Structural Shift in Global Natural Gas Markets—Demand Boom in Asia, Supply Shock in the US

by Franziska Holz, Philipp M. Richter, and Christian von Hirschhausen

The significance of natural gas is on the rise due to the restructuring and decarbonization of energy systems worldwide. Natural gas is widely available and flexible as it can be used in electricity generation, manufacturing, transport, and private households. Compared to other fossil fuels, natural gas produces relatively low carbon dioxide emissions during combustion. For this reason, the natural gas sector also has an important supportive role to play when it comes to the European energy transition towards renewable energies. Against this backdrop, DIW Berlin has examined the potential of the global natural gas market and carried out model-based analyses of possible scenarios for meeting different climate change targets.

The structural shift in the international natural gas market that has been observed for some years now is also set to continue in the medium and long term. While the Arab states of the Persian Gulf, particularly Qatar, will remain swing suppliers due to their geographical location, Russia's significance in supplying Europe will decline in the future. New techniques such as fracking enable the exploitation of unconventional natural gas resources, which could potentially see the US become a strong natural gas exporter and also give other regions around the world the opportunity to extract their own natural gas. However, in Europe, the potential for additional production of domestic resources by extracting shale gas through fracking is rather limited for technical reasons and due to a lack of political support in the context of an adequate international natural gas supply. Asian demand for natural gas is expected to strongly rise as a result of the ever-increasing appetite for energy generated by economic growth. This demand region will absorb the major share of future natural gas trade. In Europe, the situation could develop along a number of different trajectories, depending on whether natural gas is used as a "bridge fuel" in the transition toward an energy system based on renewable energies or as a complement to fluctuating renewable power generation in the long term.

Natural gas is generally defined as a mixture of gases containing roughly 95 percent methane. It is either produced as a by-product of oil extraction (associated natural gas) or on its own. Natural gas deposits are subdivided into conventional and unconventional resources: conventional deposits are large, contiguous fields which can be exploited using industrial-scale extraction methods. Unconventional natural gas resources, however, are characterized by impermeable rock formations requiring special extraction technologies such as horizontal drilling and hydraulic fracturing (also known as "fracking"). The latter technique uses a mixture of water, sand, and chemicals to create fractures in the rock surrounding the natural gas deposits.

The German Advisory Council on the Environment (SRU) primarily distinguishes between three different types of unconventional natural gas resources:

- Tight gas in impermeable rock formations such as sandstone, limestone, and clay mineral,
- Shale gas in hydrocarbon-rich sediments, such as argillaceous and oil shale and,
- Coalbed methane from coal seams.[1]

In addition, some seabed areas contain large quantities of gas hydrates, the extraction of which is technically difficult, however, and therefore not commercially viable in the medium term.[2]

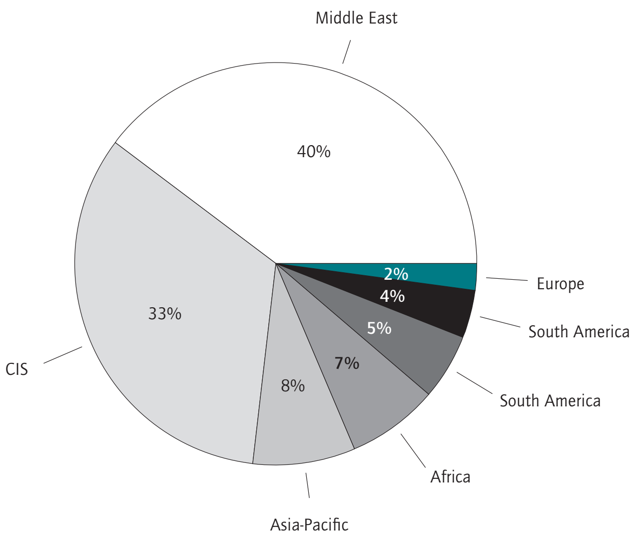
1 See SRU, "Fracking for Shale Gas Production: A contribution to its appraisal in the context of energy and environment policy," Statement no. 18, May 18, 2013, p. 7.

2 In particular, the Japanese government has high hopes that methane hydrates can be exploited commercially in the long term and is promoting research into the exploration and development of this product; see www.mh21japan.gr.jp/english/, last accessed on July 8, 2013.

Figure 1

Natural Gas Reserves by World Region

Shares[1] in percent



1 Average across three studies.
Sources: BP; Detusche Rohstoffagentur (DERA); Energy Information Administration (EIA); calculations by DIW Berlin.

Almost three-quarters of global natural gas reserves are in the Middle East and CIS countries.

Table 1

Natural Gas Reserves by World Region

In trillion cubic meters

	BP (2012)[1]	DERA (2012)[2]	EIA (2012)[3]	Average
Middle East	80.0	79.7	76.1	78.6
CIS	74.7	62.3	61.3	66.1
Asia-Pacific	16.8	16.8	15.2	16.3
Africa	14.5	14.6	14.7	14.6
North America	10.8	9.8	10.7	10.4
South America	7.6	7.6	7.6	7.6
Europe	4.0	4.3	4.4	4.2
Total	**208.4**	**195.1**	**189.9**	**197.8**
R/P ratio[4]	62	58	57	59
CO_2 content[5] in gigatons	444	416	405	422

1 BP, Statistical Review of World Energy (2012).
2 DERA, DERA Rohstoffinformation. Energiestudie 2012 (2012). Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen. (Hannover: BGR).
3 EIA International Energy Statistics (Washington D.C.: US Department of Energy, 2012).
4 Reserves in relation to volume produced in 2011 according to DERA (2012).
5 Average emission factors for natural gas combustion according to Intergovernmental Panel on Climate Change (IPCC) 2006. IPCC Guidelines for National Greenhouse Gas Inventories 2, Energy, Geneva.
Sources: BP; DERA; EIA; calculations by DIW Berlin.

Reserve estimates are very similar, with the exception of those for the CIS.

No Long-Term Threat to Natural Gas Availability

Geological estimates attempt to quantify the natural gas resource potential, (the total existing quantity) and the more narrowly defined volume of reserves (resources that can be economically recovered at current prices). These estimates differ in terms of the degree of detail, technical classification types, and supplemental expert opinions. Consensus largely prevails with regard to the volume of available reserves: global estimates broken down by region place current reserves at around 200 trillion cubic meters (see Table 1). Assuming annual production equals that of 2011, reserves would last for approximately 60 years.

By far the largest natural gas reserves can be found in the Middle East and CIS countries which together account for roughly three-quarters of all reserves (see Figure 1). There are also significant reserves in Africa, the Asia-Pacific region (East and Southeast Asia and Oceania), and North and South America, while Europe by far has the smallest natural gas reserves with around 4.2 trillion cubic meters, located mostly in the Netherlands and Norway.

To date, information on unconventional natural gas deposits has rarely been captured by the reserve statistics, but has been included in the more comprehensive resource statistics instead. The discrepancies between different estimates of the existing natural gas resource potential are particularly significant with regard to the share of unconventional resources (see Table 2). The conventional resources numbers span a narrow range of 321 to 498 trillion cubic meters. Unconventional resources estimates, on the other hand, vary widely (between 275 and 917 trillion cubic meters). For example, the estimates by Rogner (1997) and Rogner et al. (2012) are almost three times as high as the more conservative estimates (DERA, 2012, and IEA, 2012).[3] This has less to do with the timing of the survey, but is more a result of the different geo-scientific and statistical survey methods. These differences are less relevant, however, for

3 H.-H. Rogner, "An Assessment of World Hydrocarbon Resources," Annual Review of Energy and the Environment 22 (1997): 217–262; H.-H. Rogner, R. F. Aguilera, C. Archer, R. Bertani, S. C. Bhattacharya, M. B. Dusseault, L. Gagnon, H. Haberl, M. Hoogwijk, A. Johnson, M. L. Rogner, H. Wagner, and V. Yakushev, "Energy Resources and Potentials," chap. 7 in: Global Energy Assessment – Toward a Sustainable Future (Cambridge, New York, and Laxenburg: Cambridge University Press and The International Institute for Applied Systems Analysis, 2012), 423–512;
International Energy Agency (IEA), World Energy Outlook 2012 (Paris: OECD/IEA, 2012).

Table 2

Estimated Worldwide Natural Gas Resources
In trillion cubic meters

	Conventional	Unconventional				Total	RP/P ratio[1]	CO_2 content[2] in gigatons
		Tight gas	Shale gas	Coalbed methane	Total			
DERA (2012)	498	63	160	51	275	772	232	1,647
IEA (2012)	462	81	200	47	328	790	237	1,684
Rogner (1997)[3]	389	208	453	256	917	1 306	391	2,784
Rogner et al. (2012)[4]	321	211	392	245	848	1 170	350	2,493

1 Resource Potential in relation to volume produced in 2011 according to DERA (2012).
2 Average emission factors for natural gas combustion according to Intergovernmental Panel on Climate Change (IPCC) 2006. IPCC Guidelines for National Greenhouse Gas Inventories. 2, Energy, Geneva.
3 For better comparability, the volume that was already produced between 1995 and 2011 was deducted from the conventional resources figures (volume produced according to BP, 2012).
4 Excluding pseudo-unconventional resources such as deep-sea natural gas with a volume of roughly 200 trillion cubic meters. For conventional natural gas resource potential, Rogner et al. refer to USGS (2008): Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle. Fact Sheet 2008–3049. US Geological Survey, Washington DC.
Sources: BP; DERA; IEA; Rogner; Rogner et al.; calculations by DIW Berlin.

Resource estimates vary according to the institution providing them, particularly for unconventional natural gas resources.

the purposes of a medium-term analysis of natural gas trade patterns.

Irrespective of the source used, it is apparent that the physical availability of natural gas will not be a limiting factor in the coming decades as it should last around 232 to 391 years. Theoretically, this would mean that natural gas could both cover a continued demand boom in Asia and also act as a more climate friendly substitute for coal in electricity production.

However, one potential problem is the level of carbon dioxide released during the assumed complete combustion of natural gas. Current natural gas deposits designated as reserves are associated with approximately 400 gigatons of CO2 emissions.[4] For comparison: according to a rule of thumb, the available carbon budget is around 1,000 gigatons of CO2 for the next decades in order to still have a good a chance of achieving the two-degree global warming target.[5] However, emissions from the use of coal and crude oil in particular, which currently account for a significantly higher share of total emissions, are also included in this ceiling. Consequently, a global, politically determined emissions ceiling would in fact result in a binding reduction in future natural gas consumption.

Shale Gas: Production Boom in US, Limited Potential in Europe

In the 2000s, the US experienced a strong price increase from less than three US dollars per MBtu[6] at the beginning of the millennium to a peak of more than 13 US dollars per MBtu in mid-2008.[7] As a result, the country has seen a boom in the exploration and production of unconventional shale gas enabled by the use of new production technologies, particularly horizontal drilling and hydraulic fracturing. Overall, natural gas production in the US climbed from 520 billion cubic meters (2006) to around 680 billion cubic meters (2012).[8] This corresponds to a 25-percent increase and is exclusively the result of growth in shale gas production. This supply shock rendered the previous expectations of a growing need for imports obsolete. The drop in the natural gas wholesale price in the US since mid-2011, at times to under two US dollars per MBtu (early 2012), resulted in an increase in domestic use, particularly for electricity generation.

Until recently, the US did not meet the conditions, both from a technical and a foreign trade law perspective, to export significant quantities of natural gas outside North

4 According to even the most conservative estimates, burning all natural gas resources would release at least 1,647 billion tons of CO_2 over a longer period of time.

5 See M. Meinshausen, N. Meinshausen, W. Hare, S. C. B. Raper, K. Frieler, R. Knutti, D. J. Frame, and M. R. Allen, "Greenhouse-gas emission targets for limiting global warming to 2°C," Nature 458, no. 7242 (2009): 1158–1162.

6 Million British thermal units.

7 Henry Hub natural gas spot price on the wholesale market collected by the Energy Information Administration (EIA), a division of the US Department of Energy, www.eia.gov/dnav/ng/hist/rngwhhdD.htm, last accessed on July 16, 2013.

8 EIA, Annual Energy Outlook, (Washington D.C.: US Department of Energy, 2009); IEA, Medium-Term Gas Market Report (Paris: OECD/IEA, 2013).

America. Due to its geographical location, these exports must be in the form of liquefied natural gas (LNG) but the LNG export infrastructure is still under developmental. Exports to countries that have not signed a free trade agreement with the US (currently the case for Europe and Japan) must be authorized by the US authorities (Department of Energy). During the course of the permitting process for some terminals, a lively debate took place in the US as to whether or not it is in the public interest to authorize exports. However, the US Department of Energy recently granted general export licenses for five terminals for a total annual export capacity of almost 70 billion cubic meters.[9] Applications have been submitted for licenses to increase the annual export capacity to a total of 340 billion cubic meters per annum. It remains to be seen whether or not the entire capacity will be developed, but it appears unlikely.

Apart from North America, there are also other regions in the world with significant shale gas resources (see Table 3). It is assumed or has been extrapolated from initial exploration that this is particularly the case in South America, South Africa, Australia, and China. However, the figures obtained from such explorations are subject to considerable uncertainty as the most recent update of estimates by the US Energy Information Administration (EIA) demonstrates. Accordingly, the International Energy Agency (IEA) has focused for some years on establishing the requisite conditions for widespread production of shale gas.[10] It is assumed that China in particular is likely to commence shale gas extraction in the near future. However, it is not anticipated that regions with equally significant conventional reserves such as Russia will embark on the presumably more expensive shale gas production, even in the long term.

In Europe, too, there is some hope that a shale gas boom could help to improve the competitiveness of the continent's energy-intensive industries. However, information available to date does not substantiate this hope: the more stringent environmental regulations in some European countries, low and very uncertain estimates of shale gas resources, the wider dispersion of (smaller) deposits, public ownership of land rights (as opposed to private ownership in the US), the higher population density in Europe, and bans on the extraction of shale gas that have already been enacted in some EU countries (including France and Bulgaria) are effective obstacles to easy and cost-effective exploitation of shale gas deposits. A push for shale gas extraction cannot be expected in Germany, either: a draft law for the regulation of shale gas exploration has been under discussion for some years but, once again, was not introduced in the parliamentary debate in June 2013. In a recent statement, the German Advisory Council on the Environment (SRU) concludes that fracking is not necessary from an energy policy point of view and shall currently not be allowed on a commercial scale due to serious knowledge deficits.[11]

Table 3

Ranking of 15 Countries with Largest Shale Gas Resources

In trillion cubic meters

	DERA (2012)[1]	EIA (2011)[2]	EIA (2013)[3]
Argentina	21.92	21.92	22.71
Mexico	19.29	19.28	15.43
US	16.41	24.41	18.83[4]
South Africa	13.74	13.73	11.04
Australia	11.22	11.21	12.37
Russia	9.50	n.a.	8.07
China	8.60	36.10	31.57
Libya	8.21	8.21	3.45
Algeria	6.51	6.54	20.02
Brazil	6.40	6.40	6.94
Poland	5.30[5]	5.30	4.19
France	5.10	5.10	3.88
Canada	3.65	10.99	16.23
Norway	2.35	2.35	0.00
Chile	1.80	1.81	1.36

1 DERA, DERA Rohstoffinformation. Energiestudie 2012 (2012). Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen. (Hannover: BGR).
2 EIA, World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States (Washington D.C.: US Department of Energy, 2011).
3 EIA, Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale formations in 41 Countries Outside the United States (Washington D.C.: US Department of Energy, 2013).
4 www.eia.gov/analysis/studies/worldshalegas/, last accessed on July 8, 2013.
5 Polish Geological Institute, Assessment of Shale Gas and Shale Oil Resources of the Lower Paleozoic Baltic-Podlasie-Lublin Basin in Poland. First Report (Warsaw: 2012) estimates resources that can be extracted in Poland at under a trillion cubic meters.
Sources: DERA; EIA; calculations by DIW Berlin.

Shale gas can also be found in many countries that do not have significant conventional resources.

Global Natural Gas Trade and Liquefied Natural Gas on the Rise

Currently, both the supply and demand structures in global natural gas trade are undergoing significant

9 See US Department of Energy list http://energy.gov/fe/downloads/summary-lng-export-applications.

10 IEA, "Are We Entering a Golden Age of Gas?," Special Report. World Energy Outlook 2011 (Paris: OECD/IEA, 2011); IEA, Golden Rules for a Golden Age of Gas – World Energy Outlook special report on unconventional gas (Paris: OECD/IEA, 2012).

11 SRU, Ibid, 2013, p. 42.

Kasten

The Global Gas Model (GGM)

The Global Gas Model is a comprehensive partial equilibrium model for the natural gas market that represents the entire natural gas value chain including production, transport, storage, as well as end users in the electricity sector, industry, and private households. The model was developed in cooperation with NTNU Trondheim and is one of the most comprehensive models currently available. Based on the European Gas Model[1] and the World Gas Model,[2] the Global Gas Model is designed to provide geographically detailed calculations for approximately 120 countries or regions up to 2040. The model's base year is 2010. Typical information provided by this model includes production volumes and trade flows as well as regional prices and infrastructure expansion projects. The focus of the analyses presented here, however, is on the volumes produced and traded and on capacity requirements. The model's high geographical disaggregation allows the specific regional availability and production costs of shale gas to be incorporated into the calculations and regional consumption patterns to be distinguished.

The model was most recently used within the Energy Modeling Forum 28 to calculate the effect of different climate scenarios on European and global natural gas markets.[3] It illustrates Asia's increasing significance for the global market and simultaneously waning demand in Europe, which will not only result in a shift in trade flows but also in infrastructure investment.

1 R. Egging, S.A. Gabriel, F. Holz, and J. Zhuang, "A Complementarity Model for the European Natural Gas Market," Energy Policy 36, no. 7 (2008): 2385–2414.

2 R. Egging, F. Holz, and S. A. Gabriel, "The World Gas Model – a multi-period mixed complementarity model for the global natural gas market," Energy 35, no.10 (2010): 4016–4029.

3 F. Holz, P.M. Richter, and R. Egging, "The Role of Natural Gas in a Low-Carbon Europe: Infrastructure and Regional Supply Security in the Global Gas Model,"DIW Discussion Paper, no. 1273 (Berlin: 2013).

shifts. On the supply side, along with the Gulf States, the Asia-Pacific region is gaining ground; in the medium term, the US may become a significant natural gas exporter. On the demand side, Asia is emerging as a key region for future natural gas markets due to exponential growth.

The following presents the results of computations with a model developed by DIW Berlin in collaboration with the Norwegian University of Science and Technology (NTNU) Trondheim with the aim of forecasting future natural gas trade and the natural gas infrastructure that will be required in form of pipelines and LNG terminals. To this end, the Global Gas Model (GGM) was used, which provides a very detailed representation of global natural gas markets (see box).[12] In a Base Case the continuation of incremental climate and energy policy is assumed, particularly in Europe and the OECD countries which achieve 30 percent reduction, or seven percent respectively, in CO_2 emissions by 2035 compared to 1990. The climate scenario, on the other hand, assumes more stringent global climate policy in order to achieve the two-degree global warming target. The reference point for natural gas production and consumption are the recent estimates developed by the International Energy Agency.[13]

The model calculates the consumption and extraction volumes in 2010 and projections for 2040, differentiated by region and scenario (see Figures 2 and 3). The values differ significantly, both over time and between the two scenarios. While the Base Case shows an increase in natural gas consumption in all regions (globally by more than 50 percent compared with 2010), developments are more strongly differentiated in the climate scenario: in Europe, Russia, and North America, demand falls, whereas especially the Asia-Pacific region sees a strong increase in its market share driving global demand, which is projected to increase by 20 percent between 2010 and 2040. In both scenarios, North America extracts the most natural gas but an increase in volume is also observed in the Asia-Pacific region. Nevertheless, this region is dependent on increasing imports and over time overtakes Europe as the largest natural gas importer. However, Europe's imports continue to increase despite falling overall demand as domestic production plummets. Overall, in both scenarios, global trade flow volumes more than double compared to current levels.

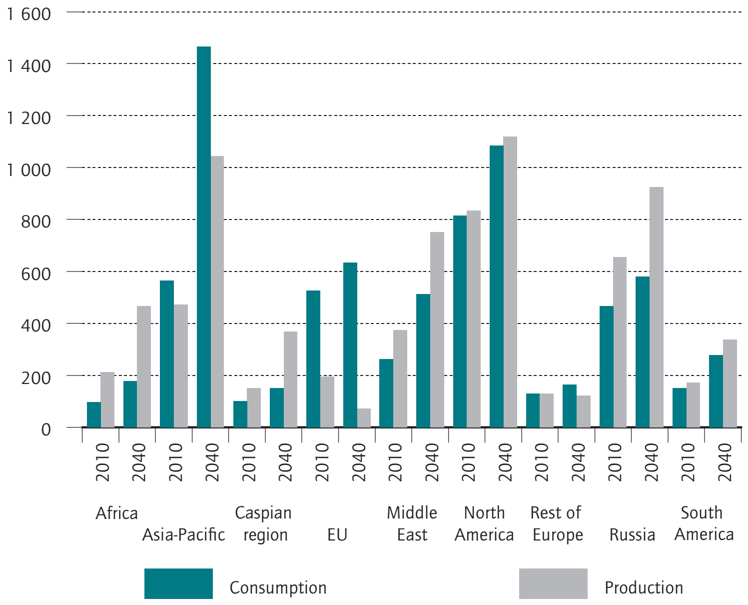
12 This Wochenbericht summarizes research findings from the "RESOURCES" Project in the framework of the BMBF funding priority, "Economics of Climate Change".

13 IEA, World Energy Outlook 2012 (Paris: OECD/IEA, 2012).

Figure 2

Regional Natural Gas Balances in Base Case

In billion cubic meters



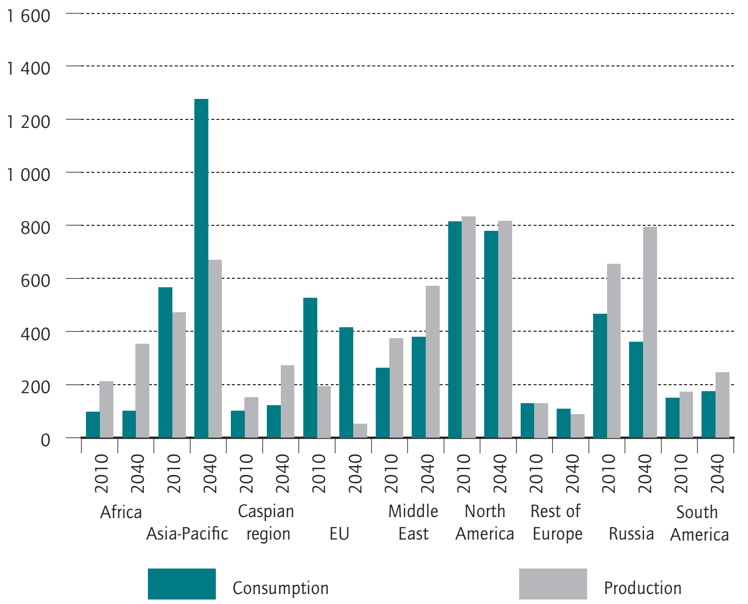
Source: calculations by DIW Berlin.

The Asia-Pacific region will overtake North America as the world's largest natural gas consumer.

Figure 3

Regional Natural Gas Balances in Climate Scenario

In billion cubic meters



Source: calculations by DIW Berlin.

Consumption is declining in regions that are currently significant, while growth in the Asia-Pacific region is all the more substantial.

The demand boom in the Asia-Pacific region is not limited to a small number of countries but rather affects the whole region. In as early as 2025, the region could be consuming more natural gas than North America, which has traditionally been the largest consumer. Some Asian countries such as Japan and Korea have already been importing natural gas on a significant scale for many decades. It was the supply of natural gas in particular that helped Japan to maintain a stable power system after all nuclear power plants were shut down in the wake of the Fukushima disaster in March 2011. Other countries such as China or India only recently started using natural gas in appreciable quantities and are steadily expanding their consumption. All producer countries in the region will increase their production of conventional, but also unconventional natural gas (at this stage predominantly in the form of coalbed methane). The most significant growth in production will occur in Australia and China. Despite impressive growth in domestic natural gas production in China, natural gas is likely to continue to play a relatively marginal role in the coming decades compared to coal, and natural gas imports from Central Asia combined with LNG will be needed to complement the domestic supply.

Apart from the clear shift in trade flows toward Asia, the growth in LNG trade is also particularly striking (see Figure 4). In contrast to Europe, the Asian import countries such as Japan, India, and China have only had limited connections with potential suppliers via pipeline networks to date. Thus the import of LNG will continue to dominate over pipeline gas. The climate scenario sees the net import of LNG increasing from approximately 100 to over 300 billion cubic meters. This development requires a large number of infrastructure projects.

The Asia-Pacific region continues to import its LNG in particular from the Middle East (almost exclusively from Qatar). The Middle East remains a swing supplier between the Atlantic and Pacific Oceans due to its geographical location and significant LNG export capacity. Thus, the region supplies importers both on the Atlantic market (e.g., Europe) and also in Asia. However, it is likely that African producers such as Algeria and Nigeria will play an increasingly significant role in global trade. Russia will increase its exports to Asia in order to profit from the region's growth in demand. Simultaneously, Europe will be able to reduce its dependence on Russia due to the expansion of import infrastructures from Africa and the Caspian Sea region. The abandon of the Nabucco Pipeline project just a few months ago will not affect this situation as there are already alternative plans for the import of gas from the Caspian region.

Development Trends in Europe: Natural Gas as Bridge or Backup for Renewable Power Generation?

Over the next 20 years, natural gas will be vital for the decarbonization of the European energy economy, particularly the electricity industry. Its development can essentially take one of the following two directions:

Natural gas could play a bridge role in the transition to a system of electricity supply secured predominantly by renewable energy sources; according to this scenario, natural gas would be used over the next 15 to 20 years to offset fluctuating supply from wind and solar energy, and its significance would decline when penetration rates of renewables have reached 80 to 95 percent. The almost entire replacement of fossil fuels in this scenario would lead to a significant reduction in CO_2 emissions.

Alternatively, it may be deemed necessary to use natural gas as a long-term backup to cope with the variability of renewable energy sources. Consumption would remain at a high level even beyond 2030 and may actually even increase further Europe-wide. The achievement of an ambitious carbon emissions reduction target would be impossible with this scenario, however.

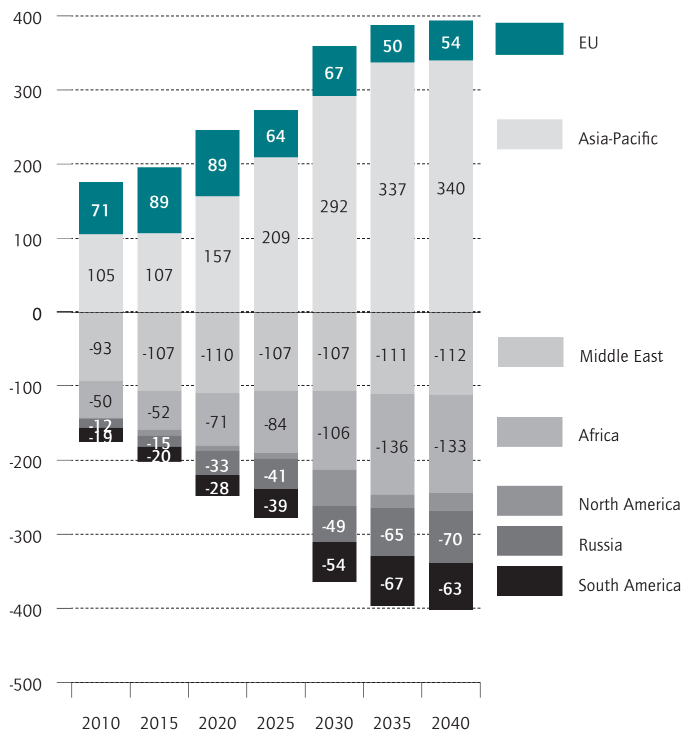
As part of an international model comparison to estimate future infrastructure requirements, the Global Gas Model was applied to these two scenarios for the European natural gas market (see Figure 5).[14] DIW Berlin also analyzed infrastructure expansion requirements such as new pipelines and LNG terminals in the EU and compared them with the Ten-Year Network Development Plans developed by the European gas pipeline operators which regularly evaluate and list requirements and projects.[15] In addition to the diversification of European natural gas supplies, these plans also anticipate the expansion of reverse flow capacity which would create import opportunities by Eastern Europe from Western European countries, i.e., in the opposite direction to traditional supply routes.

The bridge scenario analyzed by DIW Berlin would see a slight increase in European natural gas consumption by 2030, followed by a substantial fall. Around the end of the period analyzed, natural gas disappears de facto from the European power generation landscape and is only used in industry and households. As a result of

Figure 4

Net Trade Flows for Liquified Natural Gas (LNG) in Climate Scenario

In billion cubic meters



Source: calculations by DIW Berlin.

Even if ambitious climate change targets are met, global trade in liquefied natural gas will still see a strong increase by 2040.

the decline in fossil fuel consumption, the EU is able to meet the target of reducing greenhouse gas emissions by 80 percent by 2050 in comparison with 1990 levels. Accordingly, import dependency decreases in the natural gas sector which plays only a marginal role from 2040 on as a result of the plummeting volumes. At that time, production in Europe is also focused on Norway, (i.e., a non-EU country). In this scenario, companies invest very little in the natural gas infrastructure as investment would not pay off during such a short period. During the transition phase of strong consumption up to 2030, the region largely taps the flexible LNG import capacity available in many European coastal countries.

In the backup scenario, on the other hand, natural gas consumption steadily increases until 2050, when it reaches 580 billion cubic meters. Due to sustained use of fossil fuels, this scenario sees only a smaller reduction in greenhouse gas emissions in the EU, i.e, approximately 40 percent in relation to 1990. In light of decli-

14 F. Holz, P.M. Richter, and R. Egging, "The Role of Natural Gas in a Low-Carbon Europe: Infrastructure and Regional Supply Security in the Global Gas Model," DIW Discussion Paper, no. 1273 (Berlin: 2013).

15 For Europe: ENTSOG, Ten-Year Network Development Plan (Brussels: various years (2009–13)).

ning natural gas production in Europe due to limited reserves, import dependency rises to over 90 percent. Our model calculations indicate, however, that the dependency on Russia falls since Russian exports are increasingly focused on Asia, especially China. Some new pipelines are built to transport increasing natural gas imports from other regions such as North Africa or the Caspian region to Europe.

Conclusion

Natural gas is an important building block in the decarbonization of energy systems, not only in the German energy transition, but across Europe, in the US, and in the future also in Asia. Currently, supply and demand structures are shifting: while the Middle East remains a strategic supplier, Russia's significance in supplying Europe with natural gas is declining. Simultaneously, the US is moving from its position as a natural gas importer to a potential exporter. Additionally, global demand for natural gas is shifting further toward Asia.

For Central and Eastern Europe, which in recent years has suffered repeatedly from supply disruptions of Russian natural gas, the shift in global trade flows toward Asia will result in a decline in the region's dependency on Russia: in the future, natural gas can increasingly be transported from the west (e.g., from Norway via Denmark or Germany) to Poland or the Czech Republic. In combination with the Russian natural gas that Central and Eastern Europe will continue to use, albeit to a lesser extent, this will result in a more diversified and thus also more secure natural gas supply for the region.

The continued reliable import of natural gas into Europe requires only small infrastructure investment, primarily to further diversify European imports, for example, from North Africa and the Caspian Sea region and also in reverse flow capacity. In light of the current financial crisis, the EU must be prepared to step into the breach in case of possible funding shortfalls for reverse flow capacity.

In Europe, the potential of the new fracking technology to exploit more domestic shale gas appears small due to technical reasons and a lack of political support in the context of an adequate international natural gas supply.

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JEL: Q31, Q47, Q54
Keywords: natural gas, resources, reserves, trade, Asia, Europe

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Volume 3, No 11.12
13 December, 2013
ISSN 2192-7219