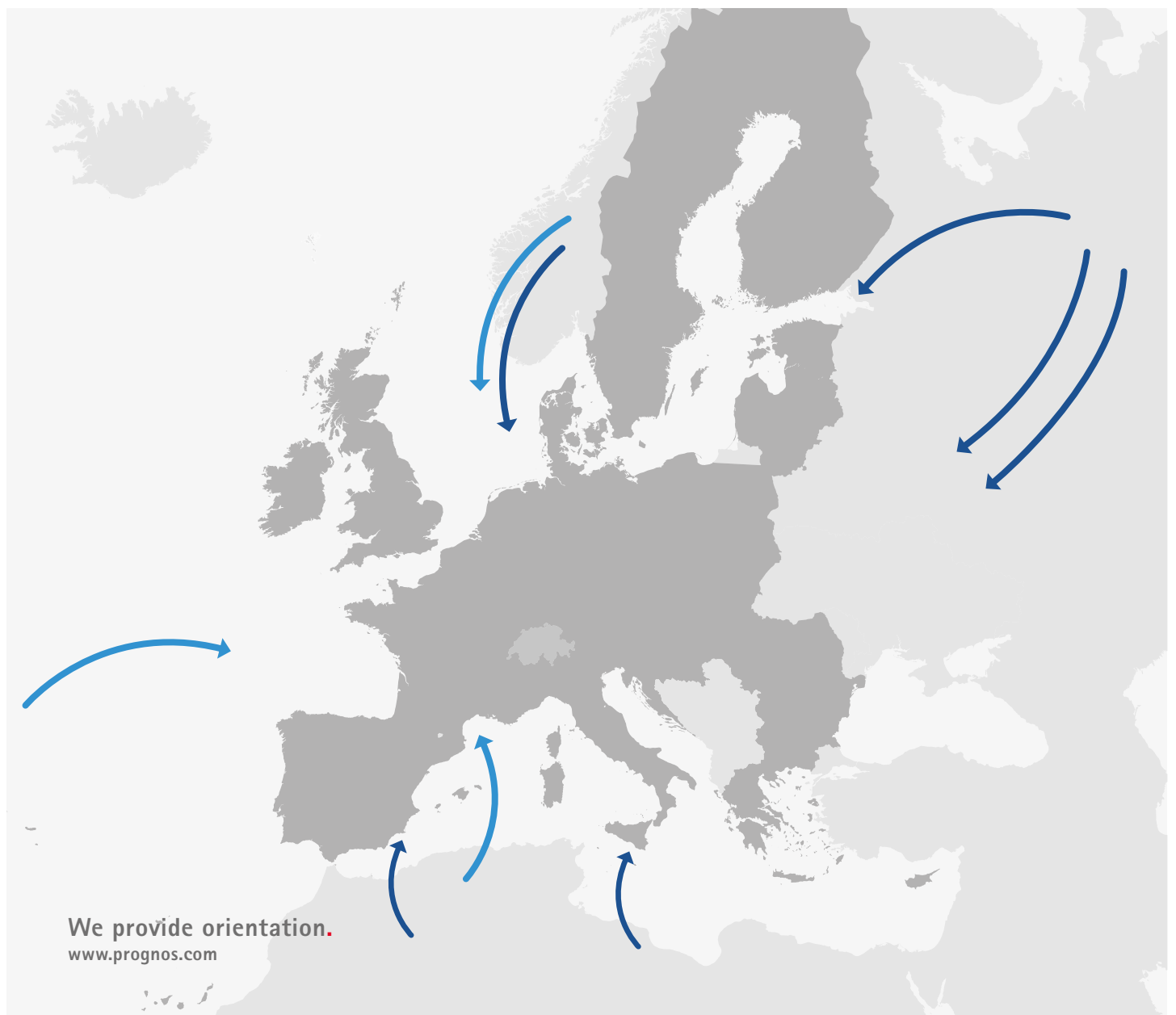


Final Report

Current Status and Perspectives of the European Gas Balance

Analysis of EU 28 and Switzerland



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Preliminary remarks

In June 2016, Prognos AG was commissioned by **Nord Stream 2 AG** to prepare a gas balance for EU 28 and Switzerland until the year 2050. The background for this project is a planned new natural gas pipeline ("Nord Stream 2") between Russia and Germany, with a total annual transport capacity of 55 billion standard cubic meter (Sm³ at 20 degrees Celsius and 10.5 kWh/m³).

This study uses the **terms gas and natural gas** in general as synonyms. In case that the term natural gas is used, it refers explicitly to gas that is extracted from the ground, and not to biogas or similar.

The present analysis is based on the **EU Reference Scenario 2016** (short: EU Ref 2016) (EC, 2016b) and other studies, regarding the energy demand of Switzerland, for instance. EU Ref 2016 was prepared on behalf of the European Commission and constitutes a reference document for the European energy supply. The study was published in July 2016. After EU Ref 2016 went to press, three EU countries have published new forecasts and decisions regarding the extraction of natural gas that significantly affect the European gas balance. For this reason, EU Ref 2016 was modified using current extraction forecasts for these countries. When EU Ref 2016 was prepared, it was based on data prior to 2015. Data for 2015 was only partially available, which means that the figures in EU Ref 2016 are higher than those that Eurostat now provides for 2015.

The current study mainly discusses the situation for **EU 28** and **Switzerland**. However, in Chapter 4.4 we also include data on gas supplies from the West to **Ukraine** that affect the quantitative balance of the EU gas market. Chapter 2 provides additional methodological information.

1 Summary

In June 2016, Prognos AG was commissioned by Nord Stream 2 AG to prepare a gas balance for EU 28 and Switzerland until the year 2050. The **results** of the analysis are as follows:

- The **gas demand** has been decreasing during the last years of the analysed period. For the future, EU Ref 2016 predicts a stagnation of the gas demand. The importance of natural gas for power generation will increase, whereas the gas used in heating markets will decrease.
- The EU's **domestic gas production** has gone down substantially. And this decrease will continue. Already in 2025, the EU's internal gas production will be about 41 billion Sm³ lower than the extraction in 2015.
- The **gas import demand** of EU 28 and Switzerland excluding the volume that the West supplies to Ukraine will therefore increase from 340 billion Sm³ (2015) to 360 billion Sm³ in 2020. Until 2025, the demand is expected to increase by 41 billion Sm³ compared to 2015. After that, the import demand will remain unchanged, and from 2030 onwards, it will continue to increase.
- The fact that the supplying countries Algeria and Norway will supply less natural gas in the future, will result in an accordingly increased, additional demand from **other supplying regions**. In the short and medium term, mainly Russia and the LNG world market are supposed to supply this additional demand.
- In 2015, Russia and the LNG world market¹ supplied about 168 billion Sm³ natural gas to EU 28 and Switzerland. **The demand supplied by these sources** is expected **to increase by 32 billion Sm³ until 2020 and by 76 billion Sm³ until 2025** (cf. Figure 1).
- We also have to add the gas supplied by the West to **Ukraine**. In 2015, the EU supplied about 9 billion m³ and Russia about 7 billion m³ to Ukraine. Since November 2015, Ukraine has not received any natural gas deliveries from Russia via its Eastern border (SZ, 2015). Ukraine's gas import demand is expected to remain stable at 16 billion m³ and to be completely supplied by EU countries. This volume has to be added to the import demand during the analysed period.
- When calculating future values, the additional volume has not been **allocated** to LNG or Russian pipeline gas, respectively. We assume that the competition between LNG and Russian pipeline gas will determine the delivery shares.
- A **sensitivity analysis** discusses the opportunities and risks for the gas balance in case of deviations from the assumed reference development. Several risks already concern the period until the year 2025, whereas most of the opportunities are assumed to become effective only after 2025. In the short term, the risks are prevalent.

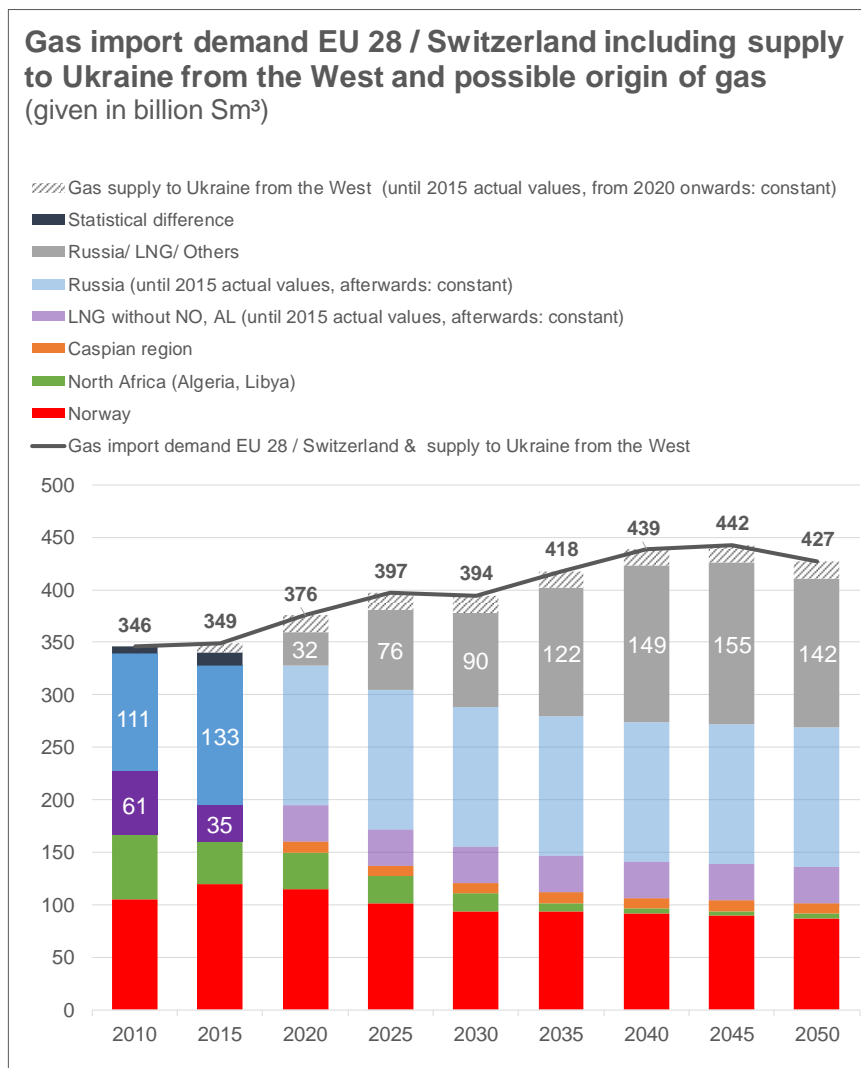
The largest **risk factor** is the transit through Ukraine, which amounted to 63 billion m³ in 2015, whereof 48 billion m³ to the EU. According to our estimations, there is a medium to high risk of the negotiations failing and a temporary disruption of the transit (cf. Chapter 6.3). Other risks with a medium probability are further possible

¹ LNG world market here without deliveries from Norway and Algeria.

reductions of the gas extraction in the Netherlands as well as reduced exports from Algeria and Libya.

Opportunities regarding the European gas balance result, among others, from a lower gas demand and new gas discoveries. The largest effect could be produced by the European Decarbonisation Pathway Initiative that was adopted in the wake of the Paris decisions. Using renewable energies and increasing energy efficiency, may result in a substantial medium- to long-term decrease of the gas import demand compared to the reference development. Prior to 2025 the probability of this opportunity is considered to be low, however after 2025/2030, the probability is assessed to be medium-high. However, the implementation of such an international decarbonisation strategy would require further wide-ranging (political) measures in order to restructure the energy system.

Figure 1: Gas import demand EU 28 and Switzerland and possible origin of the gas, 2010 to 2050



Source: Own presentation based on (EC, 2016b), (BP, 2016a), (NPD, 2016) (OIES, 2016a), (Prognos AG, 2012).

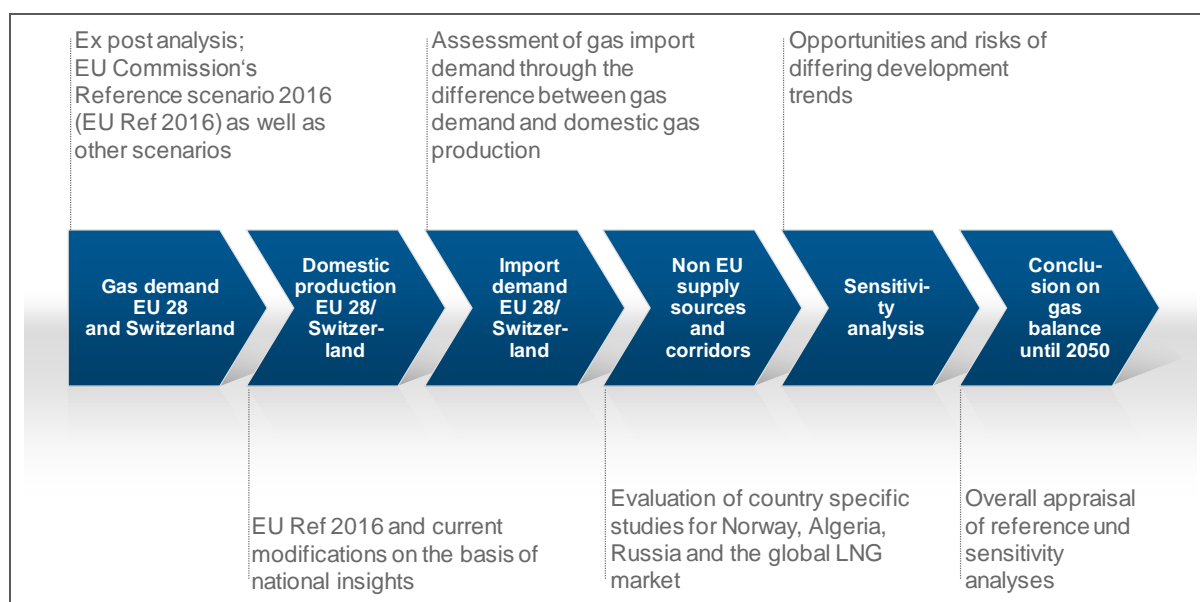
2 Background, task and methodology

In early June 2016, Prognos AG was **commissioned** by Nord Stream 2 AG to prepare a European gas balance until the year 2050. The main **question** to be answered is whether, and under what circumstances, the EU would have a demand of additional gas imports.

The **background** of this study is that Nord Stream 2 AG has the intention to build an additional natural gas connection (with two pipelines) from Russia to Germany with a total capacity of 55 billion Sm³ per year.

The analysis is mainly based on **published studies** of recognised authors and institutions (such as the European Commission and the IEA). The heart of the study is the EU Reference Scenario 2016 (short: EU Ref 2016), which was published by the European Commission in July 2016 (EC, 2016b) and (BFE, 2014) for Switzerland. In addition, current extraction forecasts for important gas extracting countries were included. Prognos' own assessments are mainly presented in the chapter "Opportunities and risks of the European gas supply" (cf. Chapter 6) and are marked as such. The following table shows **how the study was carried out**:

Figure 2: Study design



Source: Prognos AG

The **area analysed** in this study includes the European Union (EU) and Switzerland. When this study was commissioned, the EU had

28 member states. Possible consequences from the BREXIT decision on 26 June 2016 have not been taken into account. In this study, the numbers referring to the EU until 2050 include the UK. We assume that the UK's exit from the EU will not have any decisive impact on the results of this study.

Switzerland as an enclave within the EU was included in the analysed area as all Swiss imports can be assumed to transit EU territory. That means that the main focus is the area EU 28 and Switzerland.

In addition to the gas demand in the analysed area, **Ukraine's** gas supply via the new Western connections from Poland, Slovakia and Hungary is assessed to be important and therefore included in this study. Since 2014, Ukraine has been covering a significant part of its gas demand via these Western connections; and since November 2015, it has been importing gas exclusively via these pipelines from the EU. This gas volume has to be supplied via the European gas transmission network and therefore has to be added to EU Ref 2016 as it is not included in the import demand of the area analysed in EU Ref 2016 (cf. Chapter 4.4).

Other gas flows via EU territory in order to supply non-EU areas (e.g. Balkan countries and Kaliningrad) have not been included due to their low volumes and to the fact that they are difficult to handle statistically.²

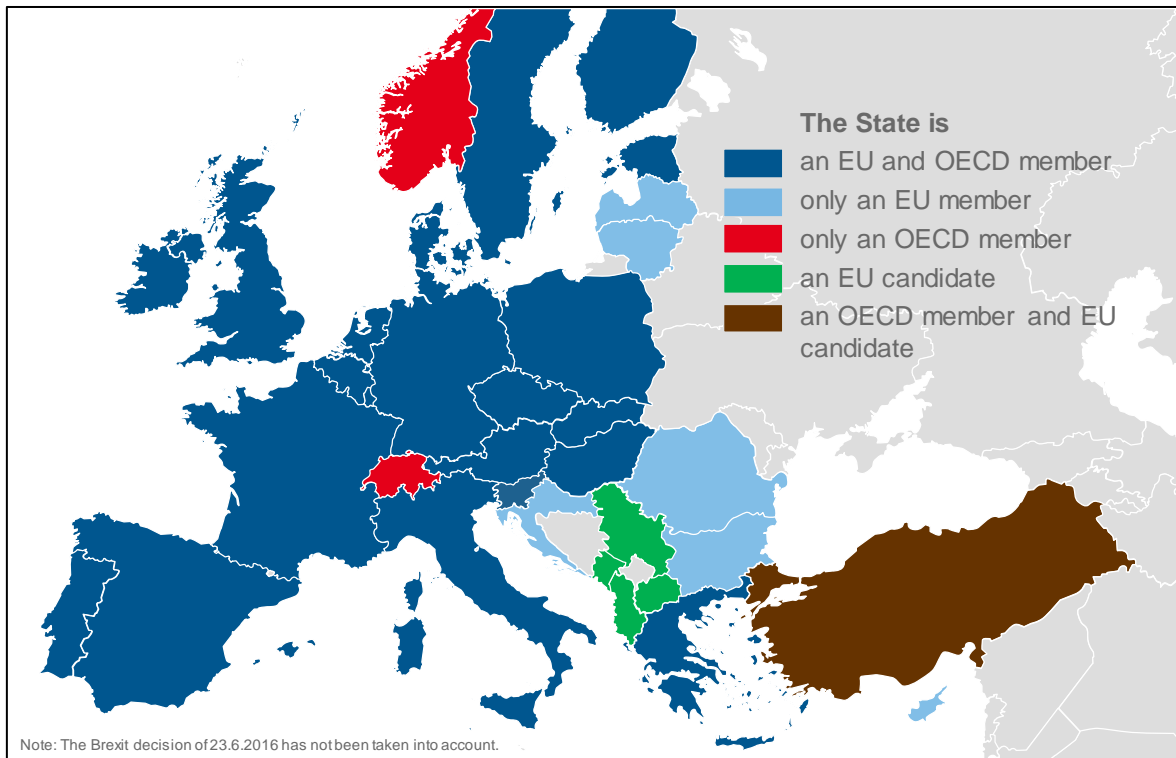
There are several other studies on the European gas demand that differ regarding the area that is analysed. In general, these studies refer to **OECD Europe**. It is not possible to convert these two concepts into each other as individual data for the countries are not publicly available. OECD Europe includes Norway (net gas exporting country) and Turkey (large gas consuming country), but not the EU countries Romania, Bulgaria, Croatia, Latvia and Lithuania, which is the **main difference** to the area EU 28 and Switzerland. The following figure illustrates the different geographical areas that were included. In 2015 - i.e. during the period analysed in this study - EU 28 and Switzerland used about 4,700 TWh and OECD Europe about 5,020 TWh (not adjusted for temperature).

Particularly the inclusion or non-inclusion of Turkey affects the result. According to available forecasts, Turkey's demand of imported gas will increase, which means that the import demand of OECD Europe can be expected to grow faster than that of EU 28 and Switzerland. In order to be able to compare the two areas, Prognos uses presentations with **indices**, i.e. the gas demand of the forecast year is related to the respective base value (2015 =

² Serbia, for instance, imported only 1.55 billion m³ of natural gas in 2010 (BP, 2011), the other Balkan countries imported even less. Kaliningrad is supplied via a direct transit pipeline from Belarus and Lithuania. Within the context of this study, these gas flows are not relevant.

1.0) and represents a dimensionless value that shows the relative development (cf. Figure 33).

Figure 3: Analysed area EU 28 and Switzerland vs. OECD Europe



Source: Prognos AG

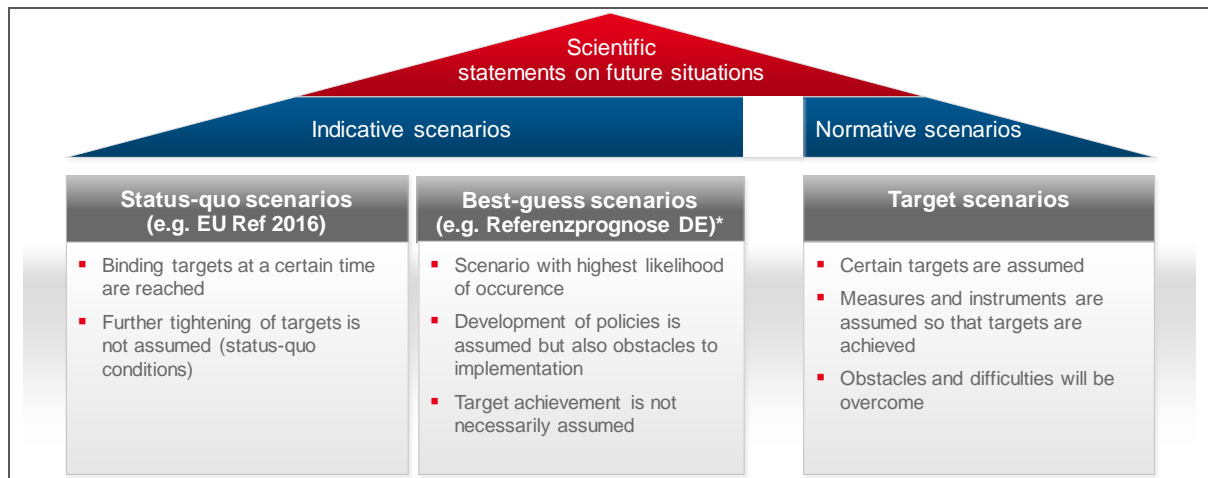
Scenario theory

Scenarios are the preferred tool for illustrating possible future developments under different conditions. As nobody can predict the future with a hundred percent certainty, futurist have to make assumptions in order to determine how these assumptions affect future developments. Thus, scenarios are always “if-then” statements that put cause and effect into a relation.

Forecasts in a stricter sense are a specific kind of scenarios. In general, they intend to describe a future development that should have a high probability of occurrence. Therefore, forecasts are sometimes called “**best-guess**” scenarios.

In order to arrive at a categorisation, we will describe the different **types of scenarios**. As Figure 4 shows, the individual types of scenarios have different purposes, and the type of scenario used will substantially affect the development of the gas demand

Figure 4: An overview of the scenario types



Source: Own presentation based on (EC, 2016b)

In general, scientific statements on future situations are divided into indicative and normative scenarios and it applies that the farther away in the future the situation that a statement refers, the lower the probability that this situation will occur:

- **Indicative statements on future situations** describe possible future developments in relation to the assumptions made. This way, the effect of instruments, political approaches, technological pathways, market designs and other things is tested. In general, these scenarios are open regarding the outcome which means that the scenarios do not assume that specific targets - unless they are legally binding - should be reached.
 - There are sub-types of indicative scenarios such as **status-quo scenarios** that perpetuate today's political framework conditions into the future. EU Ref 2016 is such a scenario. The EU will use this scenario as an orientation for its future energy policy in order to define political measures for further decreasing energy consumption and CO₂ emissions.
 - A specific type of indicative scenarios are so called **"best-guess" scenarios**. Strictly speaking, forecasts are mostly best-guess scenarios as they are supposed to represent - from today's perspective - the most likely future development. This may include targets to be reached, but not necessarily, as there may be obstacles and difficulties. We are not aware of any reknown study on the European energy supply (e.g. recognised by the EU Commission or the IEA) that includes a "best-guess" scenario or a forecast in a stricter sense.

- Both status-quo and best-guess scenarios are called reference scenarios.
- There are also **target scenarios**, which have to be distinguished from indicative scenarios. They answer the question what measures, instruments or policies are necessary to reach a certain target. These scenarios assume that political targets, for instance resulting from the Paris climate conference (COP 21) should be reached, and that obstacles and difficulties will be overcome.

The actual development will deviate from the results in the scenario, which means that scenarios and forecasts are not different regarding this aspect. Reasons for such deviations may be the following:

- Technological breakthroughs, e.g. improvements of horizontal drilling methods and hydraulic fracking that may increase oil production from mature oil and gas fields, or a cost degression of photovoltaics and offshore wind power.
- New applications, e.g. mobile phones
- Political upheaval, e.g. reunification of Germany
- Economic shocks, e.g. financial and economic crisis in 2009

In general, such factors can only be predicted to a very limited extent or not at all. However, **sensitivity analyses** can be used to examine deviating developments. They create a corridor of possible deviating developments “around the expected result”. The current study also includes a sensitivity analysis (cf. Chapter 6).

Selection of scenarios

Various issues are important when selecting scenarios for the infrastructure planning of the EU. Paragraph 1 of the German Energy Industry Act, for instance, defines the goal of the most **secure, economical, user-friendly, efficient** and **environmentally friendly** energy supply. This means that not only the target of environmental and climate compatibility are decisive for the selection of the scenarios.

For the above mentioned reasons, scenarios can arrive at several diverging results. **However, the dimensioning of an infrastructure can only be based on one result.**

- If the infrastructure is dimensioned based on scenarios with a comparatively high gas demand, generally it will also automatically cover a lower gas demand development. In

this case, there is a risk that the gas network will be oversized.

- If the infrastructure is dimensioned based on scenarios with a comparatively low gas demand, there is a risk that customers cannot be supplied or not be supplied to the required extent. In this case, the security-of-supply target may not be reached.

Ultimately, the gas network planning is adapted to the expected peak load, which is correlated to gas demand though. Commonly, gas network operators apply indicative scenarios (status-quo/ best-guess scenarios) for infrastructure planning in order to maintain an infrastructure that is sufficient even if saving targets, for instance, are not reached. The network development plans of the large European gas economies are based on indicative scenarios and not on individual forecasts in a stricter sense. The Ten Year Network Development Plan, for instance, is based on indicative scenarios. For reasons of security of supply, the network development plans generally do not assume that ambitious climate targets will be reached, even though such target scenarios nowadays are part of the evaluation of network development plans. The Prognos report (Prognos, 2016) thoroughly discusses this subject.

Why EU Ref 2016?

The study EU Ref 2016 was published at about the same time we started working at the present study (July 2016). At that point, EU Ref 2016 was the most current and comprehensive study on European energy demand.

Prognos has modified EU Ref 2016 using updated extraction forecasts that were partially published after the publication of EU Ref 2016.

The EU reference scenario shows a possible future development under status-quo conditions. EU Ref 2016 assumes that the legally binding targets for greenhouse gas emissions (GHG) and the expansion of renewable energies will be implemented by the year 2020. The efficiency target (reducing the energy demand by 20 % in relation to the reference scenario 2007) will be missed by a minor margin. (EC 2016b)

EU Ref 2016 assumes that the measures agreed on EU and national level prior to 2015 will be implemented. The effects of the Paris Agreement of December 2015 were not included. From the summary of EC (2016b, p. 1):

“Ref 2016 provides a consistent approach in projecting long term energy, transport and climate trends across the EU and is a key support for policy making. However, it is not a forecast since, as with any such exercise, there are several unknowns. These range from macroeconomic growth, fossil fuel prices, technological costs, and the degree of policy implementation across EU. Moreover, Ref 2016 does not include the politically agreed but not yet legally adopted 2030 climate and energy targets.”

EU Ref 2016 already includes the option that total energy demand - and above all green-house gas emissions - could be lower if the already agreed, but not yet legally binding targets were implemented.

Were there any alternatives to EU Ref 2016?

The **sensitivity analysis** in the current study (cf. Chapter 6) comprehensively examines which developments diverging from the reference assumption could be an alternative. Several scenarios produced by other authors or institutions were analysed. In November 2016 – just before the editorial deadline of this study - the **World Energy Outlook 2016** (WEO-2016) was published by the International Energy Agency (IEA). The IEA is one of the most reknown institutions when it comes to preparing scenarios relating to the energy industry, which means that their publications are of particular interest. WEO-2016 also presents several scenarios, but no forecasts in the above mentioned stricter sense. The chapter on the methodology applied in WEO-2016 states:

“With so many uncertainties and (occasionally competing) priorities, no path of development of the global energy system can be confidently drawn to 2040. That is why as in previous years, this edition of the World Energy Outlook presents several scenarios.” (IEA, World Energy Outlook 2016, 2016), p.33.

This means that it is not reasonable to prepare a single forecast because of the existing uncertainties. We can characterise the scenarios provided by the IEA in WEO-2016 as follows:

The Current Policies Scenario (CPS)

“The accomplishment of announced, new policy targets cannot be taken for granted. The Current Policies Scenario depicts a path for the global energy system shorn of the implementation of any new policies or measures beyond those already supported by specific implementing measures in place as of mid-2016.” (IEA, World Energy Outlook 2016, 2016), p. 33.

The approach of this scenario is quite close to the EU Commission’s scenario EU Ref 2016.

- **The New Policies Scenario (NPC)**
“Based on a detailed review of policy announcements and plans, the New Policies Scenario reflects the way that governments, individually or collectively, see their energy sectors developing over the coming decades. Its starting point is the policies and measures that are already in place, but it also takes into account, in full or in part, the aims, targets and intentions that have been announced, even if these have yet to be enshrined in legislation or the means for their implementation are still taking shape.” (IEA, World Energy Outlook 2016, 2016), p. 33.
 NPC assumes a further political development and could have been a scenario option for the current study.

- **The 450 Scenario**
“The decarbonisation scenarios start from a certain vision of where the energy sector needs to end up and then work back to the present. The decarbonisation scenario described in detail in WEO-2016 is the 450 Scenario, which has the objective of limiting the average global temperature increase in 2100 to 2 degrees Celsius above pre-industrial levels.” (IEA, World Energy Outlook 2016, 2016), p. 35.
 Thus, the 450 Scenario is a target scenario. It was included in the sensitivity analysis of this study.

A comparison of the EU's gas demand in EU Ref 2016 and the results in WEO-2016 shows the following **results**:

- The **Current Policies Scenario** has similarities to the approach used in EU Ref 2016. In this scenario, the IEA expects the EU's gas demand to continuously grow until 2040; and it therefore exceeds the expectations in EU Ref 2016.

- The **New Policies Scenario** assumes a substantial further development of the EU's energy and climate policy. This scenario includes a slight increase of gas demand until 2025, with the demand remaining at the same level until 2035 and decreasing afterwards. The results are quite similar to those in EU Ref 2016.

- The **Scenario 450** was included in the sensitivity analysis in Chapter 6. Here gas demand increases until 2020, and then decreases – at first slowly, but faster after 2030.

Conclusions: The IEA scenario whose design has most similarities to EU Ref 2016 arrives at a substantially higher EU gas demand than EU Ref 2016, above all in the long run. As opposed to this, the New Policies Scenario shows similar results to EU Ref 2016 regarding the gas demand. However, WEO-2016 does not

provide individual data for each EU country, which means that the data would not have been sufficient for the desired level of detail.

At the time of the editorial deadline of the current study in December 2016, there were no other scenarios prepared by public institutions on the EU's gas demand that would include the required high data resolution.

Use of Units

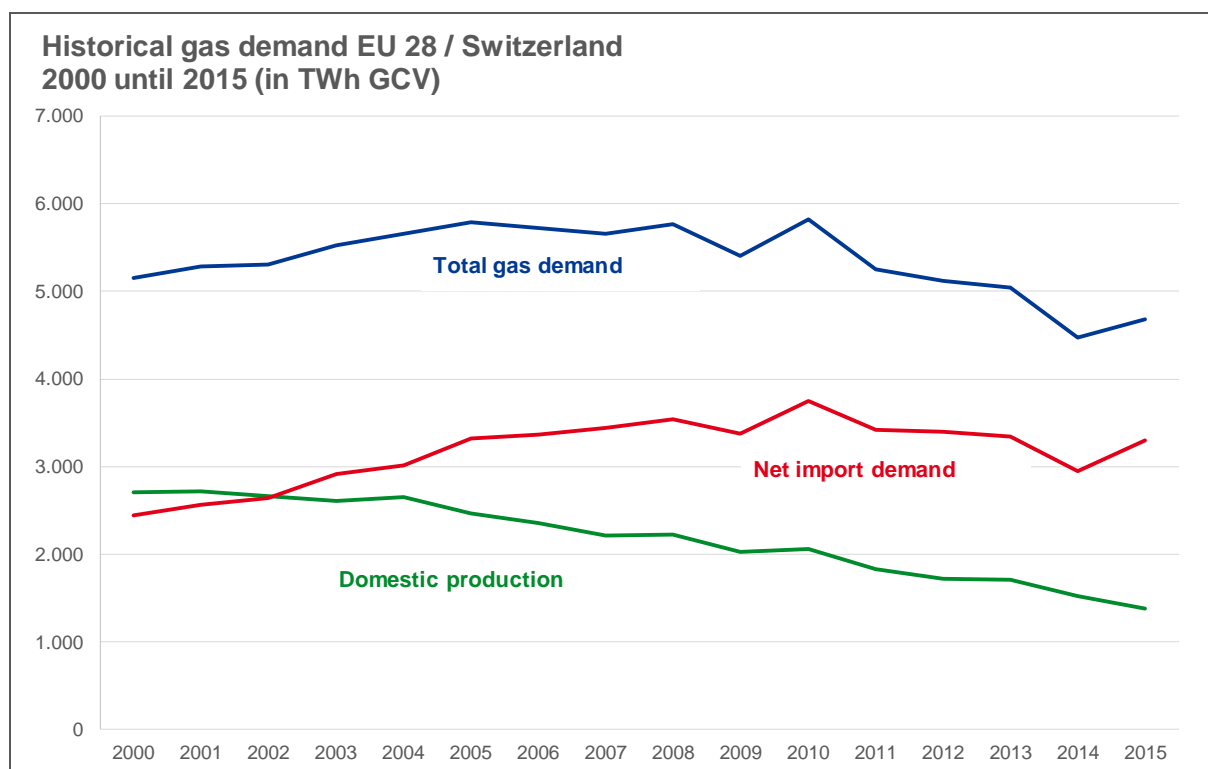
This study uses both the unit TWh (terawatt hours = billion kilowatt hours) and billion m³ (billion cubic meter) or Sm³ (standard cubic meter). As natural gas has slightly varying compositions, a cubic meter of natural gas may contain varying amounts of energy, depending on the proportion of higher-grade gases (e.g. propane, butane) and on the pressure and temperature the data refers to. Norwegian statistics, for instance, specify the calorific value of Norwegian gas with 11.1 kWh/m³. Dutch and German gas, on the other hand, has a lower calorific value (9.77 kWh/m³). In order to be able to compare the gas quantities, Prognos first converted all quantities into calorific values. Then, the data was converted into standard cubic meter. The Russian standard value is used in order to be able to compare the data with the pipeline capacities of Nord Stream 1 and 2. The (gross) calorific value of the standard cubic meter is 10.5 kWh/m³ or 10.5 TWh/billion m³, respectively. For further information on the conversion factors, see Chapter 10.

3 Ex post analysis: European gas balance 2000 to 2015

The ex post analysis shows the past development of gas demand, extraction and imports and provides an initial idea of trends that possibly may be perpetuated into the future. However, a pure perpetuation of trends is not very meaningful as it is not able to represent developments that differ from the past, such as the reassessment of gas in power generation.

Between 2000 and 2005, the gas demand in the EU and Switzerland grew continuously, then it remained constant - with the exception of 2009 due to the economic crisis - and since 2010 it has been decreasing.

Figure 5: Development of the gas demand in the area EU 28 and Switzerland between 2000 and 2015³



Source: Own presentation based on (Eurostat, 2016), (BFE, 2014), (Prognos AG, 2012); data not adjusted for temperature

³ This study defines calorific value as the gross calorific value including the condensation heat of the gas. This physical unit is commonly used in the gas industry whereas statistics comparing energy sources (e.g. energy balances or EU Ref 2016) mainly apply the net calorific value. The gross calorific value (GCV) for natural gas exceeds the net calorific value by about 11 %. (cf. Chapter 9: Conversion factors).

Gas extraction in the EU is decreasing. In 2000, it still amounted to about 2,700 TWh. In 2015 it had decreased to about 1,380 TWh, slightly more than half of the volume extracted in 2000. During the past years, extraction has been decreasing faster than gas demand. That has resulted in an increased net gas import demand, which means that the EU has to import more gas from non-EU sources.

We also have to take into account that energy demand varies with temperature fluctuations. 2010 was an exceptionally cold year. As opposed to this, 2014 and 2015 were particularly warm. When comparing 2015 and 2010, the decreasing trend appears to be much stronger than when adjusting the two reference years for temperature.

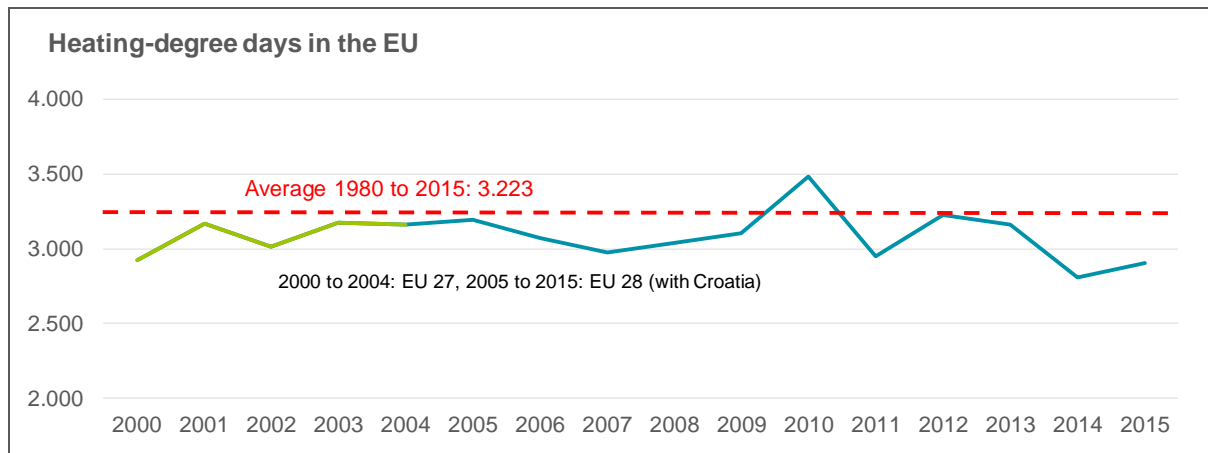
The impact of the weather on the energy demand is usually described in terms of heating-degree days. They measure if temperatures were lower than a specified value during one day; and if so, by how many degrees (Celsius or Kelvin, respectively). This represents the behaviour of heating equipment that is switched on at a specific, low temperature (e.g. below 15°C, the so-called heating-temperature threshold in Germany).

The days with temperatures below the heating-temperature limit are counted and each degree below this temperature constitutes one heating-degree day. A low number of heating-degree days corresponds to a warm year and results in a lower heating energy demand.

The following figure shows the development of the heating-degree days for the mentioned period. It becomes obvious that since 2000 most years have been warmer in comparison; and therefore, the value for the heating-degree days has been lower than the long-term average of the period 1980 to 2015. However, 2010 was a year in the recent past that was about 8 % colder than the long-term average.

The Winter Outlook 2015/2016 prepared by ENTSOG (ENTSOG, 2015c) compares the demand of the winter half-year of a reference year with that of a cold winter. It shows that the gas demand during a cold winter exceeds that of the reference winter by about 10 %.

Figure 6: Development of heating-degree days in the European Union between 2000 and 2015



Source: Own presentation based on (Eurostat, 2016)

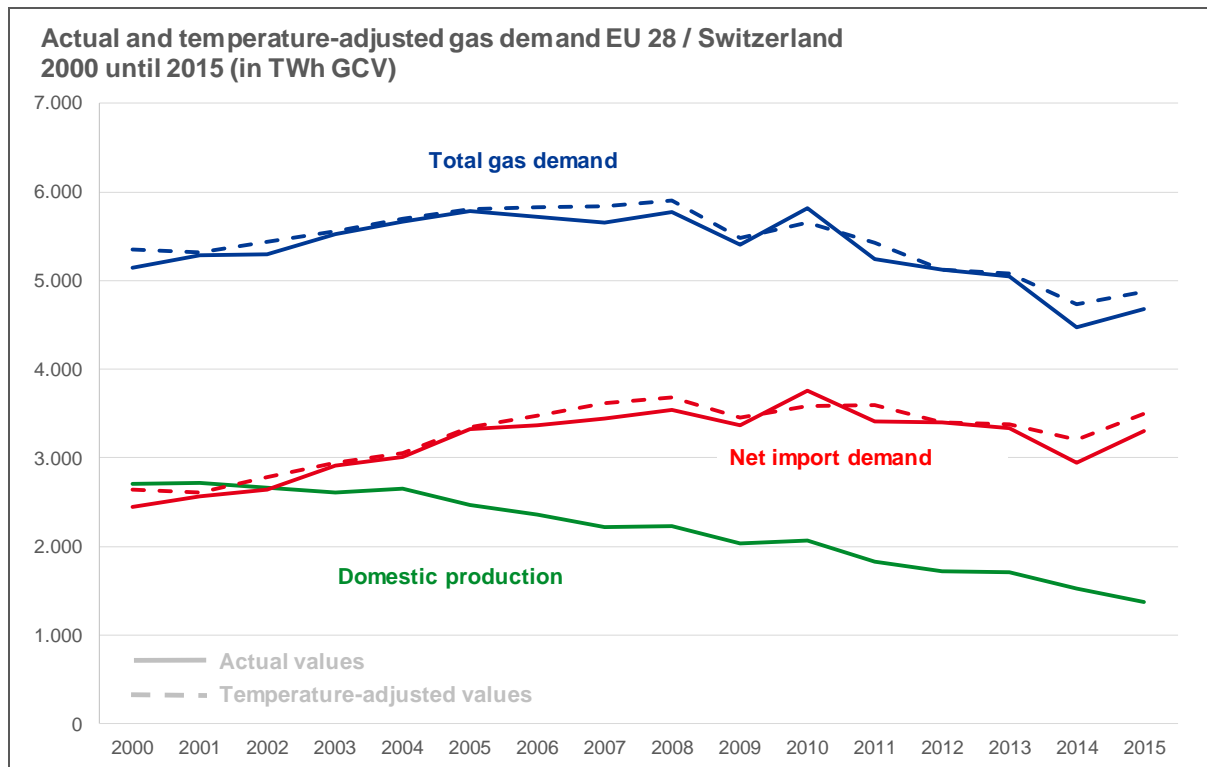
In order to eliminate the impact of the weather on the statistics and to better assess long-term trends, the study applies the following **procedure**:

- We assume that temperature fluctuations mainly affect the heating demand of buildings. The demand of process energy (e. g. for industrial production) does not depend on the temperature.
- When adjusting for temperature, this study assumes that within the analysed region 38 % of total gas demand is subject to temperature fluctuations.⁴
- We apply the simplifying assumption that domestic gas production is independent of temperature variations.

The following figure shows the temperature-adjusted gas demand for the analysed area:

⁴ Prognos' own estimates based on the following assumptions: The proportion of gas demand that is subject to temperature fluctuations amounts to 80 % in households, 70 % for commercial, trading, service entities, 15 % for the industry, and 10 % for the conversion industry (especially power stations).

Figure 7: Actual and temperature-adjusted gas demand for the analysed area between 2000 and 2015



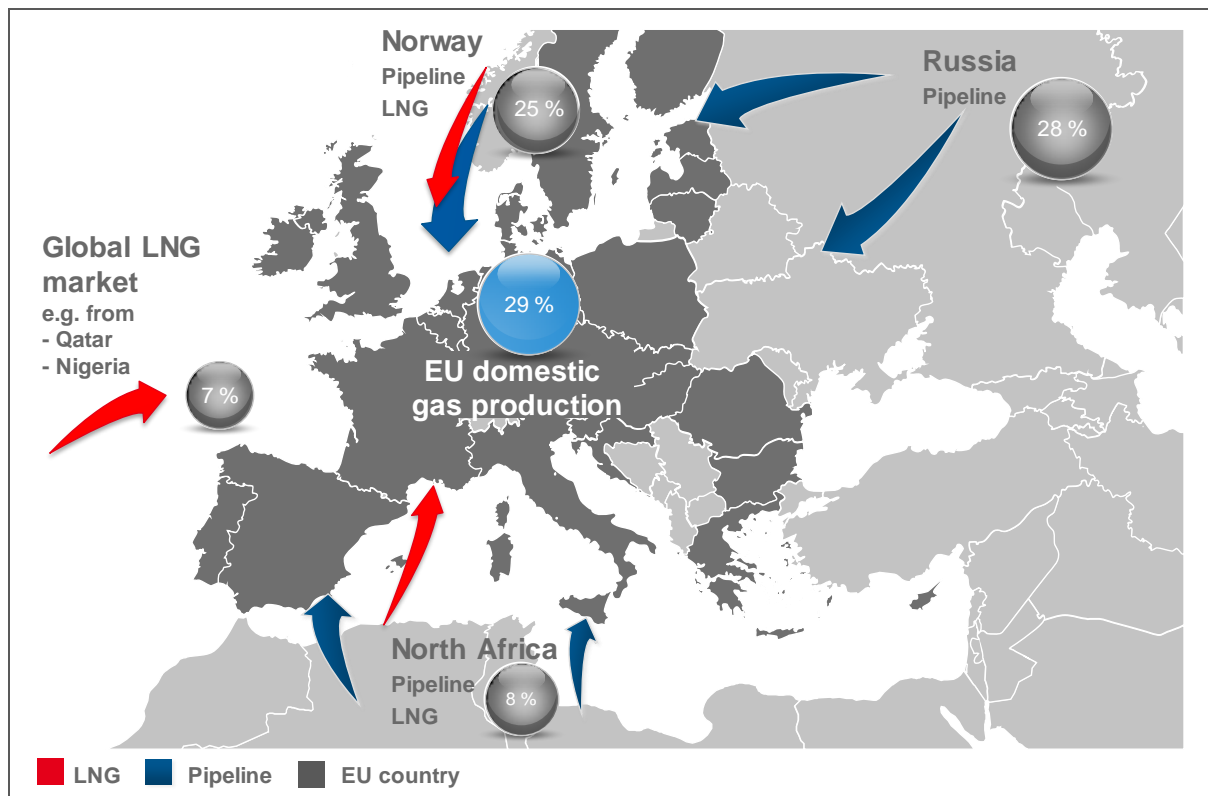
Source: Own presentation based on (Eurostat, 2016), (BFE, 2014), (Prognos AG, 2012); adjusted for temperature by Prognos

The following **key information for the gas demand** can be stated for the analysed area:

- Since 2010, the temperature-adjusted decrease of the gas demand has been amounting to 2.9 % per year. Since the year 2000, Europe's internal extraction has been decreasing on average by 4.4 % p.a.
- As a result, the gas import demand has been increasing since the year 2000. Since 2012, the gas import demand has been fluctuating around 3,300 TWh (adjusted for temperature: 3,400 TWh). This corresponds to about 314 billion Sm³ (adjusted for temperature: about 323 billion Sm³). For 2015, EU Ref 2016 states slightly higher values. This is due to the following: When EU Ref 2016 was prepared, it was based on data prior to 2015. Data for 2015 were only partially available, which means that the information in EU Ref 2016 differs from information that Eurostat now provides for 2015.
- The **import ratio** of the analysed area EU 28 and Switzerland is about 71 %.
- The demand is mainly supplied by domestic extraction (29 %) and imports from Russia (28 %) and Norway (25 %).

Russia and Norway together provide about 75 percent of the imports. During the analysed period, gas was also supplied from North Africa (about 8 %) and from the LNG world market (about 7 %); the difference to 100 % is due to the withdrawal of gas from storage reservoirs and to statistical differences in 2015.

Figure 8: Origin of gas demand in 2015 for the area EU 28 and Switzerland



Note: proportions in % refer to the gas demand in 2015. The missing 100 % are due to the withdrawal of gas from storage reservoirs and to statistical differences
Source: Own presentation based on (EC, 2016b), (BP, 2016b)

4 Gas demand scenarios for the period 2015 to 2050: EU 28 and Switzerland as well as the supply of Ukraine from the West

This chapter deals with the import demand of natural gas of EU 28 and Switzerland as well as the gas volumes supplied to Ukraine via EU territory. We apply the following steps:

- Initially, we evaluate EU Ref 2016 and the scenarios from Switzerland regarding the expected gas demand (**consumption**) until 2050.
- Then we present the expected **gas extraction** in the EU according to EU Ref 2016 and modify it using current extraction forecasts for the Netherlands, the UK and Germany.
- The next step is to derive the **import demand** for the analysed area.
- In addition, we show the gas volumes that **Ukraine** receives via its Western borders. These increase the gas import demand of the EU.

4.1 Development of the gas demand (consumption)

4.1.1 EU Reference Scenario 2016 (EU Ref 2016) for EU 28

The EU reference scenario shows a possible future development under status-quo conditions. EU Ref 2016 assumes that the legally binding targets for greenhouse gas emissions (GHG) and the expansion of renewable energies will be implemented by the year 2020. The efficiency target (reducing the energy demand by 20 % in relation to the reference scenario 2007) will be missed by a small margin. (EC 2016b)

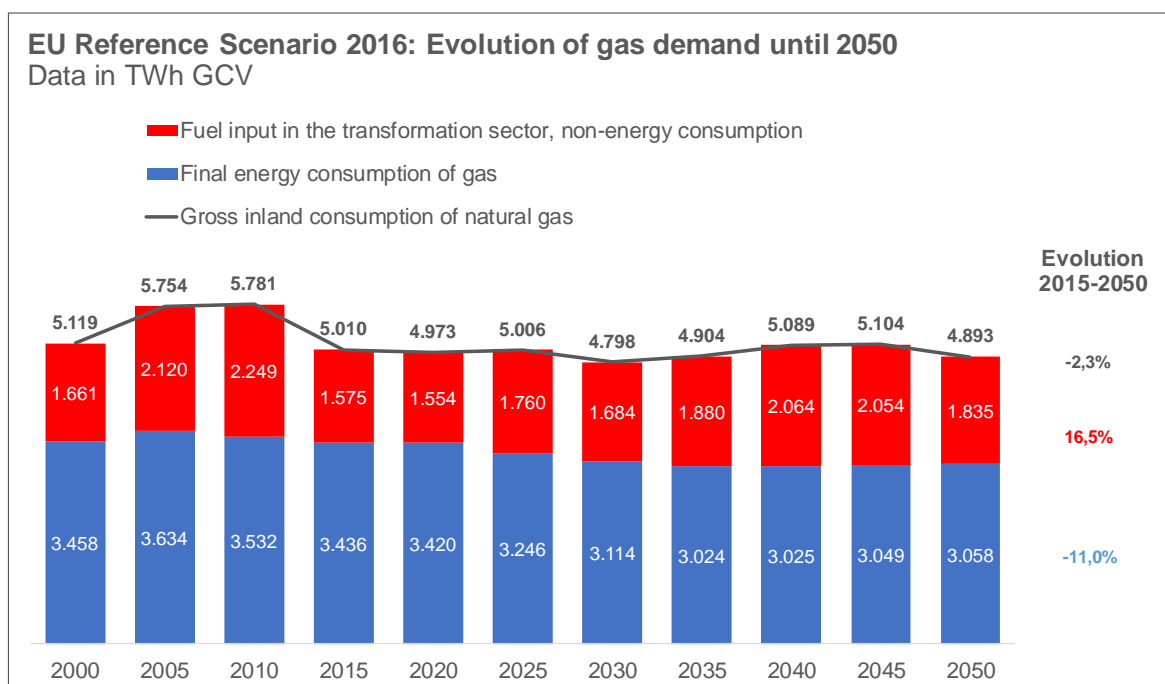
EU Ref 2016 assumes that the measures agreed on EU and national level prior to 2015 will be implemented. The effects of the Paris Agreement of December 2015 were not included. From the summary of (EC, 2016bb), p.1:

“Ref 2016 provides a consistent approach in projecting long term energy, transport and climate trends across the EU and is a key support for policy making. However, it is not a forecast since, as with any such exercise, there are several unknowns. These range from macroeconomic growth, fossil fuel prices, technological costs, and the degree of policy implementation across EU. Moreover, Ref 2016 does not include the politically agreed but not yet legally adopted 2030 climate and energy targets.”

EU Ref 2016 already mentions the possibility that total energy demand - and above all greenhouse gas emissions - could be lower than in EU Ref 2016 if the already agreed, but not yet legally binding targets were implemented.

Whether this will lead to a short- or medium-term lower gas demand remains unclear as gas could also be used as substitute energy for coal and could gain more importance for power generation. The following figure shows that EU Ref 2016 assumes an almost constant gas demand, with the final energy consumption of gas (e.g. for heating purposes) decreasing and the gas use in the conversion sector (for instance power stations and CHP) increasing.

Figure 9: Development of gas demand in EU 28 until 2050 according to the EU Reference Scenario 2016



Source: Own presentation based on (EC, 2016b)

4.1.2 Reference scenario and target scenario for Switzerland

Switzerland does not belong to the EU and is therefore not included in the study EU Ref 2016. However, Switzerland does not have any domestic gas extraction and therefore supplies its entire gas demand via EU territory. Therefore, the future gas demand of Switzerland is relevant for this gas balance. The gas demand of Switzerland corresponds to less than 1 % of the EU gas demand, though.

The scenarios we present for Switzerland originate from Energy Perspectives Switzerland (Prognos AG, 2012). These scenarios represent widely varying strategies and measures, in order to provide a decision-making basis for planning the Swiss energy supply. A central issue is for how long Switzerland will continue to use nuclear energy to generate power and what generation capacities could replace this energy production.

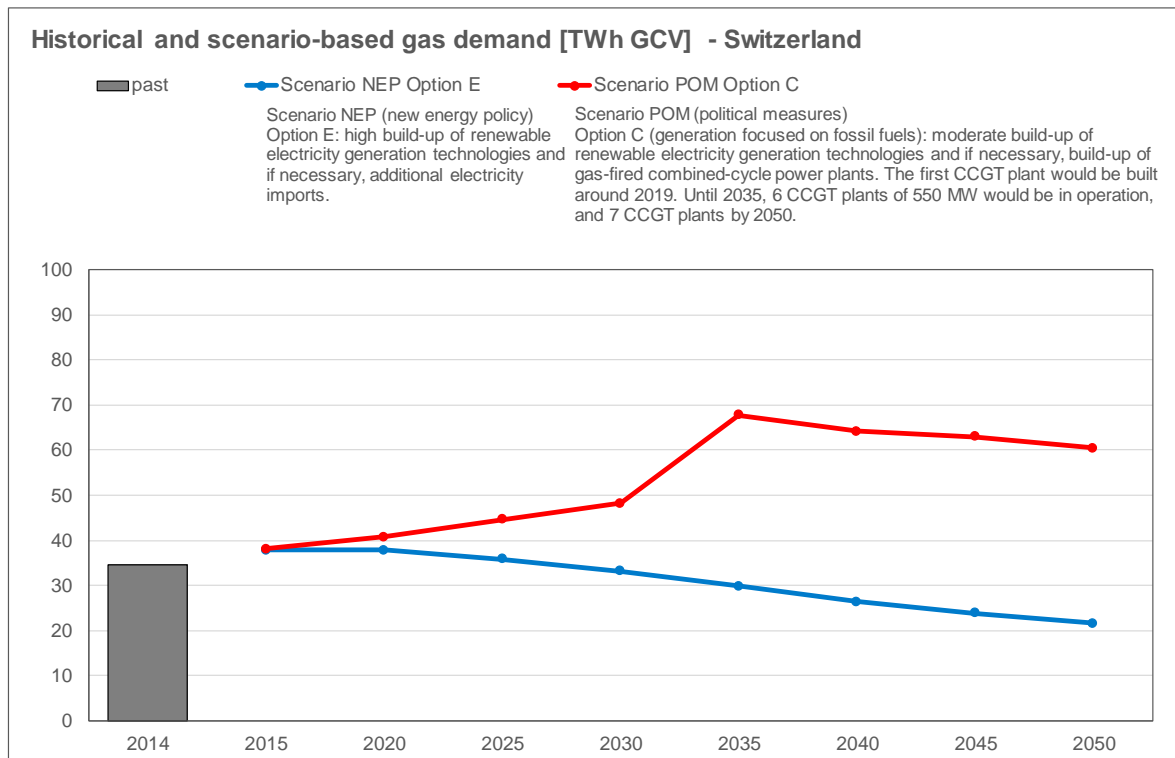
Three demand scenarios were developed. The scenario “Weiter wie bisher” (WWB - business as usual) perpetuates an autonomous trend towards energy efficiency, aided by the instruments that were available at the time of this study. In comparison to WWB, the scenario “Politische Maßnahmen” (POM - political measures) includes the measures adopted by the Swiss government on 18 April 2012. The scenario “Neue Energiepolitik” (NEP - new energy policy) constitutes a target scenario that evaluates how to reach the target of reducing CO₂ emissions until 2050 to 1.5 t per capita or below.

In addition, several options for the power supply were modelled for each demand scenario. In general, it was assumed - based on the decisions of the Swiss government in May 2011 - that the existing nuclear power stations will not be replaced at the end of their operating lives. In Option C, power demand will be supplied from within the country. If demand exceeds Switzerland’s power supply, additional combined-cycle gas turbine plants (CCGT) will be built. In Option E, power demand will be supplied by renewable energies, to the largest extent possible. Power will be imported if necessary.

The following figure shows selected gas demand scenarios that were calculated in the study for Switzerland (Prognos AG, 2012). The presented scenarios correspond in general to the division into indicative and target scenarios in Chapter 2. The scenario NEP (with power supply option E) constitutes a target scenario and POM (with power supply option C) a reference scenario. When deriving the gas demand in the area EU 28 and Switzerland, the scenario POM Option C is used for Switzerland. This scenario analyses how the most important political steps affect the Swiss energy demand, using existing technologies. POM Option C is

therefore a suitable reference and will be used within the framework of this study.

Figure 10: Development of the gas demand in Switzerland until 2050



Source: (Prognos AG, 2012), (BFE, 2014)

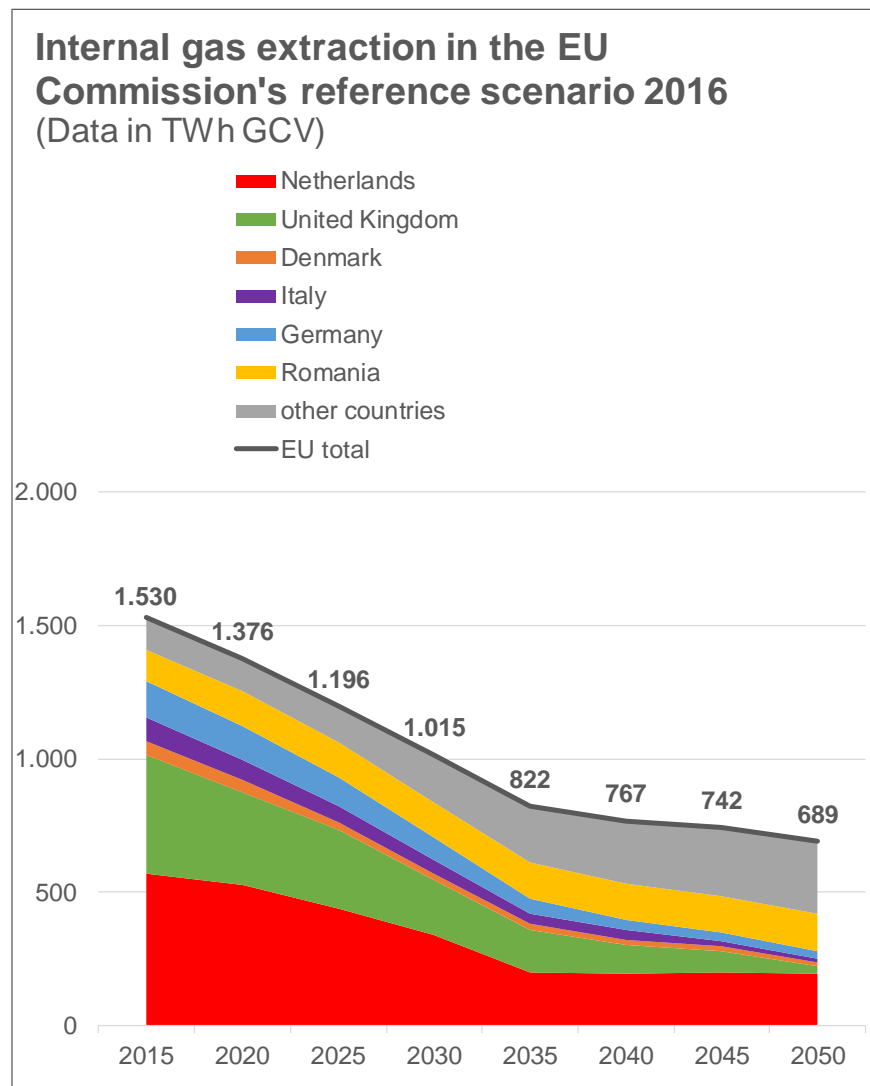
4.2 Development of the gas extraction

In the following, the development of the gas extraction in the EU will be presented. Also here, we rely on the scenario EU Ref 2016. The study includes assumptions regarding all EU member states. For three countries - the Netherlands, the UK and Germany -, the assumptions had to be modified as there are recent government decision or forecasts that have not yet been included in the scenario EU Ref 2016. These modifications are presented in detail in Chapter 4.2.2. There is no natural gas extraction in Switzerland, and it is not assumed for the future either.

4.2.1 EU Reference Scenario 2016 (EU Ref 2016)

In total, the scenario EU Ref 2016 expects the EU's **internal extraction of gas** to decrease from today's approximately 1,530 TWh (146 billion Sm³) to about 690 TWh (66 billion Sm³) in 2050. This corresponds to a decrease of about 55 %.

Figure 11: Development of the gas extraction in EU 28 until 2050 according to the EU Reference Scenario 2016



Source: Own presentation based on (EC, 2016b)

Regarding the six largest European gas-producing countries, the scenario assumes a long-term, stable or increasing gas production only for Romania. For the other five large gas producers, the decrease until 2050 is between 66 % (the Netherlands) and 94 % (both in Denmark and the UK) (EC, 2016b).

For the remaining countries, the gas production is expected to increase over the analysed period from about 123 TWh (12 billion Sm³) in 2015 to about 272 TWh (26 billion Sm³) in 2050. This corresponds to an increase of about 121 %. The increase is mainly due to a growing gas production in Poland (from shale gas) and Cyprus (supplying the LNG market) (EC, 2016b). The increase assumed in EU Ref 2016 is subjected to a sensitivity analysis and discussed critically in Chapter 6.2 as the exploration of Polish shale gas deposits has not met the expectations yet (SGIP, 2015).

4.2.2 Taking into account current extraction forecasts in the Netherlands, the UK and Germany

EU Ref 2016 was published in July 2016. After EU Ref 2016 went to press, new forecasts and decisions regarding the natural gas extraction in three EU countries (the Netherlands, Germany, the UK) were published. According to EU Ref 2016, in 2015 these three countries are also those with the largest internal extraction and have a significant impact on the European gas balance. Therefore, the assumptions for the gas extraction in the Netherlands, Germany and the UK have been modified compared to the scenario EU Ref 2016.

The Netherlands

The Netherlands are the **most important gas-extracting country in the EU** and export natural gas to several EU countries. The Netherlands are essential for the supply of the European L-gas area⁵. The **Groningen gas field** was discovered in 1959 and is very important for the gas supply. Due to **earthquake issues**, among others, in the region Groningen, the allowed extraction volume of the Groningen field was reduced.

For the Dutch gas extraction, the assumptions of EU Ref 2016 were compared with the assumptions of the Dutch network development plan (NOP 2015) and other current developments. The grey areas in figure 12 show the forecast Dutch gas extraction (Groningen quality: conversion factor 9.7692 kWh GCV/m³) for the Groningen field as well as for the other Dutch gas fields according to the **Dutch network development plan** (GTS, 2015). Due to the earthquake debate, the Dutch government decided the following **additional reductions regarding the Groningen field**:

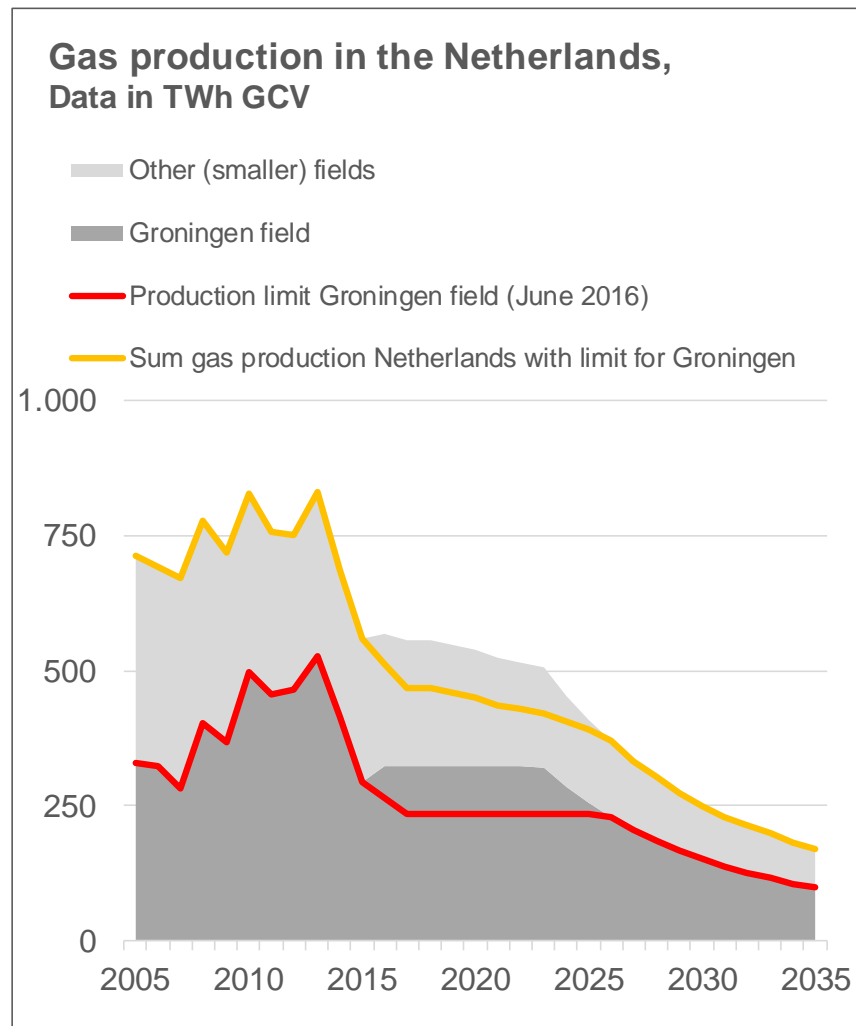
⁵ In general, we distinguish between H-gas (natural gas with a high calorific value) and L-gas (natural gas with a low calorific value). H-gas has a higher proportion of methane and therefore also a higher calorific value than L-gas. According to the individual gas extraction site, the chemical composition of the natural gas varies. L- and H-gas networks are separate; converting and mixing the two gas qualities is technically possible, but costly.

- December 2014: The Dutch Department of Economy decides to limit the annual extraction to 39.4 billion m³ for the years 2015 and 2016,
- June 2015: Further reductions to 30 billion m³ for the year 2015 and 33 billion m³ for the gas year 2015/16,
- December 2015: Further reduction to 27 billion m³ for the gas year 2015/16,
- June 2016: A targeted reduction to 24 billion m³ per year for 5 years, with the exception of higher possible extraction volumes in extreme winters,
- September 2016: The reduction to 24 billion m³ per year is confirmed, with the exception of higher possible extraction volumes in extreme winters (Rijksoverheid, 2016).

It cannot be excluded that - due to the earthquake issue - there may be further reductions of the allowed extraction volumes in the Groningen area during the next years.

The comparison of the Dutch gas extraction is based on the planned extraction volumes according to **NOP 2015** and then including the subsequent **reduction of the Groningen field** to 24 billion m³. This results in a further reduction of the Dutch gas extraction in the next years, compared to the assumptions in NPO 2015 (cf. figure 12) red line for the Groningen field and yellow line for the total Dutch gas extraction). NOP 2015 includes a forecast of the Dutch gas extraction until 2035; the **perpetuation for the years 2035 to 2050** is based on the relative development of the scenario EU Ref 2016.

Figure 12: Gas extraction forecast in the Netherlands



Source: Own presentation based on (GTS, 2015), (Rijksoverheid, 2016)

Germany

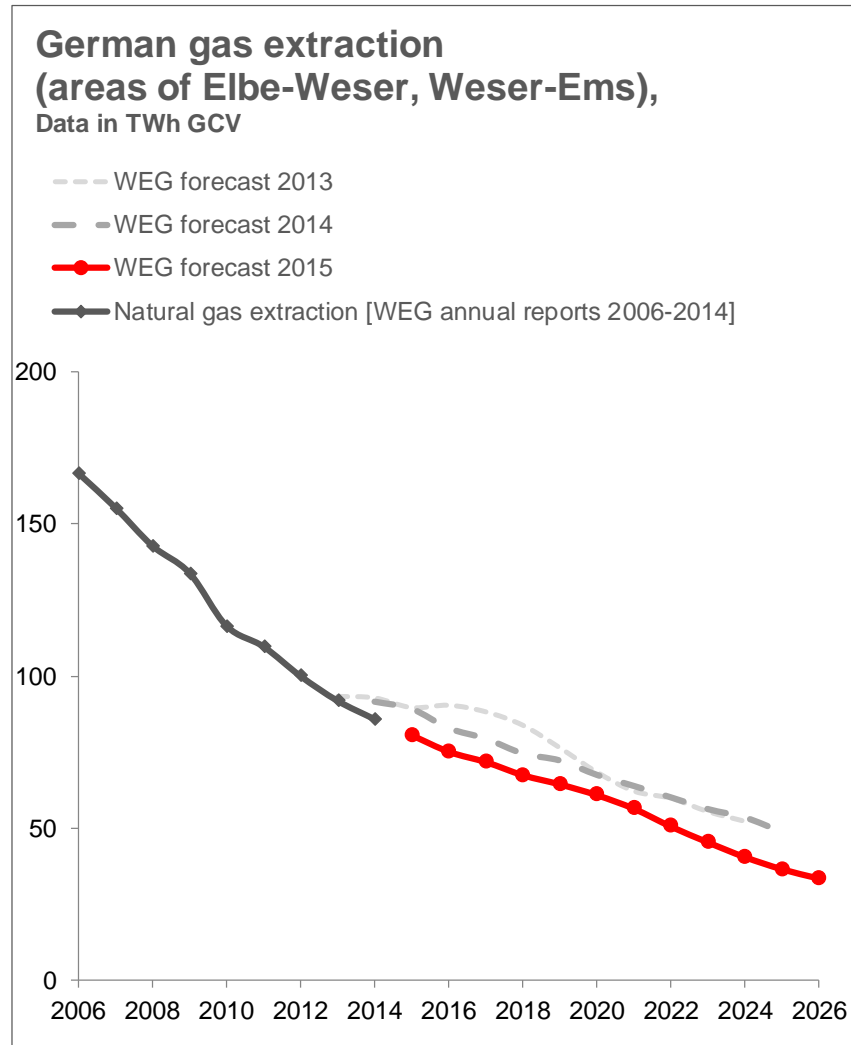
The forecast for the German gas extraction is based on the evaluation of the current **draft of the German Network Development Plan (NEP) gas 2016**. It includes the forecast of the German gas extraction until the year 2026. The forecast was prepared by **Bundesverband Erdgas, Erdöl und Geoenergie e.V.** (BVEG - Federal Association for Natural Gas, Crude Oil and Geoenergy)⁶.

Figure 13 shows the forecasted development of the German natural gas production according to the draft of the German NEP Gas 2016, published on 1 April 2016. The German natural gas production is expected to **continuously decrease** from about 81 TWh (8 billion Sm³) in 2015 to approximately 33 TWh (3 billion

⁶ Note: Previously Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V. (WEG - Industrial Association Crude Oil and Natural Gas Extraction)

Sm³) in 2026 (FNB Gas, 2016).⁷ For the years between 2026 and 2050, the **perpetuation** of the German gas extraction is based on the relative development of the scenario EU Ref 2016.

Figure 13: Gas extraction forecast Germany



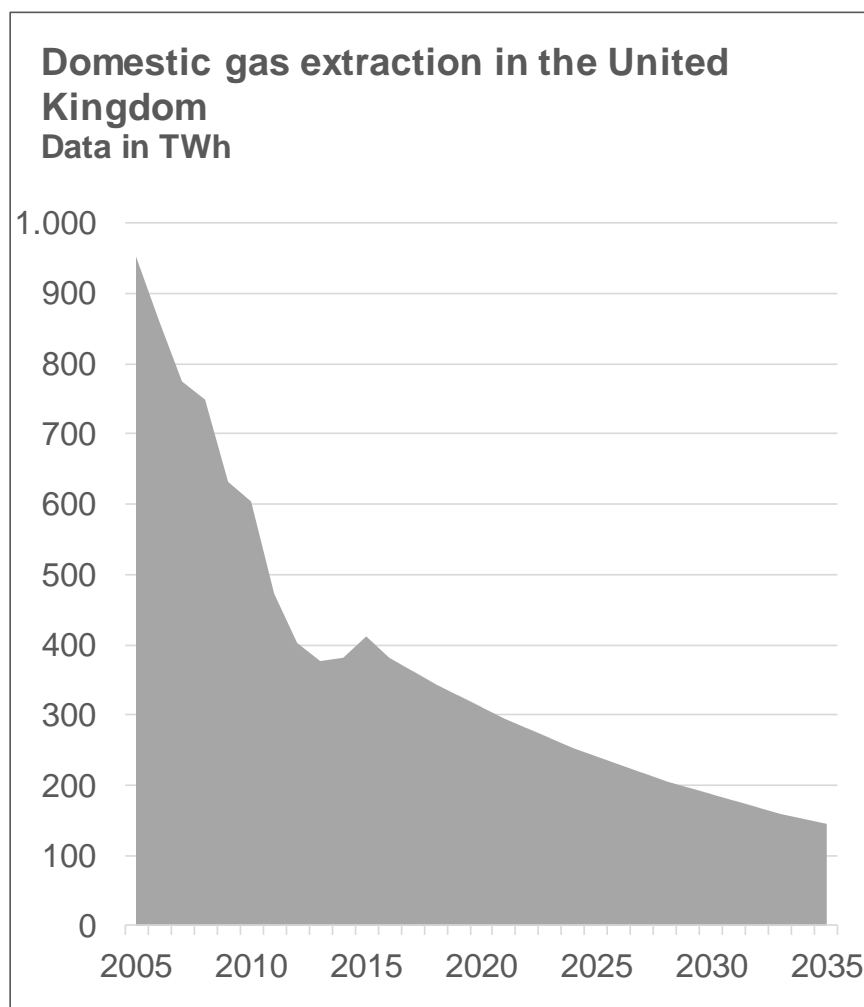
Source: Own presentation based on (FNB Gas, 2016)

The United Kingdom

The assessment of the development of the UK gas extraction is based on the analysis of the gas extraction forecasted by the **British Department of Energy and Climate Change (DECC)**, which is shown in Figure 14:.. Between 2015 and 2035, the **gas extraction** is expected to **decrease** by about 65 % to 144 TWh (14 billion Sm³) (DECC, 2016).

⁷ Original data in billion m³ with conversion factor 9.7692 kWh GCV/m³ differ accordingly.

Figure 14: Gas extraction forecast in the UK



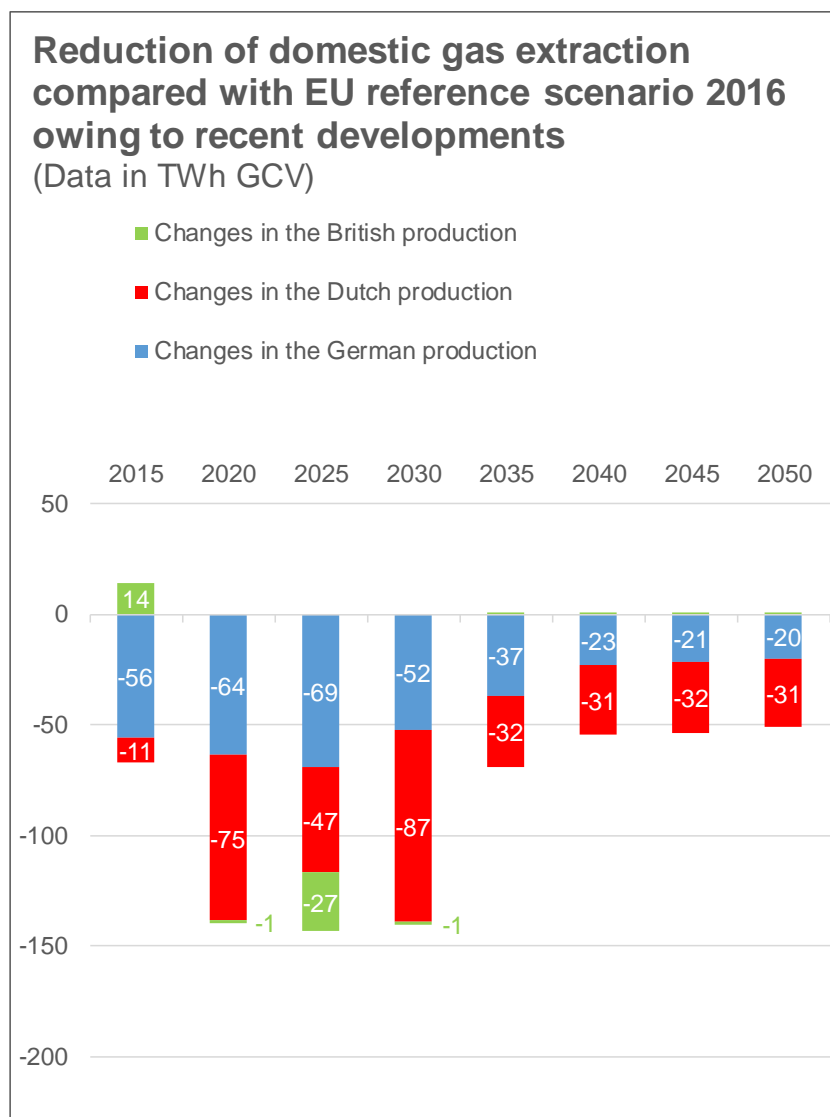
Source: Own presentation based on (DECC, 2016)

Summary of the differences between EU Ref 2016 and the current forecasts of the gas extraction

The following figure shows the differences between the gas extraction forecasted in the scenario EU Ref 2016 and the updated extraction forecasts in the three countries the Netherlands, Germany and the UK.

Taking into account current extraction forecasts, in particular for the Netherlands and Germany, it becomes obvious that **the gas extraction will decrease more** than assumed in the scenario EU Ref 2016. The following discussion of the European **gas import demand** is based on the above presented current extraction forecasts ("modified reference scenario").

Figure 15: Difference between the gas extraction forecast in the scenario EU Ref 2016 and current extraction forecasts for the countries Netherlands, Germany and UK



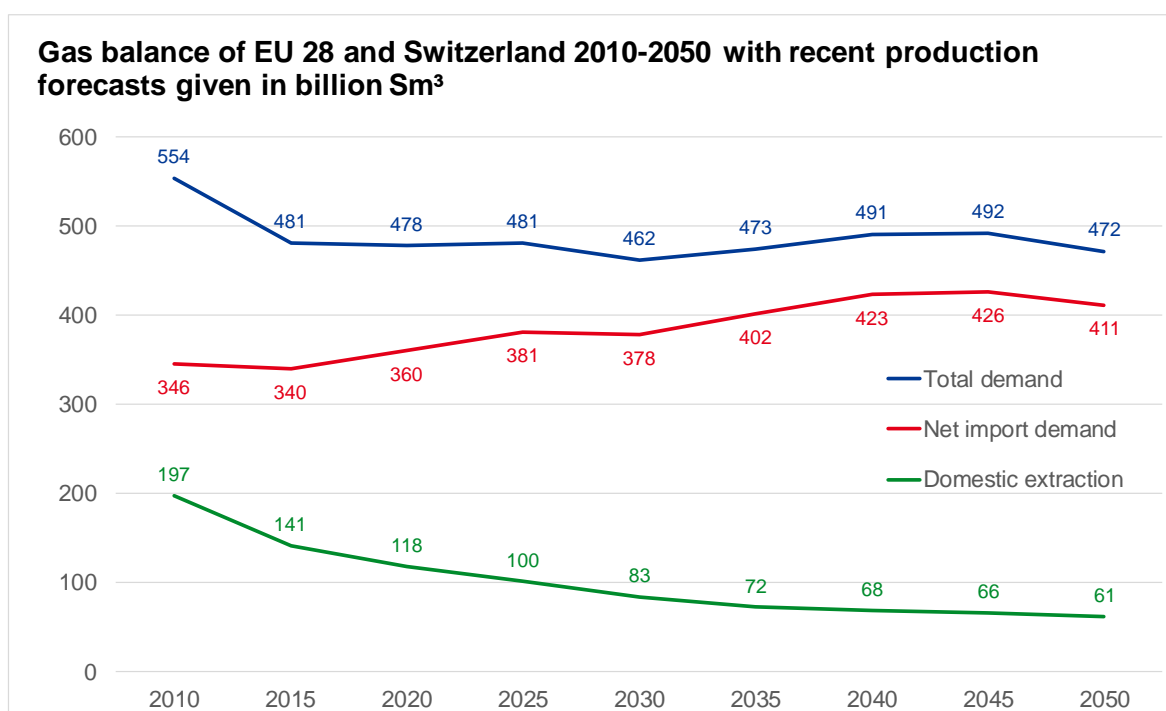
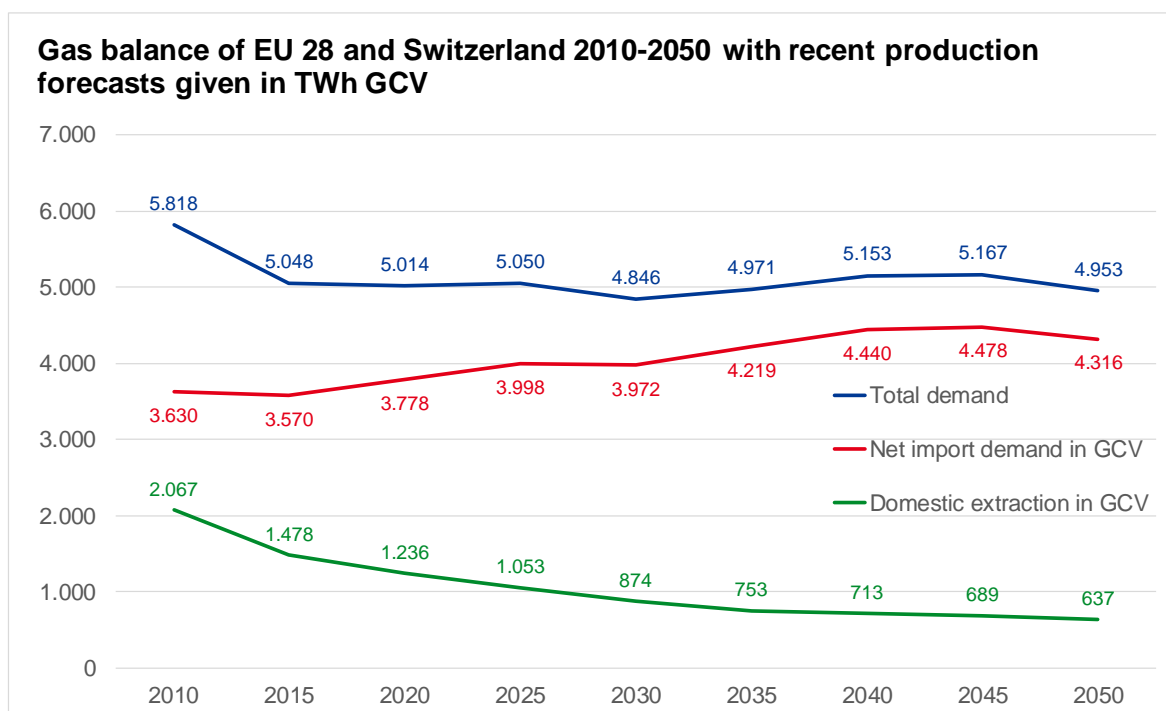
Source: Own presentation based on (GTS, 2015), (Rijksoverheid, 2016), (FNB Gas, 2016), (DECC, 2016), (EC, 2016b)

4.3 Development of the gas import demand in the analysed area

The difference between the development of gas demand (cf. Chapter 4.1) and gas extraction (cf. Chapter 4.2) results in the gas import demand for the analysed area. Thus, the gas import demand of EU 28 and Switzerland is based on the scenario EU Ref 2016 modified by current extraction forecasts for the Netherlands, Germany and the UK (**modified reference scenario**). For Switzerland, we use a reference scenario.

As a result, in 2015 the **gas import demand** amounts to 340 billion Sm³ (3,570 TWh GCV). Until 2020, it will increase by approximately 20 billion Sm³ and until 2025 by about 41 billion Sm³. This means that between 2015 and 2025 the gas import demand will increase by over 12 % (cf. Figure 16). Also **after the year 2030** the **gas import demand** is expected to **further increase**.

Figure 16: Derivation of the gas import demand of EU 28 and Switzerland until the year 2050



Source: Own presentation based on (GTS, 2015), (Rijksoverheid, 2016), (FNB Gas, 2016), (DECC, 2016), (EC, 2016b)

Note: In 2010, gas supplies were withdrawn from gas storage reservoirs which means that net import demand and domestic production does not add up to total consumption. From 2015 onwards, we assume a balanced feed-in and feed-out from storage reservoirs.

4.4 Gas supply to Ukraine

In addition to the gas (import) demand of EU 28 and Switzerland, we have to take into account gas volumes that are transported via EU territory and that affect the EU's supply balance. In the introductory Chapter 2, we have already mentioned that in addition to the development of the import demand in the analysed area, this study includes gas volumes transported to Ukraine.

In 2013, **Ukraine** started to cover an increasing part of its import demand from EU countries using pipelines to Slovakia, Poland and Hungary. For systematic reasons, these volumes are not represented in EU Ref 2016. In 2015, Russia still supplied about 7 billion m³ and Europe about 9 billion m³ to Ukraine (BP, 2016b). In November 2015, Ukraine stopped importing gas from Russia altogether (SZ, 2015), (Sputnik, 2016).

The statistics of "Trade movements per pipeline" in the BP Statistical Review of World Energy clearly illustrate that:

Table 1: Ukraine's gas import including its origin (in billion m³)

Year	Imports from Russia	Imports from remaining Europe
2013	25.1	1.8
2014	12.9	4.6
2015	7	9.2

Source: (BP, 2014) (BP, 2015), (BP, 2016b)

Note: BP and this study use very similar conversion factors (10.46 kWh/m³ and 10.5 kWh/m³), which means that these data are readily comparable to those used in our study. Other sources partially state slightly divergent values.

This was obviously possible due to the fact that in the last years Ukraine's gas demand has substantially decreased. According to (BP, 2016b), in 2015 alone, the gas demand fell by about 22 % to approximately 29 billion m³.⁸ In 2015, according to (BP, 2016b) gas demand and import demand reached their lowest point in decades.

The future development of Ukraine's gas demand, production and import demand is currently hard to predict. Even though important steps towards reforming the Ukrainian gas industry were adopted in 2015 and 2016, it is hard to predict their implementation and the effects.

⁸ (OIES, 2016b), however, states 34 billion m³ for 2015. According to Naftogaz, the 2015 gas demand was 43 billion m³ and the import demand about 20 billion m³ (Naftogaz, 2016). The underlying calorific values are not clear, though.

If Ukraine's gas demand will grow again it is hard to see where the additional demand will be supplied from. For the purpose of this study, it is sufficient to use simple, plausible assumptions.

Therefore, we use the following assumptions about the future:

- Ukraine's gas demand levels will not decrease any further as, for instance, heating-market customers are not able to quickly switch to other energy sources.
- Ukraine's internal extraction will remain more or less stable.
- Import demand levels will not decrease any further.
- In the foreseeable future, according to Ukraine's intentions, gas import demands will be supplied from the West.
- If the gas demand should grow again, it is assumed that these gas volumes are not supplied by the West.

This means, that in the following years about 16 billion m³ of natural gas will be imported from the West. Ukraine's supply from the West increases the gas demand and thus also the EU's import demand (cf. also Figure 30).

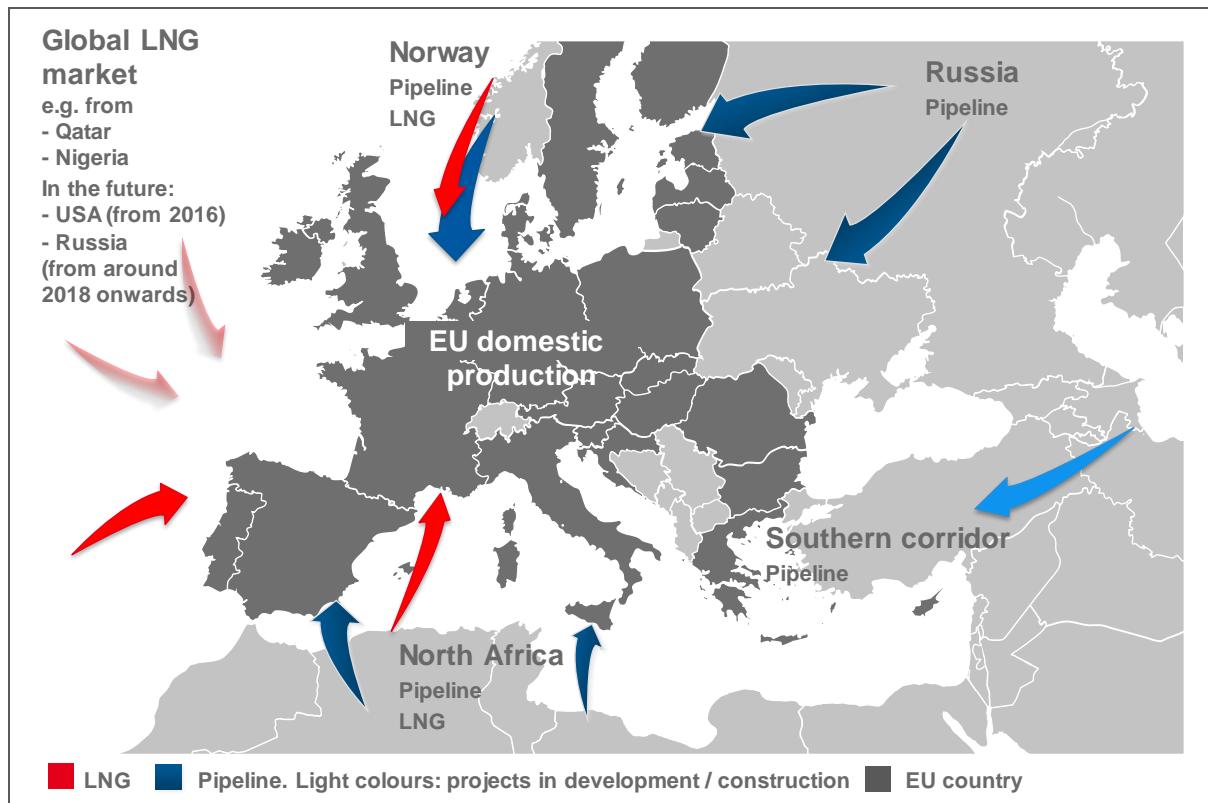
5 Status quo and perspectives of gas imports to Europe

Chapters 1 to 4 of this study have derived the EU's and Switzerland's gas import demand as well as Ukraine's import from the West. It was illustrated that the import demand of the analysed area is supposed to substantially increase due to decreasing internal extraction. This demand has to be supplied to Europe from non-EU countries via pipelines and as LNG. In the following, we will present a worldwide geographical spread of natural gas reserves and a possible development of the gas supply from currently existing or potential supplying countries. For this, we will focus on the export potentials in order to compare the expected annual volumes with the import demand in the analysed area. Export potential refers to a country's capability to produce natural gas in excess of its domestic demand. In addition, this chapter will provide an overview of the transport infrastructure.

5.1 Non-EU gas sources and corridors for the gas transport

The EU's and Switzerland's gas import demand is supplied by pipeline-bound imports from Norway, Russia and North Africa as well as by LNG imports. The map below shows current (dark colours) and future (light colours) sources of import. In principle, all LNG-exporting countries qualify as LNG suppliers (e.g. also Australia). As transport costs for gas are substantial, the Australian exports are likely to be absorbed by the Asian market, though.

Figure 17: Possible sources for supplying the European gas import demand



Source: Own presentation based on (EC, 2016b), (BP, 2016b)

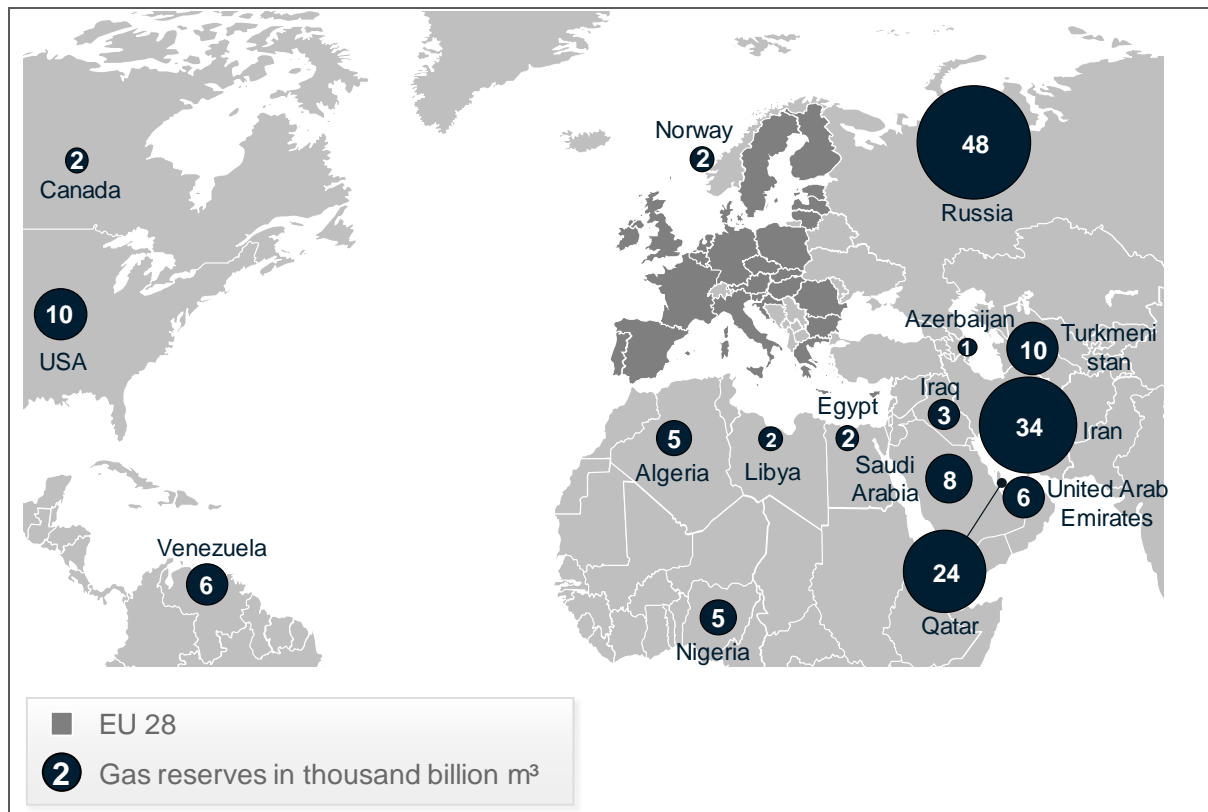
An increase in pipeline-bound imports to Europe could be based on infrastructure projects in the “Southern corridor”. The Trans-Adriatic Pipeline (TAP) and the Trans-Anatolian Pipeline (TANAP) - both currently under construction - enable future gas imports from Azerbaijan to Italy.

The question of which countries could be potential long-term natural gas suppliers is closely connected to the available **resources or reserves**. The German “Bundesanstalt für Geowissenschaften und Rohstoffe” (BGR, Federal Institute for Geosciences and Natural Resources), defines reserves as “verified energy resources that can be economically exploited at current price levels using current technology” (BGR, 2016). Reserves are therefore an important indicator of the medium-term availability of energy resources. Russia, Iran and Qatar have the largest gas reserves worldwide (BGR, 2016).

The following figure shows the gas reserves outside the EU that - due to their geographical position in relation to the EU - are likely to potentially supply the EU. This mainly refers to the gas reserves of the “Atlantic Market”, in Russia and the Middle East. Other far-away gas reserves are less relevant for the supply of the European gas demand as they will primarily supply other regions (Asia,

Pacific region etc.). In theory, it would be possible to import LNG from far-away countries (such as Australia). However, this is less likely due to high transport costs.

Figure 18: Overview of the gas reserves in regions of interest to the EU (in thousands of billion m³)



Source: Own presentation based on (BGR, 2016)

In the following, we will discuss the markets that are potential gas suppliers of the EU and evaluate their future capability to export gas.

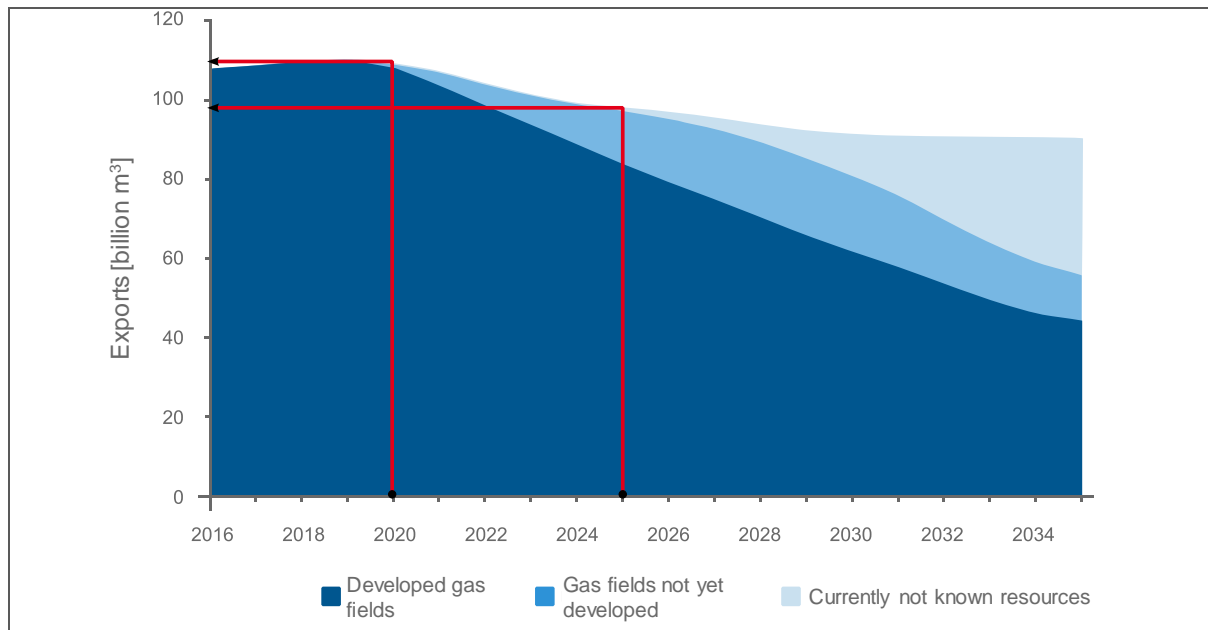
5.1.1 Norway

Norway has 1,922 billion m³ of conventional gas reserves (BGR, 2016). It has a yearly pipeline-bound export capacity of about 180 billion m³ (IEA, 2016a) to the European Union; and together with Russia, it is among the most important countries supplying natural gas to the European Union. Actual deliveries are much lower though. Export capacities include flexibility margins in order to supply different markets according to their respective demand. The pipelines reach the EU shore in the UK, Germany, Belgium and France (IEA, 2016a). In addition, Norway has LNG export capacities of 6.24 billion m³ (GIE, GLE, 2016). There are no plans to expand export capacities in the next ten years (ENTSOG, 2015b).

In 2014, Norway extracted about 107 billion m³ of natural gas, in 2015 even 115 billion m³. This was the largest Norwegian gas production ever. The domestic demand of natural gas is low, which means that almost the entire extracted volume is exported (114 billion m³ in 2015).⁹ Extraction started in 1977 and has substantially increased from the mid-1990s onwards (NPD, 2015). In the short term, the Norwegian Petroleum Directorate expects extracted volumes to decrease to 2014 levels, but forecasts an increase to 111 billion m³ by 2019. For the medium and long term, the Directorate expects exports to decrease to approximately 90 billion m³ in 2035 (cf. Figure 19). However, these volumes include extraction both from fields that have not been explored yet (approximately 13 billion m³) and from resources that are not known yet (approximately 32 billion m³). By 2035, extraction from currently explored fields will be reduced to 42 billion m³ (NPD, 2016). From 2025 to 2050, Norwegian gas exports are perpetuated by - 0.5 % p.a.

⁹ This means that Norway would have an internal demand of only 1 billion m³. As opposed to this, BP 2016 states a demand of 4.7 billion m³. The statistics of NPD 2016 leave some questions open. Using a very cautious estimate, it is assumed that "Sales Gas" refers to the export volume. These data can be downloaded under "Exports" on the homepage of the Petroleum Directorate.

Figure 19: Expected natural gas exports from Norway for the years 2016 to 2035



Note: Red lines make it easier to read the values for 2020 and 2025

Source: (NPD, 2016); According to this source, the Norwegian Sm^3 has 11.1 kWh.

Figure 20: Norway's export pipelines to the EU



Source: (ENTSOG, 2016b)

5.1.2 North Africa

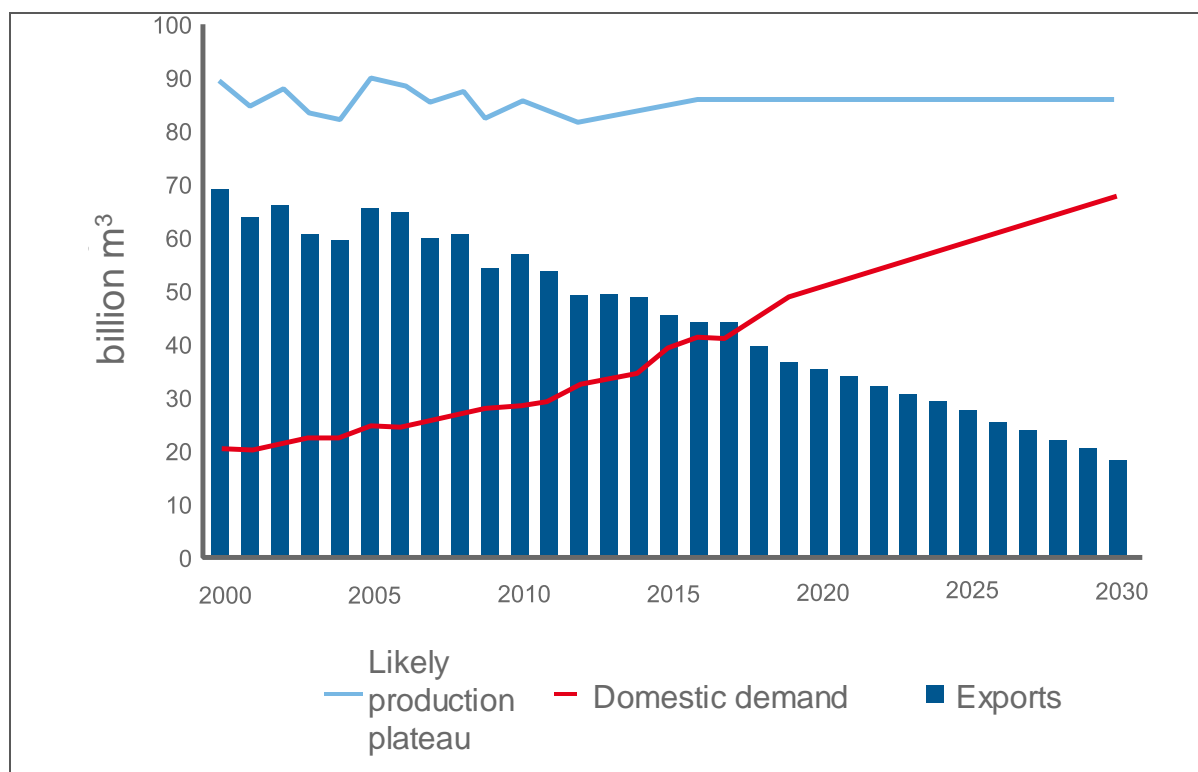
Regarding the region North Africa, large conventional natural gas reserves can be found in Algeria, Egypt and Libya (in the same order 2,745¹⁰ billion m³, 2,167 billion m³ and 1,506 billion m³) (BGR, 2016). Algeria has an annual pipeline-bound export capacity of 60 billion m³ to Spain and Italy (IEA, 2016a) and LNG terminals in Arzew and Skikda with an annual export capacity of 31.2 billion m³ (GIE, GLE, 2016). This means that Algeria is more important to the EU gas balance than Libya and Egypt and will be presented in more detail.

Libya has an annual pipeline-bound export capacity of 13 billion m³ to Italy (IEA, 2016a) and LNG terminals with an annual export capacity of 4.2 billion m³ (GIE, GLE, 2016). **Egypt** has two LNG terminals with an annual export capacity of 15.9 billion m³ (GIE, GLE, 2016).

Since 2010 **Algeria's** net gas extraction has been stable between 80 billion m³ and 83 billion m³. In 2005, it even went up to 88 billion m³. According to (BP, 2016b), however, Algeria's gas demand increased on average 4.6 % p.a. between 2000 and 2015. It can be assumed - according to (OIES, 2016a) - that Algeria's natural gas demand will keep on increasing also over the next years as policies regarding an efficient cap or reduction of the consumption are implemented very slowly or not at all. When perpetuating these trends, already until the year 2020 Algeria's export potential can be expected to decrease by about 8 billion m³ (cf. Figure 21). By 2030, about 20 billion m³ of the export potential would be lost. If the expected reduction of the export potential affects the EU and non-European trading partners equally, Algeria's gas exports to the EU would decrease from 30 billion m³ to 24 billion m³ by 2020 and to about 8 to 12 billion m³ by the year 2030 (OIES, 2016a).

¹⁰ In November 2015, data on established reserves in Algeria had to be reduced substantially. According to government information, established reserves do not amount to 4,500 billion m³, but only to 2,745 billion m³ (OIES, 2016a).

Figure 21: Development of Algerian gas demand, gas extraction and gas export potential



Source: (OIES, 2016a)

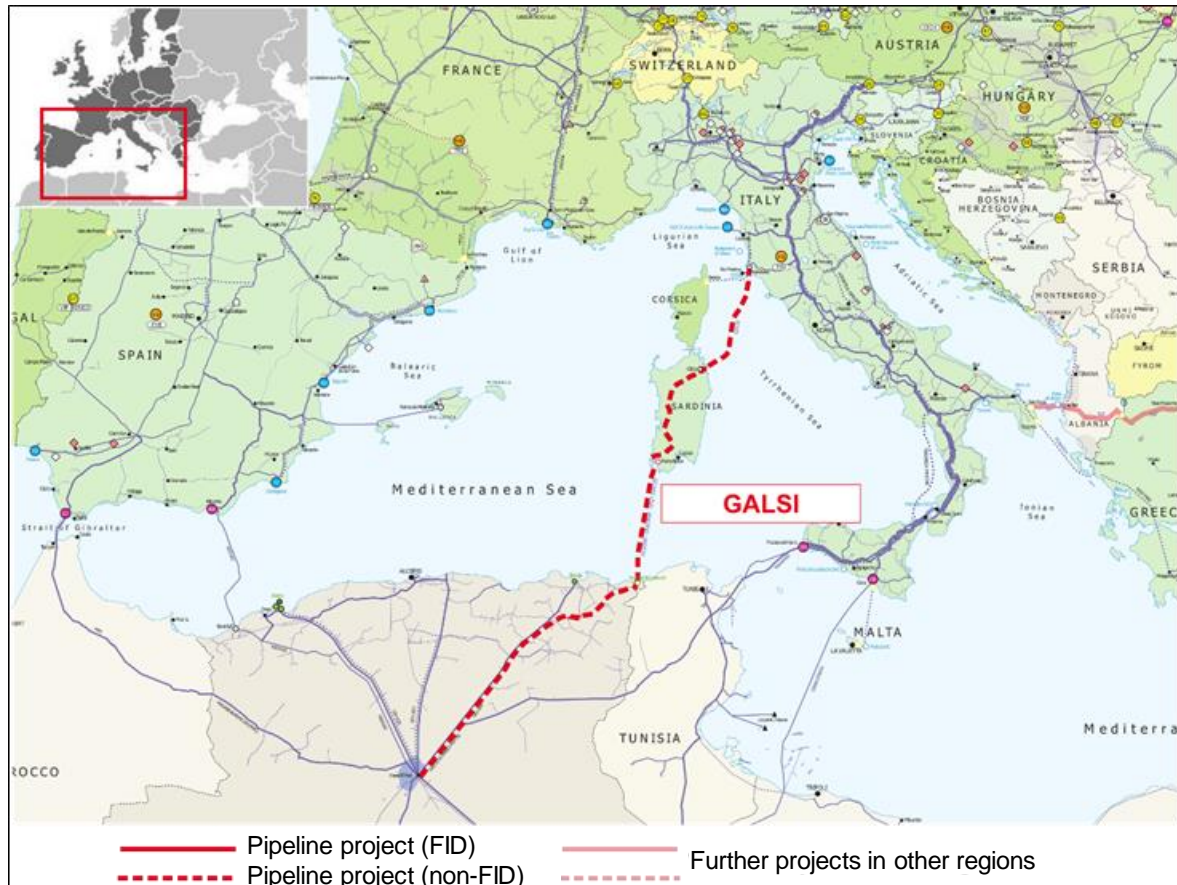
Already in 2005, a feasibility study showed that export capacities could be expanded by 8.8 billion m³ through the GALSI pipeline from Algeria to Italy (ENTSOG, 2015b). However, no final investment decision has been taken yet regarding the project. Taking into account the low utilization rate of the pipelines from Algeria (about 48 % in the period 2014/15 (IEA, 2016a)) and the decreasing export potential, an implementation of this project does not appear to be likely. Algeria's export potential is not limited by infrastructure, but by extraction volumes available for export.

In 2015, export from **Libya** to Italy was 6.5 billion m³ per pipeline. In 2010 exports amounted to as much as 9 billion m³; in 2011 the exported volume fell to only 2 billion m³ due to an export stop that lasted several months (IEA, 2016a), (BP, 2016b). We assume that 6 billion m³ could also be supplied in the future as Libya has a low extraction rate in comparison to its reserves. However, Libya's political situation is much more instable than that of Algeria. Currently, there are no plans to expand the export infrastructure (ENTSOG, 2015b).

In spite of its reserves, **Egypt** is a net importing country of natural gas. Initially Egypt exported from 2003 onwards LNG to Europe and other buyers on the world market as well as pipeline gas to countries in the Middle East. Due to the largely increased domestic

demand for natural gas, Egypt started importing natural gas from Israel in 2013. The large natural gas reserves recently discovered close to the shore may be expected to be absorbed - in the foreseeable future - by the domestic demand (Abdel Ghafar, 2015). We assume that for now no gas will be exported to the analysed area.

Figure 22: North African export pipelines to the EU



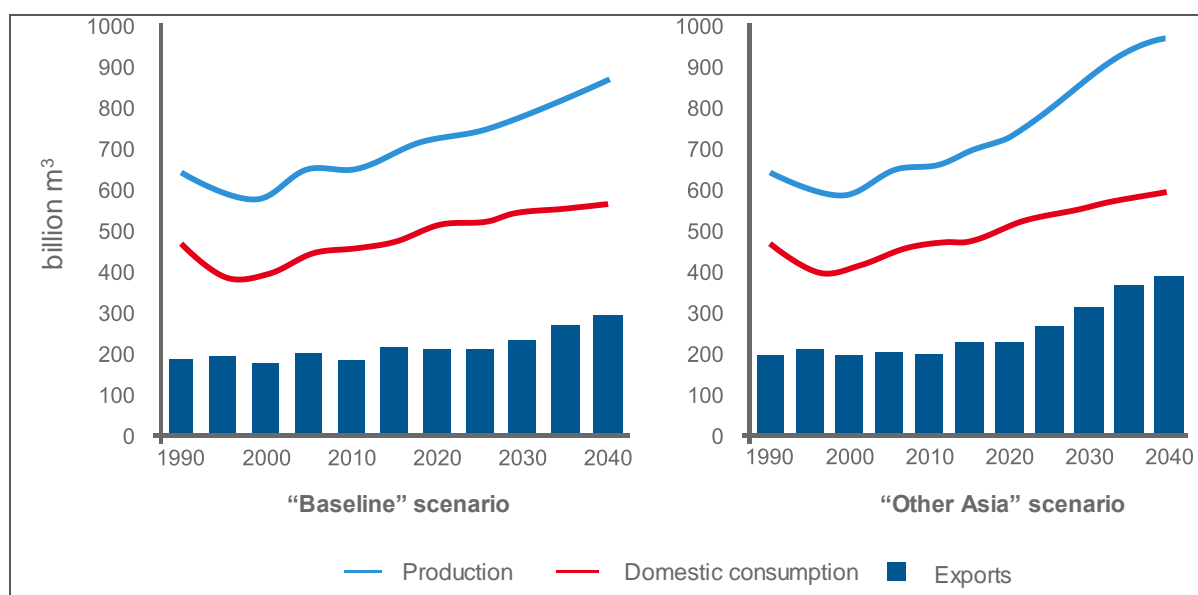
Source: (ENTSOG, 2016b)

5.1.3 Russia

Russia has 47,768 billion m³ of conventional natural gas reserves (BGR, 2016). It has an annual pipeline-bound export capacity of 278 billion m³ towards the EU, partially via Belarus and Ukraine (IEA, 2016a). Russia has also an LNG terminal (Sakhalin 2) at the Sea of Japan (ERI RAS, 2014a). According to information from Total, the first of three trains of the Yamal LNG project with a total capacity of 16.5 million t LNG (corresponding to about 22 billion m³ of natural gas) is supposed to start deliveries in 2018. In addition, there are other LNG projects, both for the Atlantic region (Baltic LNG) and the Pacific region (Vladivostok).

In 2015, Russia's net extraction amounted to about 700 billion m³, with the main part originating from the region Nadym-Pur-Taz, which is also relevant for the export to Europe (ERI RAS, 2014a). With the Yamal province, another province with gas reserves of a similar order has been explored. In 2015, the export rate of the gas extracted in Russia amounted to approximately 35 %. According to ERI RAS (2014a)¹¹, the export rate can be further increased in the long term (cf. Figure 23). In its Gas Medium-Term Market Report 2016 (including forecasts to the year 2021), the IEA states that Gazprom has an unused production capacity of 100 billion m³ (IEA, 2016b).

Figure 23: Expected net exports from Russia



Source: (ERI RAS, 2014a)

¹¹ Figure 23 shows that ERI RAS (2014a) analyses different scenarios for Russia's expected net gas exports. It becomes clear that Russia's extraction capacities could, in addition, even supply a larger Asian demand.

(OIES, 2015) also assumes that this extraction capacity will be available as Russia has invested in the exploration of new gas fields based on an expected increase of the gas demand. Henderson and Mitrova arrive at the conclusion:

„The combined effect of all these market forces has left the company [Gazprom] with a surplus of supply capacity totalling as much as 100 bcm/a.” (OIES, 2015), p. 76*

* inserted by Prognos

In addition to the expansion of LNG capacities, there are plans for two large pipeline connections - Nord Stream 2 to Germany as well as TurkStream 1 and 2 to Turkey. According to ENTSOE (2015), the pipeline Nord Stream 1 has a capacity that is 5 billion m³ larger.

The Nord Stream 2 project comprises two parallel pipes with a total annual capacity of 55 billion m³. This project is already being implemented. In mid-September 2016, the first permit-granting applications were submitted in Sweden. Orders for pipes and concrete casings as well as pipeline laying services have already been placed (DRWN, 2016). Nord Stream 2 is planned to start operations at the end of 2019 (Nord Stream 2 AG, 2016).

The TurkStream Pipeline from Russia via the Black Sea to Turkey is also planned to start operations at the end of 2019. The two pipes of the pipeline have a total capacity of about 32 billion m³, with one pipe of about 15.75 billion m³ being intended to supply the Turkish market. The 15.75 billion m³ of the second pipe could supply the European market. In 2014 the project was put on hold due to diplomatic tensions between Russia and Turkey. On 10 October 2016, a government agreement between Turkey and Russia was signed after the governments of the two countries had come closer again (Reuters, 2016).

Figure 24: Russia's export pipelines to the EU



Source: (ENTSOG, 2016b)

5.1.4 Southern corridor

In this context, the term Southern corridor refers to gas imports towards Europe, mainly imports via Turkey or the Black Sea from the countries bordering the Caspian Sea, with Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan having large conventional natural gas reserves (in the same order: 1,166 billion m³, 1,929 billion m³, 9,934 billion m³, 1,400 billion m³) (BGR, 2016). Until now, there is no gas being exported via pipelines to the EU. Current exports towards Europe have been limited to 15 billion m³ (in 2015) to Turkey (BP, 2016b). For several years, pipeline connections from the region to Europe have been under discussion. The most prominent projects are the TAP/TANAP pipeline that is under construction and the intended connections AGRI (pipeline/ LNG) and White Stream pipeline.

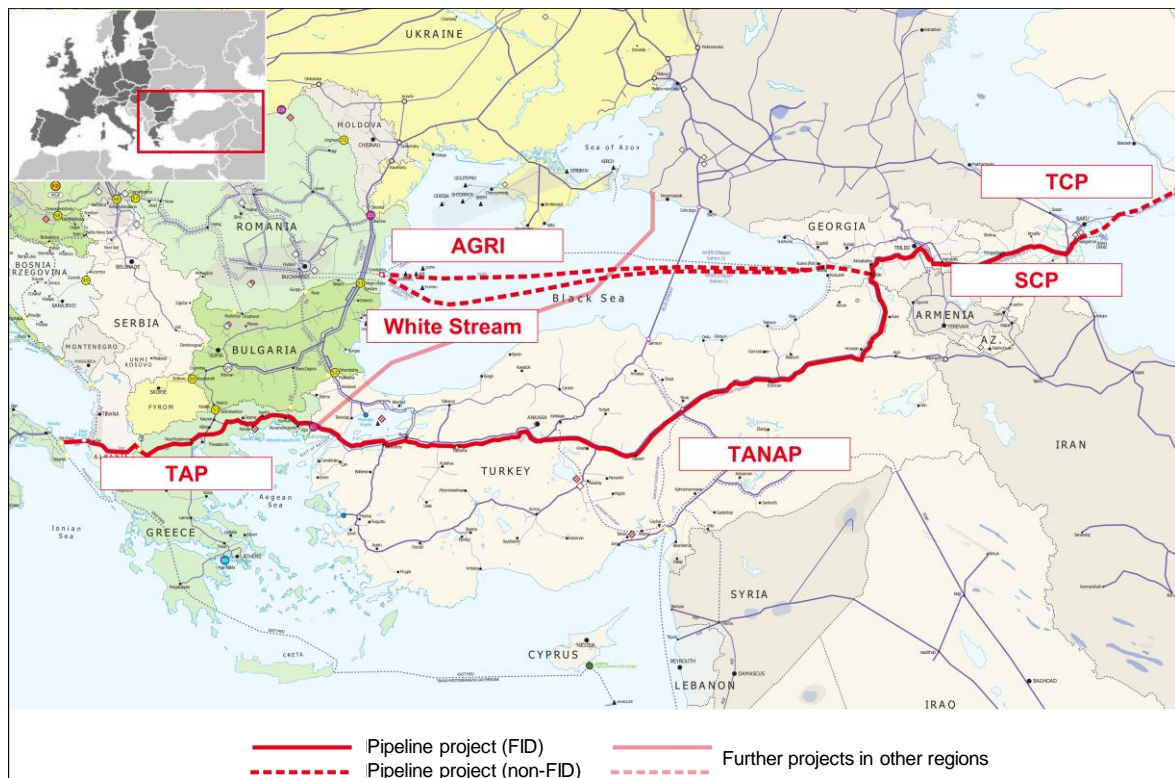
The **TAP/TANAP pipeline** consists of the Trans-Anatolian pipeline (TANAP) and the Trans-Adriatic pipeline (TAP). TANAP is connected in Eastern Turkey to the South Caucasus Pipeline (SCP) in order to transport gas from the Shah Deniz II field off Azerbaijan's shore through Turkey. From 2018, TANAP is supposed to reach an initial annual capacity of 16 billion m³, then 24 billion m³ and eventually 31 billion m³ of gas (TANAP, 2016). In the West, TANAP connects to TAP which transports gas to Italy via Turkey, Greece, Albania and the Adriatic Sea. In 2020, TAP is supposed to start operations with an annual transport capacity of 10 billion m³ that - depending on the demand - could be extended by two additional compressor stations to over 20 billion m³ (TAP AG, 2016a). The pipeline is supposed to be able to operate in reverse flow as well. The construction of the TAP pipeline started mid-2015 (TAP AG, 2016b).

Further infrastructure projects that are supposed to transport gas from the Caspian Sea area to Europe are far from being implemented. The planned AGRI LNG connection would consist of an LNG terminal in Georgia and one in Romania that would be connected to the existing network in Hungary. The planned annual regasification capacity, i.e. the project capacity, amounts to 8 billion m³ (AGRI, 2016). However, the Azerbaijani energy supplier SOCAR deemed the construction of an LNG terminal on the Georgian side to be unnecessary in the near future (Azernews, 2016).

The White Stream pipeline that is intended to cross the Black Sea constitutes an **alternative** to the AGRI project. It consists of a pipeline from Georgia to Romania that in the East could be connected to the Trans-Caspian pipeline that is currently under discussion, in order to transport gas from Turkmenistan to Europe. The pipeline would reach an annual transport capacity of 16 billion m³ and be completed in 2022 at the earliest (EC, 2015). However, no feasibility study has been carried out for this project yet (White Stream, 2015).

Due to the early project phases of the infrastructure projects and the overall political uncertainty in the involved countries, we assume that - with the exception of the TAP/TANAP pipeline - there will be no gas supplied via the Southern corridor to the EU.

Figure 25: Export pipelines of the Southern corridor to the EU



Source: (ENTSOG, 2016b)

5.1.5 LNG

In 2015, the most important countries supplying LNG to Europe were Qatar, Algeria and Nigeria, but also Norway delivers part of its gas exports to Europe as LNG. The first LNG tanker from Sabine Pass in the US was unloaded in Portugal in April 2016. In the future, imports from the US may increase. Also, Russia builds an LNG export terminal in the Yamal area. No deliveries from Yamal LNG are to be expected prior to 2018.

LNG strategy of the EU

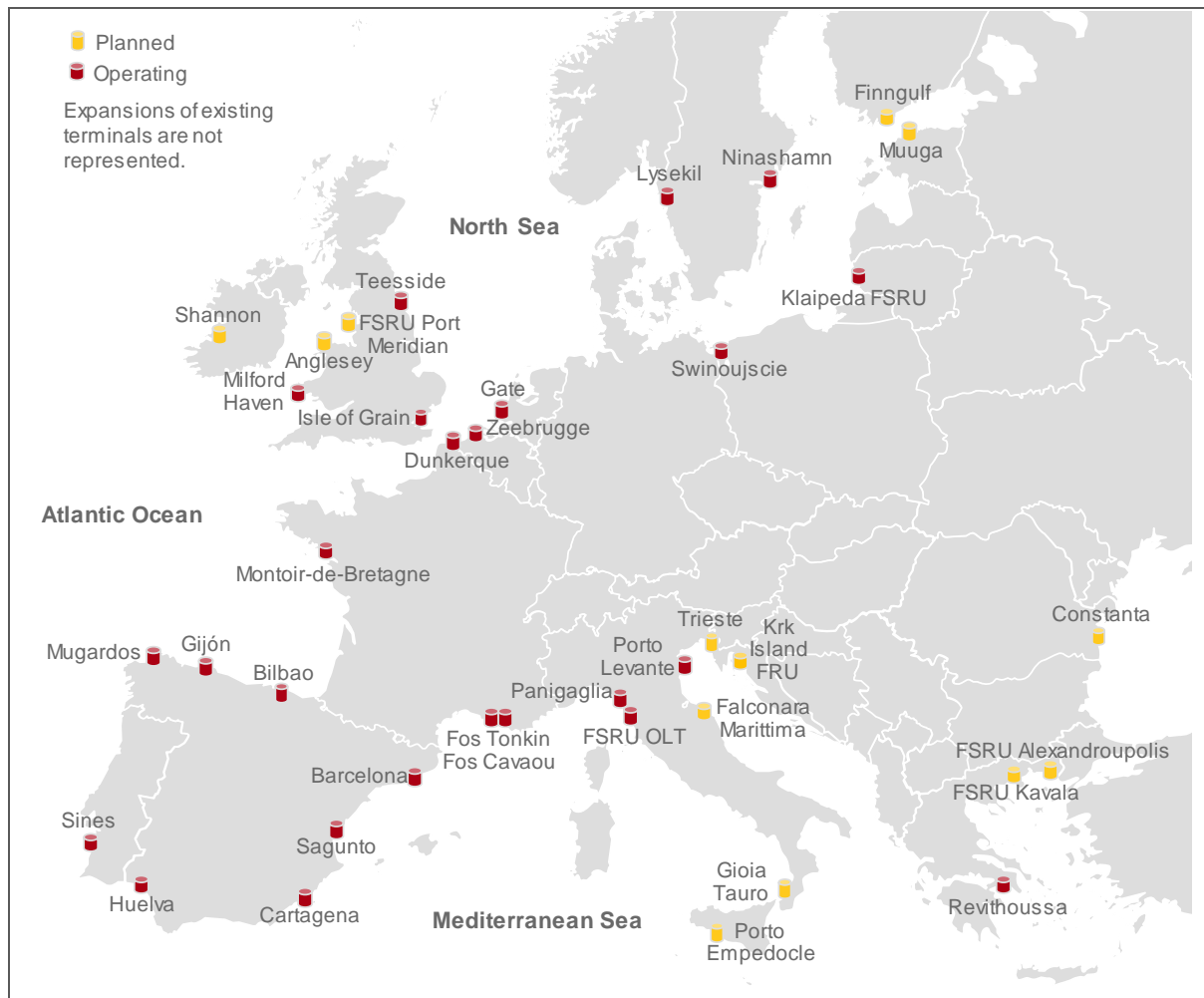
In its bulletin COM (2016) 49 final (EC, 2016c), the European Commission described the EU strategy for liquefied natural gas (LNG) and the storage of gas. It points out that, on the one hand, by the year 2020 there will be increasing gas liquefaction capacities worldwide, and particularly in the US and Australia, and on the other hand, there are significant unused import capacities in some EU countries. The aim of the EU's LNG strategy is to use these market changes in order to develop a secure, diversified and affordable gas supply.

The strategy aims at an optimized geographical spread and access to LNG capacities, improving border-crossing points, completing the implementation of an EU single gas market and improving the international cooperation with the largest LNG suppliers and importers. In some cases, LNG floating storage and regasification units (FSRU) may be a cost-efficient solution. Even though the creation of an infrastructure - if possible - should be driven by market forces, EU funds are also mentioned as possible financing sources for specific projects. Trading obstacles as well as regulatory and legal barriers between efficient regional gas hubs and the markets of individual countries are to be abolished. An improved trans-border access to gas reservoirs and more flexible storage options would add to the potential advantages of the intended increased use of LNG. (EPRS, 2016)

Import capacities

In 2015, LNG imports (incl. LNG from Norway and Algeria) supplied about 14 % of the gas demand of EU 28 and Switzerland. Already today, Europa has large **LNG import capacities**: In 2015, Europe had the third largest import capacities worldwide, with 196 billion m³ p. a. (GIE, GLE, 2016) (GIE, 2016), in the hypothetical case of full utilization, this would correspond to about 58 % of the 2015 gas import demand of EU 28 and Switzerland. More than 70 % of the capacities are located in Spain, France and the UK (Figure 26).

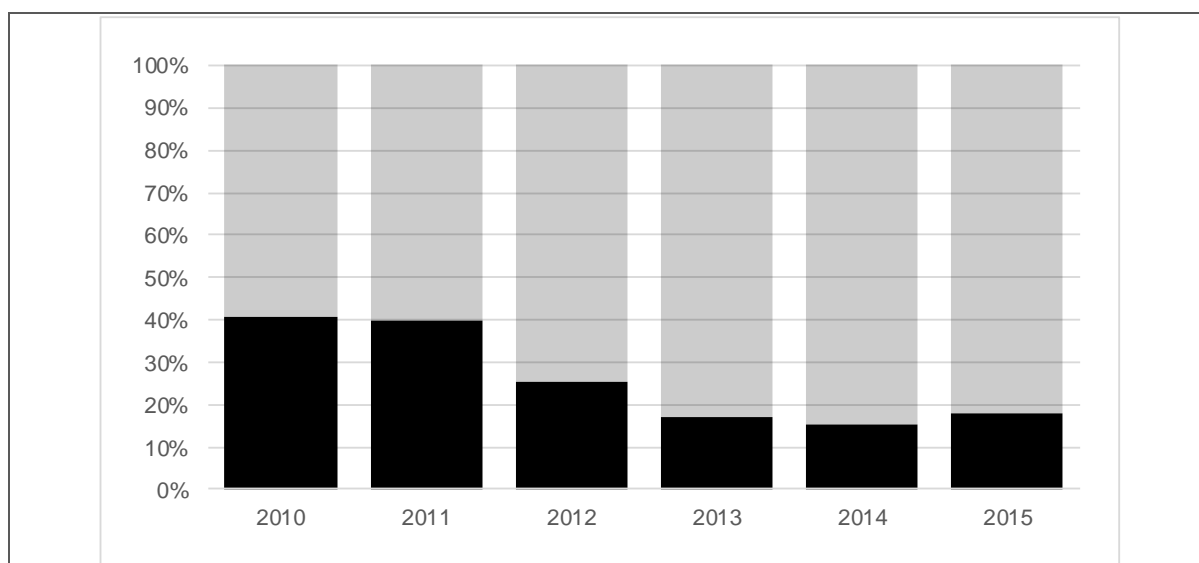
Figure 26: LNG regasification terminals in the EU in 2015



Source: (GIE, GLE, 2016)

However, the regasification terminals have a low utilization rate. Whereas the EU import pipeline had a utilization rate of about 54 % in 2015, LNG import capacities had a utilization rate of only 20 % (in comparison, the regasification terminals worldwide had a utilization rate of about 33 %) (IEA, 2016a). In 2010, when gas demand in the analysed area was higher than in 2015, LNG terminals had a utilization rate of about 40 % (cf. Figure 27).

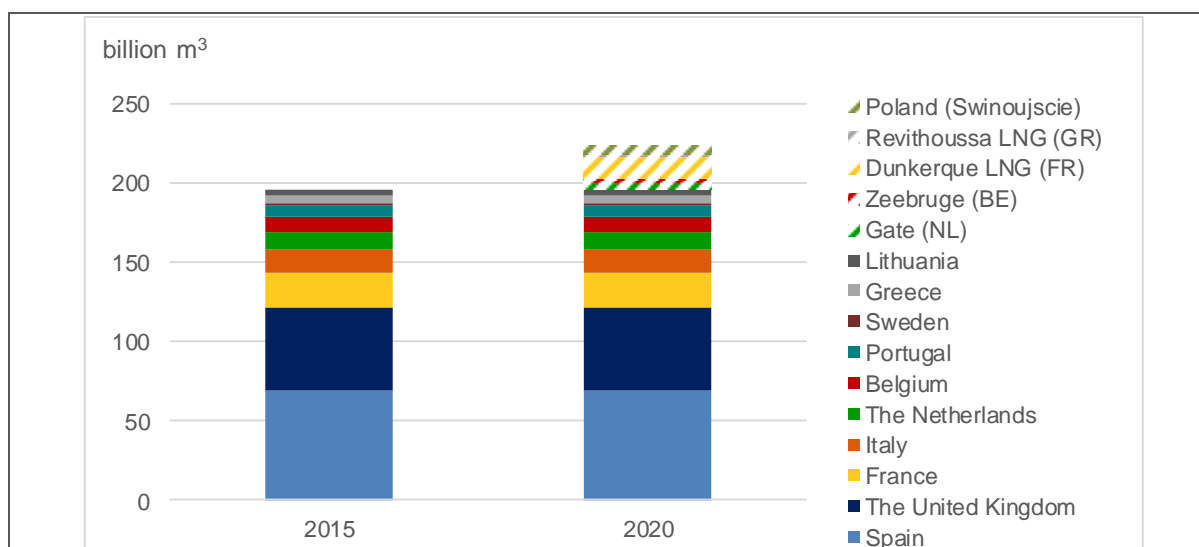
Figure 27: Development of the utilization rate of LNG import capacities in EU 28



Source: (GIE, 2016), (IEA, 2016a)

In spite of the low utilization rate, in 2016 **new LNG projects** were built in Poland (Swinoujscie LNG: 5 billion m³ annual import capacity) and France (Dunkerque LNG: 13 billion m³ annual import capacity). In addition, the **expansion** of existing LNG terminals is planned (stated as additional annual import capacity): Zeebrugge LNG in Belgium (+3 billion m³), Gate LNG in the Netherlands (+4 billion m³) and Revithoussa LNG in Greece (+2 billion m³). In total, the European import capacities could increase by about 27 billion m³ to 223 billion m³ in 2020 (cf. Figure 28).

Figure 28: Development of LNG import capacities in EU 28



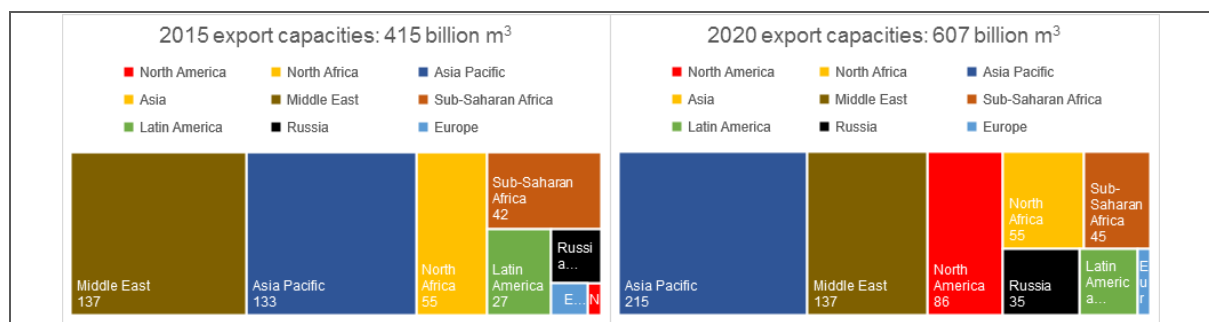
Source: (GIE, GLE, 2016)

When evaluating the capacities of the LNG terminals, we have to take into account that a large part of the Spanish terminals are not fully available. In the medium term, these capacities can only be used to a limited extend for the supply of neighbouring countries, as the border-crossing capacities between Spain and France are weakly dimensioned. Due to the low capacity at the border-crossing points, currently only about 9 % of possible LNG gas imports can be exported from Portugal and Spain to France.

Export capacities

In the short and medium term, a substantial **development of LNG export capacities** worldwide can be assumed to take place and could potentially supply large gas volumes to Europe. According to (IGU, 2016), between 2015 and 2020, LNG export capacities worldwide will increase by about 46 %, which means from a current 415 billion m³ to 607 billion m³ (+192 billion m³). This increase is mainly due to projects in the **US and Australia** (cf. Figure 29). For the European market, the countries of the Atlantic Basin and the Gulf States are relevant.

Figure 29: Development of LNG export capacities worldwide



Source: (IGU, 2016); GCV values (European standard)

In many cases, the decision to build **LNG projects** was taken during times of higher gas prices when the IEA expected a „golden age“ for gas (IEA, 2011).

A wave of LNG developments has created excess supply on the **LNG market** that is expected to continue until at least 2022; after that, it may be absorbed depending on the development of the demand in Asia. In addition, weak crude oil prices and low demand exert a downward pressure on gas market prices as they are often indexed to oil prices. Even though low gas prices enhance gas imports, they make the development of further LNG capacities unattractive. Investments in LNG capacities are partially already being slowed down; LNG projects in Canada, Russia and East Africa have been postponed or cancelled. This means that the long-term development of the LNG market is rather uncertain. In Europe, LNG has even to compete with pipeline gas.

Europe has sufficient LNG import capacities in order to benefit from this short- to medium-term excess supply. However, there are two obstacles that could restrict LNG imports to Europe. On the one hand, the EU **competes with other buyers**, particularly from Asia, regarding the existing LNG volumes. On the other hand, there are some **infrastructural bottlenecks** in the EU. At the Spanish-French border, for instance, there are only very limited border-crossing capacities, which means that LNG imports reaching the Iberian Peninsula can hardly be transported to other EU countries. Therefore, it is questionable whether a permanent, extensive development of LNG imports to Europe can be successful.

5.1.6 Interim conclusions

In general, we can say that currently the analysed area EU 28 and Switzerland has good access to **various gas sources**. In the future, the gas import demand is expected to increase (cf. Chapters 4.3 and 5.2) which constitutes a challenge to the European **security of gas supply**.

Several **non-EU gas sources**, such as Algeria and also Norway, are not an option for future additional gas exports to Europe. Above all, the supply from Algeria can be expected to decrease substantially.

The **Southern corridor** offers the possibility of a number of future infrastructure projects. However, these are still very uncertain in the context of the required sources. Particularly until the year 2025, we cannot expect an increase in gas volumes imported to Europe, in excess of the already included 10 billion m³ to be imported via the TANAP/TAP system from Azerbaijan.

The **LNG market** faces a worldwide expansion of import and export capacities. The EU will benefit from this situation, mainly until the early 2020s. After that, a demand competition with other LNG buyers - above all from Asia - is to be expected.

Russia has a large, unused production potential that is available for exports.

The **additional gas import demand** of EU 28 and Switzerland is expected to be mainly supplied by **pipeline gas from Russia** and **LNG**. Competition, i.e. the market, will determine the respective proportions.

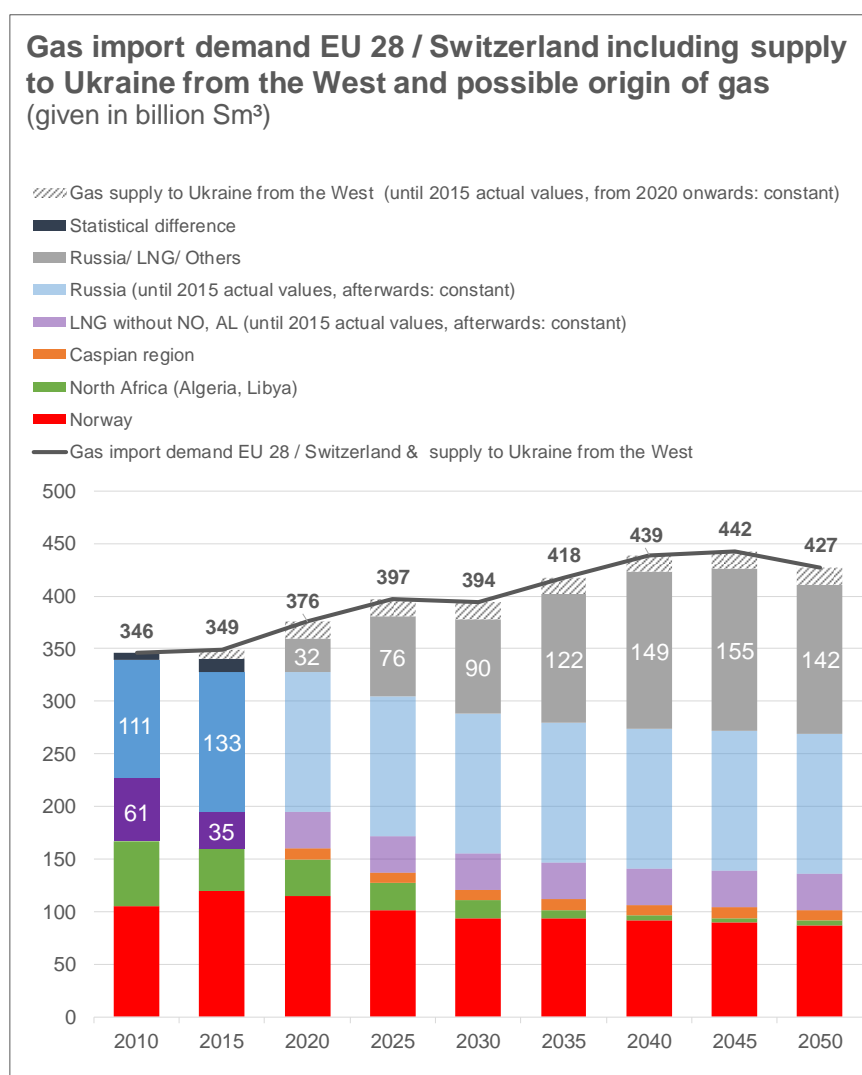
5.2 Perspectives of supplying the gas import demand until the year 2050

5.2.1 Supplying the gas import demand from sources outside the EU

Chapter 4 derives the gas import demand of the analysed area. It is expected to increase substantially until 2025, stagnate between 2025 and 2030 and then continue to grow further. An overview including gas sources in non-EU countries of origin (cf. Chapter 5.1) shows the need of additional imports, which is derived as follows:

- Due to the decreasing availability, imports from **Norway** and above all from **Algeria** to EU 28 and Switzerland will be reduced substantially already prior to 2030. In 2040, Algeria's export potential could be depleted.
- New natural gas sources, e.g. in the **Caspian region** or Iraq/Iran, will be **hardly available** due to missing transport corridors and extraction infrastructure; in the medium term, they can therefore only contribute to a very limited extent to the supply of the European gas demand.
- In 2015, **Russia** and the **worldwide LNG suppliers** (excluding Norway and Algeria) delivered together about 168 billion Sm³ to the EU.
- If the actual 2015 values for Russia and LNG are perpetuated into the future, there will be an additional gas import demand that is represented in Figure 30 as a grey bar.
- Already in 2020, about 32 billion Sm³ would have to be imported additionally from Russia and/or the global LNG market; the value for 2025 would be 76 billion Sm³.
- We also have to add the gas supplied by the West to **Ukraine**. In 2015, the EU supplied 9 billion m³ and Russia about 7 billion m³ to Ukraine. From 2020 onwards, the supply from the West to Ukraine is assumed to be 16 billion m³.
- The demand has not been assigned individually to the LNG world market and Russia, as these sources (and other possible sellers) compete with each other. The market finally determines who will supply the here presented additional demand.

Figure 30: Gas import demand EU 28 and Switzerland and possible origin of the gas, 2010 to 2050



Note: For an explanation of "statistical difference" see the appendix.

Source: Prognos based on several sources, among others (EC, 2016b), (BP, 2016a), (OIES, 2016a), (NPD, 2016), (Prognos AG, 2012)

5.2.2 Comparison of the results with other scenarios

A limited number of studies analyse - in addition to the development of the European gas demand - both the European import gas demand and the possible sources of the additional gas demand and are therefore suitable to **verify the results** of the current study.

- **IHS Cera** (IHS, 2016) - a data provider of the energy sector offering original scenarios with high spatial resolution (on country level) - constitutes the only source that allows a direct comparison with the current study. The scenario "Rivalry" evaluated here shows an almost linear slight increase in gas demand for the area EU 28 and Switzerland.

Europe's internal extraction is also assessed to decrease, however not as much as in the current study. As a result, the gas import demand increases during the analysed period from about 3,400 TWh (323 billion m³) in 2015 to about 4,900 TWh (467 billion m³) in 2040. This means that IHS Cera expects a **higher gas import demand** in 2040 than this study has calculated (423 billion m³). The higher gas import demand can be partially explained by the fact that IHS Cera forecasts a continuously **increasing EU gas demand** that grows by about 15 % between 2015 and 2040.

- **Cedigaz**, a non-profit data service provider specialising in the gas industry, has created its own reference scenario for the development of the gas import demand and the origin of natural gas supplies. Even though the 2015 publication evaluated here (Cedigaz, 2015) refers to the EU and seven other countries, it is possible to roughly compare the results to the current study.¹² The study expects a moderate **increase of the gas demand** until 2020, followed by a substantial further increase until 2035. At the same time, the study predicts a substantial decrease of Europe's internal gas extraction, which means that gas import demand will rise above all after 2020. For Europe, the expected increase between the base year (2013) and the year 2020 amounts to about 616 TWh (58.7 billion m³). It will double between 2020 and 2035 and increase to 1,274 TWh (121 billion m³) by then. According to Cedigaz, the **additional gas import demand** will be supplied by higher LNG imports (23 % of the gas supply in 2035 compared to 8 % in 2013), Russian pipeline gas imports (about 36 % of gas supply in 2035 compared to approximately 30 % in 2013) and an increased unconventional gas extraction (6.8 % of the gas supply in 2035 compared to 0.2 % in 2013). In a study published in June 2016 (Cedigaz, 2016), Cedigaz has updated the European gas demand. It takes particularly into account the targets of the EU climate and energy policy until 2030 that were adopted by the EU Heads of States and Governments in October 2014 and are based on the Climate and Energy Package 2020. Cedigaz still expects an increase between 2014 and 2020, as stated in (Cedigaz, 2015). However, the gas demand from 2020 onwards has been adjusted. Due to the larger role that renewable energies will play in 2030 (at least 27 % of the energy end-use), Cedigaz does not expect any increase of the European gas demand between 2020 and 2035.
- In June 2016, the Norwegian oil and gas group **Statoil** published a study with the title "Energy Perspectives 2016". The study contains three future scenarios that are called Reform, Renewal and Rivalry. Reform represents the

¹² The region Europe includes the following countries: EU 28, Switzerland, Turkey, Norway, Serbia, Bosnia, Albania and Macedonia.

national obligations derived from Paris 2015, Renewal is a target scenario that assumes that the 2-degrees target is reached. Rivalry, on the other hand, describes a world with uncoordinated developments characterized by geopolitical conflicts. Reform describes a “middle” path. A balance of the future gas import demand was also established. The analysis refers to “Europe” without any specifications; and the sources of the gas supply are not discussed either (Statoil, 2016). The Reform scenario which appears to be suitable for a comparison expects the **European gas demand to decrease** between 2015 and 2040 (-6 %). The **internal production** was only simulated until the year 2020 and refers to the European gas extraction excluding Norway. Until 2020, the gas extraction is expected to decrease by about 14 % with the gas import demand increasing only slightly (3 %) due to a decreasing gas demand.

- In 2016, the US energy group **ExxonMobil** published a vision of the long-term development of the energy markets until the year 2040 (ExxonMobil, 2016). This study presents, among others, a gas balance for seven regions¹³ for the years 2010, 2020, 2030 and 2040. Here, the region Europe is larger than EU 28, but similar to the Statoil study without any further specifications. ExxonMobil expects the **European gas demand** to decrease by 10 % between 2010 and 2020. According to the study, gas demand will then increase and in 2040 exceed the 2010 levels. The **gas import demand** will remain unchanged at approximately 2,650 TWh (252 billion m³) between 2010 and 2020, with the decreasing European gas demand being offset by a lower European gas production. After that the gas import demand will increase and level out at approximately 4,150 TWh (395 billion m³) in 2040.

The different results of the studies show a possible **variation regarding the development of the European gas import demand** (cf. Figure 31).

The assessment of the gas demand varies widely. EU Ref 2016 is at the low end of the analysed reference scenarios. However, Chapter 6.1 shows that several target scenarios expect a lower gas demand in the long term.

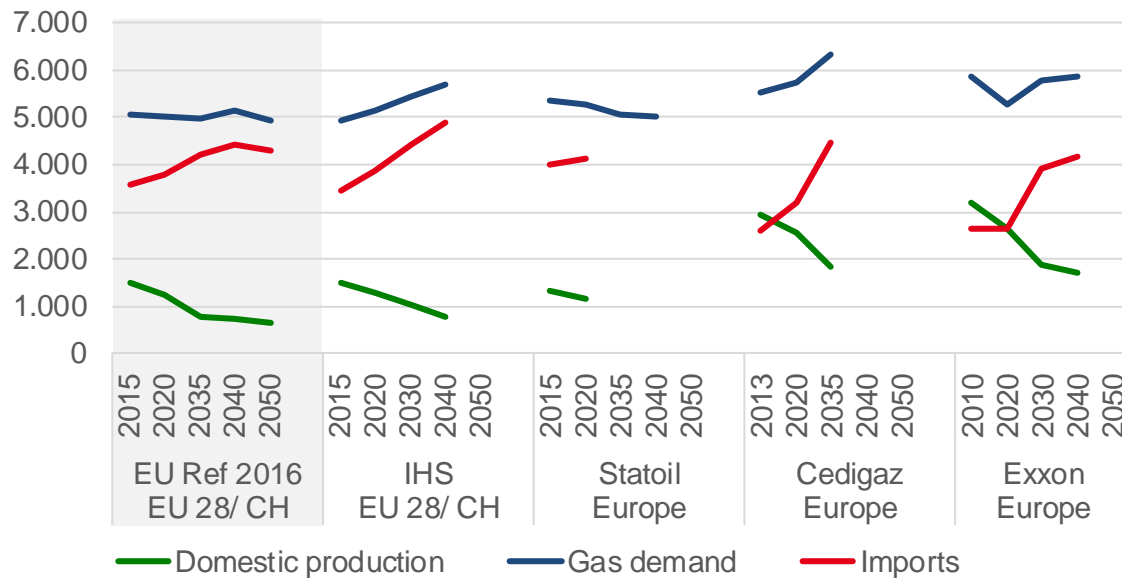
All studies assume a decreasing internal gas production in Europe.

In total, the included reference scenarios with a gas balance of their own expect a growing gas import demand.

¹³ North America, Latin America, Africa, Europe, Russia/Caspian area, Middle East, Asia/Pacific region.

Figure 31: Comparison of the development of the gas balance in various studies

Gas balance according to studies [TWh]

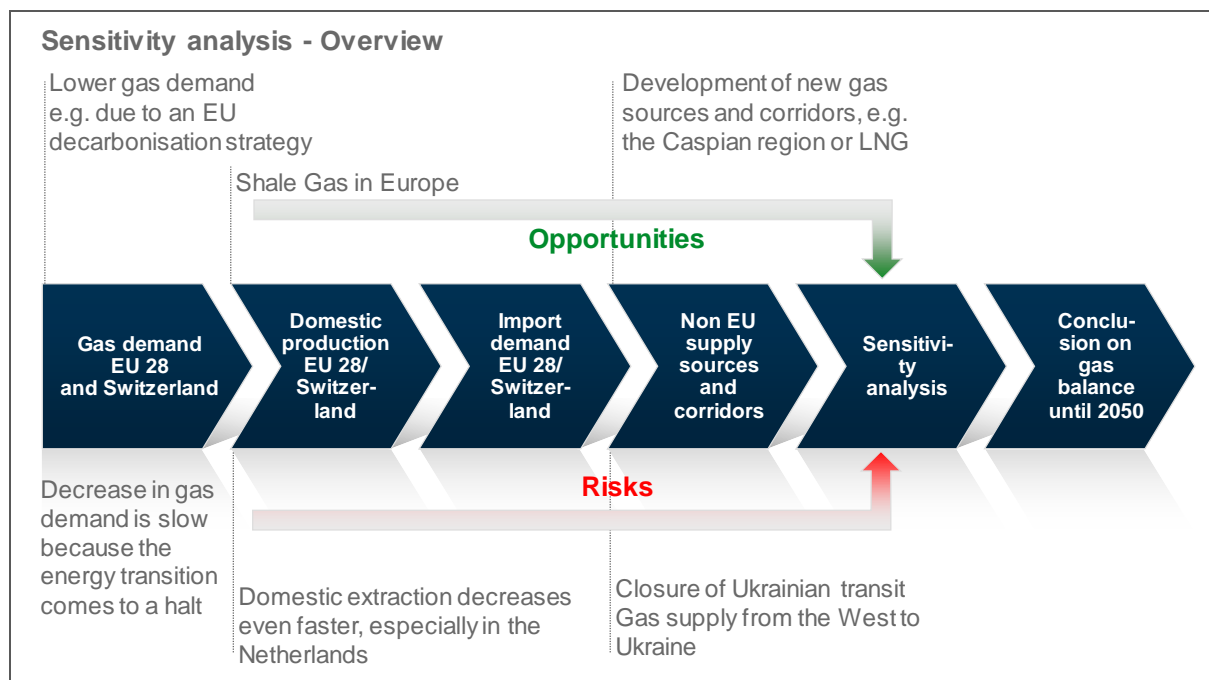


Note: The studies prepared by Statoil, Cedigaz and ExxonMobil refer to the analysed area "Europe" which means that they differ geographically from EU 28 and Switzerland.
Source: Own presentation and calculations based on (Cedigaz, 2015), (ExxonMobil, 2016), (Statoil, 2016), (EC, 2016b), (IHS, 2016)

6 Sensitivity analysis: Opportunities and risks for the European gas balance

The previous chapters have derived the gas import demand of EU 28 and Switzerland until the year 2050. Numerous expert publications were evaluated and additional assumptions were made regarding the development of gas demand, gas extraction and gas infrastructure. The used information and assumptions regarding future situations are naturally prone to **uncertainties** which means that all components of the gas balance may include developments that deviate from the reference. This chapter uses a sensitivity analysis to discuss various opportunities and risks for the European gas balance, and their impact. For this purpose, assumptions made in previous parts of this study will be varied. Figure 32 illustrates how this is part of the overall design of the study.

Figure 32: Overview sensitivity analysis



Source: Prognos AG

Unpredicted events (e.g. crises), **decisions** (e.g. regarding the climate policy) or **developments** (e.g. extraction technology) may result in future developments differing from expectations. This may have an unfavourable or favourable effect on the gas balance. In the context of the **security of supply**, the following definition of opportunities and risks for the gas balance is used:

- Here **opportunities** improve supply in relation to demand, e.g. through the exploration of new fields or lower gas demand. This way the gas balance is rather “long”, i.e. characterized by excess supply. This situation can also be described as a “buyers’ market” as the buyers (or consumers) have a stronger position in this case.
- **Risks** in this context result in a deterioration of the gas supply in relation to the gas demand, e.g. by a faster decrease of the gas extraction or additional gas demand. This way the gas balance is rather “short”. And we are faced with a sellers’ market.

In general, we can assume that in a functioning market - due to the corresponding price signals - supply and demand will be balanced, with a certain time lag.

The following tables present **opportunities and risks** for the European gas balance and assess their probability and impact intensity in a qualitative way. Here, risks or opportunities always refer to **deviations from the reference**, i.e. from the presented assumptions and relationships.

The following subchapters will describe the individual aspects in more detail. The following tables do not claim to be exhaustive. Above all, **Prognos has not analysed any technical risks**.

Table 2: Opportunities for the gas balance

Opportunity	Description	Probability of occurrence	Indications over the intensity of impacts
Lower gas demand	Greater use of renewable energy sources and energy efficiency leads to a lower gas demand compared with the reference scenario	before 2025: low after 2025/2030: medium	See Figure 33
Development of unconventional gas	Europe develops unconventional gas, e.g. shale gas. The decline of domestic production slows down.	low	Not quantifiable, medium-term few billion m ³
Biomethane production and network feed-in	Europe produces more biomethane, which is injected into the transport network.	low	Theoretical potential: high Realistic potential: few billion m ³
Higher gas extraction in Poland	Poland increases its gas extraction activities faster than expected.	low	See Risks
Higher gas extraction in the Netherlands	The Netherlands lift restrictions to the development of Groningen field.	low	Between December 2014 and September 2016, gas output in Groningen field decreased by 15 billion m ³
Higher gas exports from Norway	Development of known reserves takes place more rapidly.	low	Gas flows from non-developed fields could amount to 10 billion m ³ in 2025 according to projections.
Higher gas exports from Algeria	Algeria successfully introduces measures to curb gas demand, which would make more gas available for exports	low	Algerian supplies to Europe in 2015 amounted to around 34 billion m ³ , the decline being partly taken into account
Higher gas exports from Libya	The stabilisation of Libya leads to higher gas exports	low	All-time peak of Libyan exports (9 billion m ³ in 2010) exceeds the reference assumptions by 3 billion m ³
Higher gas exports from Russia	Russia increases its gas exports / competition with the global LNG market	high	Export amounts from Russia would result from competition with LNG.
Development of new gas sources outside of Europe	Iraq, Iran, Turkmenistan or other countries expand their production capacities. The southern corridor gets further production and transport capacities for exports.	low	Not quantifiable, theoretically big potential
Higher gas exports from the global LNG market	The expansion of LNG export capacities worldwide maintains the oversupply.	Until 2025 medium, long-term low	LNG imports in 2010: 79 billion m ³ , 2015: 40 billion m ³ . Import capacities in Europe are much bigger.

Sources probabilities of occurrence: Estimates by Prognos; impact intensity: see tables

Table 3: Risks for the gas balance

Risks	Description	Probability of occurrence	Indications over the intensity of impacts
Higher gas demand	Gas demand reduction slows down, e.g. because the energy-refurbishment of buildings takes longer than expected in the reference	low	See Figure 33
Cold winter	The use of gas for heating fluctuates with the temperatures, so that gas demand increases during particularly cold years	high	Gas demand increases up to 10% during very cold years compared with average years
Lower gas extraction in Poland	The estimated production forecasts for Poland will not be reached.	medium	Poland extracted 4,5 billion m ³ gas in 2015, EU Ref 2016 assumes an increase to 6 (2025), 10 (2030), 14 (2040), 18 (2050) billion m ³ . IHS estimates are 1-3 billion m ³ lower.
Lower gas extraction in the Netherlands	Due to further earthquakes, the Netherlands reduce their gas extraction even more.	medium	Most recently (2016), gas extraction has been reduced by 6 billion m ³ . Further decline has already been partly taken into account.
Lower gas exports from Norway	Development of known and unknown reserves cannot take place or will be delayed	until 2030: low, after 2030: medium	According to a study from IHS, gas exports could be around 10 billion in 2035 and 24 billion m ³ in 2040 lower than our assumptions
Lower gas exports from Algeria	Algerian gas demand increases faster or production declines, so that even less gas is available for exports to Europe.	low to medium	Algerian supplies to Europe in 2015 amounted to around 34 billion m ³ , the decline being partly taken into account
Lower gas exports from Libya	The disintegration of state structures in Libya affects gas extraction activities and leads to declining exports.	medium	Libyan supplies to Europe in 2015 amounted to around 6 billion m ³ . In 2011, exports collapsed to 2 billion m ³
Lower gas exports from Russia	Russian export potential does not increase so quick as expected	low	Export amounts from Russia would result from competition with LNG.
Stalled gas transit through Ukraine	An agreement on gas transit through Ukraine after 2020 fails to be reached.	medium to high	Supplies through Ukraine in 2015 amounted to around 63 billion m ³ , including 48 billion m ³ for the EU
Lower exports from gas sources outside of Europe	Completion of TAP/TANAP pipelines fails or is delayed	low	Transport capacity in the EU (Italy) 10 billion m ³
Lower gas exports from the global LNG market	LNG export capacities do not rise so fast as expected	low	LNG amounts would result from competition with Russian (pipeline) gas.

Sources probabilities of occurrence: Estimates by Prognos; impact intensity: see tables

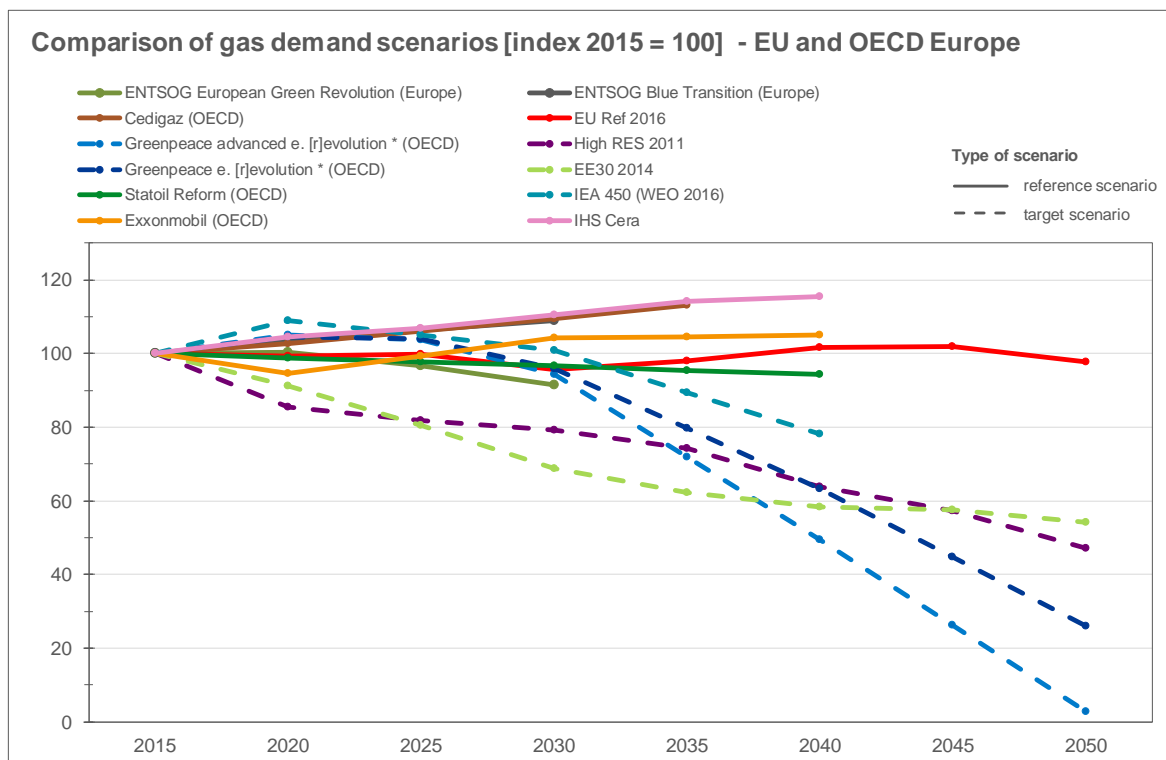
6.1 Demand-side opportunities and risks

Gas demand lower / higher

There is a **large number of different scenarios** regarding the future gas demand to be expected in the EU or Europe. The expected gas demand varies substantially **depending on the scenario**. Particularly, from 2030 onwards the results show a wide spread. Here, the **type of scenario** is essential as the scenarios use different assumptions. In general, reference scenarios (cf. chapter 2) expect a higher gas demand.

In the EU Commission's **reference scenario 2016** - that is central to this study – it is assumed, for instance, that all targets and measures that are already passed will be implemented. However, *“Ref 2016 does not include the politically agreed but not yet legally adopted 2030 climate and energy targets”* (EC, 2016b), p. 5. The following Figure 33 represents the development of the gas demand in several of the analysed scenarios.

Figure 33: Development of the European gas demand in different scenarios (presentation as indices)



Source: Own presentation based on (Cedigaz, 2015), (EC, 2016b), (E3M, 2014), (ENTSG, 2015a), (ENTSG, 2016c), (Greenpeace, 2015), (IEA, 2015), IEA (2016), (Statoil, 2016), (ExxonMobil, 2016), (IHS, 2016)

Figure 33 illustrates that most scenarios expect a comparatively stable gas demand until 2030. This applies to all reference scenarios and even to the target scenarios *IEA 450* and *energy revolution* of Greenpeace. The EU Commission's target scenarios from 2011 and 2014 - assuming an ambitious development of renewable energies and an energy efficiency increase in line with the target - expect the gas demand to decrease substantially already by 2030.

The scenario *Statoil Reform* is already based on Nationally Determined Contributions (NDCs) for a reduction of green-house gases. However, the NDCs adopted until 2015 are not completely consistent with the target of limiting global warming to "substantially below 2°C". This means that *Statoil Reform* lies somewhere in between a reference scenario and a target scenario. This scenario expects the gas demand to decrease slightly until 2040.

From 2030 onwards, the results of the scenarios regarding the gas demand show a substantial spread. Both the Greenpeace scenarios and IEA 450 expect an accelerated decrease of the gas demand for this period. In the *advanced energy revolution* scenario, hardly any fossil natural gas will be required by 2050. However, the analysed reference scenarios expect a comparatively stable or even slightly increasing gas demand from 2030 onwards.

It does not fall within the scope of this study to verify the probability of certain scenarios materialising. Given the numerous political challenges, a comprehensive and fast implementation of the targets regarding energy efficiency and the development of renewable energies is currently not very likely. In an article on the consequences of Brexit published in July 2016, Geden and Fischer come to the following conclusion:

"In the forthcoming year, Brexit is going to absorb a major part of the political attention of central players in the EU. Energy and climate policy can be expected to be clearly downgraded on the priority list of the Heads of States and Governments. (...) This will not jeopardize the transformation of the European energy systems in principle, but may slow it down at least in the medium term."
(Geden & Fischer, 2016)

In addition, it is currently not possible to predict which policy the new US government will pursue. So far, statements rather suggest that fossil fuels may be strengthened which may even complicate the implementation of the climate policy in the EU (Dröge, 2016).

Most scenarios assume today that for a transitional period of a few decades, **natural gas-fired power stations** will constitute a suitable complement to the fast expanding contribution of renewable energies to power generation. However, most scenarios

assume that nuclear and coal-fired power stations will remain operative during several more decades, and that - due to their lower generating costs - they can produce cheaper power than gas-fired power stations during larger parts of the year. Whereas in Germany, the discontinuation of the utilization of **nuclear energy** is already legally binding and therefore included in the scenarios, particularly in France the future utilization of nuclear energy remains an open issue. Except for the nuclear power plant in Flamanville that is still under construction, all French nuclear power stations will become older than 40 years during the period analysed in this study. It is not likely that all nuclear power stations in France will be granted permits to continue operations after 40 years. This means that generation capacities probably will have to be replaced. Part of the power previously generated from nuclear energy may then be replaced by generation from gas-fired power stations. Similar relationships apply to other European nuclear power plants. In the EU, there are currently 129 nuclear power stations in 14 countries with a total generation capacity of 120 GW_{el} (EC, 2016).

In addition to the question if nuclear energy will be used in Europe also in the future, we have to ask what role **coal** will play in the future power generation. Germany, for instance, is discussing whether an accelerated discontinuation of the utilization of coal should be targeted in order to reduce CO₂ emissions. In the short or medium term, it will not be possible to replace the entire power generation from nuclear energy and coal by renewable energies. Particularly, in the case that the two energy sources will be discontinued simultaneously, natural gas may be playing an increasing role in power generation.

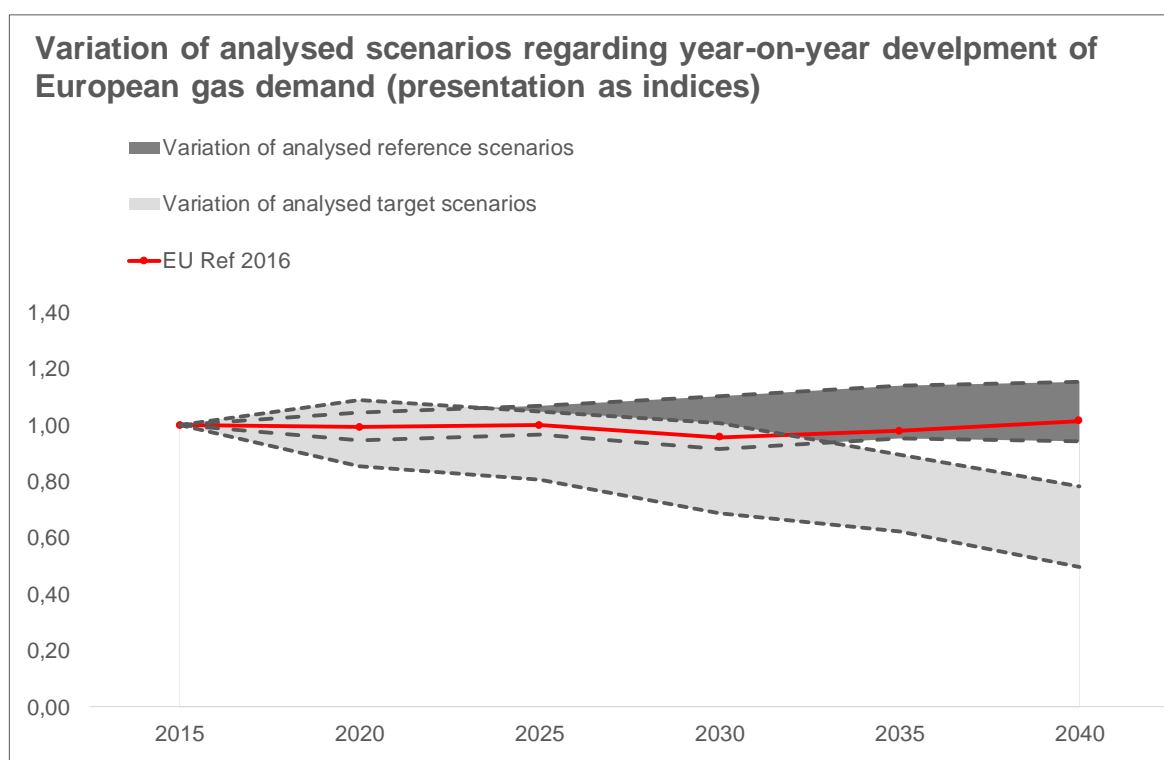
From the perspective of the authors of this study, there is a risk - that cannot be quantified without detailed simulations - that the power generation from gas will be increasing during a transitional period until the contribution from renewable energies including large-scale storage technologies becomes large enough to replace coal and nuclear power. EU Ref 2016 expects the utilization of gas in the conversion industries (mainly in power stations) to increase by 12 % until the year 2025, followed by a slight decrease until 2030 and after that a renewed increase until 2040 (cf. Figure 9).

Risk of a higher gas demand in the EU

The analysed scenarios can be divided into different groups of scenarios. The following figure compares EU Ref 2016 with the other analysed scenarios, with bands showing the respective results of the target and reference scenarios. As several analyses only comprise the period until 2040, the presentation ends that year.

It becomes obvious that EU Ref 2016 is at the lower end of the analysed reference scenarios. The risk of a higher gas demand can be described with the band of the reference scenarios. In 2020, the upper end of the gas demand band lies about 6 percentage points above EU Ref 2016. In 2030, the difference is 14 percentage points, in 2040 13 percentage points. This means that these scenarios show a significantly higher gas demand.

Figure 34: Variation of the European gas demand in different types of scenarios (presentation as indices)



Note: The presentation ends in 2040 as some scenarios only include the period until 2040.
Source: Own presentation based on (Cedigaz, 2015), (EC, 2016b), (E3M, 2014), (ENTSOG, 2015a), ENTSOG (2016c), (Greenpeace, 2015), (IEA, 2015), IEA (2016c), (Statoil, 2016), (ExxonMobil, 2016), (IHS, 2016).

Conclusions Demand: According to the authors of this study, the gas demand is not likely to **decrease** substantially in the analysed period, in comparison to the reference and above all until 2025. After 2025/2030, we assess the probability of the gas demand being lower than in the reference to be medium-high.

We consider the probability of a **higher** gas demand than in the reference to be low as the expected decrease of gas in the heating markets will offset the increase of gas used for power generation.

This means **that on the demand side the opportunities prevail, but only after 2030.**

Cold winter

Natural gas is mainly used for heating private households as well as commercial, trading and service facilities. In Chapter 3, we have already pointed out that the weather can have a significant impact on the gas demand. For instance, in 2010 - a particularly cold year - the gas demand was substantially higher than in 2009; however this was partially also due to other factors such as the economic crisis in 2009). When comparing the warm year 2014 with the climatically more typical year 2012, we can perceive a substantial decrease. The gas demand can vary up to 10 % between a climatically typical year and a cold year. The Winter Supply Outlook 2015/16 prepared by ENTSOG confirms this assessment in principle; however, this outlook is limited to the winter half year. The variation in the winter half year is stated with 10 %. The possible variation thus amounts to about 300 TWh (about 28 billion Sm³) (ENTSOG, 2015c). As the magnitude of temperature variations can be straightforwardly assessed, they are taken into account when dimensioning the EU's internal gas transport systems. EU Directive 994/2010 regulates that. However, not only capacity is important, but also the available annual volumes, particularly if there are several consecutive cold winters.

6.2 Opportunities and risks of the gas production in the EU

The mentioned gas extraction forecasts are also prone to **uncertainties** in the form of risks and opportunities for the European gas balance.

Exploration of unconventional natural gas

There is a potential of **shale gas** explorations in Europe. The US Energy Information Administration (EIA) has prepared a scenario assuming a substantial increase in the European gas extraction based on shale gas (EIA, 2016). However, EIA/ USGS' estimates regarding the Polish resources of shale gas were much too high (by a factor of at least 5) in comparison to the drilling results, as the estimates were based on an analogy to the US.

Global natural gas resources of commercially used conventional and unconventional deposits are estimated to amount to about 638 billion m³ and, including aquifer gas and gas hydrate, to 845 billion m³. Regarding unconventional natural gas resources, **shale gas resources** are dominant (about 206 billion m³ worldwide). Naturally, these resource data contain uncertainties. For **Europe**, shale gas resources are currently stated at about 12.9 billion m³. This corresponds to more than half the European

natural gas resources. In general, there is a growing amount of information on shale gas resources, however - due to the existing uncertainties - hardly any data on reserves. **Commercial shale gas extraction** is currently mainly limited to North America/ the US. (BGR, 2016)

The **commercially successful exploitation** of existing resources requires a number of technological and infrastructural factors. In addition, there are **other limiting factors**, such as **geological prerequisites, social acceptance** and **regulatory frameworks**.

The **extraction of shale gas** is therefore - among others due to the lacking political acceptance, but also to geological reasons - **associated with risks**. Until now, hardly any shale gas has been extracted in Europe, as the extraction of this gas usually requires the controversial fracking technology. Also, the estimates of shale gas resources in Poland have been significantly lowered.

A substantial increase in the European shale gas extraction, as expected by **EIA** appears **unrealistic** against the background of the described risks regarding the shale gas extraction in Europe. In our opinion, a shale gas boom similar to that in the US is currently not to be expected in Germany and Europe.

Production and grid feed-in of biomethane

Europe has a significant **biogas potential**. Biomethane - corresponding to natural gas specifications - can directly replace natural gas. However, currently it constitutes only a very small part of the biogas production as it is very costly to process biogas to natural gas quality. Most the biogas is used directly for local power generation at its place of production, which means that it indirectly affects natural gas demand. Currently, 70 % of biogas is produced through agriculture. The remainder comes, among others, from waste water treatment plants and landfills (European Biogas Association, 2015). However, data on the potential varies in the different studies and depends to a large extent on the assumptions. One of the most important assumptions concerns the portion of agricultural areas and products that will be used for energetic purposes. In addition, different factors, such as gas prices, production costs and financial incentives for the energetic utilization of biomass, affect the biogas generation. The technical **biogas potential in Europe** varies between **80 billion m³** (AEBIOM, 2009) and **250 billion m³** (DBFZ, 2012). Recently, biomass utilization has been re-evaluated, which means that it is now assessed to be less important as an energy source. Currently, the European biogas production amounts to approximately 15 billion m³ (about 50 % of which in Germany) (European Biogas Association, 2015). Almost all biogas is used for power generation at its place of origin, without being fed into the network. This

means it does not directly affect the European gas balance. Today, the existing biomass potential is not exploited. A growth dynamic for biomass - for instance due to incentives similar to the Renewable Energies Act in Germany - does not appear imminent; biomass production rather stagnates. Therefore in general, opportunities regarding a fast growth of biogas are assessed to be small; and we assume that also in the future biogas will be used for power generation close to the consumers or that it will be used as liquid biomass in the transport sector (SGC, 2013), (IE, 2007), (AEBIOM, 2009), (DBFZ, 2012).

Gas extraction in Poland lower / higher

The assessment of the gas extraction in Poland is slightly more optimistic in EU Ref 2016 than in IHS Cera (IHS, 2016). For 2030, the difference is about 4 billion m³, and for 2040 about 3 billion m³ (see risk table). We consider it more likely that the Polish gas extraction will not reach the assumed level than that it will exceed it, as the exploration of the Polish shale gas deposits has been disappointing, so far (SGIP, 2015).

Gas extraction in the Netherlands lower / higher

Between December 2014 and July 2016, the Netherlands adopted several reductions of the gas extraction in the Groningen field due to the earthquake issue (cf. Chapter 4.2.2). The modified reference scenario of this study includes the current status as of June 2016. If further problems occur, it cannot be excluded that the Netherlands will take decisions on further **extraction cuts**, in addition to those currently adopted. In this case, the gas balance would run short in comparison to the reference development. At least in the short and medium term, Dutch gas would have to be replaced by non-EU gas deliveries, which would increase the gas import demand accordingly.

We consider the probability of a renewed increase in extraction volumes in the Netherlands to be low.

Gas extraction in other extracting countries lower / higher

Also in other extracting countries, such as **Germany**, gas extraction forecasts have been repeatedly lowered (cf. Figure 13). The current low wholesale gas prices tend to decrease the profitability of further investments in **maintaining extraction levels**. There is a risk of further extraction cuts in addition to the already expected level. The situation is similar in other extracting countries in Europe. We assess a higher extraction to be unlikely.

6.3 Opportunities and risks of non-EU gas sources and transport corridors

Further opportunities and risks for the European gas balance result from the availability of non-EU gas resources and the development of transport corridors (cf. Chapter 5.1). In general, direct connections between a delivering and receiving country are considered to be more secure than supplies that require transit countries. EU transit countries are considered to be more secure than countries that are not subject to the regulations of the European single market.

Gas exports from Norway higher / lower

Norway has a guaranteed and well explored resource basis. Extraction forecasts of the Norwegian Petroleum Directorate show a substantial decrease in the existing fields (cf. Figure 19). In order to maintain extraction levels, further discoveries and the exploration of new gas fields are necessary. In case of low gas prices, such investments may be postponed which means that gas extraction in the new fields will not grow as fast as assumed. On the other hand, the Petroleum Directorate mentions an opportunity of more gas being found than assumed in the forecasts. IHS Cera (IHS, 2016) expects the Norwegian gas exports to decrease to about 80 billion m³ by 2035 and to 63 billion m³ by 2040. This means that in 2035 gas exports in comparison to our assumptions would be about 10 billion m³ lower and in 2040 about 24 billion m³. The authors of this study consider the **opportunity, but also the risk** of a deviating extraction in Norway **until 2030** to be low. From 2030 onwards, in our assessment there is a **medium risk** of Norwegian exports being lower than we have assumed because from that time onwards the contribution of not yet discovered fields would have to increase substantially. The opportunity of increasing the export potential in excess of the assumed value is low, in our opinion.

The **transport** risk from the Norwegian fields to the EU is low as all deliveries are carried out directly from Norway into the member states of EU 28.

Gas exports from Algeria higher / lower

Chapter 5.1.2 has already pointed out Algeria's decreasing gas export potential. This was included in the presented development of the supply of the gas import demand (cf. Chapter 5.2.1). According to OIES' assessment, this is a cautious forecast of Algeria's export potential (OIES, 2016a). In another scenario - that is also deemed possible by the OIES - Algeria will have no more gas export capacity already by 2030 because the extracted gas

would be completely absorbed by the Algerian internal demand. Theoretically, Algeria could also initiate a policy change that may reduce the past fast growth of demand in the medium or long term. This way, Algeria's export potential may decrease less rapidly. From today's perspective, this opportunity is low. Due to the mentioned reasons, we consider the risk of Algeria supplying less than assumed to be low to medium; and the opportunity of Algeria supplying more to be low.

Algerian gas is **transported** to the EU via Morocco (to Spain) and via Tunisia (to Italy). In addition, more than 20 % of the gas exports are delivered as LNG to different EU countries. Due to the decreasing volumes, these transport channels are utilized to a diminishing degree. This will create "reserve capacities". The transport risk is therefore considered to be low. Against this background it is hardly to be expected that the GALSI pipeline from Algeria to Italy - that has been suggested for a long time - will be necessary. It would neither transport any additional gas volumes to Europe.

Gas exports from Libya higher / lower

The reliability of Libyan gas deliveries is difficult to assess. Exports from Libya to Europe varied between 2 billion m³ (2011) and 9 billion m³ (2010). 2014 and 2015, Libya collapsed in a civil war whose consequences will not be overcome for a long time. There is a latent risk of conflicts to rekindle. In addition, part of the reserves is not controlled by the internationally recognised government in Tripoli. The risk of extraction downtimes is therefore considered to be medium. For the reasons mentioned above, the authors of this study assess the opportunity of a medium-term increase of gas exports to be low.

Gas is transported from Libya via a **Mediterranean pipeline** to Italy without transiting any other country. Libya has also an LNG terminal; its operation was disrupted in 2011 because it was damaged in the civil war. Risks regarding the Mediterranean pipeline are assessed to be low.

Russia

Russia has the largest gas reserves worldwide and a flexible and complex natural gas infrastructure. Because of early expectations of a substantially growing demand of natural gas in Europe, Russia has invested in the exploration of gas sources and has established additional production capacities of about 100 billion m³ p. a. (cf. Chapter 5.1.3). Information on Gazprom's homepage states that since 2005 the replacement rate of the company's gas reserves has been continuously exceeding 1.0, which means that Gazprom has discovered more gas than it has extracted. Between 2011 and

2015, the replacement rate was 1.4 on average (Gazprom, 2016). Based on the evaluated information, the risk related to the Russian gas reserves is assessed to be low.

This study does not assume any specific scenario for Russian gas deliveries towards Europe. We assume that the gas volume delivered in the future will be at least as high as that supplied in the past. In addition, Russia has an export potential exceeding this volume. This constitutes an **opportunity** for the European gas balance.

Russian gas can be transported to the EU via the following **corridors** that are partially interconnected within Russia:

The first gas deliveries to EU countries came from the gas field in Orenburg - situated in the south close to the Kazakh border - via the Soyuz pipeline that connects the field to **Ukraine's** western border close to Ushgorod. The pipeline's utilization rate has clearly diminished due to the fact that the main production has been shifted to Siberia.

In the Nadim-Pur-Taz region, the gas fields Urengoy (originally 8,100 billion m³ extractable reserves) and Yamburg (originally 4,700 billion m³ extractable reserves) were explored in the 1970s and 1980s; and the gas was transported via several large-scale pipelines (Encyclopedia Britannica, 2016). The **Central corridor** runs south of Moscow with three 56-inch pipelines (i.e. a diameter of 1.42 m; 1 inch = 2.54 cm) and two 48-inch pipelines close to Sudja in Ukraine. Two 56-inch pipelines (Urengoy-Pomaru-Ushgorod and the parallel Progress pipeline) cross Ukraine to its Western border at Ushgorod. The third 56-inch pipeline transports gas to the Ukrainian-Romanian border at Ismail.

The pipelines of the **Northern corridor** (*Northern lights*) connect the region Nadym-Pur-Taz to the areas North of Moscow, with two 48-inch export pipelines continuing through Belarus to Ushgorod in Ukraine. In addition, there is the 56-inch Yamal pipeline that starts at the pipeline hub in Torshok and goes through Belarus and Poland to Frankfurt/Oder in Germany. At the beginning of this millennium, the exploration of the Yamal region started, with reserve estimates reaching 20,000 billion m³, among them the Bovanenkovo field. The new gas volumes will be transported via new pipelines to Ukhta where they feed into the Northern corridor.

The gas extracted in Yamal will be transported via the Northern corridor and fed into the Yamal pipeline as well as Nord Stream 1 - which was originally intended for the Shtokman offshore field, whose exploration has been postponed. Nord Stream 2 would also be used for transporting gas from Yamal. For this purpose, the pipeline connections of the Northern corridor are being reinforced (new pipeline between Ukhta and Torshok).

Whereas the **transit through Belarus** currently does not constitute any problem after the gas dispute between Belarus and Russia (2010) was settled, Russian-**Ukrainian** relations become more and more difficult. Due to the large importance of this transit, we will discuss the **Ukrainian transit** in more detail.

In 2015, about 63 billion m³ of Russian gas were transported through Ukrainian pipelines, 15 billion m³ of which were destined for Turkey. The agreement between Gazprom and Naftogaz Ukrainy, that regulates the transit, ends on 31 December 2019 (OIES, 2016b). If Gazprom and Naftogaz Ukrainy do not reach a follow-up agreement, Russian supplies have to be transported on other routes to its European customers. However, an analysis by Simon Pirani and Katja Yafimava (OIES, 2016b) shows that it is difficult or even impossible to divert the entire transit flow through Ukraine to another transport route until Nord Stream 2 becomes operative. Gazprom has underlined its interest in an agreement if the terms and conditions are acceptable. Without an agreement, Ukraine would be threatened by a considerable loss of revenues from transit fees. The EU does not have any interest in a blockade situation after 2020 either. Pirani and Yafimava come to the following conclusion:

“For this reason, it is argued here that the optimal outcome for Europe would be to reach a compromise: an inclusive solution, allowing Nord Stream 2 to go ahead, while assuring that Ukraine would continue to play a transit role (albeit reduced) even after Nord Stream 2 is built.”
(OIES, 2016b), p. 26.

Due to the Ukrainian **sanction law** that entered into force in September 2014 allowing Ukraine to use economic sanctions to a much more generous extent, a solution of the conflict has become more difficult. Article 4, paragraph 1, point 3 of the law allows the disruption of the transit capacities („*partial or complete cessation of transit resources, flight and transportation through the territory of Ukraine*“) (Rada, 2014).

According to newspaper reports, Ukraine stopped **importing gas from Russia** in December 2015 (SZ, 2015). Gazprom invoked an acceptance duty and claims payment for the non-accepted gas volumes (Markets, 2016).

In 2016, the conflict between Ukraine and Russia escalated further. Ukraine’s antitrust commission sentenced Gazprom to a **financial penalty** of 3.4 billion USD due to its abuse of a market-dominating position. In September 2016, the highest court of Ukraine overruled the appeal filed by Gazprom (Oilprice, 2016).

Even for **technical reasons**, an agreement on the utilization of the Ukrainian section of the transport pipelines Yamal-Europe, Urengoy-Pomaru-Ushgorod and Progress would be urgently

required. Apparently, at least parts of the Ukrainian transport system are in poor conditions. In 2014, the European Bank of Reconstruction and Development (EBRD) and the European Investment Bank (EIB) granted Ukraine credits of up to 150 million EUR each, to be transferred to NAK Naftogaz in order to carry out an *Emergency Pipeline Upgrade and Modernisation* program. Four sections of the Urengoy-Pomary-Ushgorod gas pipeline with a total length of 119 km are supposed to be in need of repair. EBRD refers to a technical study that found critical faults in the above mentioned sections (EBRD, 2014) (EIB, 2014).

Given the political tensions between Russia and Ukraine as well as the financial dispute between Naftogaz and Gazprom, the authors of this study consider the risk of - at least temporarily - reduced transit capacities through Ukraine from 2019 onwards to be medium to high. Using external mediation including top politicians, a robust compromise may be feasible. Commercial interests and political tensions between Russia and Ukraine and within Ukraine overlap. Here, also the restructuring of Ukraine's gas industry has to be mentioned. It is not yet completely unbundled, which means that it is not always clear who actually is the negotiation partner regarding the transport to Europe through Ukraine.

Conclusion for Russia: Russia has the potential to increase its gas exports to the West. This constitutes an opportunity for the European gas balance. The risk of that export potential not being available is considered to be low.

Risks regarding Russian gas deliveries concern mainly the transit through Ukraine. Here, the **risk** of the negotiations of a follow-up agreement for the expiring transit agreement failing is **medium to high**.

New gas sources outside Europe / Southern corridor

Azerbaijan and the Caspian Sea countries as well as North Iraq have **large gas resources**. An increased extraction and, above all, the transport to Europe is not yet possible due to insufficient extraction capacities and the missing connection to the European gas network. The **TANAP pipeline** is supposed to transport mainly Azerbaijani gas to Turkey. Whether additional natural gas can be fed into the European gas transmission system, is still unknown. According to European gas transmission system operators, the **TAP pipeline** (Trans-Adriatic pipeline) - connecting to TANAP - is supposed to transport 10 billion m³ of natural gas to Europe. This was already assumed in Chapter 5.2.1. In the medium term until 2025, additional gas volumes via the Southern corridor are not to be expected as the **geopolitical situation** in the region is very tense. For this reason, the opportunity of additional gas volumes to be supplied from the Caspian area is considered to be low. However, the risk of TAP and TANAP not to be completed is also considered to be low.

LNG

Currently, the global LNG market is experiencing an **expansion** phase. By 2022, numerous projects will be completed and about 200 billion m³ of export capacity will be added to the world market (cf. Chapter 5.1.5). Until 2015, however, it has not been possible to detect any substantial increase in the traded gas volumes worldwide. The European LNG imports have even been diminishing since 2010.

In general, we can say that until 2022 LNG has - in principle - a large **growth potential** and that there are sufficient import capacities in Europa available to participate in this growth (cf. Figure 28). On the European market, LNG will be part of a suppliers' competition for **market shares**. If demand exceeds supply - which could be the case from 2022 onwards - there will be an increasing procurement competition with the very much larger Asian LNG market, even more so as the main Asian purchasing countries do not have many alternatives to LNG.

Even if Europe succeeds in buying larger LNG volumes, **regional transport limitations within the EU have to be taken into account**. For instance, the border-crossing points from Spain to France have a substantially lower capacity than the LNG import terminals on the Iberian Peninsula (ENTSOG, 2015b). Thus, a comprehensive and permanent additional LNG supply to Europe also from 2025 onwards is not likely.

In addition to the here presented qualitative assessment prepared by Prognos AG, we also want to take a look at the **OECD Country Risk Classification** of the countries that produce natural gas or are transit countries for the natural gas supplied to the EU. The OECD prepares a list with seven classes describing for most countries in the world the risks regarding their creditworthiness. Countries with high BNP, particularly those belonging to the OECD, are not included in this list. Class 1 corresponds to the lowest risk; and 7 constitutes the highest risk category. On the one hand, the classes describe the transfer and convertibility risk, i.e. the risk of a government taking measures to limit or abolish the free convertibility of currencies, which could affect the capital recovery of investors. On the other hand, the rating takes into account the probability of force majeure, such as war, expropriation, revolutions, internal turmoil, inundations and earthquakes. In the following, we will present the current OECD rating of the non-EU supplying and transit countries that could be relevant to Europe's gas supply.

This list is updated several times during the year, which means that the following table constitutes a snapshot.

Table 4: OECD risk classification of countries of origin and transit countries regarding the European gas supply

Country of origin	Transit country	Current classification (as of 28 Oct. 2016)
Algeria		4
	Morocco	3
	Tunisia	4
Libya		7
Azerbaijan		5
	Georgia	6
	Turkey	4
	Albania	6
Russia		4
	Ukraine	7
	Belarus	7
Qatar (LNG)		3
Nigeria (LNG)		6

Source: (OECD, 2016), as of 28 Oct. 2016

This means that among the relevant **countries of origin**, Qatar, Algeria and Russia have a medium-high rating whereas Azerbaijan and Nigeria (LNG) have an elevated risk. According to the OECD, Libya has the highest risk.

Regarding **transit countries**, the bad rating of Belarus and Ukraine is striking. But also Georgia and Albania as transit countries of TANAP and TAP receive the second-worst rating. As opposed to this, the transit countries of Algerian gas are rated as having a medium risk.

6.4 Interim conclusions

As explained above, all positions of the gas balance can show **results and developments that deviate** from the assumed reference expectations (cf. Chapter 5.2.1, among others), which may lead to deviations in the European gas import demand.

A large number of different scenarios regarding the **demand side** were analysed (cf. Chapter 6.1). Both reference and target scenarios were studied. It has become obvious that EU Ref 2016 represents the lower end of the analysed reference scenarios, but lies above the expected values of the target scenarios. The authors assess the risk of the gas demand exceeding the presented reference to be low.

With an **ambitious decarbonisation strategy** using large portions of renewable energies and a fast increasing energy efficiency, the European gas demand could be substantially lower in the long term. This constitutes an opportunity for the gas balance as the European gas demand would be lower than stated in the reference. In our opinion, this may take effect above all from 2025/2030 onwards, due to the inertia of political systems and national economies. This is also confirmed by Figure 33. Until 2030, the developments of the European gas demand in the reference and target scenarios overlap, because also some of the target scenarios include the larger role that natural gas may play until 2030.

Regarding **Europe's internal gas production**, risks are predominant until 2025; in the long term, however, there are **opportunities due to shale and biogas**, with limited potentials though. For **non-EU sources**, opportunities prevail until the early/mid-2020s due to the possible expansion of the LNG world market. After that, a clear assessment is not possible.

Regarding transport corridors, the risk related to Ukraine is assessed to be the highest. If Gazprom and its Ukrainian negotiation partners do **not reach an agreement regarding the use of the gas transport system**, there will be a large risk as 48 billion m³ - which correspond to 14 % of the 2015 European gas imports - are transported via this transit route. Due to the entrenched conflict, it is probable that the negotiations fail. On the other hand, all parties (Russia and Ukraine as well as the involved companies and European partners) should be interested to reach a follow-up solution for the period from 2020 onwards.

7 Final conclusions

The analysis of the present study shows that the **gas import demand** of the area EU 28 and Switzerland that has to be supplied by “other sources” may increase by 32 billion Sm³ from 2015 to 2020 and by 76 billion Sm³ until 2025. In addition, the gas supply from the West to Ukraine has been increasing by 7 billion m³ since 2015.

Russia and the LNG world market have been identified as suitable suppliers as they have sufficient reserves and production capacities and as there is an export, transport and import infrastructure in place that would make these gas reserves useable for the EU – particularly with Nord Stream 2 creating additional capacities towards Europe.

The **sensitivity analysis** has shown the opportunities and risks of a development that may deviate from the reference development. When comparing opportunities and risks, we can observe the following:

- Most the **opportunities** have rather low probabilities or will become effective only in the medium or long term (from 2025 onwards). The most important opportunity is the decarbonisation policy with renewable energies and increased energy efficiency. Here we see a medium-high opportunity for a substantially decreased demand after 2025/2030; until that time, however, gas demand may even increase due to a shift from coal and nuclear energy to gas.
- Several **risks** will become effective already in the short term and were assessed to have a medium to high probability.

Thus, opportunities and risks are not symmetrically distributed. In the short term, the risks are prevalent. Therefore, the authors of the present study consider it more likely - above all for the period until 2025 - that the gas import demand will rather exceed than fall short of the values determined in Chapter 4.

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9 Abbreviations and Glossary

AGRI	Azerbaijan-Georgia-Romania-Interconnector
AL	Algeria
bcm	billion cubic meters (billion m ³)
BE	Belgium
BFE	Bundesamt für Energie in der Schweiz (Swiss Federal Office of Energy - SFOE)
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geoscience and Natural Resources)
bill. m ³	billion cubic meters
BP	BP p.l.c.
DBFZ	Deutsches Biomasseforschungszentrum (German Biomass Research Centre)
DRWN	Deutsch-Russische Wirtschaftsnachrichten (German-Russian business news)
EBRD	European Bank for Reconstruction and Development
EC	European Commission
RE	Renewable Energies
EIA	U.S. Energy Information Administration
ENTSO-G	European Network of Transmission System Operators for Gas
ERI RAS	The Energy Research Institute of the Russian Academy of Sciences
ES	Spain
ETS	Emission Trading System
FNB Gas	Vereinigung der Fernleitungsnetzbetreiber Gas e. V. (Association of Transmission Network Operators Gas)
FQD	Fuel Quality Directive
FR	France
GCV	Gross Calorific Value; states the calorific value of natural gas including condensation heat.
GHG	Green-house gases
GIE	Gas Infrastructure Europe
GR	Greece
GTS	Gasunie Transport Services B.V.
GÜP	Border-crossing point
GW	Gigawatt
Heating-degree days	Measure of the required heating energy.
H-gas	High-calorific gas.
Hi	Inferior Calorific Value; also Net Calorific Value (see NCV)
Hs	Superior Calorific Value; also Gross Heating Value (GCV)

IE	Institut für Energetik und Umwelt gGmbH
IEA	International Energy Agency
IGU	International Gas Union
ILUC	Indirect Land Use Change
IMF	International Monetary Fund
incl.	including
kWh	Kilowatthour
L-gas	Low-calorific gas, mainly extracted in NL and DE, GCV 9.77 kWh/m ³
LNG	Liquefied Natural Gas
LT	Latvia
MidCat	Midi-Catalonia
Mtpa	million tons per annum
NCV	Net calorific value; states the calorific value of natural gas excluding condensation heat.
NEP	Netzentwicklungsplan Gas (Network Development Plan Gas)
NL	The Netherlands
NO	Norway
NOP	Netwerkontwikkelingsplan
NPD	Norwegian Petroleum Directorate
OIES	The Oxford Institute for Energy Studies
p. a.	per annum
PL	Poland
RES	Renewable Energy Sources
Reserves	Reserves are the geologically known portion of the total deposits of a natural resource that can (at today's prices) be economically extracted.
Resources	For resources, the degree of exploration is lower and a possible profitable extraction is not proven.
RT	Russia Today
SCG	South-Caucasian pipeline
SGC	Svenskt Gastekniskt Center AB
Sm ³	standard cubic meter, in this study mostly 10.5 kWh/m ³
stat.	statistical
TANAP	Trans-Anatolian pipeline
TAP	Trans-Adriatic pipeline

10 Conversion factors

Unit		Source
1 Sm ³ (standard cubic meter)	= 10.5 kWh (stated as GCV at 20°C, Russian standard cubic meter) = 10.83 kWh (stated as GCV, European standard cubic meter)	Data from Nord Stream 2 Eurogas
1 billion m ³	= 10.5 TWh (20°C, Russian standard cubic meter) = 10.83 TWh (European standard cubic meter, according to Eurogas)	
1 ktoe	= 0.01163 TWh = 1.11 million m ³ (at NCV) = 1.23 million m ³ (at GCV)	IEA Energy statistics manual
1 Mtpa LNG per year	= 1.30 billion m ³ of natural gas = 1.36 billion m ³ of natural gas (EU standard: 15°C)	IGU (International Gas Union) BP Statistical Review of World Energy June 2016/ IEA Energy statistics manual
GCV (gross calorific value)	= 1.111 * NCV (net calorific value) When converting energy into volumetric units (m ³) it has to be taken into account whether the calorific value is stated as GCV or NCV. Depending on the country of origin and the gas composition, different calorific values per volume unit are used. In addition, also the thermodynamic parameters pressure and temperature of the respective volume definition have to be taken into account.	
1 standard cubic meter (0°C)	= 1.055 standard cubic meter (15°C)	IEA Energy statistics manual

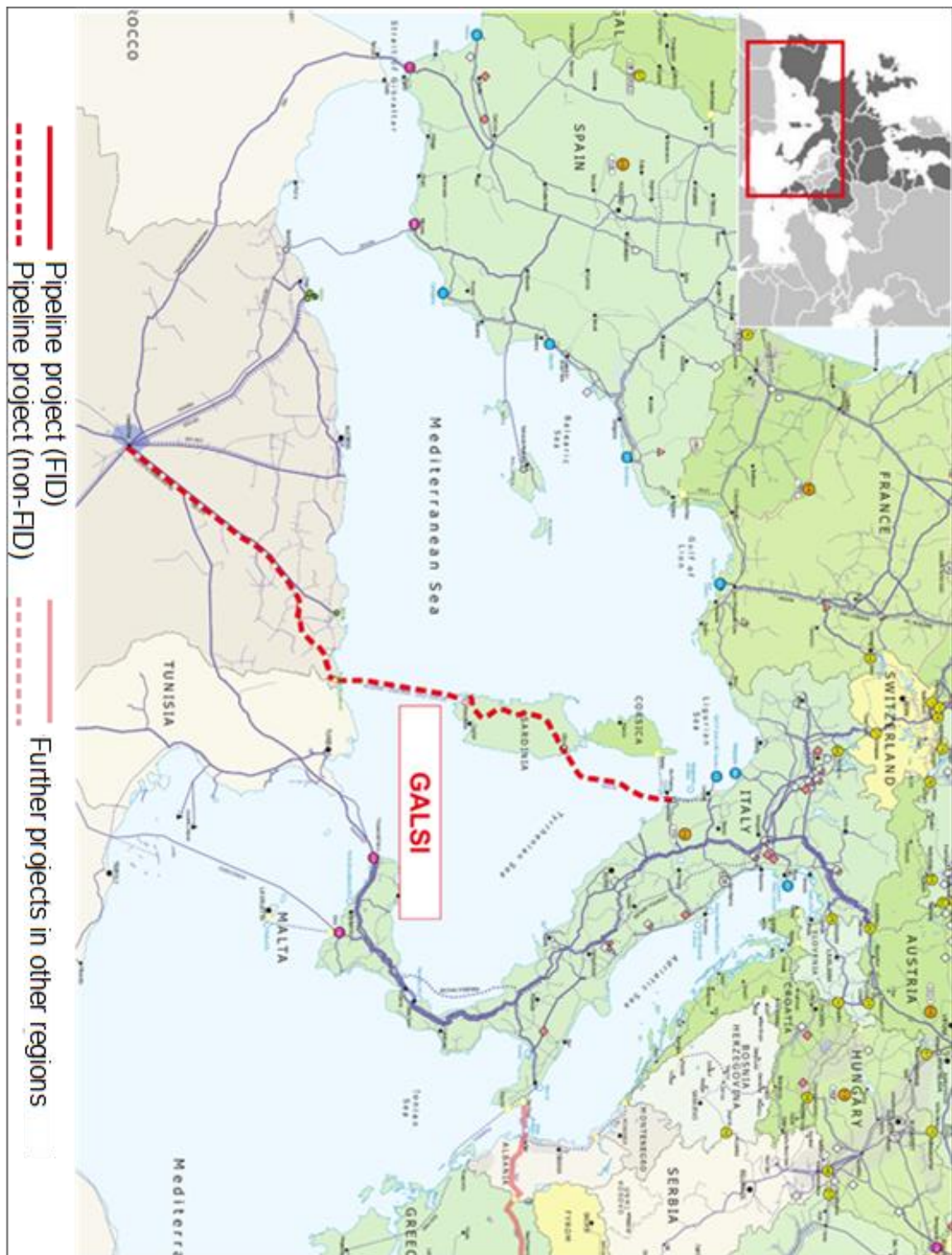
11 Appendix A: Map extracts

Norway



Source: Extract from (ENTSOG, 2016b)

North Africa



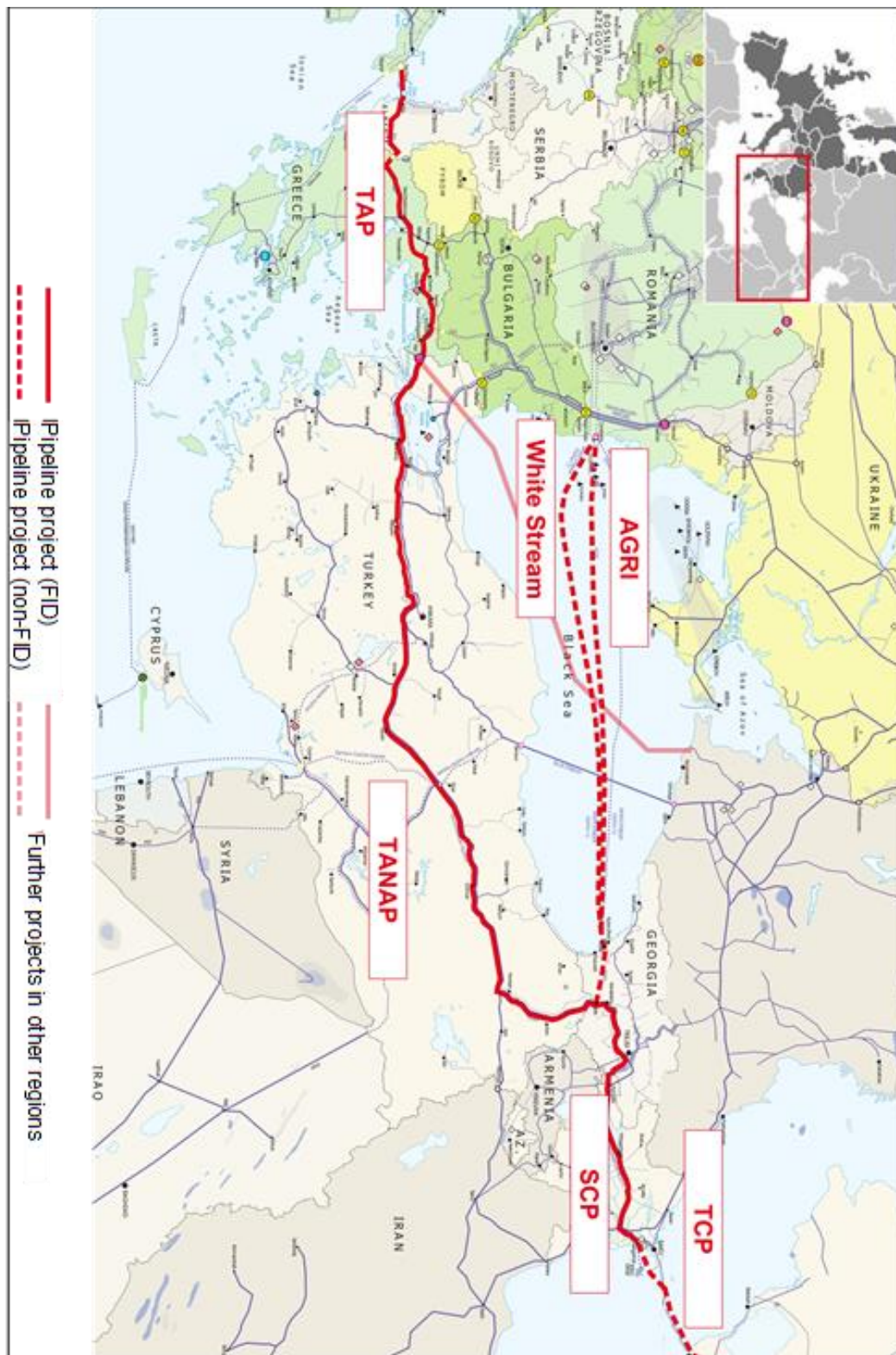
Source: Extract from (ENTSOG, 2016b); The planned location of projects described in the text are marked in red.

Russia



Source: Extract from (ENTSOG, 2016b); The planned location of projects described in the text are marked in red.

Southern corridor



Source: Extract from (ENTSOG, 2016b); The planned location of projects described in the text are marked in red.

12 Appendix B: Explanations

Explanation of the statistical difference in Figure 30

Figure 30 shows the development and possible origin of the additional gas import demand in the analysed area EU 28 and Switzerland. For the years 2010 and 2015, the presentation contains a so called **statistical difference**. The reasons are as follows:

1. In general, the data of the import demand and its supply come from **different sources**. The import demand is basically derived from EU Ref 2016 and the Swiss energy statistics; however, the origin of the gas supply is taken from the BP Statistical Review of World Energy which is based on different trading statistics that cannot be verified in detail. A possible reason for the difference in 2010 could be the conversion factors of energy units into m³ for the individual countries that are not always clearly documented. In addition, traded volumes can differ from physical deliveries. Against this background and due to the large number of individual sources, the difference of about 6 billion m³ in 2010 (about 1.8 % of the import demand) is low.
2. The study EU Ref 2016 was finalized before statistics regarding the EU's actual gas use was available. This means that the **2015** values in the EU reference scenario 2016 are already forecast values (not the result of a simulation). Forecasts are always stated without the effect of the weather, i.e. adjusted for temperature.
3. The data on import volumes according to origin (Algeria, Norway etc.) are based on the mentioned BP statistics that states **actual values**. As 2015 was slightly warmer than the long-term average, actual deliveries were lower than the 2015 value that was calculated in EU Ref 2016 and adjusted for temperature.
4. Further reasons for statistical differences could be the fact that it is not always clearly established whether statistics provide **gross or net calorific values**.
5. The statistical difference is eliminated from the forecast as it is temperature-adjusted for both import demand and origin of the gas supply.

Explanations regarding deviations between the summary EU Ref 2016 and the numbers presented here

As already mentioned in several parts of this study (e.g. Chapter 10), the energy content of hydrocarbons (oil, natural gas) may be stated as the net calorific value or the gross calorific value. The difference between the two values consists in that the gross calorific value includes the entire energy produced during the combustion process, whereas the net calorific value is gross calorific value minus the energy that is absorbed by the evaporation of the water produced during the combustion. For natural gas, the ratio between net and gross calorific value amounts to 0.9, which means that the net calorific value is 10 percent lower than the gross calorific value.

Energy balances (such a EU Ref 2016) are usually stated as energy units in relation to the net calorific value. As opposed to this, studies in regards to the gas economy usually refer to the gross calorific value. Thus, the energy content of gas flows is stated as the gross calorific value per volume unit.

When analysing gas flows we also have to take into account the standardised temperature and pressure the stated gas volume refers to. Gas expands with increasing temperatures resulting in less molecules per cubic meter; and with increasing pressure, a cubic meter contains more molecules. Depending on the context and specific application, there are different standardisations of the reference values for gas, as is shown in the following table:

Table 5: Comparison of different standards for gas

Defined in...	Temperature	Pressure	Note
DIN 1343	273.15 Kelvin (0° Celsius)	1.0135 bar	"Normal cubic meter"
DIN 2533	288.15 Kelvin (15° Celsius)	1.0135 bar	"Standard cubic meter"
DIN 6358	293.15 Kelvin (20° Celsius)	1.0 bar	Corresponds to the Russian standard

Sources: (IEA, *Energy Statistics Manual*), (Gazprom, *PJSC Gazprom Annual Report*, 2015)

The present study refers to the Russian standard cubic meter, as it mainly analyses the development of the additional gas import demand of EU and Switzerland as well as Ukraine. The additional import capacity is to be compared with the capacity of Nord Stream 2 whose capacity is stated in Russian standard cubic meters.

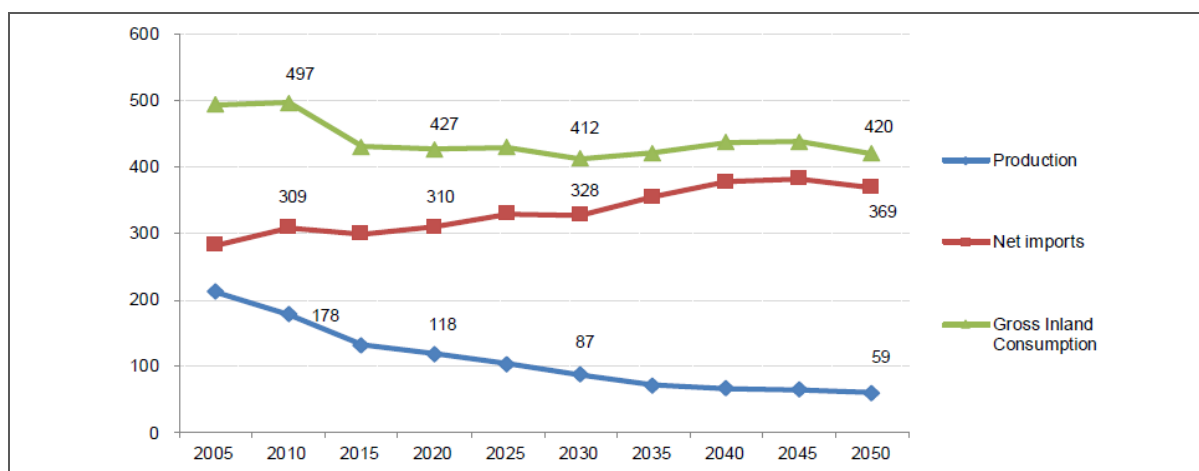
The following example for the **year 2010** illustrates how the energy data in EU Ref 2016 is converted into volume data in the current study:

Table 6: Derivation of the volume calculation in the current study, illustrated for the year 2010

	2010
Gas demand of EU 28 net calorific value according to EU Ref 2016	447,394 ktoe
This corresponds to gas demand EU gross calorific value	497,104 ktoe
Compare: Gas demand EU (gross calorific value) according to Eurostat	496,727 ktoe
This corresponds to a gross calorific value of (0.01163 TWh/ktoe)	5,781 TWh
Gas demand Switzerland (gross calorific value)	37 TWh
Gas demand gross calorific value EU 28 / Switzerland (cf. Figure 16)	5,818 TWh
This corresponds to cubic meter according to the Russian standard (10.5 TWh / billion m ³)	554 billion m ³
Cubic meter according to Eurogas Standard (10.83 TWh / billion m ³)	537 billion m ³

The summary of EU Ref 2016 (document “Main results”) contains the follow graphic:

Figure 35: Gas (import) demand of EU-28 according to EU Ref 2016 – Main results (in billion m³)



Source: EU Ref 2016 – Main results, p. 4 (EC, 2016bb)

According to this source, the **conversion factor** 1 Mtoe = 1.11 billion m³ was used to calculate the volume in cubic meter from the net calorific value of 447,394 Mtoe (NCV). Here, EU Ref 2016 refers to BP. (Quote: „The conversion rate of 1 Mtoe = 1.11 bcm was used for natural gas, based on the BP conversion calculator.“ Source: EU Ref 2016 – Main results, p. 4). For the inverse calculation, 0.9 Mtoe / billion m³ was used; this is also based on BP. It corresponds to 10.47 TWh / billion m³ or 10.47 kWh / m³.

It remains unclear whether BP uses ktoe (NCV) or ktoe (GCV); the standard conditions for the volume are not described either.

The **conversion factor used by BP** relates to the European and Russian standards as follows:

Table 7: Comparison of the conversion factors for natural gas

Source	Conversion factor
BP	10.47 kWh / m ³
Eurogas GCV	10.83 kWh GCV/ m ³
Russian standard GCV (at 20°C)	10.5 kWh GCV/ m ³ at 20°C

Source: (BP, 2016b) (Eurogas, 2015), (Gazprom, PJSC Gazprom Annual Report , 2015)

Pure methane (the most important component of natural gas) amounts to 10.48 kWh GCV/ m³ (at 15°C).

Thus, the value stated by BP corresponds to the value used in this study to determine the Russian standard cubic meter (stated as the gross calorific value of a cubic meter at 20 degrees Celsius).

The assumption that the conversion factor used by BP refers to the net calorific value would result in a very high specific gross calorific value that actually does not occur in the EU.

If we adjust the 2010 numbers in the summary of EU Ref 2016 by the ratio of NCV to GCV of $1 / 0.9 = 1.1111$ before applying the BP conversion factor, the gas demand would amount to $497 * 1.1111 = 552$ billion m³ and the gas import demand to $309 * 1.1111 = 343$ billion m³ in 2010. These values would match the results in this study very well (cf. Figure 16).

About Prognos.

Prognos develops practical strategies for firms, organizations and public sector authorities across Europe on the basis of rigorous and objective analyses.

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