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The Impact of Recent Gas Market Developments on Long-Term Projections for Global Gas Supply

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Abstract Production from unconventional resources, increases in upstream development costs and sluggish demand growth have significantly impacted the global natural gas market in the recent past; and will likely continue to do so during the next decade. Taking these developments into account, we provide a projection of global natural gas supply until 2030 applying the MAGELAN world gas model by the Institute of Energy Economics at the University of Cologne (EWI). Apart from presenting the results of this simulation, the focus of this paper is thereby on the effects of recent supply, midstream and demand side trends on future gas supply compared to earlier studies and projections. While lower demand growth generally leads to relatively less international gas trade, pipeline exports are affected more strongly than trade in liquefied natural gas. In terms of gas output, this volume effect is found to mainly affect high cost gas producers at the upper end of the supply curve. Exports of suppliers with lower production costs and abundant reserves actually benefit.

Die Auswirkungen aktueller Entwicklungen im Gasmarkt auf das globale Erdgas-Angebot

Zusammenfassung Die zunehmende Rentabilität der Förderung unkonventioneller Reserven, steigende Kosten bei der Erschließung neuer Felder und hinter den Erwartungen zurückbleibende Nachfragezuwächse haben den globalen Erdgasmarkt in der jüngsten Vergangenheit bereits stark beeinflusst; und werden ihn auch langfristig beeinflussen. Unter Berücksichtigung dieser Trends wird in diesem Artikel eine Simulation des globalen Erdgasmarktes mit dem MAGELAN Modell des Energiewirtschaftlichen Instituts an der Universität zu Köln (EWI) erstellt. Neben der Vorstellung der Ergebnisse dieser Projektion liegt der Fokus des Beitrags dabei auf den Auswirkungen der Entwicklungen im Angebots-, Nachfrage- und Transportkostenbereich im Vergleich zu früheren mit demselben Modell erstellten Simulationen. Generell führen ein steigendes einheimisches Angebot (Unconventionals, vor allem in den USA) und nach unten korrigierte Nachfrageentwicklungen dabei weltweit zu einem relativen Rückgang des internationalen Gashandels, welcher jedoch eher zu Lasten von Pipelineexporten als zu einem Rückgang von Handel mit verflüssigtem Erdgas (LNG) geht. Ein relativer Rückgang der Absatzerwartungen zeigt sich dabei vor allem für Erdgasanbieter mit Produktionskosten am teureren Ende der Angebotskurve. Die Exporte von Lieferantenländern mit relativ niedrigen Produktionskosten steigen im Vergleich zu früheren Gasmarkt-Projektionen sogar an.

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1 Introduction

Regional and global projections of future gas supply are compiled by various institutions ranging from commercial consultancies to international bodies to research institutes. Scope, methodology and level of detail thereby largely depend on the studies' purposes.[1]

[1]The literature mentioned and discussed in this introduction merely present a small excerpt of existing gas market models. A larger se-

Game-theoretic model are often used to investigate the degree of market power exercised by upstream producers and/or midstream players or the potential impacts of cartel formation on the gas market. Typically, such models abstract from a global perspective and focus on the European gas market. This implies that Europe has been an interesting market to study these issues and that, in the long-run and on a global scale, there are a larger number of (potential) producers with significant gas reserves which might limit the benefits of strategic behavior. Examples of such game-theoretic models of the European gas market are GASTALE (van Oostvoorn and Lise 2007) and GASMOD (Holz et al. 2008). Models used for longer-term projections usually incorporate the up-, mid- and downstream sections of the market with greater detail and are based on larger datasets. Therefore, they abstract from possible strategic behavior and assume competitive market structures. For Europe, such models are, for example, presented by Perner and Seeliger (2004) and Remme et al. (2008) who both estimate supplier-specific long-run gas supply costs to the European market. The assumption of competitive markets, however, also reduces the computer capabilities required to solve such models. Hence, it is possible to extend the models to a global perspective in terms of geographic coverage. This category of models, for instance, includes the Baker Institute's World Gas Trade Model (Hartley and Medlock 2005) and the MAGELAN Model by Seeliger (2006). Both models incorporate global gas supply (reserves and costs) as well as all potential transport options in great detail. MAGELAN is a linear optimization model; the World Gas Trade Model is a spatial equilibrium with an elastic demand based on historic price elasticity of gas demand data and the costs of backstop technologies.

In this paper, we apply an enhanced version of MAGELAN and an updated database to calculate a global gas market projection until 2030. The focus of the subsequent analyses is the impact of recent developments in the global gas market on market outlooks. Therefore, the new projection is compared with an earlier published MAGELAN simulation (Bothe and Lochner 2008). To interpret the results of the new simulations and their relative difference to earlier projections, the next two sections describe the most important developments in the gas market—and how they affect model parameterization—since the last published MAGELAN projection and the model itself. Results are presented in the subsequent sections ahead of some concluding remarks.

lection of models was, for example, discussed at the Energy Modeling Forum (EMF-23) at Stanford University (from 2004 to 2007) under the title of "World Natural Gas Markets and Trade".

2 Cost- and Demand Developments

That the global gas market is in a period of significant change is nothing new: demand is rising internationally as natural gas is the least carbon-intensive fossil fuel, reserves of conventional natural gas in close proximity to the consumption centers in Europe and North America are declining and, partly as a consequence of the two, liquefied natural gas (LNG) as a means to transport natural gas over large distances is rising in importance. This not only increased international trade; LNG investments being less specific than ones in long-distance transport pipelines may lead to a convergence of local gas prices as market players will exploit price differences under the no-arbitrage assumption. However, recent developments also impact this longer-term trend. On the one hand, mid- and upstream investments in transport or production capacities became partially more expensive during the last decade. As this affected some technologies more than others, it also altered the relative competitiveness of production and transport technologies. On the other hand, import demand in OECD countries developed much less bullish than expected due to declining demand (economic crisis) and increased domestic production (unconventionals in North America).

2.1 Costs

For global gas supply, transport as well as region-specific production costs are of outmost importance. Transport costs were estimated regarding onshore and offshore pipeline projects as well as LNG chain cost parameters. For pipeline projects data provided by the Oil and Gas Journal (01/2003–04/2008) was used to estimate specific cost factors for onshore and offshore pipeline projects. Compared to Seeliger (2006)—which the ewiGAS2008 project used in this paper for comparison was based on—, specific pipeline costs increased by 30 percent (onshore projects) and 70 percent (offshore projects), respectively. Thereby, specific costs for offshore projects were found to be twice as high as those for onshore projects. This increase of pipeline costs is mainly due to higher costs for steel and compressors.

Gathering comparable data regarding costs for the components of the LNG chain turned out to be much more difficult. Supported by industry players, we were nevertheless able to accumulate enough data to conduct a reasonable estimation of specific costs for the different stages of the LNG value chain.[2] Compared to Seeliger (2006), specific invests for liquefaction terminals increased by about 20 percent. In contrast to that investment costs for regasification plants remained constant; the costs for LNG vessels even decreased

[2]Data sources include the Oil and Gas Journal (01/2003–04/2008) and platts LNG newsletter (2008 and 2009 volumes).

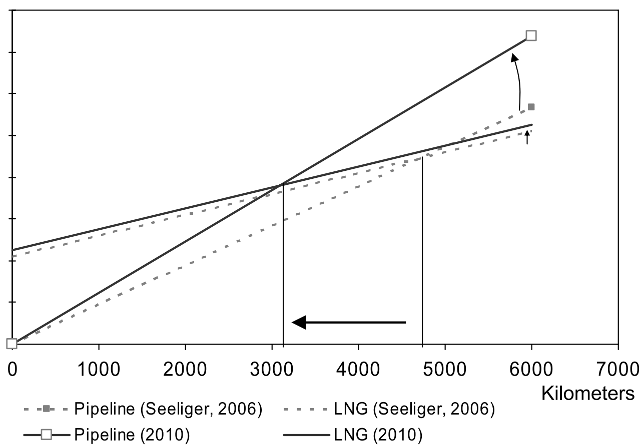


Fig. 1 Pipeline vs. LNG transport costs

by 45 percent which is mainly due to significantly larger average tanker sizes and the resulting economies of scale.

As a result, the changed cost parameters made transport of natural gas as LNG relatively more attractive. The structural change of transport costs per unit of natural gas is displayed in Fig. 1. Relative to pipeline transports, LNG has higher initial investment costs (for the first kilometer of transport distance) but lower costs for each additional kilometers of distance covered: pipeline transports require new capital investment for increasing the length of a pipeline while larger distances just affect tanker costs in LNG trade. Hence, the slope of the LNG cost curve in Fig. 1 is much smaller than the one of the pipeline cost curve. The intersection of the two curves was at about 4,800 kilometers with the Seeliger (2006) data implying that LNG transports are cheaper than pipeline transports for distances in excess of 4,800 kilometers and vice versa. This finding is, hence, roughly in line with similar analyses at the time.[3] The new cost estimates shift the LNG cost curve upwards and tilt the pipeline cost curve around the origin. Hence, the intersection of the cost curves moves from about 4,800 kilometers to 3,100 kilometers. Thus, the relative competitiveness of LNG increases significantly compared to on- and offshore pipelines.

2.2 Supply

Investments costs in production infrastructure rose even stronger than midstream capital costs during the last years. The change in upstream production costs in relative terms thereby differs slightly between regions depending on how the costs of individual fields are weighted (e.g. weighted with reserves, the discovery of a new but expensive gas deposit would increase the production costs in a region although that does not apply to the previously known reserves). Weighted with capacity additions between the two simulations, production costs were found to generally increase between 43 and 76 percent in the different regions.[4] Driven by an increase in production from unconventional reserves, which became profitable due to high prices, the factor is 159 percent for North America. In absolute terms, it was found that production costs increase strongest in regions with already high costs, i.e. Europe and North America. In relative terms, however, changes are mostly in line across all production regions. (Weighting the increase with reserves, the overall is 112 percent on average.)

This does not imply there is no direct effect of this development: With upstream costs rising faster than midstream costs relatively (see previous paragraph), upstream costs rise as a percentage of total supply costs for each combination of production and demand region. Hence, previous absolute production cost advantages of one region compared to another gain weight relatively to transport costs: Regions with generally lower production costs, e.g. in the Middle East or in Russia (Lochner and Bothe 2009) should ceteris paribus benefit from the increase in terms of market share.

Apart from the cost side, reserves are also an important parameter for the supply side. Here, the most striking difference can be observed for the United States. Estimated end-of-2010 reserves in the Lower-48 states are 18 percent higher according to the 2010 Annual Energy Outlook by the EIA (2009a) relative to EIA (2007)—the majority coming from unconventional sources. Reserves expected to be found until 2030 are also 14 percent higher.[5]

2.3 Demand

For demand, the opposite is true. The 2009 World Energy Outlook (IEA 2009) projects global gas demand in 2030 to be ten percent lower than what the IEA (2007) projected two years ago. This is mainly due to the economic crisis and lower than previously expected gas consumption in the power sector. OECD countries are affected more heavily (minus twelve percent) than non-OECD countries (minus eight percent).

Generally, it can be concluded that profound changes in the upstream (production costs), midstream (transport costs) and downstream (demand) segments of the gas market have

[3] E.g. see Jensen (2004). Labeling of the y-axis in Fig. 1 had to be omitted for data confidentiality reasons. The curves are shown for average-sized LNG facilities, tankers and long-distance pipelines and may shift slightly for different investments due to economies of scale.

[4] Based on EWI research of new gas field investments between 2007 and 2009. In regions without new investments in this time period, assumptions from similar fields in other regions were applied.

[5] This only considers reserve volumes. Production costs for gas from unconventional sources also declined significantly over the last years (relative to production from conventional sources) bringing these reserves closer to the market cost-wise.

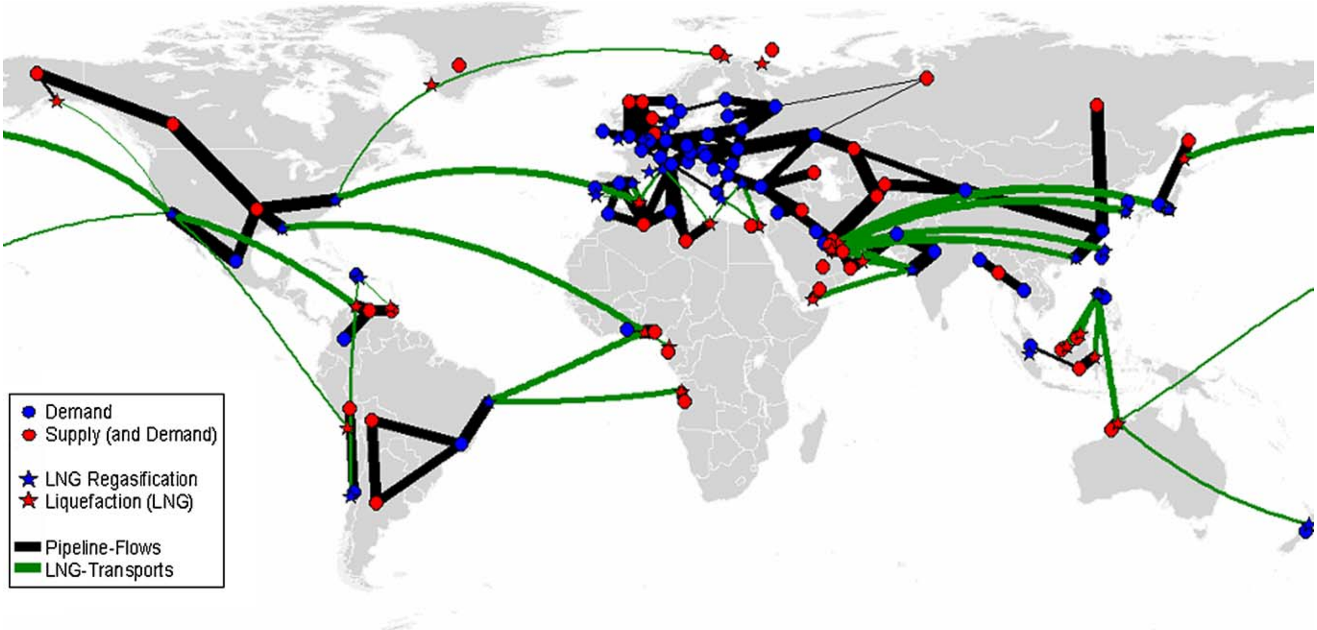


Fig. 2 Projected global gas flows in 2030

occurred in the recent past. The impacts of those developments on global gas market projections are presented in the results-section.

3 Brief Description of MAGELAN Model and Simulation Assumptions

For our simulations, we apply an updated and extended version of the MAGELAN-Model, originally developed at the EWI (Seeliger 2006). MAGELAN is a long-term gas supply model which optimizes natural gas supply including investments in production and transport infrastructure up to 2030 with an annual granularity.[6] In its scope, the cost-minimization model is intertemporal and interregional. The model's objective function includes both capital and operating costs of global gas production and transport. Market inefficiency, which could arise due to strategic behavior by market players, is therefore not reproduced by the model. However, incorporating such strategic actions would require strong assumptions regarding the type of competition which in turn would significantly impact the results of the model. Using linear optimization as an approach yields the advantage that results are solely based on observable data. These results can therefore be interpreted as a benchmark in the sense that they represent the normative, social welfare maximizing outcome.

The optimization in MAGELAN is subject to all relevant technical restrictions in production and transportation of natural gas. That includes limited reserves and resources, the need to balance demand and supply as well as in- and outflow for each country (and the system as whole) and all capacity restrictions for infrastructure. The gas world in MAGELAN is modeled as an interconnected grid consisting of 139 nodes for production, transport and consumption. One node usually represents one country. In countries where production or liquefaction or regasification of LNG takes or might in the future take place, additional nodes have been implemented to provide for these facilities. A map of the coverage of the model which includes all nodes is depicted in Fig. 2. (As this map already contains some results, only those pipeline and LNG connections actually used are shown.)

Major inputs of the model are, hence, assumptions on demand developments, existing reserves and production costs per production region as well as the existing infrastructure and all relevant cost parameters. Demand is, thereby, based on the IEA's World Energy Outlook (2009), production and reserves on BP (2009) and EIA (2009b). Regarding the existing infrastructure and production cost estimates, a global database of these parameters was compiled at EWI (and updated in 2009). Based on existing capacities on the transport and production stages, the model can endogenously expand capacities or build new facilities/pipelines in later periods where possible. Further, optimal production and transported volumes between nodes are determined. Model outputs are,

[6] The model description in this section is based on Lochner and Bothe (2009) who enhanced the model to annual granularity from Seeliger's (2006) five-year-periods. See both publications for more detailed model descriptions.

therefore, all capacity additions and expansions as well as production per production region and volume flows between nodes on an annual level.

Therefore, the model determines which producers supply gas to which importing country and hence derives annual supply mixes for each demand region.

4 Results 2010 Reference Projection

The analysis in this section will primarily deal with the projected development of the global gas market until 2030 with respect to the supply and transport side. A special focus will be on gas supply to Europe.

Our projection regarding worldwide gas production is presented in Table 1 for the years 2015 and 2030; historic data from the year 2008 is included for comparison. Generally, our results, thereby, mirror the findings of previous studies. The countries of the Community of Independent States (CIS) see the biggest increase in output and, hence, become the world's largest gas producing region. (In 2008, output in North America was still slightly higher.) Russia, which contributes 77% of CIS production in 2030, remains the world's largest gas producing country. Production in Europe declines in absolute terms and as a share of global output. Mainly caused by declining reserves in Europe, this share falls from almost ten percent in 2008 to only four percent in 2030. The largest increase in production in relative terms is projected to take place in the Middle East region: gas production reaches almost 925 billion cubic meters (bcm) per year in 2030 and the region advances to become the second largest gas supplier in the world. Despite a slight decline in production volumes compared to 2008, North American output stabilizes at around 17 percent of global production after 2015. In the 2008 to 2015 time period, North American production declines significantly according to our model due to the current overcapacity on the supply side of the global gas market. Production from unconventional gas reserves in the United States (and also Canada) is more expansive than conventional production in other regions. Hence, such investments are stopped first as they are on the left-hand side of the global supply curve. Further non-model based arguments include shorter investment lead times, lower fixed capital costs and higher variable costs than supply from conventional resources. Hence, the price elasticity of supply in the medium term is much higher than for production from conventional sources. Consequently, the medium-term supply side reaction to the lower than expected demand growth in an oversupplied market is likely to come from such production sites. After 2015, however, it again becomes more profitable to invest in unconventional gas reserves—also from a model perspective—and production volumes pick up again by close to 150 billion cubic meters annually until 2030 (see also next section). Gas production in Africa is projected to more than double from 2008 levels; its share of global gas production, however, remains below ten percent. The remaining two supply regions presented in Table 1, Asia/Pacific and Latin America, all grow relatively slowly in terms of absolute gas production volumes. This increase is thereby basically in line with total demand growth in those regions. Thus, increased supply mainly caters local demand. Exports to other regions remain on levels similar to 2008; huge export increases as in the CIS or Middle East regions are not observed. Latin America's share as a percentage of worldwide gas production increases only marginally; in the case of the Asia-Pacific region it actually declines until 2030.

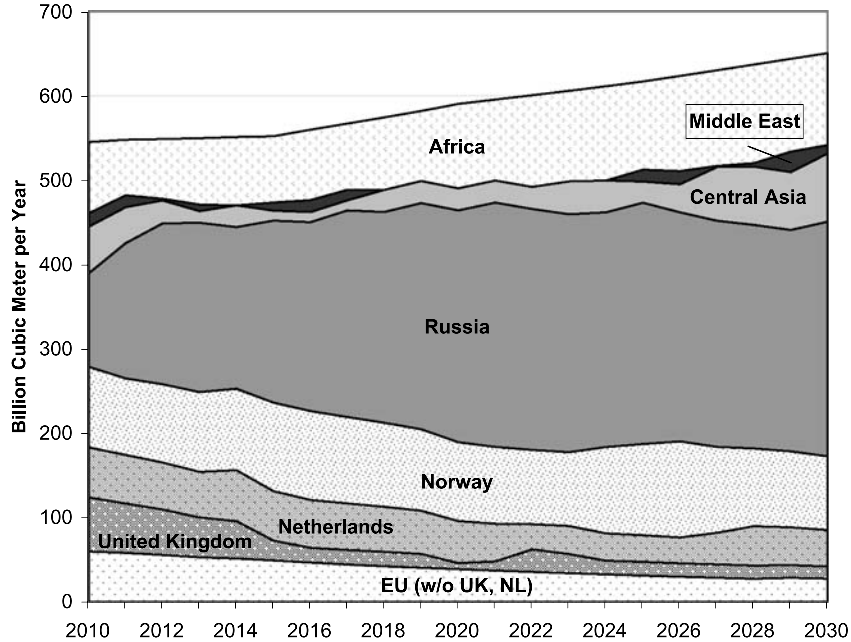
The implications of these upstream developments on global gas flows are depicted in Fig. 2 for the year 2030; the impact on the European supply mix over time in Fig. 3. Figure 2 is, thereby, a representation of the global gas market with nodes, pipelines and LNG connections as modeled in MAGELAN. The lines represent all pipelines and LNG routes which are used in that year with the thickness of the line indicating the absolute volume flow. Generally, Fig. 2 reveals that the gas market is continuing to integrate globally. To add some figures: LNG trade more than triples from

Table 1 Global production volumes in EWI 2010 reference simulation

	2008		2015		2030		Delta 2030 vs. 2008	
	BCM	%	BCM	%	BCM	%	BCM	%
Africa	214.8	7.0%	317.1	8.8%	444.1	9.9%	+229.3	+107%
Asia/Pacific	411.2	13.4%	577.8	16.0%	479.8	10.6%	+68.6	+17%
Europe	293.7	9.6%	243.0	6.7%	179.2	4.0%	−114.5	−39%
CIS	793.6	25.9%	1,041.3	28.9%	1,445.8	32.1%	+652.2	+82%
Latin America	158.9	5.2%	239.0	6.6%	263.5	5.8%	+104.6	+66%
Middle East	381.1	12.4%	553.4	15.3%	924.8	20.5%	+543.7	+143%
North America	812.3	26.5%	636.8	17.6%	769.8	17.1%	−42.5	−5%

Source: Own calculation, 2008 data based on BP (2009)

Fig. 3 European supply mix 2010 to 2030



226 billion cubic meters in 2008[7] to 715 billion cubic meters in 2030. Cross-border pipeline flows increase from 587 billion cubic meters to almost 1.4 trillion cubic meters or more than 30 percent of global gas production (see also Fig. 4). The largest increase in pipeline trade is, thereby, projected to take place in Asia with gas flows from various Russian production regions (Yamal, Eastern Siberia) and Central Asia to China and from the Middle East to China and India. LNG exports from the Middle East are also significant as the region has relatively low production costs but is relatively further away from the demand centers in Europe and Korea/Japan than Russia. Total LNG exports in the region exceed 300 billion cubic meters. These volumes thereby cater LNG demand in the Asia-Pacific region which is the largest LNG importing region with almost 400 billion cubic meters of imports. Despite the sustaining high levels of indigenous gas production, the United States is projected to remain an LNG sink with imports of almost 130 billion cubic meters in 2030. The number of LNG suppliers is significant with Sakhalin (Russia), Trinidad and Tobago, Algeria and Nigeria being the largest ones. However, the aforementioned unconventional reserves in North America allow the region to be much less dependent on imports than the other large demand centers in Europe, the Far East and China. Latin America is also projected to be further integrated into the global gas market with some countries becoming importers (Brazil and Chile) and others new exporters for LNG (Venezuela, Peru).

Turning to Europe (see also Fig. 3), the cost minimization yields that Russia remains that largest supplier and increases its market share significantly. As expected, indigenous production, including from the UK and the Netherlands, declines significantly. Norway's gas supplies to Europe are projected to remain relatively stable around 100 billion cubic meters per year before they peak in 2026 at

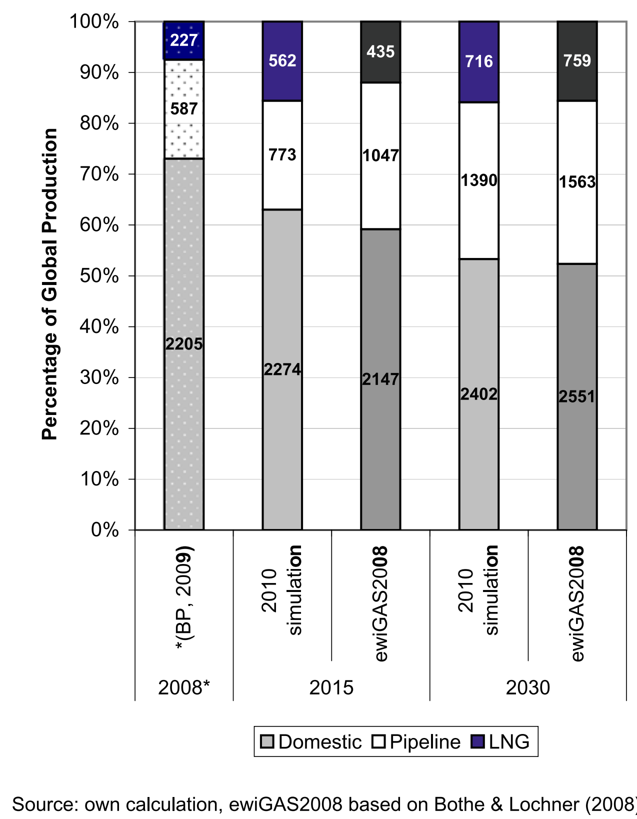


Fig. 4 International trade—simulation 2010 vs. 2008

[7] All historic trade data quoted in this section is based on BP (2009).

115 billion cubic meters. Due to an increasing availability of cheaper Russian and Caspian gas volumes, and the depletion of the lower production cost fields in Norway, output declines thereafter. However, Norway remains the most important supplier in close geographic proximity to the EU. The market share of suppliers from the Caspian region is projected to increase significantly to 13 percent of total gas consumption in 2030. However, from an economic perspective, only 12 billion cubic meters from Azerbaijan are routed to South-South Eastern Europe via Turkey in 2030. The remaining 69 billion cubic meters are transited via Russian territory. Regarding the Turkey transit route, some Middle Eastern gas volumes in the range of 10 to 25 billion cubic meters per year are also transported to Turkey. However, our model simulation shows that utilizing a significant pipeline import corridor via Turkey for the Central European market is not part of a least cost solution. Those volumes imported via Turkey from the Caspian region and the Middle East largely remain in Turkey and South-South Eastern Europe. Africa, as the main supplier of natural gas in geographic proximity to Southern Europe, remains important but does not gain market share (in contrast to the Russian and the Caspian Countries). Predefined new pipeline projects, which were given to the model, such as GALSI and Medgaz between Algeria and Italy and Algeria and Spain respectively, replace some intra-Mediterranean LNG trade by pipeline flows. Further pipeline capacity additions are, however, not implemented endogenously by the model. The major reason for that is that the pipeline and LNG import capacity built-up between 2005 and 2015—these additions were given to the model as fixed—creates sufficient import capacity to supply the European gas market until 2030 with the World Energy Outlook demand forecast which was revised downwards in 2009. This also explains the relatively minor role of Middle Eastern gas in Europe according to our projection: The import capacity from the CIS countries and North Africa already exists which makes it inefficient to build new costly infrastructures in order to benefit from lower production costs in the Middle East. (Middle Eastern gas is, hence, rather exported to regions that have no alternatives regarding import in close geographic proximity or where supply infrastructure does not yet exist, such as Japan, Taiwan, Korea and India.)

LNG supplies to Europe are not labeled explicitly in Fig. 3. However, as evident from Fig. 2, they mainly originate from North Africa (Algeria, Egypt and Libya) and make up about 55 percent of total supply from the Africa region.

5 Comparison with ewiGAS2008

The projection outlined in the preceding section is the result of the previously defined cost assumptions regarding demand, supply and transport. This section investigates how parameters that have changed since an earlier published projection with the MAGELAN model, ewiGAS2008 (Bothe and Lochner 2008), impact the results with respect to the development of upstream production capacities and international trade. Regarding gas production in 2030, volumes from ewiGAS2008 are presented in Table 2 in combination with the change to the projection in this paper in absolute and relative terms. Furthermore, the relative change is adjusted for the volume effect of lower global gas demand in the new simulation. It is thereby obvious that the total output reduction is not distributed equally across the different production regions. Two regions, North America and the CIS countries, are actually projected to have relatively higher outputs. For all other regions, gas production is lower according to the latest simulation with the magnitude of the decrease significantly differing between regions.

The explanation for the findings regarding North America is the most straightforward: reduced exploitation costs for unconventional reserves increase domestic output by 368 billion cubic meters or almost 100 percent compared to ewiGAS2008. In combination with the adapted demand assumptions, this means North American import requirements are more than 450 billion cubic meters lower which has a

Table 2 Changes in 2030 production volumes compared to ewiGAS2008

	ewiGAS 2008	Delta	Relative	Adjusted for volume effect
Africa	505.8	−61.7	−12.2%	−5.1%
Asia/Pacific	830.3	−350.5	−42.2%	−37.5%
Europe	226.0	−46.8	−20.7%	−14.2%
CIS	1,261.3	+184.5	+14.6%	+24.0%
Latin America	475.1	−211.6	−44.5%	−40.0%
Middle East	1,173.6	−248.8	−21.2%	−14.8%
North America	401.8	+368.0	+91.6%	+107.2%
Total	4,873.8	−366.9	−7.5%	0.0%

Source: own calculations including data from Bothe and Lochner (2008), Lochner and Bothe (2009) significant impact on gas production worldwide and in particular on LNG flows. This decline in LNG demand especially hits the Middle East region which was originally projected to become a major gas supplier of the United States. However, other potential LNG suppliers are also affected, especially those catering the Pacific Basin in the Asia/Pacific and Latin America regions. According to our projection, Middle East exporters are better equipped to diversify away from exports to North America by supplying pipeline gas to China and India and LNG to East Asia. Hence, the negative difference in output compared to the earlier simulation is much smaller in relative terms than for Latin America and Asia/Pacific. Obviously, this is a cost-driven result: with lower global import demand for gas, the suppliers with the highest production and transports cost—which are located at the upper end of the supply curve—are driven out of the market first. This effect is increased by the relatively stronger increase in production costs compared to transport capital costs. The affected suppliers are located to a large extent in the Asia/Pacific and Latin America regions.[8]

The smallest absolute differences for production in 2030 between the two simulations are found for Europe and Africa, see Table 2. Europe has quickly depleting reserves, so increased global supply availability makes a few costly production sites unprofitable. However, only few fields are affected. Africa also sees its output growth only slightly impacted. In this case, this is due to its relatively lower production costs (compared to Latin America) and its geographic location which allows it to find alternative consumers for its LNG exports despite the reduced import demand in North America. According to our projection (see Fig. 2), these consumers are in South America as well as in Europe.

The most striking result however is, that suppliers in the former Soviet Union (CIS region) actually benefit from the aforementioned developments in the form of increased output. This finding can be explained by two reasons: Firstly, as described in the second section of this paper, production capital costs increased much stronger than transport capital costs since the earlier simulation. As this increases the share of production in total supply costs, it benefits those production regions with generally lower production costs. Russia is one of them. Secondly, as pipeline capital costs rose much more than LNG investment costs, it is cost-optimal to better utilize the existing pipeline transport infrastructure, for example from Russia to Europe, than before as it becomes more costly to replace it at the end of its technical lifetime.

Hence, and we believe this to be a note-worthy result, not all suppliers in a specified time period would lose output if gas demand is relatively lower and production costs increase everywhere. In this case, one actually gains (apart from North America which gains due to unconventionals).

The changing relative distribution of gas production between regions has implications for international gas trade and the relative roles of pipeline and LNG trade. The aforementioned relative cost-advantage of LNG over pipeline gas compared to ewiGAS2008, thereby, directly translates into a higher share of LNG as a percentage of global trade. This comparison of the results from the new simulation and from Bothe and Lochner (2008) is highlighted in Fig. 4. For further assessment, the 2008 data is included showing that only 27 percent of global gas production was traded internationally in 2008—19 percent by pipeline and eight percent as LNG. Hence, LNG shipments accounted for 28 percent of all gas trade. According to the projection of this paper, this figure will increase to more than 42 percent in 2015 due to the significant increase in LNG facilities both upstream and downstream and the excess supply in the market in the short and medium term. The 2015 comparison also offers the largest difference to ewiGAS2008: In the earlier simulation, LNG was projected to grow much slower while pipeline trade was expected to rise faster. In the longer term (year 2030), the results are less driven by the temporal supply and demand balance but by cost-fundamentals, so results of our simulation are much closer to the previous one. Nevertheless, the relative gain in competitiveness for LNG also translates into relatively smaller declines of LNG volumes (compared to pipeline trade taking total demand decline into account). That the difference is small and that, with a share of 34 percent of total trade, LNG is only marginally more relevant than according to ewiGAS2008 (32.7 percent), is largely the consequence of the overlapping effect of the relative fall in US import demand. These volumes would have largely arrived as LNG. The decline of that LNG market is, however, almost fully compensated by an increase in LNG imports in other markets in Europe and Latin America, which is the consequence of the relatively decreasing LNG costs.

6 Summary

The projection in this article has shown that the globalization of the natural gas market is likely to continue. According to our simulation, the countries of the Former Soviet Union are the world's largest gas producing region ahead of the Middle East in 2030. Thanks to the production of gas from unconventional reserves, North American gas output is projected to decline only slightly in absolute terms—especially compared to earlier projections. Global gas trade will significantly increase from about 800 to more than 2,300 billion cubic meters in 2030 with the larger increase in relative terms coming from LNG trade. Regarding

[8]See Lochner and Bothe (2009) who focus on supply costs in the context of the presented model.

the European market, Russia is projected to increase its market share as the largest supplier. As most of its supply infrastructure to Europe is already in place or under construction (creating some temporary excess capacity), additional gas supplies from this region have a cost advantage compared to other new suppliers. Nevertheless, LNG imports, especially from Africa, remain an important source of gas for the European market.

These results partially deviate from earlier gas market projections due to upstream and midstream cost increases and changed supply and demand forecasts. While the global supply side developments are dominated by a relatively lower projection for US import dependency (due to unconventionals), the demand side impact is more general and affects most downstream markets due to lower than expected investments in gas-fired power generation and decreased demand forecasts due to the economic crisis of 2009. The latter effect implies that the intersection of the global supply and demand curve shifts to the right. Hence, especially high cost gas producers in Latin America and the Asia/Pacific regions lose market share compared to earlier projections. Midstream cost increases affect investments in long-distance transport pipelines much stronger than those in LNG. In our projection, this relatively improved competitiveness helps LNG suppliers to compensate the reduced LNG import demand of the United States. The relative rise in upstream costs being even stronger than the midstream cost increases implies that production costs become more important as a share of total gas supply costs. This also favors gas suppliers with generally low production costs, especially those in the Former Soviet Union, with respect to output and market share compared to earlier gas market projections.

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