Analysis of a liberalised German Gas Market

A Medium-Term Gas Trading Model based on Entry-Exit Network Access[1]

Philipp Scheib, Dr. Frieder Kalisch, Dr. Bernhard Graeber[2]

Corresponding Author:
Philipp Scheib[3]
EnBW Trading GmbH
Durlacher Allee 93, D-76131 Karlsruhe
Phone +49 721 63-15493
Fax +49 721 63-15433
Mail p.scheib@enbw.com

Abstract:

European gas markets are experiencing fundamental change due to decrease in domestic production, increase in demand and liberalisation efforts of the European Union. Germany represents the biggest single market in Continental Europe and is also a major transit country for gas. Gas market liberalisation in Germany, however, has so far shown few effects.

In this paper we look at how third party network access in an entry-exit regime with different balancing zones ("market areas") will influence the market. We have developed a multi-regional, inter-temporal model for Germany including transit flows to and from neighbouring countries with monthly resolution. The model is based on the following assumptions: Long term import contracts will stay in effect, network access is regulated based on an entry-exit-system, domestic production will continue to decline, no new infrastructure projects that are not known today can become operational before 2009 and access to storage is not regulated. The model focuses on the transmission system, looking at transit flows between entry-exit-zones.

The model proves to be a valuable tool for analysing different set-ups of market areas. Preliminary model results did not confirm the need for 19 market areas in Germany. Data availability still needs to be improved, in order to allow a more detailed analysis and produce tangible and robust results.

Keywords: *natural gas, trading, regulation, network industry, linear optimisation*

JEL classifications: *L95, L14, Q41, C61*

---

[1] Preliminary version for the 5th Conference on Applied Infrastructure Research (INFRADAY), Berlin University of Technology, 6-7 October 2006

[2] All EnBW Trading, Methodology & Models department

[3] Curriculum Vitae: Philipp Scheib studied industrial engineering and business administration at the University of Karlsruhe and the IECS Strasbourg. He started his career as a consultant for PricewaterhouseCoopers focusing on projects in the European utilities industry. When PwC Consulting was integrated into IBM Business Consulting Services he was responsible as Senior Consultant for the Energy Trading and Risk Management practice in Central Europe. He left IBM to become an Associate at Convergence, a consultancy focusing exclusively on utilities clients. Philipp Scheib joined EnBW Trading in 2005. He works in the Methodology & Models department and is enrolled as a PhD candidate at the University of Karlsruhe, Institute for Industrial Production (IIP).

1 Introduction

The market for natural gas in Europe is undergoing fundamental changes. Local production in countries like the United Kingdom, France and Germany is declining, thus leading to higher imports from non-EU countries like Norway, Russia or Algeria. Demand for natural gas is expected to increase further, with gas-fired power stations being a possible driver. The main challenge, however, will be how markets react to the liberalisation that is imposed by the European Union.

At present Germany is the most interesting market within the European Union from a researcher's point of view. It is not only – beside the UK – a major consumer of natural gas, but provides also a fair amount of gas storage and serves as a transit country for gas, e.g. to France, via Switzerland to Italy or via Belgium to the UK. In addition, Germany is characterized by a more complex market structure than other EU countries. Gas is traditionally delivered through a three-tier gas value chain ("Lieferkette") of few importing companies, about 15 regional transmission system operators and more than 700 local distributors or "Stadtwerke[4]".

2 Regulation of the German Gas Market

Until the late 1990s the German gas market was characterized by regional monopolies of incumbent gas companies. One exception was the company Wingas, who built separate pipelines leading to pipe-to-pipe competition to a certain extent, but always limited to areas near to Wingas pipelines.

A first approach to open up the gas market was driven by the EU Directive[5] for the internal market in natural gas in 1998. The Directive allowed member states to choose between regulated or negotiated third party access (NTPA) to gas pipelines. Germany adopted NTPA, leaving it up

[4] municipal utilities

[5] [EC 1998] Directive 98/30/EC of the European Parliament and of the Council of 22 June 1998 concerning common rules for the internal market in natural gas

to market participants to define market rules. Associations of the gas industry and industrial gas consumers negotiated the so called "Verbändevereinbarungen" ("VV", association agreements), a first version ("VVI") was signed in 2000 and a second ("VVII") was signed in 2002. Negotiations for a "VVIII" failed in 2003. NTPA was based on a point-to-point system for network tariffs making it difficult for new entrants to challenge the incumbents.

In July 2005 the new German Energy Law ("Energiewirtschaftsgesetz[6]") came into effect responding to EU Directive 2003/55/EC[7] that aimed at accelerating the market opening. At the same time the regulator[8] took up his work. In order to comply with EU legislation, market rules in Germany had to be changed towards a non-discriminatory network access based on an entry-exit system. The regulator discussed issues concerning network access with stakeholder groups[9]. Network users provided input for the debate. The rules for network access, however, were defined by representatives of network operators. Network operators and the regulator agreed on a new system that officially comes into effect 1st of October 2006. It is based on an entry-exit system. Germany will be divided into 19 entry-exit zones (so called "Marktgebiete", we will call them "market areas" in this paper). Those "market areas" are not areas in the geographical sense, but partly overlap[10]. Customers (i.e. exit points) have to be assigned to market areas. This assignment has not yet been specified in detail.

Beside entry-exit network access, German gas incumbents have pushed the regulator to allow network operators to offer a parallel system as an option ("Optionsmodell"). In the option model network users make separate bookings[11] of entry and exit capacity at every level (interregional

---

[6] [EnWG 2005]
[7] [EC 2003] Directive 2003/55/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in natural gas and repealing Directive 98/30/EC
[8] Bundesnetzagentur (www.bundesnetzagentur.de)
[9] Participants were lobby groups representing incumbent gas companies, industrial consumers and gas traders. See also [BNetzA 2006], p. 70.
[10] E.g. the city of Berlin belongs to the three market areas "H-Gas Norddeutschland", "E.ON GT H-Gas Nord" and "ONTRAS".
[11] The option model is also called "Einzelbuchungsmodell" (separate booking model).

transmission, regional transmission, local distribution) on the way top-down from the entry point to the exit point. The option model maintains regional gates and city gates. According to the Bundesnetzagentur network access with one entry and one exit contract shall be the regular case, the option model not being mandatory[12]. Therefore we have based our model structure exclusively on entry-exit network access.

3 Data and Model Description

We have modelled the German market for natural gas as a multi-regional and inter-temporal optimisation problem. Optimising models assume that the underlying market can be represented as a market with perfect competition. At present this assumption is far from correct for the German gas market[13]. On the other hand it would require even more assumptions and guess-work to model individual behaviour of market participants in a changing environment. We believe that an optimising model can still provide valuable insight into the setup of the market. When analysing results, however, the limitations both of an optimising model and data availability have to be considered.

For the model we used publicly available data. All energy flows and capacities are in GWh and GW. Where data was only available in bcm[14] or mcm/h[15] we converted with the corresponding calorific value[16]. All data is in monthly resolution.

The model consists of nodes and pipelines. Nodes represent demand regions, hubs (interconnection points of pipelines) or producing countries. The nodes are linked with pipelines. In some cases several physical pipelines are modelled as one virtual pipeline aggregating pipeline

[12] See [BNetzA 2006], chapter 5.1.2. Neues Gasnetzzugangsmodell, p. 69 - 70

[13] Other researchers, e.g. [Holz et al. 2005] assume an oligopolistic market structure.

[14] Billion cubic meters

[15] Million cubic meters per hour

[16] The calorific value represents the energy per cubic meter in kWh/m^3. Calorific values range from 9,8 kWh/m^3 (L-gas) to 12,2 kWh/ m^3 (H-gas)

capacities. Attributes for pipelines are capacities in forward and backward direction and pipeline charges. All data concerning pipelines were directly taken from TSO[17]s websites.

To take into account different gas qualities we split the pipeline system between L-gas and H-gas. Within those sub-systems gas quality issues are ignored. An assumption that is justified as long as the major physical flows do not change.

Linked to nodes are demand, production, storages and boundary conditions.

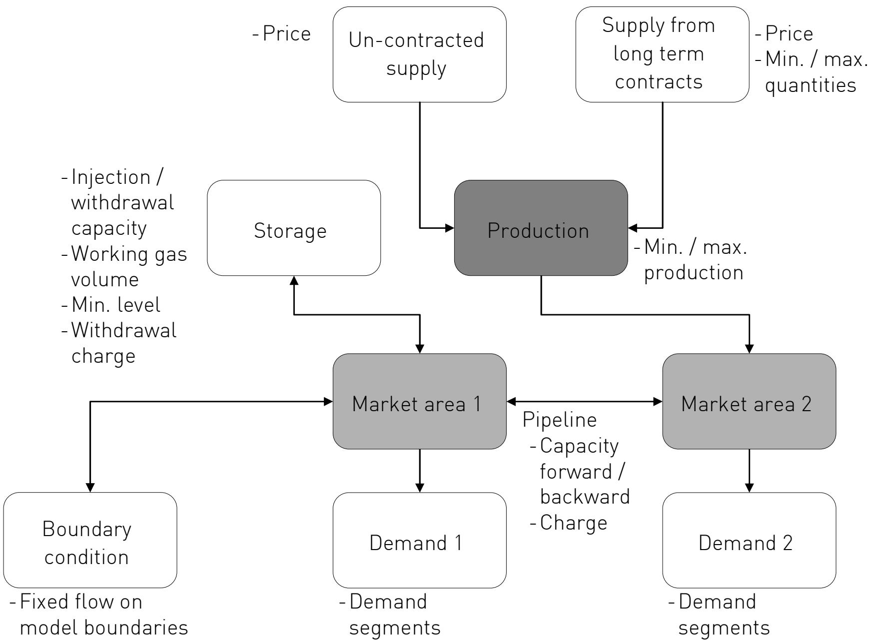

Figure 1: Model topology (schematically)

Demand is a fixed input to the model. Monthly demand is deduced from yearly figures using typical seasonality. Interruptible customers (industry, power stations) represent potential for demand reduction. We did not model demand elasticity in the proper sense, but simply put a cost on demand reduction, i.e. the model can reduce demand if the marginal price for gas exceeds a

[17] Transmission system operators

pre-defined level[18].

Production is limited by maximum annual production volumes and minimum and maximum daily production (swing). For imports from CIS[19] only production volumes meant for the modelled market were taken into account. Monthly gas demand is met by gas delivered under long term contracts, spot gas deliveries or withdrawal from storage. We modelled a set of known long term contracts with annual contract volumes and take-or-pay volumes (minimum bill).

Minimum storage levels were introduced to model behaviour of storage operators regarding security of supply. For instance storages have to be filled before the beginning of winter.

Gas flows on model boundaries are an exogenous input into the model based on historical data. Gas flows were only fixed on model boundaries where flows are not likely to change significantly in the next three to four years.

The time horizon for the model is until September 2009[20]. For that time span prices are available for traded markets.

The objective function of the model is to minimize total system cost. The total system costs include costs for gas delivered under long term contracts, gas not taken under take-or-pay agreements, gas delivered on spot markets, transport charges for entry and exit[21], costs for gas storage and a cost for demand reduction. The model was programmed in GAMS[22] and uses a standard solver.

---

[18] It should be noted that the model generally has enough gas to meet demand and demand reduction is rarely observed in the model. In markets were consumer prices are directly influenced by market prices, like it is the case for industrial customers in the UK, consumers reduce demand if gas prices exceed certain thresholds (either by switching to alternative fuels or by shutting down or postponing production processes). Fuel switching in the power sector that depends on the gas-power spread was not modelled explicitly.

[19] Community of Independent States (Russia)

[20] Gas years are 1st October to 30th September.

[21] Costs for local distribution are omitted.

[22] General Algebraic Modeling System

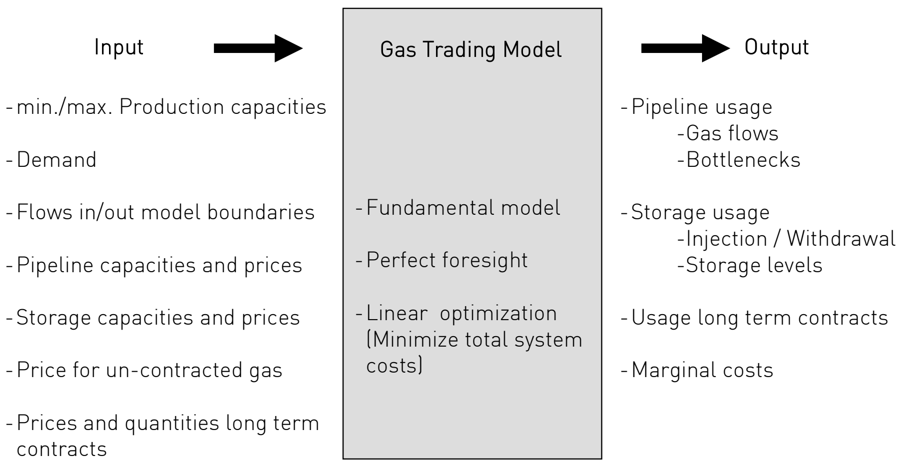

Figure 2: Model input and output

4 Simulation Results

Model outputs are the physical usage of each pipeline, storage usage, usage of long term contracts and marginal costs for gas in each market area.

Gas flows produced by the model correspond generally to typical real flow patterns, as far as these are published. By comparing physical flows and maximum pipeline capacities bottlenecks can be detected. As expected all major import pipelines (from Norway and CIS) are heavily used in winter months. Import pipelines from Norway are always used 100% in winter months; import pipelines from CIS are used between 70% and 100% in winter months. However, it should be noted, that the gas production in CIS destined for the North-West European market is limited by contract volumes of long-term contracts. As a first conclusion one could be tempted to state a contractual rather than a physical bottleneck. This statement would be rather speculative. The actual swing in long-term contracts (maximum volumes that can be taken in peak months) is not based on hard evidence since those contract details are generally not disclosed to the public. For pipeline connections within North-West Europe the model shows typical flow patterns. For example the Interconnector (IUK) from Zeebrugge to Bacton generally transports gas in winter from the continent to the UK (reverse flow) and in summer from UK to the continent. Interestingly the model uses the IUK 100% in some winter months. This does not always correspond to published flow data on the IUK. In the ideal model world all available flexibility is used. This behaviour seems to be somewhat unrealistic since market players in the real world do not consistently arbitrage between international markets but traditionally keep an eye on security of supply in their home market.

Model results show that there are sufficient storage volumes in Germany to meet normal winter demand. The question if there is enough peak withdrawal capacity can not be answered, since the model has only a monthly time resolution. If no minimum and maximum monthly restrictions were put on long term contracts and production, no storage is used at all. In this case the model uses all available flexibility in order to avoid storage costs. When we put reasonable restrictions for minimum and maximum monthly production, storage usage shows realistic yearly patterns. When we use storage prices as published by storage operators, the use of storage is extremely inhomogeneous. Gas storage that is more expensive than others is not used at all, but is replaced by storage in other market areas. This shows that published storage prices and price differentials are too high compared to transport costs. In the real world, however, storage in all market areas is used. This leads us to the conclusion that integrated gas companies use gas storage not based on published prices, but rather based on internal costs. For modelling purposes we adjusted storage costs to a uniform level, which leads to realistic results concerning storage usage. Obviously the prices for storage offered by storage operators to the market differ significantly from internal costs. This supports the idea that storage should also become regulated. At the moment gas storages in Germany are exempted from regulation[23].

Long term contracts provide almost all gas consumed in Germany. In all model runs all take-or-pay obligations were met. That means that with the given market data, there is sufficient supply by long term contracts, but no over-supply. Yet this depends on market prices for spot gas (input into the model). If spot gas is considerably cheaper than gas under long term contracts, the usage of long term contracts will go down to take-or-pay quantities.

The marginal costs represent the costs the system would save if one unit of gas less would be delivered. It should not be confused with a market price for gas. The model is not intended to do price forecasting. Different marginal costs at different nodes reflect transport costs between market areas.

Germany is divided into 19 market areas in effect from October 1st 2006 on. 14 market areas are H-gas, 5 market areas are L-gas. These 19 market areas are the result of a consultation process between the Bundesnetzagentur and network operators. So far it has not been proven that those market areas are based on physical bottlenecks. We defined the 19 market areas as the base case in our model (see figures 3 and 4).

[23] Cf. [BNetzA 2006], p. 95

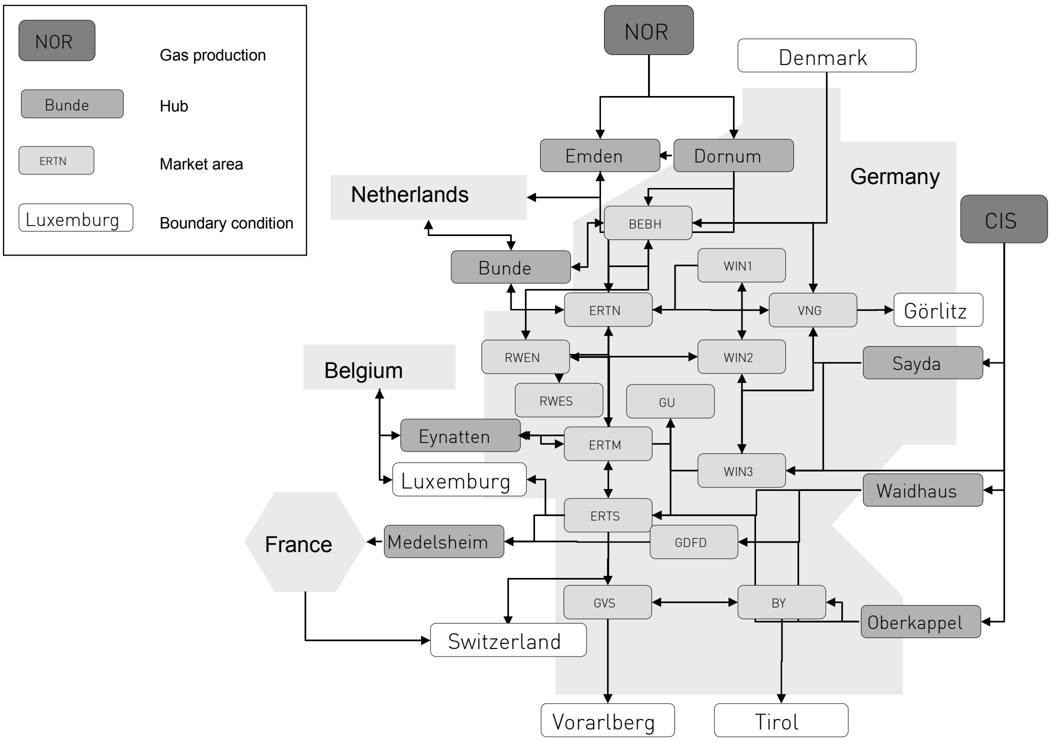

Figure 3: Model topology for German H-gas network (base case)

The German gas demand is allocated to the different market areas, but is not yet fully clear. Associations of network operators are still[24] in the process of assigning every network operator to the respective market areas. Just a few days from the official start of the new entry-exit system on October 1st this allocation was not resolved for quite a number of DSOs[25].

[24] as at September 15th 2006
[25] Distribution system operators

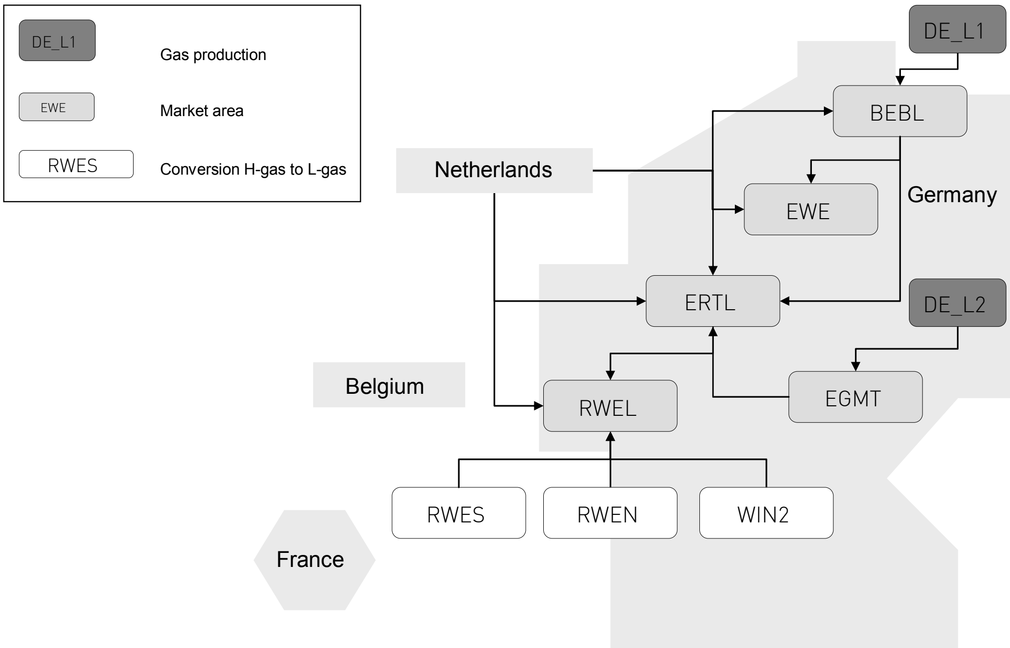

Figure 4: Model topology for German L-gas network (base case)

The fact that some DSOs can effectively be reached through pipelines of different TSOs has been widely used to argue that there is pipe-to-pipe (or pipe-in-pipe[26]) competition in Germany. For example [Floren 2005] states that 70% of the German demand can be reached by at least two different network operators. This idea of pipe-to-pipe competition has led to overlapping market areas. A report for the German Federal Ministry of Economics and Technology, however, comes to the conclusion that "the assumption, that there is actual or potential competition in the field of gas transport networks, which would supersede sector specific cost-based regulation, lacks any evidence" [27]. At present more than 500 local gas distributors are assigned to only one market area.

[26] Some major pipelines in Germany are owned by several gas companies, e.g. MEGAL, TENP, NETRA. The pipeline capacities are marketed separately by the owners.
[27] [Monopolkommission 2006], p. 14

Even if this assignment is still under discussion, it shows that pipe-to-pipe competition is rather an exception for local municipal utilities.

Network access would be simplified, if the allocation to market areas was clear. There seems to be no hard evidence that overlapping market areas can increase competition. On the other hand an unambiguous assignment of exit-points (i.e. gas consumers) to market areas would greatly simplify network access. This would mean that different TSOs offer entry capacities into that market area. Since in theory network users (traders) do not have to assign explicitly entry capacity to exit capacity (every exit point can be reached from every entry point) it is crucial to determine were bottlenecks effectively occur in the network. In case of bottlenecks, which cannot be resolved, the network can be split into different market areas.

As a scenario we divided Germany into just two market areas, one market area for L-gas and one market area for H-gas. To create this (virtual) scenario we eliminated all entry-exit-tariffs within Germany, as well as all capacity constraints within the German H-gas and L-gas network. Restrictions for conversion between H-gas and L-gas remained[28].

We ran the model for the base case "19 market areas" and the scenario "2 market areas" with the same data, except that for the scenario "2 market areas" there are no capacity constraints within the German H-gas and L-gas network. We compared gas flows to and from Germany[29]. Results for the base case "19 market areas" are shown in table 1 and for the scenario "2 market areas" in table 2. Positive numbers mean importing gas flows to Germany, negative numbers exporting gas flows. All numbers are given in TWh per gas year[30]. Monthly figures show a typical seasonality of imports in summer and exports in winter at the border point Eynatten.

---

[28] H-gas can be converted to L-gas, but not the other way round.
[29] Gas flows on the other border points are an exogenous input into the model as a boundary condition, e.g. export to Switzerland (cf. figure 3)
[30] 1st of October to 30th of September

Gas year	Frankfurt/ Oder	Sayda	Waidhaus	Ober-kappel	Medels-heim	Eynatten	NL->GER (H-Gas)	NL->GER (L-Gas)	Emden/ Dornum
2004	187	99	212	10	-121	23	145	53	376
2005	182	99	212	10	-123	12	147	64	399
2006	193	99	197	22	-89	2	147	75	401
2007	185	99	203	47	-99	19	131	85	419
2008	183	99	207	48	-101	27	144	96	422

Table 1: Base case "19 market areas": Gas flows on the German border in TWh per gas year

Gas year	Frankfurt/ Oder	Sayda	Waidhaus	Ober-kappel	Medels-heim	Eynatten	NL->GER (H-Gas)	NL->GER (L-Gas)	Emden/ Dornum
2004	196	99	205	10	-146	20	170	26	417
2005	195	99	200	10	-131	5	165	40	441
2006	187	99	203	20	-118	-23	174	49	460
2007	188	99	193	47	-103	-19	162	37	478
2008	158	99	200	49	-115	6	186	20	507

Table 2: Scenario "2 market areas": Gas flows on the German border in TWh per gas year

Compared to the base case, exports to France (border point Medelsheim) increase in the scenario as well as imports from Norway. Transits through Germany increased, since in the scenario no entry-exit-tariffs within Germany have to be paid, so gas transit through Germany becomes cheaper compared to the base case. By adjusting entry- and exit-tariffs, transit flows can be influenced.

In the scenario less L-gas from the Netherlands is imported to Germany compared to the base case. This is due to increased conversion of H-gas to L-gas in Germany. However, one should be careful when interpreting these results, since data availability on actual pipeline capacities in Germany is rather unsatisfying[31].

[31] Cf. also [BNetzA 2006], p. 73: "Data concerning technical capacities as well as capacity usage is incomplete."

Overall major gas flows stay the same in the scenario “two market areas” compared to the base case “19 market areas”, because they are determined to a large extent by entry capacities on German border points, restrictions on production and restrictions on long term contracts. Therefore the number of market areas could be reduced without creating physical bottlenecks.

Better data availability concerning pipeline capacities would allow to answer the question of the right allocation of market areas more precisely.

5 Conclusion

Third party network access is a pre-requisite for an efficient gas market[32]. We developed a model for the German gas market and neighbouring markets in order to analyse effects of the set up of market areas. In this paper we presented a methodology for analysing gas flows in a traded market under the assumption of perfect competition. Model results match reality fairly well. Availability of data, especially for pipeline capacities and historical flows in Germany, remains a critical issue.

We showed that major gas flows will not change significantly in Germany if market areas are organized differently. Therefore we can assume that there are no technical constraints which require 19 market areas in Germany. Overlapping market areas needlessly complicate network access. Available storage data suggest that gas storage is not a competitive market so far.

The model we presented in this paper provides a good basis for further research. Data availability still needs to be improved, in order to allow a more detailed analysis and produce tangible and robust results.

[32] Cf. also [Monopolkommission 2006], p. 4

References

[BNetzA 2006] Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen: *Monitoringbericht 2006*, Bonn, 2006.

[EC 1998] European Commission: *Directive 98/30/EC of the European Parliament and of the Council of 22 June 1998 concerning common rules for the internal market in natural gas*, Brussels, 1998.

[EC 2003] European Commission: *Directive 2003/55/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in natural gas and repealing Directive 98/30/EC*, Brussels, 2003.

[EnWG 2005] Deutscher Bundestag: *Zweites Gesetz zur Neuregelung des Energiewirtschaftsrechts vom 7. Juli 2005*, in Bundesgesetzblatt Jahrgang 2005 Teil I Nr. 42, Bonn, 2005.

[Floren 2005] Floren, Hans-Peter: *"Permanenter Dialog mit unseren Transportkunden"* in Energiewirtschaftliche Tagesfragen, 55. Jg. (2005), Heft 10, S 3, Essen, 2005.

[Holz et al. 2005] Holz, Franziska et al.: *A Strategic Model of European Gas Supply (GASMOD)*, Berlin, 2005.

[Monopolkommission 2006] Monopolkommission: *Mehr Wettbewerb auch im Dienstleistungssektor! Sechzehntes Hauptgutachten der Monopolkommission gemäß § 44 Abs. 1 Satz 1 GWB*, Bonn, 2006.