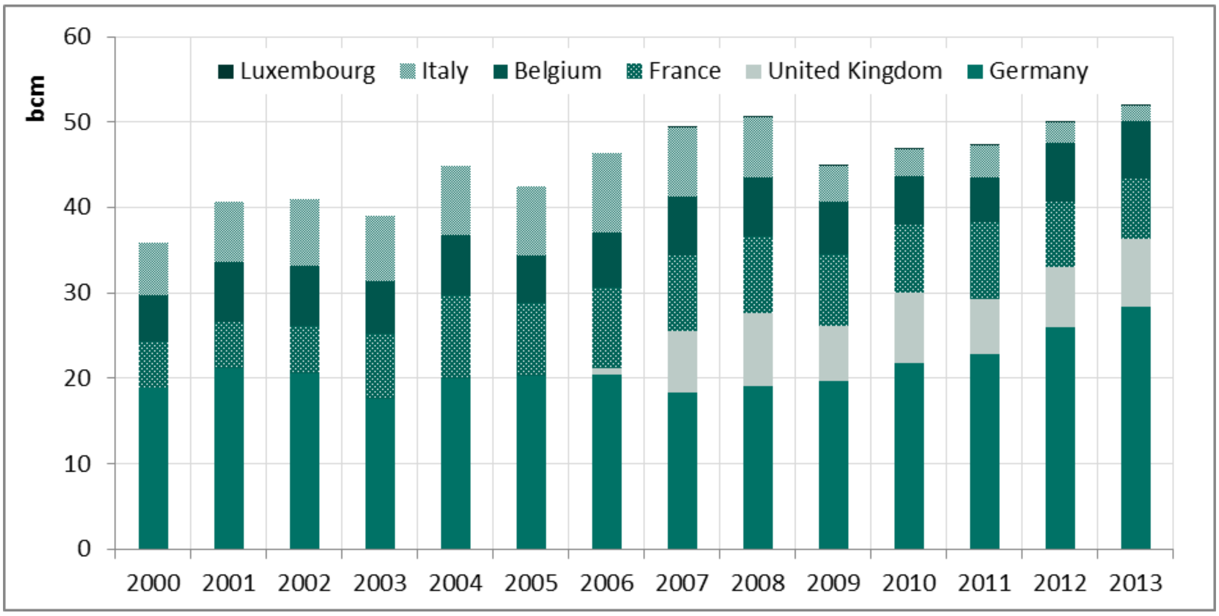

Figure 3: Imports of EU countries from the Netherlands

Source: IEA (2015)

3. Modelling Method

The Global Gas Model (GGM) is used to simulate and analyse future natural gas production, consumption and trade patterns. We contrast our Base Case for the time period 2010-2040 to two different scenarios that describe possible alternative futures of the world natural gas market, affecting especially European natural gas markets. The first scenario represents a strong reduction in Dutch gas production; the second scenario combines the lower natural gas production from the Netherlands with a lasting interruption of Russian gas supply to Europe.

3.1. Model and data description

The GGM represents the global natural gas sector as a partial equilibrium model. All important market entities along the entire value chain, i.e. producers, traders and transmission and storage system operators (TSO and SSO, respectively) are included.[12] These agents maximise profits while being restricted by operational and technical constraints. The GGM data set consists of 99 geographical nodes, which represent 79 countries, and covers 98% of the global natural gas consumption for the year 2010 (see Table 2 in the Appendix for a complete list of countries).[13]

For each country node we have collected data on current and also projected reference consumption and production level, as well as a reference price, production capacities and costs. The transmission and storage systems are constrained by maximum capacities. Infrastructure can be expanded by endogenous investment decisions: the future streams of revenues from pipeline transit fees or storage rents are weighted by the TSO, or the SSO respectively, against investment

[12] For the Dutch natural gas sector described in Section 2, this means that we include NAM (the producer), GasTerra (the trader), as well as Gasunie (the pipeline operator).

[13] In the GGM data set, Luxembourg and Malta are not included. The remaining 26 EU member states are represented by 24 geographical nodes (Lithuania, Latvia and Estonia are aggregated in the regional node "BALT").

costs. Each consumption node has an aggregated inverse demand function which represents the final natural gas consumption of all relevant sectors, i.e. industry, residential and commercial and the power sector.[14]

The inverse demand curve for each consumption node and model period is obtained through reference consumption levels and prices as well as demand sector shares and sector specific elasticities. For the industrial sector we assume an elasticity of -0.4, -0.75 for the power sector and -0.25 for residential and commercial demand. The price elasticity of the aggregate demand function depends therefore on the shares of natural gas usage in the different sectors. In contrast, the price responsiveness of suppliers is determined endogenously, depending on production and transportation costs, capacities and possible market power. Production costs are modelled following the approach by Golombek et al. (1995) with a logarithmic function that steeply increases for the last producible units before reaching the capacity constraint.

Market power can be exerted by selected traders. Rational behaviour, full information and perfect foresight of all players are being assumed. Hence, the results should be interpreted as long-term equilibria. Institutional frictions, i.e. long-term contracts or oil-price linking, are not accounted for in the model. Moreover, seasonality is included in the model in form of a high and low demand season.

The production capacities of each node are calculated by the reference production level and an additional country-specific slack. This slack varies between 2% and 15% across countries, producers and periods. The slack gives the producers flexibility, though with rising costs, to increase production in case of an exogenous shock. As for the production capacity, as well as the capacities of pipelines, LNG and storage facilities, they are determined by reference capacities which are known about the infrastructure already in place and currently under construction. After 2015, endogenous infrastructure investments can increase these capacities (in the model period 2010 no endogenous expansions are allowed).

The GGM is set up as mixed complementarity problem (MCP; cf. Facchinei and Pang 2003) and solved using the PATH solver (Ferris and Munson, 2000) by means of the software GAMS. Results are being calculated from 2010 onwards. The equilibria are calculated in five year steps and reported until 2040; the model horizon is 2050 in order to still give incentives for investments in the final periods.

The data originate from various and generally publicly available sources.[15] For instance, cross-border capacities of pipelines toward and within Europe are provided by ENTSO-G (2013a, 2014),[16] information for worldwide LNG infrastructure is given by GIIGNL (2011-2014) and storage capacities by GIE (2011-2014). Furthermore, we use IEA and EIA publications, data from national statistics offices, and company reports. The dataset includes all current pipelines,

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[14] The inverse demand function states which price the consumers are willing to pay for each quantity and it is usually a downward-sloping curve.

[15] Except for the scenario assumptions, the same data as in Richter and Holz (2015) is used.

[16] Note that entry/exit capacities given by ENTSO-G are not necessarily equal to physical restrictions but rather represent "capacity simulations performed by the respective TSOs" (ENTSO-G, 2013b, p. 29). Due to lack of an alternative comprehensive data set, we implement the ENTSO-G data as initial capacities.

storage facilities and LNG capacities of Europe (e.g. from ENTSO-G 2014, GIE, 2014 and GIIGNL, 2014). Figure 4 depicts the flows of natural gas towards the EU, the importance of natural gas imports from Russia and gas supplies from the Netherlands.

LNG regasification capacities in Western Europe amount to about 186 bcm in 2013, and no regasification capacities existed in Eastern Europe until 2014. For 2015, 8 bcm of new-built are scheduled to become operational in Poland and Lithuania and are included in the data set.

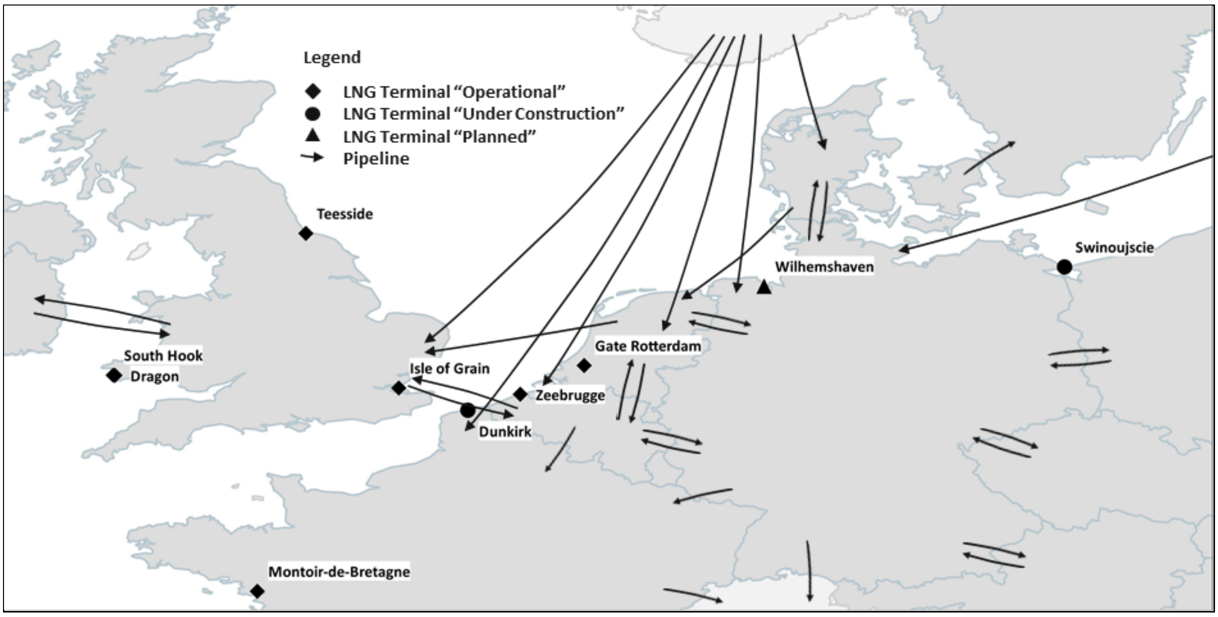

Figure 4: Northwestern European LNG and pipeline import infrastructure in GGM 2015

Source: Own illustration based on GGM database including information from GIIGNL (2014), ENTSO-G (2013a, 2014) and various sources. The blank map (shape file) is available from Eurostat: *http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/geodata/reference* May 20, 2014.

3.2. Scenario definitions

The GGM *Base Case* is calibrated to projections of the New Policies Scenario (NPS) of the World Energy Outlook 2013 (IEA, 2013), which means that reference production and consumption values from GGM are set to values from the NPS. This scenario accounts for moderate climate policy efforts. Globally, CO_2 emissions are expected to rise further by about 20% above 2011 levels, while the EU is assumed to reduce its CO_2 emissions by about 40% until 2035 compared to 1990.[17] For all EU member states, relative production and consumption levels are obtained by EU (EC, 2013). The consistency with the rest of the world is ensured by applying the shares of each EU country from EC (2013) to the total EU forecast by IEA (2013).

[17] See Holz et al. (2015) for an analysis of the role of natural gas under ambitious global climate policies.

The reference consumption for the EU28 (without Malta and Luxemburg) is 492 bcm in 2015. The assumed consumption of the Netherlands is 43 bcm, of Germany 82 bcm and in France 50 bcm, while Great Britain has the highest reference consumption amounting to 88 bcm.

Two different scenarios are being set up to analyse the effects of a reduction in Dutch natural gas production. The first one, *NL_low*, represents the declining production capacities, due to legal regulations of the Dutch government, caused by a rising threat of earthquakes in the Groningen region (see Table 3 in the Appendix for exact values of the Dutch production capacity). The second one, *RUS_NL_low*, combines the reduced Dutch production with a disruption of Russian natural gas supplies to Europe.

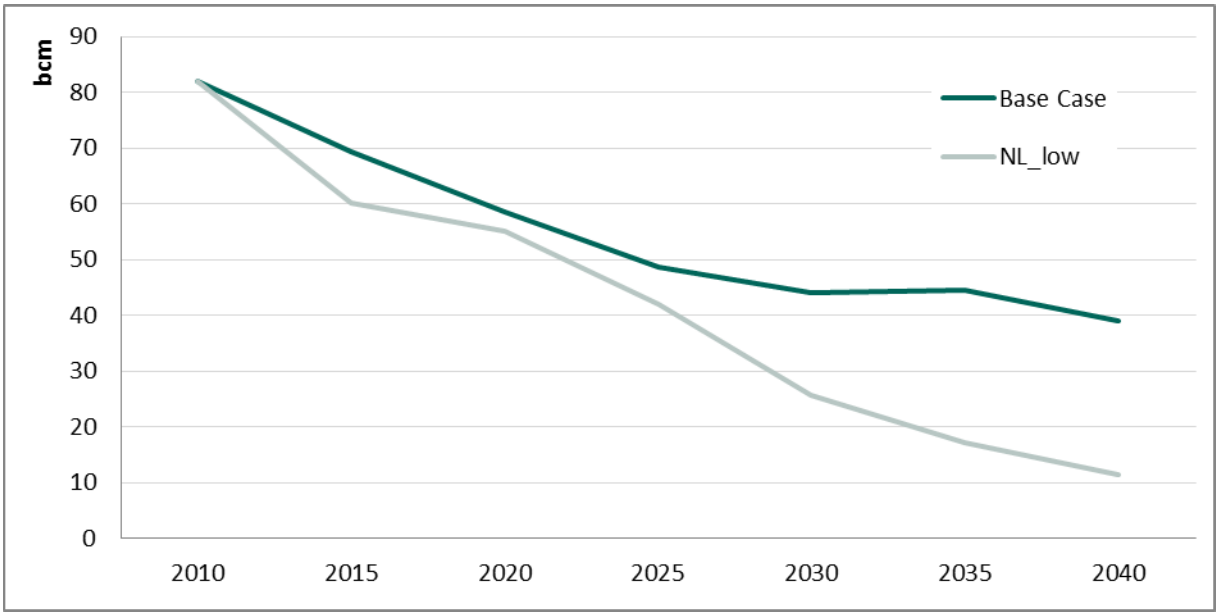

Figure 5: Comparison of Dutch production capacities in *Base Case* and scenario *NL_low* (in bcm)

The decisive scenario assumption is that the production of the Groningen field is being cut due to political decisions; from 39 to 33 bcm, already in 2015, as announced by the government in July 2015.[18] The natural gas production capacity of the Netherlands consists of the large capacity of the Groningen field and additional capacities of a number of small fields. The overall capacity is calculated in the following way: for the Groningen field the capacity is set to 33 bcm until the year 2022; after that, the original declining production forecast is assumed. The forecasts for Groningen and the small fields are summed up to obtain the total Dutch production capacity. For the years after 2035 no data is available, therefore production data is extrapolated until 2050 using the growth rates between the years 2030 and 2035.

[18] Ministry of Economic Affairs (2015): Kamerbrief Besluit Gaswinning Groningen. Letter to Parliament, June 23, 2015.

Table 1: Scenario descriptions of GGM simulation runs

Scenario Name	Description	Specific Assumption
Base Case	Projections of future natural gas production, consumption and trade based on the *New Policies Scenario* of the IEA (2012)	
NL_low	Reduction of production in the Netherlands: The production capacities are lowered due to governmental restrictions.	NLD production capacities compared to Base Case: • 2015: -13% • 2020: -6% • 2025: -14% • 2030: -42% • 2035: -61% • 2040: -70%
RUS_DISR	Long-lasting disruption of Gazprom infrastructure in Europe: Continuous disruption of Russian natural gas supply to all EU member states and other European countries (Ukraine, Serbia, Switzerland and Turkey). All Gazprom majority-owned infrastructures are not used after 2010. This lasting supply disruption can be anticipated and responded to by investments in the pipeline network from 2015 onwards (being operational as of 2020). Affected pipelines: • Nord Stream • Brotherhood • Yamal Europe • Blue Stream • South Stream • OPAL Reduced storage capacities in: • Germany • Austria • Latvia • Serbia	• Zero capacity on pipeline RUS-DEU • Zero capacity on pipeline RUS-FIN • Zero capacity on pipeline RUS-BALT • Zero capacity on pipeline RUS-BGR • Zero capacity on pipeline RUS-TUR • Zero capacity on pipeline RUS-UKR • Zero capacity on pipeline BLR-UKR • Zero capacity on pipeline BLR-POL • Zero capacity on pipeline BLR-BALT • Reduced capacity on pipeline DEU-CZE by 70% • Reduced storage capacity in DEU by 20% • Reduced storage capacity in AUT by 35% • Reduced storage capacity in BALT by 100% • Reduced storage capacity in SRB by 100% • Anticipation and unlimited investment as of 2015
RUS_NL_low	A combined low Dutch production with a long-lasting disruption of Gazprom infrastructure in Europe.	• NLD production capacities compared to Base Case as in NL_low • The same capacity and storage restrictions as in RUS_DISR

The second scenario analysed, *RUS_NL_low*, is a combination of the reduced Dutch production capacity as defined in the first scenario and a long-term disruption of Russian natural gas supplies. We follow the scenario definition developed in Richter and Holz (2015). In that long disruption scenario the entire Russian natural gas supply to Europe is interrupted and all Gazprom majority-owned infrastructure is shut down from 2015 onwards (see Richter and Holz, 2015, for more detailed scenario description and results). See Table 1 for scenario descriptions and the scenario specific assumptions.[19] The reduction of Dutch natural gas production and the

[19] Additionally, assumptions about the idle production capacity (slack) have been made: The slack for both scenarios is 2% lower in 2015, compared to the *Base Case*. The Dutch government provides estimates about possible production expansions in case of supply emergencies. This is included in the model with a high slack of 12%. The production difference from the Groningen field is 6 bcm in 2015, which represents 10% of the overall 60 bcm

disruption of Russian supplies begin in 2015. Hence, the decision variables are fixed at *Base Case* levels for 2010 and no changes of the European natural gas market in or as of 2015 are anticipated by any model agent.

4. Results and Discussion

This section presents the results from the model simulations and discusses the impacts of the lowered Dutch natural gas production on the European natural gas market. Outcomes from both scenario runs are compared to their respective Base Cases: *NL_low* with *Base Case*, and *RUS_NL_low* with *RUS_DISR*.

4.1. Lower Dutch production in the European natural gas market

Figure 5 in Section 3.2 shows that we assume the Dutch natural gas production to decrease compared to the Base Case as of 2015.[20] The difference to the Base Case is not uniform across periods and it is the largest in the last model period (2040). Hence, even though we expect the investment effects in alternative supply routes after 2015 to level out the impact over time, a large deviation from the Base Case is likely in the last model period.

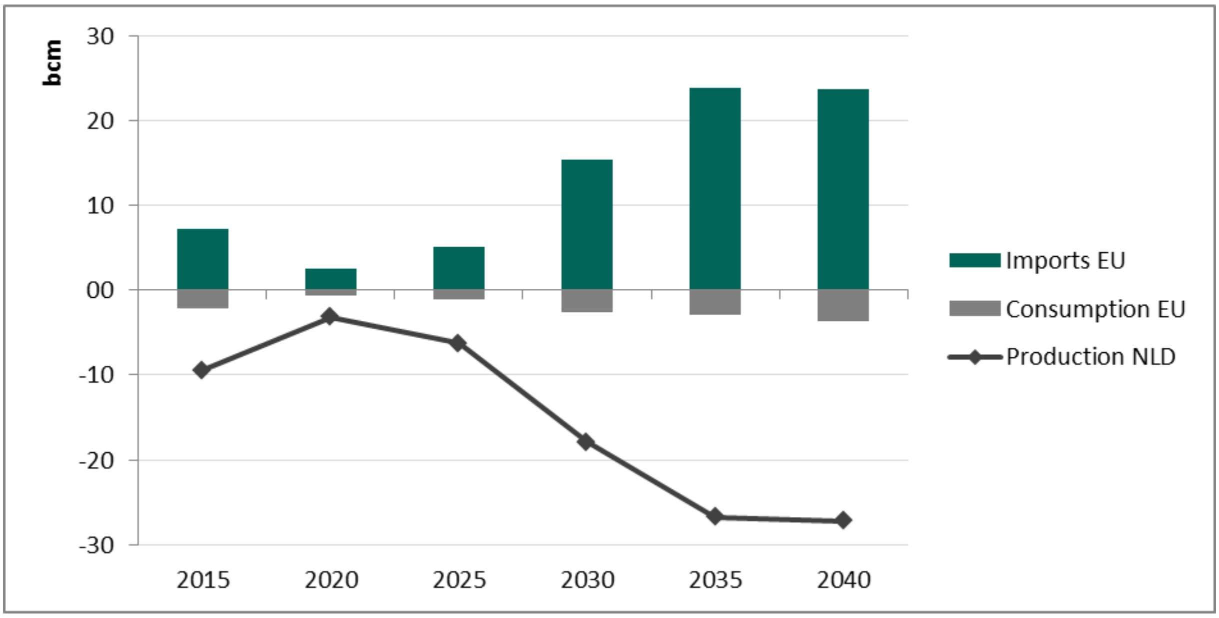

Figure 6: Impacts of lower Dutch production on EU imports and consumption (in bcm, changes *NL_low* compared to *Base Case*)

This is indeed shown in Figure 6 which presents the impacts on consumption and imports of natural gas in Europe. The strongest consequences can be seen in 2040 where the Dutch

production capacity. The default value for the slack in the GGM is 2% which adds up to the assumed 12% slack. All other model periods in the scenarios have the same slack as in the *Base Case*.

[20] The 2010 levels – including investments – are kept unchanged; in other words, we do not allow for adaptation to the new production patterns before 2015.

production is 27 bcm lower than in the *Base Case*. Despite this significant change, the total consumption in Europe is only reduced by 3 bcm; the rest can be compensated by imports from other suppliers. All earlier model periods have even smaller implications for the total natural gas consumption in Europe.

Similar to the consumption levels, in the *NL_low scenario,* prices in Europe change only slightly. The price changes in 2015 in individual European countries and on EU average can be seen in Figure 7. On average, the prices increase by only about 0.7%. Interestingly, prices do not only change in countries that import natural gas from the Netherlands, but prices rise gradually almost all across Europe. Western European countries are affected slightly stronger than Eastern member states of the EU because Western Europe has traditionally been importer of Dutch natural gas. The effects of the change in Dutch gas supplies on the European market are effectively moderate because of a shared compensation across European countries.

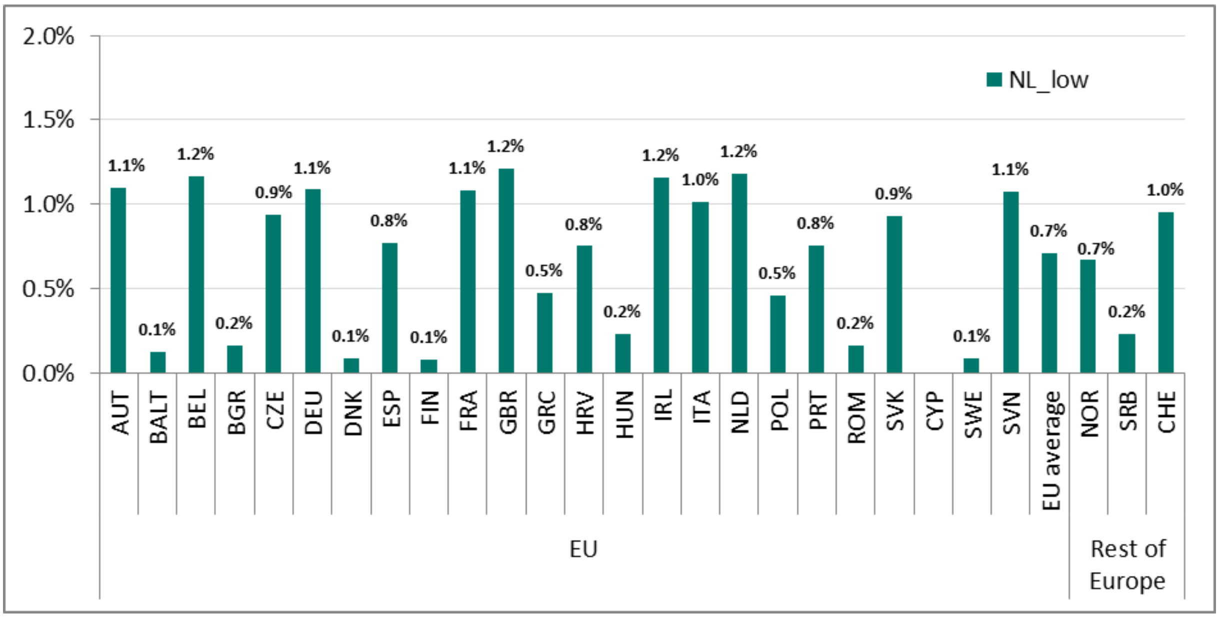

Figure 7: Price changes in Europe due to lower Dutch production (in percentages relative to Base Case, in 2015)

No country experiences a price increase higher than 1.3%. The highest increase occurs in the countries consuming Dutch gas, i.e. Belgium, Germany, France, Great Britain, Italy and the Netherlands itself. Similar to the distribution of the price effect, also the demand change is spread over many countries and no country suffers from a high consumption reduction. Great Britain, Germany and the Netherlands experience the highest demand reductions and no country lowers its consumption by more than 1 bcm per year.

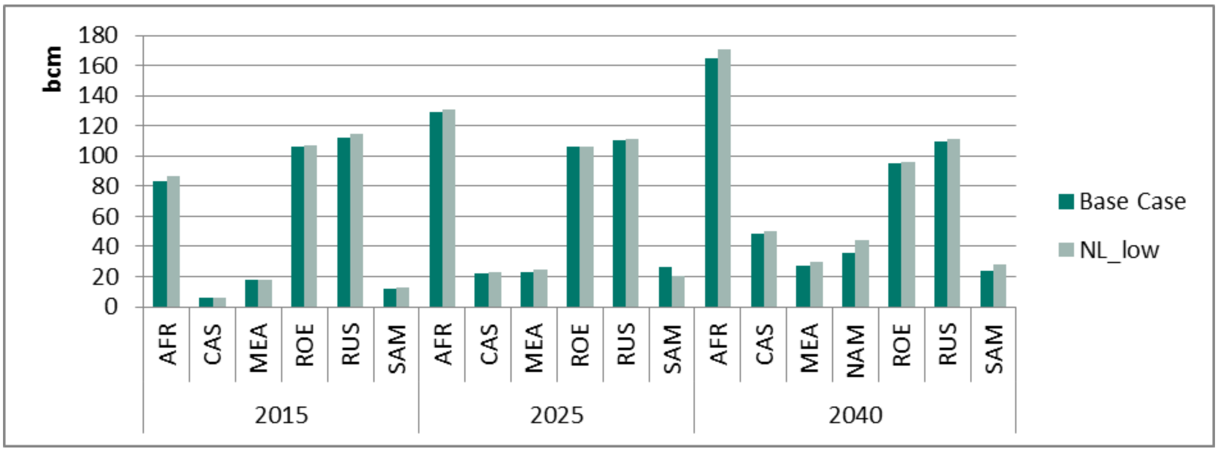

Figure 8: EU natural gas imports from various regions (in bcm)

To compensate for the lower imports from the Netherlands without a significant consumption decrease, the EU has to further diversify its imports. Over time imports rise, as shown in Figure 8. The highest import volumes after 2020 come from Africa, followed by Russia and the Rest of Europe (i.e. Norway). The highest additional imports in the *NL_low* scenario compared to the *Base Case* are supplied by North America with a 25% increase, followed by South America with 17% and the Middle East with 10% more imports (9 bcm, 4 bcm and 3 bcm, respectively). It becomes apparent that not one country compensates the change in Dutch natural gas production, but instead many countries use their opportunity to increase their exports to Europe. This is due to the oligopolistic market structure which characterizes the European natural gas market where the high prices are attractive for large array of suppliers (see, e.g., Egging et al. 2008, Holz et al. 2008). The import increase and the diversification from various sources secure the gas supply in Europe and prevent European countries from price spikes compared to the Base Case.

Europe continuously increases both its pipeline and its LNG imports, while the indigenous production decreases (see Figure 9). Until 2040 the pipeline imports rise in the *NL_low* scenario to 371 bcm (8 bcm more than in the *Base Case*), and LNG imports increase to 145 bcm (15 bcm more than in the *Base Case*).

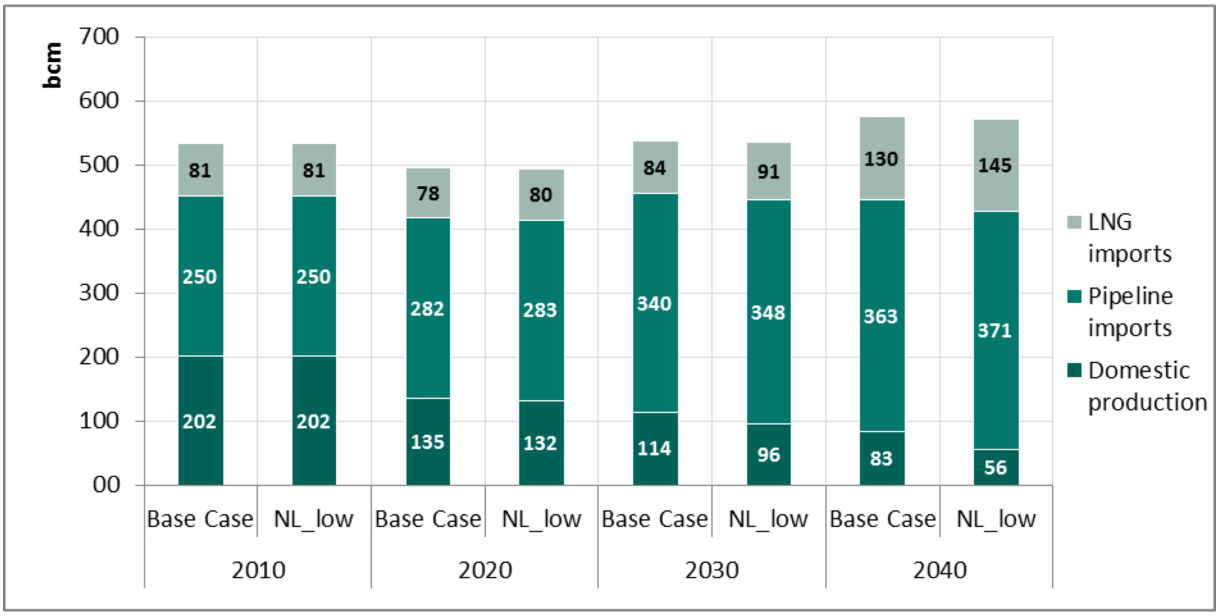

Figure 9: Supply structure in EU28 in Base Case and *NL_low* scenario over time (in bcm/year)

4.2. Russian disruption with lower Dutch production: Spreading the risk from Eastern to Western Europe?

The second scenario assumes the same reduced production rates for the Netherlands as in the first scenario, but those are additional to a complete supply disruption of natural gas from Russia to Europe. The results discussed here focus on the intensifying effects on consumption, prices and the change of trade patterns due to the lower Dutch production, compared to the impacts of a sole Russian supply stop.

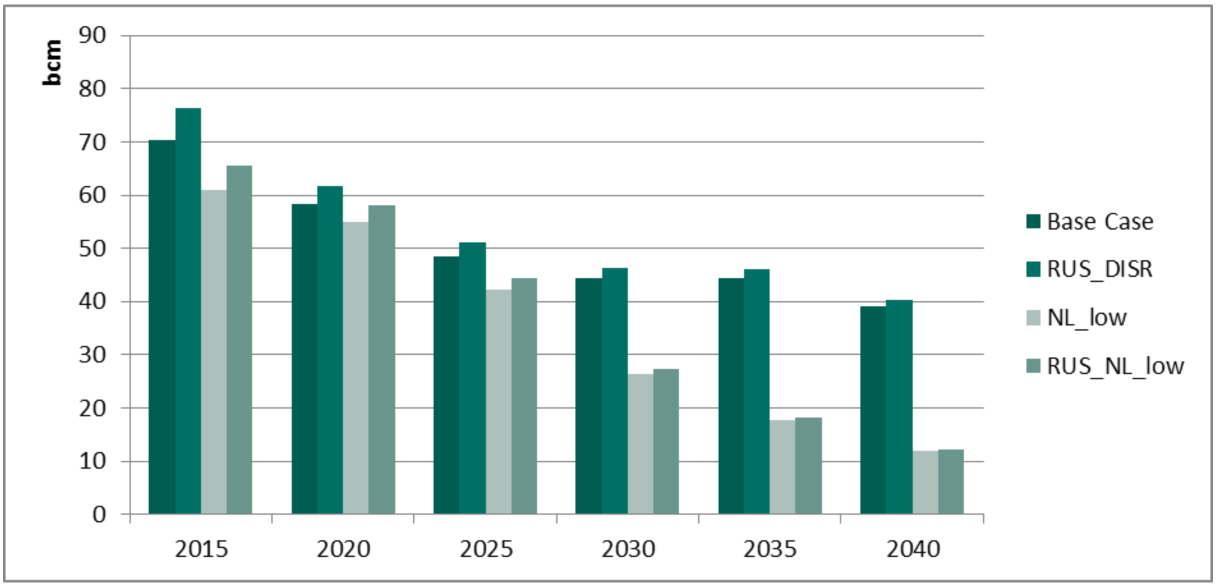

Figure 10: Domestic gas production in the Netherlands for all scenarios (in bcm/year)

Figure 10 presents the Dutch production levels in all four considered scenarios. In case of a Russian supply disruption, the Netherlands would slightly increase their production within their production capacity limit but at the expense of higher production costs. The production level in *RUS_DISR* is higher than in the *Base Case* and the Dutch output is also higher in *RUS_NL_low* compared to *NL_low*.[21] Over time the differences between scenarios diminish because of lower total production capacities in the Netherlands and, therefore, a lower leeway.

In case of a long-lasting Russian supply disruption, Eastern Europe would experience high price increases and lower demand for natural gas because the region is highly dependent on imports from Russia. Though affected, the Western European part would only slightly be afflicted compared to the impacts on Eastern countries (for an extensive discussion, see Richer and Holz, 2015). The diversification of imports to Western European countries relies on supplies from Africa and America, and also importantly from Norway and the Netherlands. Therefore it is likely that the limited Dutch supplies would have a stronger effect on the Western European countries.

As in Section 4.1, the additional impacts in Europe of a production cut in the Netherlands are rather small – despite a high reduction in Dutch gas production. Almost all negative effects can be compensated by higher imports from other countries and result only in a small reduction of natural gas consumption of EU countries (-4 bcm per year in 2040).

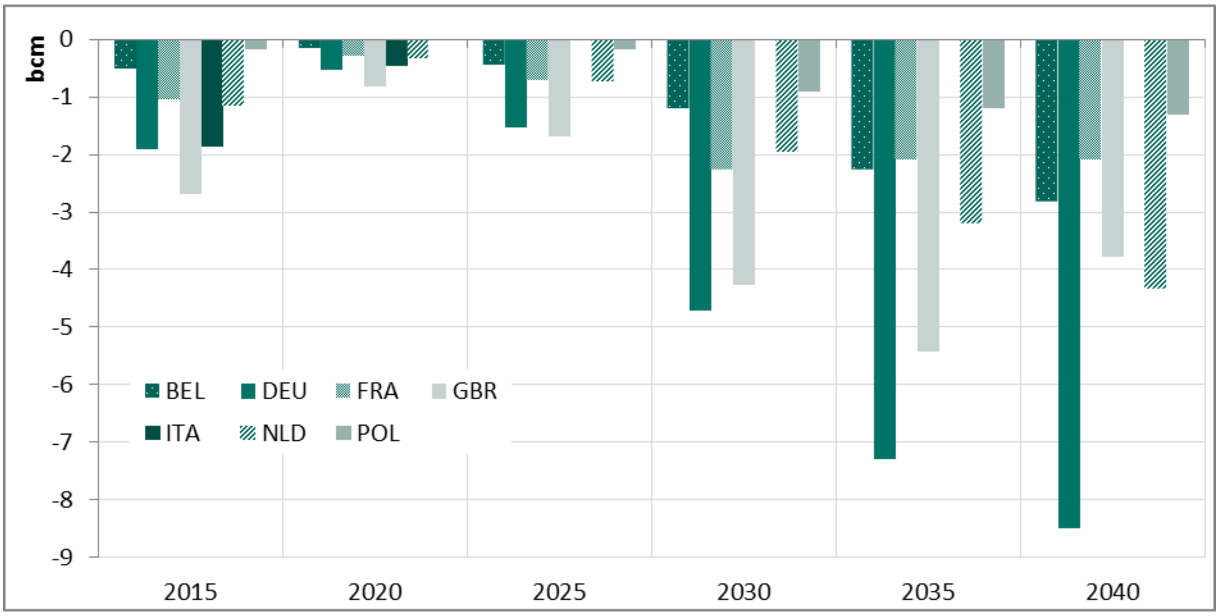

Figure 11: Change of Dutch gas supplies: *RUS_NL_low* vs. *RUS_DISR* (in bcm/year)
Note: Countries with changes lower than 1 bcm are not included.

[21] The increase in production from *NL_low* to *RUS_NL_low* is possible due to the modeled production function: A slack capacity is given, but its use has strongly increasing costs, the closer the production gets to the capacity limit. The rising market prices due to natural gas scarcity in the Gazprom scenarios allow Dutch gas companies to extract more gas at higher costs.

The direct effect of less supplies of Dutch natural gas is mainly experienced by the Netherlands and its neighboring countries (Figure 11). The reduction of consumption of Dutch gas increases with the years as the production restrictions in the Netherlands are tightened. The largest drop in consumption of Dutch gas takes place in Germany, followed by Great Britain and the Netherlands. Although, except for Poland, only Northwestern European countries are affected, the impacts are only a friction to the implications on Eastern European countries of a Russian gas disruption.

Natural gas consumption in Northwest Europe is only slightly lower and also prices increase only marginally compared to the price spikes in some Eastern countries. We conclude that a Dutch supply reduction additional to a Russian supply stop would not extend the Eastern European gas supply difficulties and price hikes to the West. The extensive natural gas infrastructure, its interconnectivity and possibilities of reverse flows offer opportunities to compensate negative impacts and spread them between neighboring countries, measures which though still have to be enforced in the Eastern part of the EU.

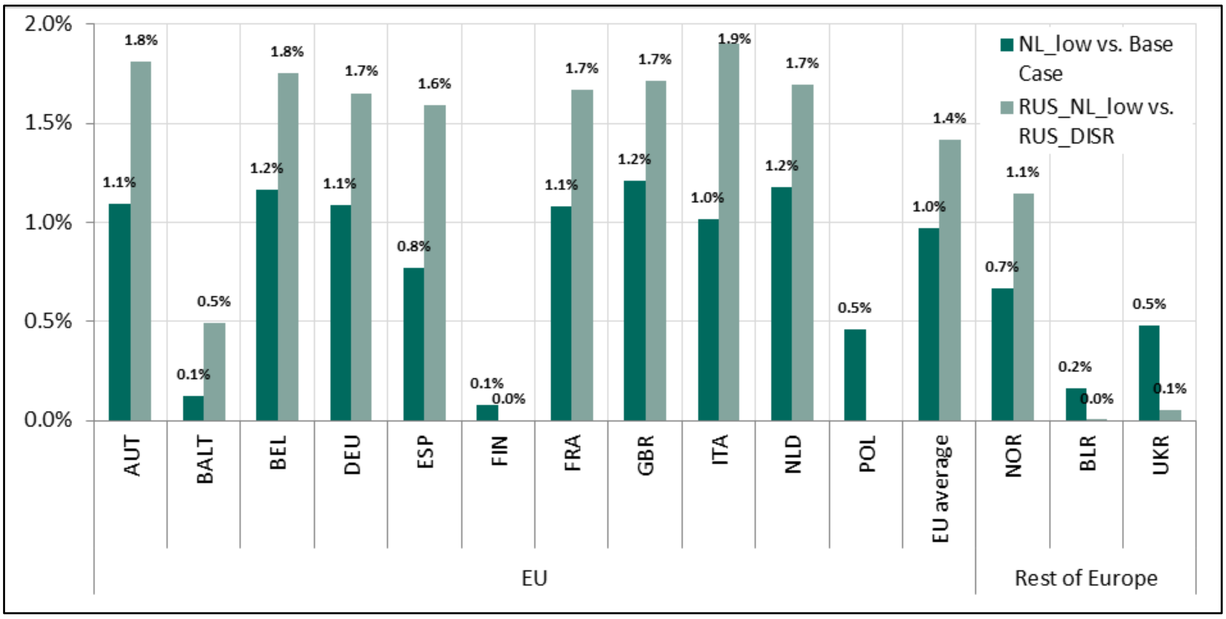

Figure 12: Deviation of prices in low-Dutch production scenarios compared to the respective Base Cases (in percentages, in 2015)

The effect of prices of low Dutch production is small, but the increase is slightly higher in case of a disruption of Russian exports (Figure 12). Despite the fact that prices for natural gas vary broadly between EU member states, the price changes are of comparable size. The relative price increase between *RUS_NL_low* and the *RUS_DISR* scenario is less than 1.5% on EU average and for no EU country is the price increase higher than 2%. A Russian gas disruption, however, causes a high absolute price increase due to a pronounced natural gas scarcity on the (East) European market (Richter and Holz, 2015). An additional reduction of available natural gas due to less gas from the Netherlands intensifies the price increase, but only by a small additional amount compared to the effect of the Russian disruption.

The supply stop of natural gas from Russia leads the EU to rely more on LNG imports. The use of LNG today differs strongly across member states. Especially Spain has already invested in large regasification capacities, while other member states like Germany rely entirely on natural gas imports by pipelines. A Russian gas disruption combined with cuts of Dutch gas forces more EU countries to expand the utilization of their existing regasification facilities and to invest in additional infrastructure. The importance of LNG imports from Africa and South America strongly increases over the years, and especially imports from North America grow rapidly from 2020 onwards (Figure 13). The Russian disruption already forces Europe to change from an import pattern dominated by pipeline to use more LNG; the Dutch supply cuts augment the LNG usage by about 15 bcm in 2040.

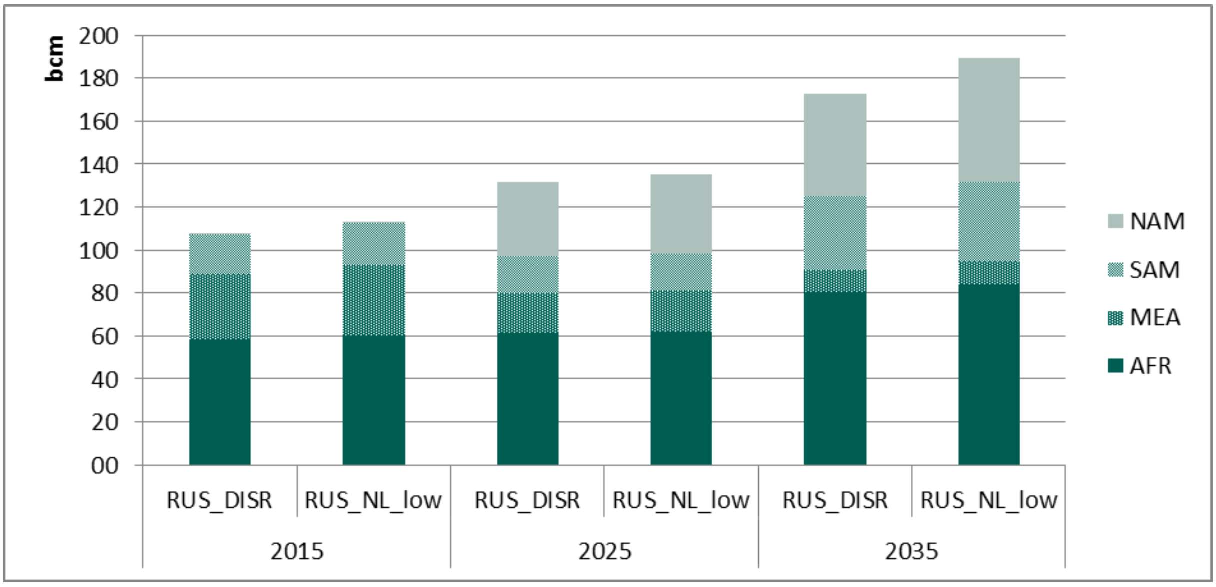

Figure 13: LNG imports to the EU28 over time (in bcm per year)

5. Conclusions and Outlook

In this paper, we have investigated the potential effect on the European Union of the production decrease that the Netherlands have recently engaged in. The production cuts have been decided after the Groningen province – where the largest Dutch gas field is located – has experienced earthquakes at high frequency. The maximum annual production rate set by the Dutch Minister of Economic Affairs for this year is considerably lower than the previous production plan had indicated and for the years to come it is unlikely that the downward correction of the production cap will be revised. However, up to now the analyses of European gas supply security have relied on the previous numbers of relatively large Dutch production. With this paper, we make a first attempt to evaluate this new geopolitical situation with lower indigenous production capacities available in Europe.

Europe's imports are currently dominated by Russia which has been perceived as a problem since the Ukraine crisis started in the winter 2013/14. Several model-based studies investigated the effects of a potential disruption of Russian exports to Europe in the short and in the long run (Richter and Holz 2015, Hecking et al. 2014, ENTSO-G 2014a). They found that the largest negative effects occur in Eastern Europe – albeit smaller than they would have been a few years ago thanks to the starting deployment of reverse flow capacities. Western Europe can rely on a diversified portfolio of suppliers and supply routes, both by pipeline and LNG, which can compensate the missing Russian exports. We show that the lower Dutch production path will not aggravate the disruption effects in case Russia decided not to export to Europe any more. In particular, we do not find that missing Dutch supplies would shift the supply risk to the West of Europe. Indeed, the diversified import portfolio in Western Europe can also compensate for the additional missing Dutch supplies. In this situation, the share of LNG would increase considerably.

Our analysis relies on the Global Gas Model which is a world-wide model of natural gas supplies and trade. Hence, the potential competition for LNG imports with Asia is taken into account, just as the potential future LNG exports from North America. We find the latter to become important with significant amounts (almost 30 bcm) towards 2030 if both Russia and the Netherlands disrupt or reduce their supplies. The additional LNG demand in Europe is small enough, however, not to have a strong price increasing effect on the global market.

However, there remains uncertainty on the future capacities of some of the compensating suppliers which we cannot address with the deterministic model setup. A stochastic model such as presented by Egging (2013) could better represent such uncertainties; however, the number of scenarios must be limited for a large-scale model to ensure solving. One important supplier with uncertain future production paths is Norway (Söderberg et al., 2009) – which is geopolitically highly relevant for the European Union given that it is the only remaining European supplier. Moreover, there is increasing geopolitical uncertainty on the supply relations with North Africa where fragile governments may not be able to guarantee the security of production and transportation infrastructure as witnessed by assaults on oil and gas infrastructure in Algeria and Libya since the Arab Spring 2011. Furthermore, while we find an increasing role for imports from the Caspian region, it remains yet to be proven that the geological potential can effectively be put into production capacities and that transport routes along the Southern Corridor can safely be built, despite Turkey closing ranks with its new Russian ally.

One last caveat to our modeling exercise needs to be mentioned: we do not represent the distinction between H-gas and L-gas that is important in the context of Dutch natural gas. We take into account the different heating values of both gas qualities. However, we abstract from the fact that the Dutch production and transportation system are primarily designed for L-gas. Keeping this system – as is the current government plan – will require additional conversion capacities to convert imported H-gas from the rest of the world into L-gas. Vice versa, traditional importers of Dutch gas in Germany, France, and Belgium have started converting their L-gas networks to H-gas networks. While the conversion cannot be done spontaneously and requires some time of planning and execution, its costs are manageable, both in size and impact on the transmission system operators that can recover them from regulated tariffs.

Hence, the network conversion is likely to be carried out smoothly – just as the transition to alternative suppliers to supplement the falling Dutch supplies is likely to be.

Acknowledgements

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Appendix

Table 2: List of countries and regions in the Global Gas Model

European Union (EU)		**North America (NAM)**		**Caspian Region (CAS)**	
AUT	Austria	CAN	Canada	AZE	Azerbaijan
BALT	Baltics	MEX	Mexico	KAZ	Kazakhstan
BEL	Belgium	USA	USA	RUS	Russia
BGR	Bulgaria			TKM	Turkmenistan
HRV	Croatia	**South America (SAM)**		UZB	Uzbekistan
CYP	Cyprus	ARG	Argentina		
CZE	Czech Republic	BOL	Bolivia	**Middle East (MEA)**	
DNK	Denmark	BRA	Brazil	IRN	Iran
FIN	Finland	CHL	Chile	IRQ	Iraq
FRA	France	COL	Colombia	KUW	Kuwait
GER	Germany	PER	Peru	OMN	Oman
GRC	Greece	TTO	Trinidad & Tobago	QAT	Qatar
HUN	Hungary	VEN	Venezuela	SAU	Saudi Arabia
IRE	Ireland			UAE	United Arab Emirates
ITA	Italy	**Asia-Pacific (ASP)**		YEM	Yemen
NLD	Netherlands	AUS	Australia		
POL	Poland	BGD	Bangladesh	**Africa (AFR)**	
PRT	Portugal	BRN	Brunei Darussalam	ALG	Algeria
ROM	Romania	CHN	China	ANG	Angola
SVK	Slovak Republic	IND	India	EGY	Egypt
ESP	Spain	IDN	Indonesia	EQN	Equatorial Guinea
SVN	Slovenia	JPN	Japan	LYB	Libya
SWE	Sweden	KOR	Korea	MOZ	Mozambique
UK	United Kingdom	MYS	Malaysia	NGA	Nigeria
		MMR	Myanmar	ZAF	South Africa
Rest of Europe (ROE)		PAK	Pakistan	TUN	Tunisia
BLR	Belarus	PNG	Papua New Guinea		
NOR	Norway	SGP	Singapore		
SRB	Serbia	TWN	Taiwan		
CHE	Switzerland	THA	Thailand		
TUR	Turkey	VNM	Vietnam		
UKR	Ukraine				

Table 3: Dutch production capacities for all model periods (in bcm)

	2015	2020	2025	2030	2035	2040	2045	2050
Base Case	69	59	49	44	45	39	39	37
Scenarios	60	55	42	26	17	12	8	5