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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 a Russian export disruption. Lately, however, the Netherlands have suffered from a series of earthquakes that are related to the natural gas production in the major Groningen field. By consequence, natural gas production rates – that are politically mandated in the Netherlands – have been substantially reduced, by almost 45 percent in 2015 compared to 2013-levels. We implement this reduced production path for the next decades in the Global Gas Model and analyse the geopolitical impacts. We find that the diversification of European natural gas imports allows spreading the replacement of Dutch natural 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. 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, Netherlands, equilibrium modelling

JEL codes: C69, L71, Q34

Highlights:

- We analyse the impact of reduced natural gas supply from the Netherlands (Groningen).
- Lower Dutch natural gas supplies do not cause severe consumption or price changes in Europe.
- Diverse pipeline and LNG imports from various countries replace Dutch gas.
- Even with less Dutch and no Russian natural gas Western countries' gas supply stays secure.

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1. Introduction

Since 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. However, several analyses show that European supplies are sufficiently diversified to sustain a short- and long-run disruption by Europe’s major supplier (Richter and Holz 2015, Hecking et al. 2014, ENTSO-G 2014a). One important part of the European supply portfolio – that can also help to balance a sudden disruption of Russian natural gas supply – is the indigenous natural gas production in the Netherlands. In 2013, total Dutch natural gas production accounted for almost 20 percent of total EU consumption (IEA, 2015), reaching 86 billion cubic meters (bcm), of which 67 bcm were exported to other EU countries (IEA, 2014a).

More specifically, it is the Groningen field that is of pivotal importance for the Dutch natural gas production. This largest of all fields in the Netherlands accounts for around 60 percent of total Dutch natural gas production and is further used to balance seasonal fluctuations (IEA 2014b). As much natural gas as possible has been extracted from the small fields to conserve the reserves in the Groningen field to, on the one hand, preserve the status as a swing supplier and, on the other hand, extend the number of years where the Netherlands remain a net-exporter (Schipperus and Mulder, 2015). Since 2013, however, an unprecedented series of earthquakes has rattled the country’s Northeastern provinces. This has imposed costs on house owners and gas extraction companies, while, additionally, raising concerns about soil subsidence and further earthquakes (cf. Koster and van Ommeren, 2015). As the seismic activity is related to the natural gas extraction in the Groningen field, there has been increasing public opposition to the resource extraction in the Netherlands. In consequence, the Dutch Minister of Economics lowered the production ceilings for Groningen natural gas such that no more than 70 bcm in 2014, and 60 bcm in 2015 respectively, were produced in the Netherlands in total (Gasunie, 2015; Ministry of Economic Affairs, 2015a). The expected pathway of even lower natural gas production in the coming decades constrains the Dutch capacity to deliver substantial amounts of natural gas to the European market.

The contribution of this paper is twofold. Firstly, we provide a concise overview of the governance of natural gas production and trade in the Netherlands. We thereby explain what decision process has led to the altered production cap for the Groningen field. Secondly, we analyse the impact that reduced Dutch production capacities have on the European natural gas market. To this end, we use numerical modelling and conduct a scenario analysis with the Global Gas Model (GGM; Egging, 2013). This equilibrium model of the global natural gas market allows us to analyse production patterns, trade flows and infrastructure expansions. Relative to the GGM *Base Case*, we investigate the global natural gas market in reaction to reduced Dutch production where we focus on European consumers. Moreover, to take account of the geopolitical risk posed by Europe’s main natural gas supplier Russia, we further model an accelerated decline in Dutch production levels jointly with a long-term disruption of Russian natural gas exports to Europe.

Our results show that Dutch natural gas can be replaced by a diversification of European natural gas imports, using many alternative suppliers, including diverse pipeline and LNG routes. There will be hardly any price or demand reduction effect – neither on average nor for neighbouring

countries that currently strongly rely on Dutch natural gas. Similarly, even in the case of Russia failing to supply Europe, the additional impact of the lower Dutch production is moderate.

Dutch natural gas production was already scheduled to decline prior to the current earthquakes that shake the Dutch society.¹ The Groningen reserves are limited, as are the reserves of the remaining small fields. Moreover, the densely populated country is unlikely to pursue shale gas production. Nevertheless, the unexpected tightening of the production cap in the wake of current earthquakes reduces short-term production capacities pronouncedly, which could pose substantial supply pressure on the European natural gas market. Our analysis shows, however, that long-run results diverge less from the *Base Case* 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 in detail the Dutch natural gas market and the decision process that led to the production cap for the Groningen field. In Section 3, the GGM and its underlying dataset are presented, and scenario definitions are laid out. Section 4 discusses our main results. Section 5 concludes.

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

Natural gas production in the Netherlands started in the 1960s. The three main actors in the gas market are the Dutch central state, Royal Dutch Shell and 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 natural gas sales have been significant both for the state and the private parties. In 2013, 70,000 people were employed in the Dutch natural gas sector and the central government gained revenues of 13 billion euros. This corresponds to 4.5 percent of total government revenues (IEA, 2014b).

In the following, we focus on the organisation of the production from the Groningen field. The Groningen field is the largest deposit of natural gas in the Netherlands and the main source for uncertainty of the Dutch natural gas production in the years to come.

2.1. Dutch regulation and the Groningen cap

The Ministry of Economic Affairs is the most important player for the regulation of the Groningen field, as it exclusively grants licences to explore and extract raw minerals or geothermal heat in the Netherlands.² In addition, the state-owned company EBN (*Energie Beheer Nederland* – Energy Management Netherlands) takes a 40 percent share in all gas and oil projects and is an instrument for the Dutch state to ensure the 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

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

² Article 6 of the Mining Act of the Netherlands (Mijnbouwwet).

<http://www.nlog.nl/resources/Legislation/Engelse%20vertaling%20Mijnbouwwet1.pdf>, accessed March 15, 2016.

multi-year period (425 bcm maximum production between 2006 and 2015, and 425 bcm maximum production between 2011 and 2020; IEA, 2014b).

Decisive for the natural gas extraction are, additionally, Shell and ExxonMobil, which together form the *Nederlandse Aardolie Maatschappij* (Netherlands Petroleum Partnership, NAM). Together, NAM and EBN form the *Maatschap Groningen* (Partnership Groningen), which manages the production of Groningen gas. While NAM holds 60 percent of the shares and EBN 40 percent, both decide with equal voting shares. The Groningen gas is extracted on account of the *Maatschap*, but NAM is the operator of the Groningen gas field and GasTerra is responsible for sales. GasTerra is owned by the state (10 percent), EBN (40 percent), Shell (25 percent) and ExxonMobil (25 percent). Long-term 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* (regarding production), as well as the strategy for GasTerra (regarding sales). The Minister of Economic Affairs makes the final decision on whether to approve the production plan by NAM and is, furthermore, authorized to intervene in case of safety concerns.

Crucial for the final production permission is also the State Supervision of Mines (SSM), which assesses and advises on the effects of mining on the environment and on subsidence. In this role, it advises the Ministry of Economic Affairs on its decisions regarding licensing and approval of production plans. SSM's advice in 2013 to reduce gas production from the Groningen field as quickly and reasonably as possible has been the trigger for the Economic Minister to reduce the Groningen production plan in 2014 and further decrease it to 30 bcm in 2015.³ This represents a production rate that is 45 percent below 2013 levels (54 bcm; Ministry of Economic Affairs, 2015a).

The crucial influence that the central government has on the natural gas output of the Netherlands has become a key political issue. With all current opposition parties being very critical about natural gas production, the parliamentary elections in early 2017 will have an impact on the future natural gas extraction in the country.

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 (Onderzoeksraad voor Veiligheid, 2015), there are already first signs that the Ministry of Economic Affairs increases 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 (Ministry of Economic Affairs, 2015b).

Giving municipalities a stronger say in natural gas production will also have a strong impact on potential shale gas extraction in the Netherlands. The discussion about shale gas is highly controversial: One camp sees the opportunity of shale gas as a compensation for the declining

³ In case of a cold winter a total production from the Groningen field of 33 bcm is needed to guarantee the security of supply and meet domestic demand and long-term contracts with foreign parties. The buffer of 3 bcm will only be used in case of necessity for security of supply (Ministry of Economic Affairs, 2015a). To account for this option, the maximum capacity of the Groningen field is set to 33 instead of 30 bcm in the modeling exercise (see below).

conventional production, while the other camp is referring to major risks related to the unconventional natural gas extraction for people and the environment. 226 out of 393 municipalities declared themselves as “shale gas free” and suspended formerly planned test drillings until further notice.⁴ The Ministry of Economic Affairs ruled out commercial shale gas production in the Netherlands until 2020.⁵ In this context, shale gas extraction also appears unlikely after 2020, due to strong public and municipal opposition.

2.2. Dutch natural gas production and the role of L-gas

Most natural gas produced in the Netherlands is so-called L-gas (“low-calorific gas”). In contrast, all other large international natural gas suppliers produce so-called H-gas (“high-calorific gas”).⁶ Groningen gas, also called G-gas in the Netherlands, is a variant of L-gas. L-gas consists of lower proportions of higher hydrocarbons and contains therefore less energy per volume than H-gas. Notably, 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 has the statutory duty to convert H-gas to L-gas. With lower future production of Groningen, there will be an increased need for quality conversion facilities from H- to L-gas, to 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 facilities are limited in capacity and subject to costly investments and operations. Gasunie reports that it can cost up to tens of millions of euros per year of additional operational 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 a new conversion plant opens in 2019. This plant increases the total capacity to 20-29 bcm. The declining L-gas production in the Groningen field therefore does not only impose higher costs for conversion facilities, but also restricts the amount of imported natural gas that can compensate for the reduced output.

Notably, 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.⁷ They plan to use only H-gas by 2030 at the latest. In the following modelling exercise

⁴ Schaliegasvrij, Overweldigende meerderheid voor motie tegen schaliegas op VNG jaarcongres (2015), accessed July 1, 2015, <https://www.schaliegasvrij.nl/2015/06/03/overweldigende-meerderheid-voor-motie-tegen-schaliegas-opvng-jaarcongres/>

⁵ Y. Schavemaker, Shale Gas in the Netherlands (TNO, 2015), accessed October 23, 2015, <http://www.shale-gas-information-platform.org/areas/the-debate/shale-gas-in-the-netherlands.html>

⁶ The Wobbe index is a measure of gases that combines heating value and specific gravity (density). A higher value of the Wobbe index corresponds to a type of natural gas of higher energy content. L-gas has a Wobbe index lower than 46.5 MJ/m³, whereas H-gas has a Wobbe index above this threshold. 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 Groningen-gas is 43,8 MJ/m³ (Source: Ministerie van Economische Zaken Directie Energiemarkt (2013): Groningengas op de Noordwest-Europese Gasmarkt - Samenvattende rapportage bij de onderzoeken 7, 8 en 9). This must be compared to a Wobbe index of Norwegian gas of 52-53 MJ/m³, of Russian gas with 52-54 MJ/m³, and of LNG imports to the Netherlands with 53-55 MJ/m³ (Gasunie, 2013).

⁷ 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”;

we abstract from the L-gas and H-gas distinction and use standard calorific value equivalents.⁸ Kuper and Mulder (2016) 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 1). In general, one can observe a rising trend in EU imports from the Netherlands in the last years. Germany is the biggest importer, with Belgium, France and the United Kingdom following. While the United Kingdom has rapidly gained importance since 2007, Italy's shares of Dutch imports have declined.

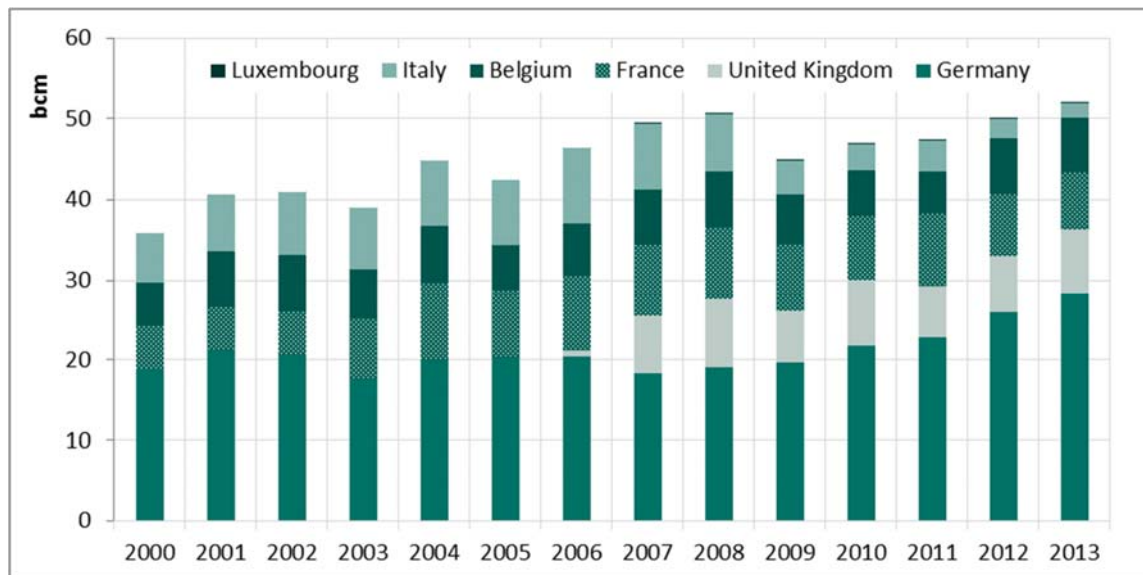


Figure 1: Imports of EU countries from the Netherlands

Source: Own illustration based on IEA (2015).

3. Modelling method

We use the Global Gas Model (GGM) to simulate and analyse future patterns of natural gas production, consumption, and trade (cf. Egging, 2013). We construct two scenarios incorporating the Dutch production decline as laid out in Section 2 and analyse their impact on European natural gas markets. While the first scenario represents the reduction in Dutch natural gas production only, the second scenario combines the lower natural gas production from the Netherlands with a lasting interruption of Russian gas supply to Europe.

in Belgium, Fluxys “Fluxys Indicative Investment Programme 2010-2019 for the Development of Natural Gas Infrastructure in Belgium”.

⁸ 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).

3.1. Model and data description

The GGM is a partial equilibrium model of the global natural gas sector. All important market entities along the entire value chain are represented, including producers, traders and transmission and storage system operators (TSO and SSO, respectively).⁹ These representative agents maximise profits while being restricted by operational and technical constraints. The GGM is a long-run investment model, which additionally includes seasonality in form of a high and low demand season.

Final natural gas consumption in each demand node is modelled by an aggregated inverse demand function which combines final consumption of all relevant sectors, i.e. industry, residential and commercial and the power sector.¹⁰ Specifically, 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 power sector we assume an elasticity of -0.75, -0.40 for the industrial sector, and -0.25 for residential and commercial demand. The price elasticity of the aggregate demand function then depends 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 of Golombek et al. (1995) by means of a logarithmic function that steeply increases for the last producible units before reaching the capacity constraint (see Huppmann, 2013, for a detailed discussion of the properties of a Golombek production function). The production capacities of each node are calculated by the reference production level and additional country-specific slack capacities (i.e. idle production capacities). This slack varies between 2 percent and 15 percent across countries, producers and periods. The slack allows producers to increase their production above reference levels in case of an exogenous shock, though at steeply rising marginal costs.

The transmission and storage systems are constrained by maximum capacities. The capacities of pipelines, LNG and storage facilities are determined by reference capacities based on the infrastructure already in place and projects that are currently under construction. One distinguishing feature of the model is that infrastructure can be expanded by endogenous investment decisions: the future streams of revenues from pipeline transit fees or storage rents are weighted against investment costs by the TSO, or the SSO respectively. In the model period 2010 no endogenous expansions are allowed. But starting 2015 for pipelines and 2020 for LNG facilities only endogenous infrastructure investments can increase capacities.

The oligopolistic market structure of the European natural gas sector is taken into account by allowing selected traders to exert market power. Apart from that, rational behaviour, full information and perfect foresight of all players is assumed. Institutional frictions, i.e. long-term

⁹ For the Dutch natural gas sector, as described in Section 2, we include NAM (the producer), GasTerra (the trader), as well as Gasunie (the pipeline operator).

¹⁰ The inverse demand function gives the willingness-to-pay of consumers for a given amount of natural gas. It is modelled as a downward-sloping curve.

contracts or oil-price linking, are not accounted for in the model. Hence, the results should be interpreted as equilibrium solutions after market adjustments have taken place.

The GGM dataset consists of 99 geographical nodes, representing 79 countries that cover 98 percent of the global natural gas consumption for the year 2010.¹¹ For each node, we collected data on current and projected reference consumption and production levels as well as reference prices, production capacities and costs. The data come from a broad range of public sources. Pipeline infrastructure capacities within and toward Europe are obtained from ENTSO-G (2013a, 2014),¹² while GIIGNL (2011-2014) provides data on worldwide LNG infrastructure and GIE (2011-2014) on storage capacities. Additional data on consumption and trade relations as well as costs are obtained from company reports, national statistical offices and IEA and EIA publications.

Figure 2 depicts the cross-border trade infrastructure (pipelines and LNG terminals) around the Netherlands. Total LNG regasification capacities in Western Europe amount to about 186 bcm in 2013, and no regasification capacities existed in Eastern Europe until 2014. However, planned LNG terminals and those under construction are exogenously included in the model for later periods, e.g. in Poland, Lithuania or Croatia.

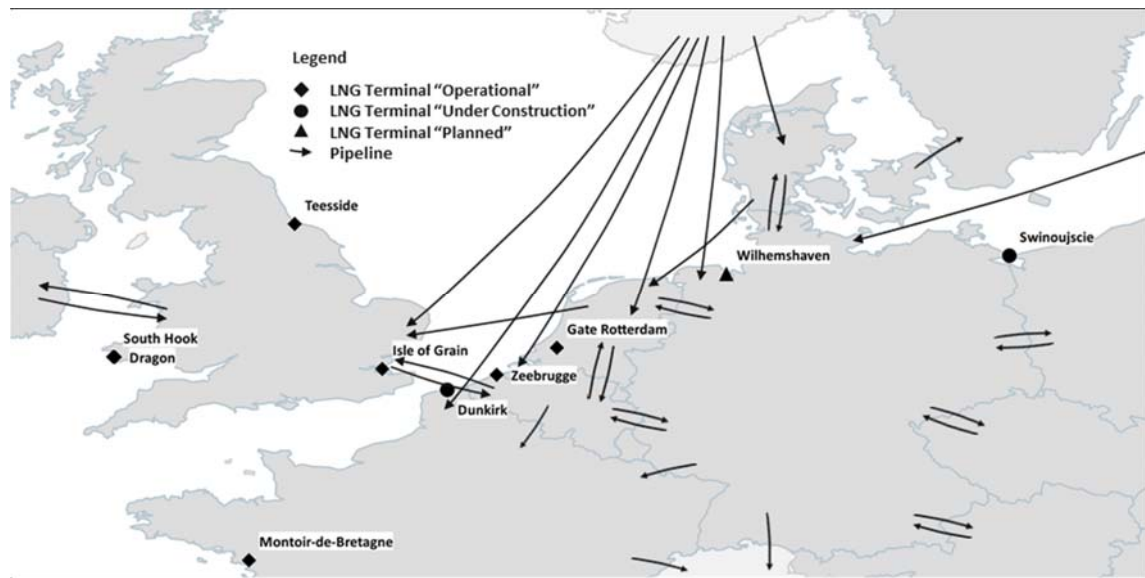


Figure 2: Northwestern European LNG and pipeline import infrastructure in GGM 2015

Source: Own illustration based on the GGM database relying on information from GIIGNL (2014) and ENTSO-G (2013a, 2014). The blank map (shape file) is taken from Eurostat.

¹¹ 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”). Other large countries like the USA, China, Russia, Canada, and India, are also split into several nodes. See Table A.1 in the Appendix for a complete list of included countries.

¹² ENTSO-G actually provides data on entry/exit capacities. These do not necessarily equal physical capacities but rather represent “capacity simulations performed by the respective TSOs” (ENTSO-G, 2013b, p. 29). Nevertheless, as we lack alternative comprehensive data, we use the data of ENTSO-G to calculate initial capacities.

The GGM is formulated 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 give incentives for investments in the final periods.

3.2. Scenario definitions

We calibrate the GGM *Base Case* to projections of the *New Policies Scenario* (NPS) of the *World Energy Outlook* 2013 (IEA, 2013). Accordingly, reference production and consumption values from GGM are based on values from the NPS. This scenario accounts for moderate climate policy efforts. It implies a rise in global CO₂ emissions until 2035 by about 20 percent above 2011 levels, while the EU is assumed to reduce its CO₂ emissions by about 40 percent compared to 1990.¹³

For EU member states, production and consumption data are obtained from EC (2013). Consistency with the rest of the world is ensured by applying the corresponding country shares within the EU to the aggregate EU level as being forecasted by IEA (2013). The reference consumption for the EU28 (without Malta and Luxemburg) is given by 492 bcm in 2015.

Two different scenarios are set up to analyse the effects of a reduction in Dutch natural gas production. The first one, *NL_low*, represents the downward-regulated production capacities in the wake of a series of earthquakes in the Groningen region (as discussed in Section 2). The second one, *RUS_NL_low*, combines these reduced Dutch production capacities with a long-lasting disruption of all Russian natural gas supplies to Europe. We follow Richter and Holz (2015) for assumptions on the Russian disruption case. 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. For the sake of comparison, this scenario is replicated as *RUS_DISR* and serves as additional reference case for the *RUS_NL_low* scenario. *RUS_NL_low* combines the scenario assumptions of *RUS_DISR* and *NL_low*, to analyse joint effects. See Table 1 for concise scenario descriptions and scenario-specific assumptions.

¹³ The role of natural gas under ambitious global climate policies is not self-evident. See Holz et al. (2015) for a discussion on how future natural gas markets may develop.

Table 1: Scenario descriptions of GGM simulation runs

Scenario Name	Description	Specific Assumption
Base Case	Natural gas production, consumption and trade forecasts from the <i>New Policies Scenario</i> in IEA (2013).	
NL_low	Reduction of production in the Netherlands: The production capacities are lowered due to governmental restrictions.	<ul style="list-style-type: none"> NLD production capacities compared to <i>Base Case</i>: • 2015: -13 percent • 2020: -6 percent • 2025: -14 percent • 2030: -42 percent • 2035: -61 percent • 2040: -70 percent
RUS_DISR	<p>Long-lasting disruption of Gazprom infrastructure in Europe: The supply with Russian natural gas to all EU member states and other European countries is continuously disrupted from 2015 onwards. Additionally, all infrastructure that is majority-owned by Gazprom cannot be used. TSO and SSO can react to the long-lasting supply disruption by infrastructure expansions not earlier than 2015.</p> <p>Affected pipelines:</p> <ul style="list-style-type: none"> • Nord Stream • Brotherhood • Yamal Europe • Blue Stream • South Stream • OPAL <p>Reduced storage capacities in:</p> <ul style="list-style-type: none"> • Germany • Austria • Latvia • Serbia 	<ul style="list-style-type: none"> • Anticipation and unlimited investment as of 2015 • Zero capacity on pipelines: <ul style="list-style-type: none"> ◦ Russia – Germany ◦ Russia – Finland ◦ Russia – Baltic States ◦ Russia – Bulgaria ◦ Russia – Turkey ◦ Russia – Ukraine ◦ Belarus – Ukraine ◦ Belarus – Poland ◦ Belarus – Baltic States • Reduced capacity on pipeline: <ul style="list-style-type: none"> ◦ Germany – Czech Republic by 70 percent • Reduced storage capacities: <ul style="list-style-type: none"> ◦ in Germany by 20 percent ◦ in Austria by 35 percent ◦ in Baltic States by 100 percent ◦ in Serbia by 100 percent
RUS_NL_low	A combined low Dutch production with a long-lasting disruption of Gazprom infrastructure in Europe.	<ul style="list-style-type: none"> • NLD production capacities as in <i>NL_low</i> • Capacity and storage restrictions as in <i>RUS_DISR</i>

Both scenarios, *NL_low* and *RUS_NL_low*, rely on reduced Dutch production capacities implemented as follows. In line with the regulated capacity cuts for the Groningen field in 2015 (see Section 2), we assume the production to be no larger than 33 bcm until the model period 2020. As of 2025, we rely on the declining production forecast provided by Gasunie (2015). As for years after 2035, no data is available and we extrapolated production levels are until 2050 using the (negative) growth rates between the years 2030 and 2035. In contrast, we assume no changes relative to previous forecasts for the small fields. Jointly, the forecasts for Groningen and the small fields amount to the total Dutch production capacity used in the GGM. This declining path of Dutch production capacities is depicted in Figure 3 in comparison to the GGM *Base Case*, while Table A.2 in the Appendix provides the exact values. The difference to the Base Case is not uniform across periods and it is the largest in the last model period.

Additionally, assumptions on the Dutch slack production capacity had to be made. In 2015, the slack in both scenarios is set 2 percentage points lower than in the *Base Case*. This is based on information from the Dutch government that provides estimates about possible production reactions in case of supply emergencies. To represent the flexible potential of the Groningen field for additional short-term gas extraction in case of a security of supply threat, the total slack is

assumed to be 12 percent. All other model periods in the scenarios have the same slack as in the *Base Case*.

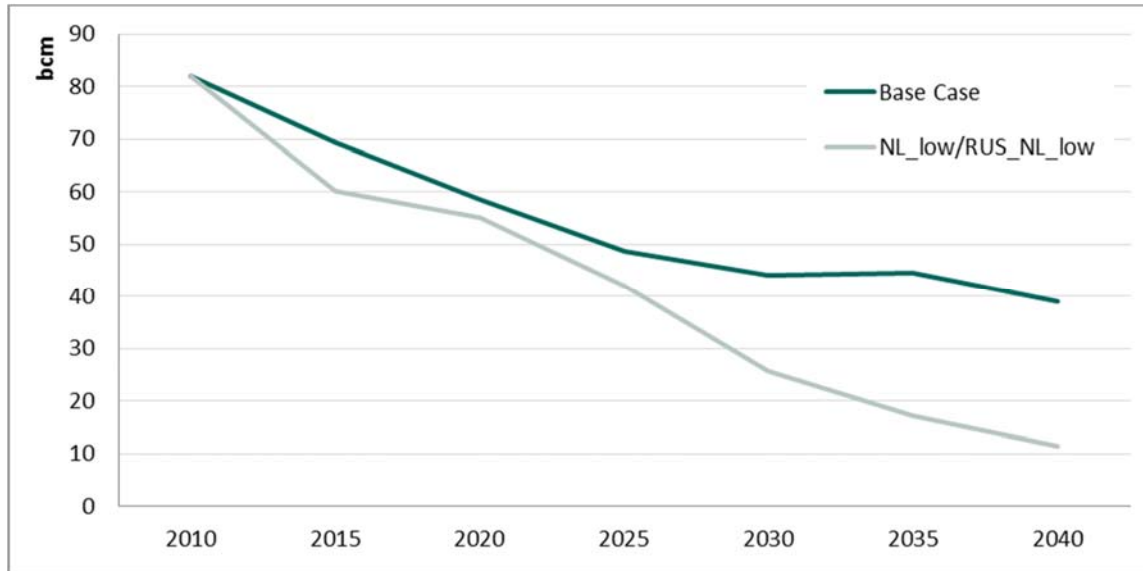


Figure 3: Comparison of Dutch production capacities in *Base Case* and scenario *NL_low* (in bcm)

We assume all deviations from the *Base Case*, i.e. both the reduction of Dutch natural gas production and the disruption of Russian supplies, to materialise as of 2015. Hence, for the year 2010 all decision variables are fixed at *Base Case* levels and no future changes of the European natural gas market are anticipated by any model agent.

4. Results and discussion

This section presents our modelling results and discusses the impacts of reduced Dutch natural gas production on the European natural gas market. To this end, we first compare the results under the *NL_low* scenario to the GGM *Base Case*. We then present results from the *RUS_NL_low* scenario that we discuss with a particular focus on the comparison with the *RUS_DISR* scenario.

4.1. Lower Dutch production in the European natural gas market

Figure 4 presents the impacts of Dutch production reductions on consumption and imports of natural gas in Europe. The strongest consequences can be seen in 2040 where the Dutch 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 remainder can be compensated by imports from other suppliers. The overall demand reduction is spread over many states. The UK, Germany as main importers of Dutch gas and the Netherlands itself experience the highest demand reductions but no country sees its consumption fall by more than 1 bcm per year.

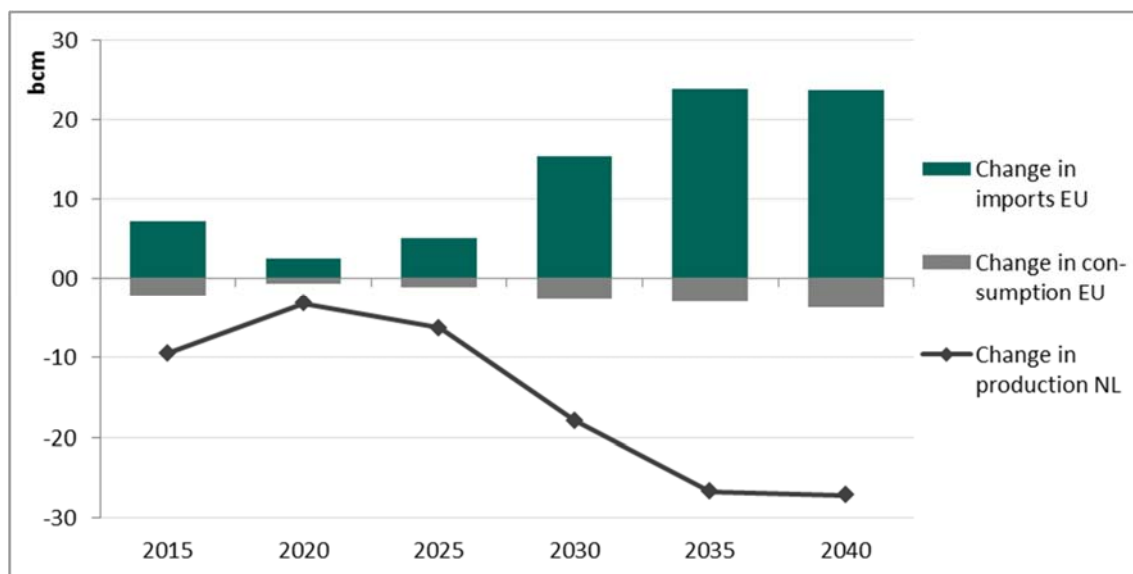


Figure 4: Impacts of lower Dutch production on EU imports and consumption (in bcm, changes in *NL_low* compared to *Base Case*)

Consumption reductions are only minor because the EU manages to augment and diversify their imports even further, see Figure 5. In 2015, especially African states gain importance for the European market, delivering 4 bcm out of total 8 bcm additional imports. The additional African supplies – mainly from Algeria, Nigeria and Egypt – rise over the modelled period and total almost 6 bcm in 2040. Natural gas from Qatar also contributes from 2015 onwards to compensate for the missing Dutch gas, beginning with 0.5 bcm in 2015 and growing up to almost 3 bcm in 2040. Another important supplier from 2030 onwards are the USA, delivering almost 9 bcm to the European Union in 2040. A broad range of other suppliers from Russia, over Norway and Turkey, to Brazil and Venezuela provide the rest of the missing natural gas supplies.

The highest absolute import volumes in 2040 come from Africa (171 bcm), followed by Russia (111 bcm) and the Rest of Europe (96 bcm) (i.e. Norway). The additional imports in the *NL_low* scenario compared to the *Base Case* in 2040 represent a 25 percent increase from North America, followed by South America with 17 percent and the Middle East with 10 percent 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 facilitated by the oligopolistic market structure which characterizes the European natural gas market where the high prices are attractive for a large array of suppliers (see, e.g., Egging et al. 2008, Holz et al. 2008).

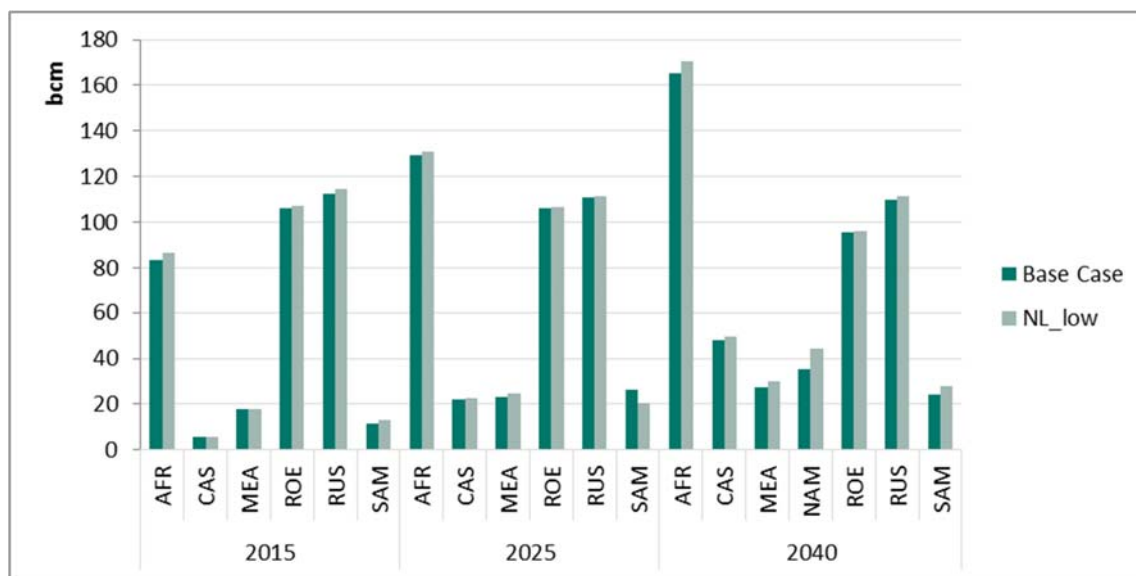


Figure 5: EU natural gas imports from various regions (in bcm)

The diversification leads Europe to continuously increase both its pipeline and its LNG imports, while the indigenous production decreases (see Figure 6). 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*). The share of LNG in total European imports rises from 24 percent in 2010 to 28 percent in 2040 (compared to 26 percent in the *Base Case*).

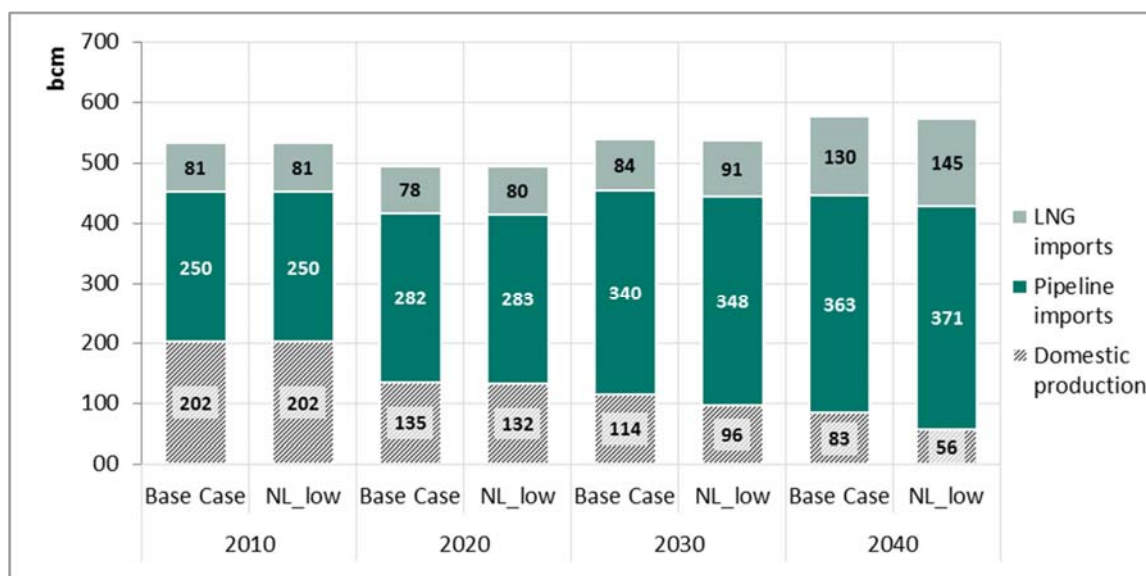


Figure 6: Supply structure in EU28 in Base Case and *NL_low* scenario over time (in bcm/year)

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 percent. 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 an importer of Dutch natural gas. No country experiences a price increase by more than 1.3 percent. The highest increase occurs in those countries that consume Dutch natural gas, i.e. Belgium, Germany, France, the UK, Italy and the Netherlands itself. The effects are moderate because of the shared compensation across European countries through market forces.

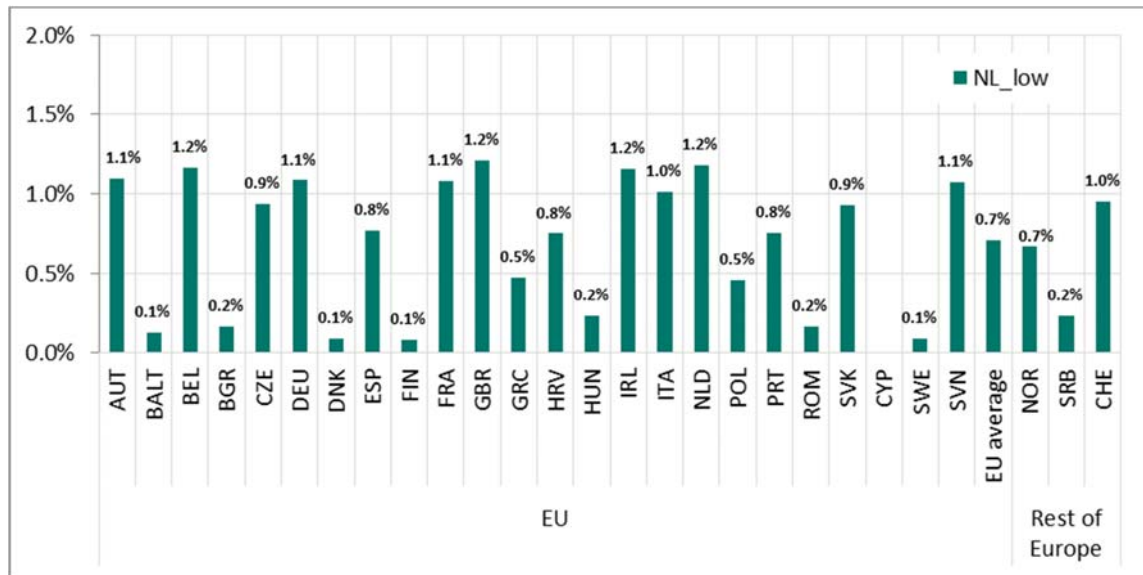


Figure 7: Price changes in Europe due to lower Dutch production (in percentages relative to Base Case, in 2015)

Accordingly, the impact of reduced Dutch natural gas production alone seems manageable. In the following we combine the lower Dutch production with a disruption of Russian natural gas supply to Europe, to analyse whether the European gas supply can still be secured when two of the main suppliers stop delivering natural gas.

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

We discuss the results of the *RUS_NL_low* scenario focussing 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. As shown by Richer and Holz (2015), 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. By contrast, the West could compensate the missing Russian supply by its diversified supply sources and transport routes. The diversification of imports to Western European countries relies on supplies from Africa, America, Norway and also importantly the Netherlands. Therefore, it is likely that the limited Dutch supplies would have a stronger effect on the Western European countries, spreading the negative effects from East to West. However, the model results presented in the following prove this hypothesis wrong, showing that the Dutch supply reductions can largely be compensated also in case of a Russian supply stop.

Figure 8 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*.¹⁴ Over time, the differences between scenarios diminish because of lower total production capacities in the Netherlands and, therefore, a lower leeway.

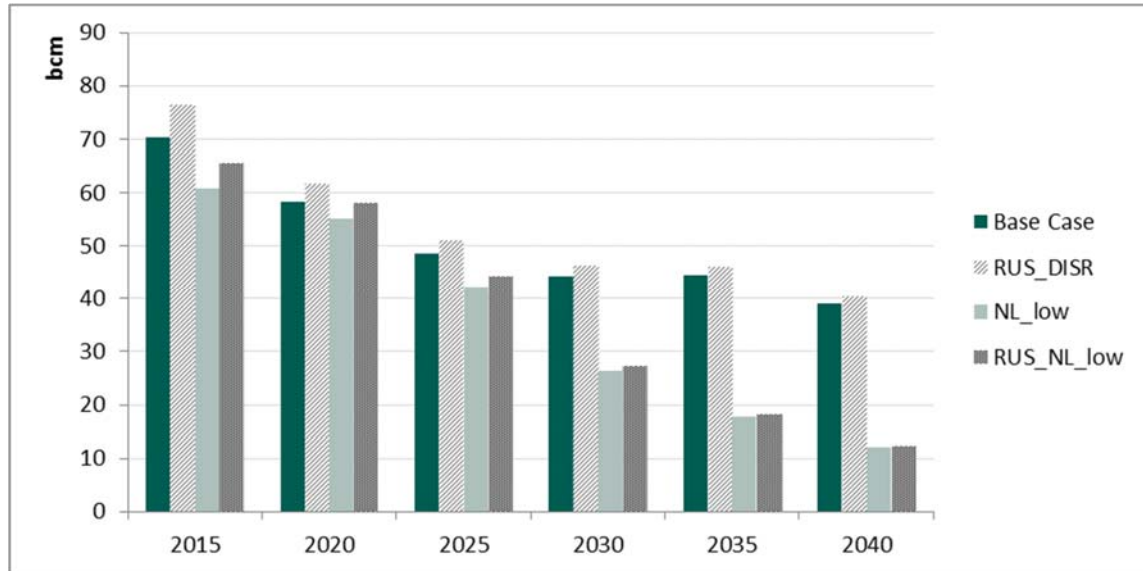


Figure 8: Domestic gas production in the Netherlands for all scenarios (in bcm/year)

The additional impact in Europe of a production cut in the Netherlands is rather small – despite a high reduction in Dutch gas production. Almost all negative effects can be compensated by higher imports from other countries and lead only to a small reduction of natural gas consumption in EU member states (by 4 bcm in 2040). Additional imports come, as in *NL_low*, from Africa (+3 bcm in 2015) and Qatar (+2 bcm). However, in contrast, the main new supplier is now from 2015 onwards the USA, with already 10 bcm in 2015 (0 bcm in *RUS_DISR*), rising to 76 bcm in 2040. In absolute terms Africa remains the major supplier with 205 bcm in 2040, followed by Norway (91 bcm), USA (76 bcm), Qatar (52 bcm) and the Caspian region (42 bcm). The remaining natural gas supplies come mainly from Brazil (16 bcm) and Venezuela (12 bcm).

¹⁴ The rising market prices due to natural gas scarcity in the Gazprom scenarios allow Dutch gas companies to extract more gas at higher costs.

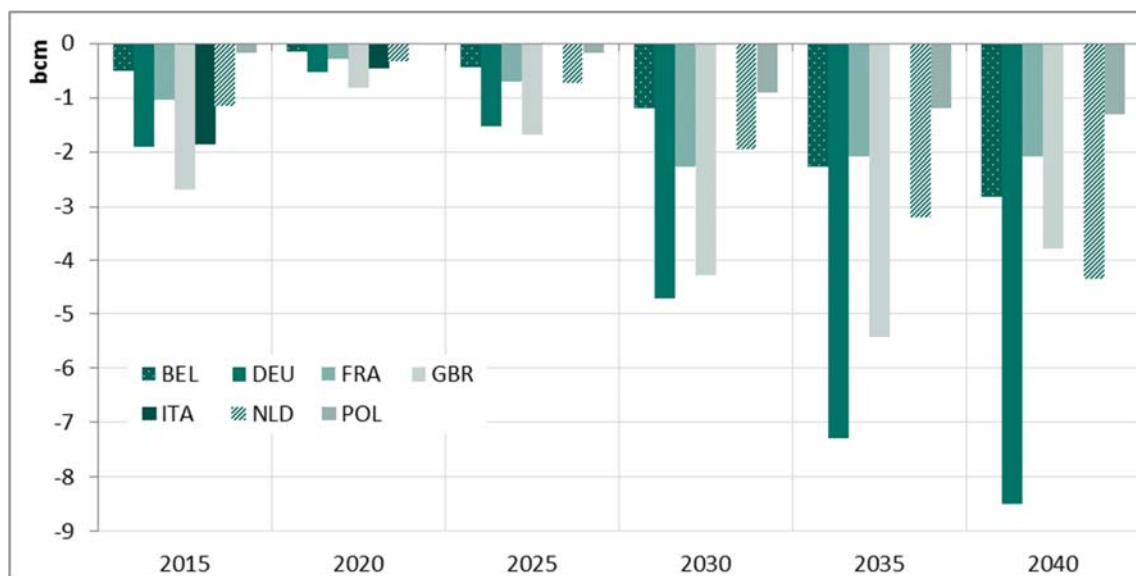


Figure 9: Change of Dutch gas supplies: *RUS_NL_low* vs. *RUS_DISR* (in bcm/year)

Note: Countries with changes lower than 1 bcm are not included.

The direct effect of less supply of Dutch natural gas is mainly borne by the Netherlands and its neighbouring countries (Figure 9). 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 merely a friction compared to the implications on Eastern European countries in case of a Russian gas disruption.

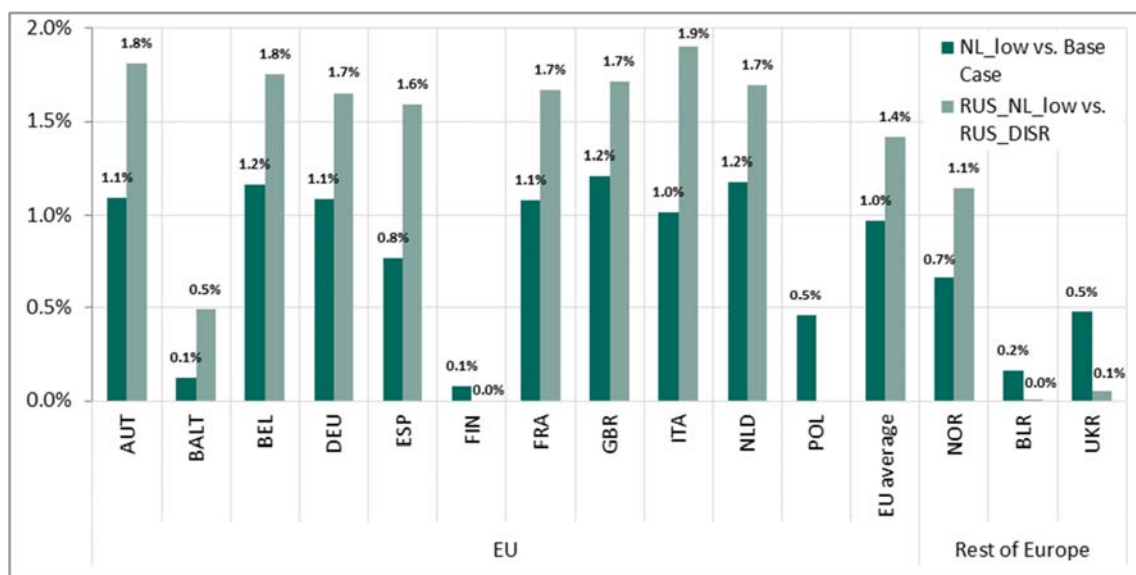


Figure 10: Deviation of prices in low-Dutch production scenarios compared to the respective Base Cases (in percentages, in 2015)

The additional effect on prices of low Dutch production is small, but the increase is slightly higher in the combined case with a disruption of Russian exports (Figure 10). 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 percent on EU average and for no EU country is the price increase higher than 2 percent. 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 lower natural gas production in the Netherlands intensifies the price increase. Compared to the effect of the Russian disruption, however, the 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 effective opportunities to compensate negative impacts and spread them between neighbouring countries in Western Europe.

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 after 2015 (Figure 11). 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.

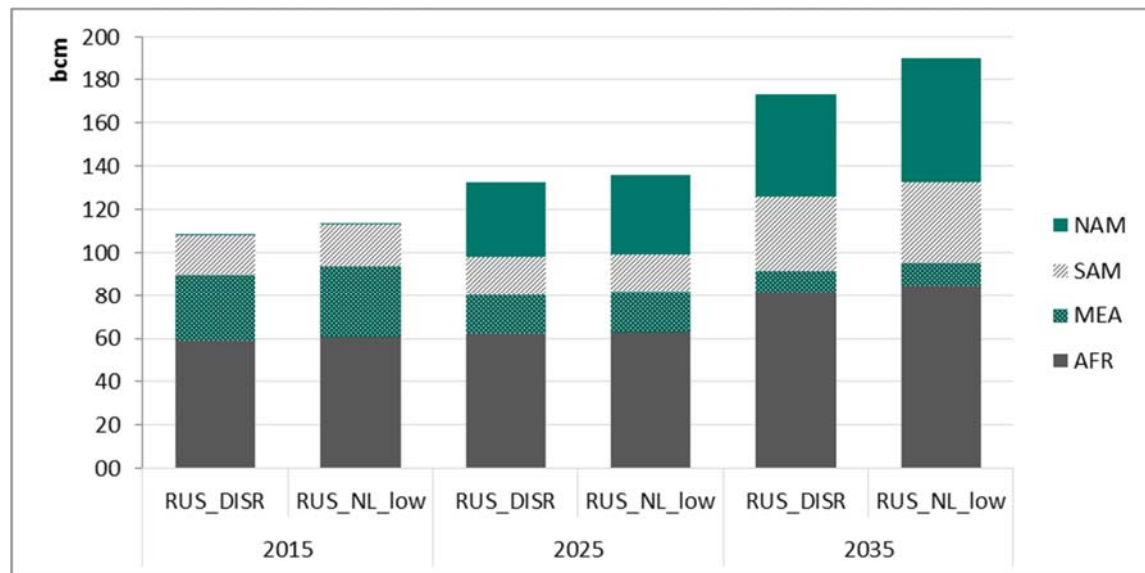


Figure 11: LNG imports to the EU28 over time (in bcm per year)

5. Conclusions and outlook

In the wake of a series of earthquakes related to natural gas extraction in the Groningen field, the maximum annual production rate has been set considerably lower by the Dutch Minister of Economic Affairs than the previous production plan had indicated. It is unlikely that this downward correction of the production cap will be revised for the years to come. However, current analyses of European natural gas supply security rely on previously foreseen relatively high Dutch natural gas production. With this paper, we make a first attempt to evaluate this new geopolitical situation of lower indigenous Dutch production capacities and investigate its potential impact on the European natural gas market. We argue that this is particularly important at a time of rising concern about the reliability of supplies from Russia – the most important natural gas exporter to Europe. The Netherlands are expected to play an important role in compensating missing Russian exports, especially in Western Europe, so that the low production cap could have severe consequences for the natural gas supply of the EU.

Contrary to our expectations, our findings suggest that the lower Dutch production path would not significantly aggravate the effects of a Russian export disruption. In particular, we do not find that missing Dutch supplies would shift the supply risk from the east to the west of Europe. Indeed, the diversified import portfolio in Western Europe can well compensate for missing Dutch production. In the situation of both Russian and Dutch supplies to Europe being reduced, the share of LNG would increase considerably, including LNG imports from North America with almost 30 bcm towards 2030. Likewise, in the case that only Dutch supplies are lowered, the European gas market can almost fully compensate the missing natural gas supplies, by further diversifying its imports, without substantial price hikes or demand reductions. For both scenarios, imports from Africa, the USA, Norway, Qatar and the Caspian region gain pivotal importance until 2040.

Our analysis relies on the GGM – a model of world-wide natural gas supplies and trade. While the model features a great level of detail both in representing the value chain of natural gas and in terms of global coverage, some qualifications of our results should not remain unmentioned.

While we take into account the different heating values of both gas qualities, we abstract from the fact that the Dutch production and transportation system primarily relies on L-gas. Keeping this system – as currently intended by the Dutch government – will require additional capacities to convert imported H-gas into L-gas. Vice versa, traditional importers of Dutch natural 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 planning, its costs are manageable, both in size and impact on the transmission system operators as they can be recovered from regulated tariffs. Hence, the network conversion is likely to be carried out smoothly – just as the transition to alternative suppliers to replace the falling Dutch supplies is likely to be.

However, there remains uncertainty on future production possibilities of some of the compensating suppliers. One important supplier with uncertain future production possibilities is Norway (Söderbergh et al., 2009) – which is geopolitically highly relevant for the EU given that it is the only remaining European supplier of size. 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 after the Arab Spring in 2011 (cf. Lochner and Dieckhöner, 2012). 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.

Finally, it remains to be seen what influence future climate policies will have on the role of natural gas in the European energy mix. The globally agreed objective to limit global warming at a maximum of 2°C effectively translates into a phase-out of fossil fuels. Accordingly, climate policy could lead to a rapidly declining consumption of natural gas. This alone would already attenuate the impact of supply shortages from the Netherlands. However, as natural gas is the least carbon-intensive fossil fuel per energy, it is often described as a bridge technology on the way to a decarbonized future, with consumption potentially increasing to a mid-term peak. In this case, possible supply disruptions pose a risk on European natural gas markets and deserve further attention.

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Appendix

Table A.1: 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	Middle East (MEA)	
CZE	Czech Republic	BOL	Bolivia	IRN	Iran
DNK	Denmark	BRA	Brazil	IRQ	Iraq
FIN	Finland	CHL	Chile	KUW	Kuwait
FRA	France	COL	Colombia	OMN	Oman
GER	Germany	PER	Peru	QAT	Qatar
GRC	Greece	TTO	Trinidad & Tobago	SAU	Saudi Arabia
HUN	Hungary	VEN	Venezuela	UAE	United Arab Emirates
IRE	Ireland	Asia-Pacific (ASP)		YEM	Yemen
ITA	Italy	AUS	Australia	Africa (AFR)	
NLD	Netherlands	BGD	Bangladesh	ALG	Algeria
POL	Poland	BRN	Brunei Darussalam	ANG	Angola
PRT	Portugal	CHN	China	EGY	Egypt
ROM	Romania	IND	India	EQN	Equatorial Guinea
SVK	Slovak Republic	IDN	Indonesia	LYB	Libya
ESP	Spain	JPN	Japan	MOZ	Mozambique
SVN	Slovenia	KOR	Korea	NGA	Nigeria
SWE	Sweden	MYS	Malaysia	ZAF	South Africa
UK	United Kingdom	MMR	Myanmar	TUN	Tunisia
Rest of Europe (ROE)		PAK	Pakistan		
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 A.2: Dutch production capacities for all model periods (in bcm)

	2015	2020	2025	2030	2035	2040	2045	2050
<i>Base Case</i>	69	59	49	44	45	39	39	37
<i>NL_low; RUS_NL_low</i>	60	55	42	26	17	12	8	5