Bocconi

IEFE
Centre for Research on Energy and Environmental Economics and Policy

Research Report Series – ISSN 2036-1785

Balancing Systems and Flexibility Tools in European Gas Markets

Leen Dickx , Caterina Miriello and Michele Polo

Research Report n. 14

February 2014

IEFE - Centre for Research on Energy and Environmental Economics and Policy at Bocconi University
via Guglielmo Röntgen, 1 - 20136 Milano
tel. 02.5836.3820 - fax 02.5836.3890
www.iefe.unibocconi.it – iefe@unibocconi.it

Michele Polo (IEFE, Department of Economics and eni Chair in Energy Markets, Bocconi University)

Caterina Miriello (IEFE - Bocconi University)

Leen Dickx (IEFE - Bocconi University)

Balancing Systems and Flexibility Tools in European Gas Markets[1]

Leen Dickx[(a)] **Caterina Miriello**[(a)] **Michele Polo**[(a),(b)]

February 2014

Abstract

This report investigates on the creation of wholesale markets for natural gas, viewed as a consequence of balancing needs following market liberalization. In the first part we analyse the balancing issue and how it evolves with liberalization, creating a demand for individual imbalances clearing that can be provided by wholesale transactions. Once market liquidity increases, wholesale trade can be used as a second source of gas supplying in parallel with long term contracts. Balancing and second sourcing, being linked to the physical delivery of gas, are expected to develop in each national gas transmission system. The third phase that we envisage refers to the development and trading of financial instruments to hedge price risks that may concentrate on a small number of larger gas exchanges. We apply this framework to review in detail the different regulatory steps that must be addressed to create an efficient and functioning wholesale gas market. In the second part we carefully examine the wholesale natural gas market of eight European countries (Austria, Belgium, France, Germany, Italy, Netherlands, Spain and UK), analysing their balancing systems and tools for physical and commercial flexibility. The choice of these countries has been dictated by their higher degree of development and their evolving regulation. In our view each of these countries represents a different evolutionary stage in gas market development, and as such will serve to set a case study.

JEL Classification: Q48; L95

Keywords: natural gas markets; gas balancing; market liquidity.

---

[1]We thank Guido Cervigni, Monica Giulietti and Jonathan Stern for their helpful discussion and the participants of ZEW Mannheim Energy Conference for suggestions and comments. A particular thank goes to Giulia Andreoni for her valuable and competent assistance.

(a) IEFE - Centre for Research on Energy and Environmental Economics and Policy, Bocconi University, Milan – Italy.
(b) Department of Economics and eni Chair in Energy Markets, Bocconi University, Milan – Italy.

Contents

Tables

Figures

1 Introduction

1.1 Background

In this study we analyse the creation of wholesale markets seen as a natural consequence of market liberalization that brings in a fragmentation in the market shares of individual operators at all the stages of the value chain, apart from transmission.

A gas transmission system has to guarantee the pressure in the pipelines within certain thresholds for security and operational reasons, which in turn requires maintaining the injections into the system and the withdrawals from it balanced at the aggregate level. In turn, with the progresses in the liberalization the market structure in the upstream (shippers) and downstream (suppliers) segments tend to become more articulated than under the pre-liberalization monopoly. Thus, while in a pre-liberalization environment the same vertically integrated monopolist was responsible for most of the injections and withdrawals balancing the ex-post shocks in supply or demand by managing its portfolio of contracts, after liberalization different agents reciprocally contract covering each a small fraction of the aggregate trade gas volumes. Then, individual imbalances may be adjusted within the agents' portfolio to a lesser extent than before, while wholesale trade may offer a way to compensate shocks of opposite sign occurring in the contracts of different agents.

The development of a liquid wholesale gas, however, requires defining and implementing a set of rules and mechanisms that are crucial to its success. The aim is to exploit, through commercial transactions, the flexibility margins that the different sources of injection and withdrawal put at disposal. The specific solutions are therefore conditioned by the different features of the national gas systems in terms of flexibility tools (imports, production swings, line-pack, storage, interruptible demand). The most adequate regulatory framework to translate physical flexibility into commercial flexibility requires to address quite similar issues, including the definition of a transmission system model, the design of the balancing rules and the set up of transparency requirements.

This report, after describing the framework used to analyse the development of gas hubs, reviews the evolution of wholesale gas markets in eight European countries, which can be considered as representing different steps in the evolution towards a mature and liquid economic venue where physical and financial products linked to gas are traded.

We initially analyse the balancing issue and how it evolves with liberalization, creating a demand for individual imbalances clearing that can be provided by wholesale transactions. Secondly, we review in detail the different regulatory steps that must be addressed to create an efficient and well functioning wholesale gas market. Third, we investigate the wholesale natural gas market in Austria, Belgium, France, Germany, Italy, Netherlands, Spain and UK, analysing their balancing systems and tools for physical and commercial flexibility. We chose these countries as, in our view, each of them represents a different evolutionary stage in the development of wholesale gas markets, which we analyse considering both the regulatory framework adopted and the structural features of each case. We focus on balancing and flexibility since all the changes that are currently going on in this sense will call for a rigorous and organic comprehension of the matter, and because it is through balancing regulation that wholesale trade in gas market was born in the first place.

1.2 Literature review

Although the dynamics of gas markets are receiving increasing attention, a comprehensive analysis of the development of wholesale gas markets in Europe and of the regulatory issues involved is in our view still missing in the literature. NERA and TPA (2005) review and evaluate balancing rules in some EU countries, but the report is by now outdated. Migliavacca (2009) surveys some aspects of the Italian balancing system, highlighting the contacts with the electricity sector, while KEMA (2009) offers an interesting report that deals nonetheless only briefly with balancing and flexibility, being concerned with transmission tariffs. Lapuerta (2010) examines some balancing mechanisms and analyses the balancing system in the UK and Germany and Kayaerts et al. (2011) deal with flexibility issues, with a focus on line-pack. About (physical) flexibility tools, and access to flexibility tools, it is worth recalling Cretì (2009), Cavaliere (2011) and Ejarque (2011) that examine storage under different perspectives. Many studies deal with the consequences on gas market of European integration: among others Asche et al. (2002), Roller et al. (2007) and Pollitt (2011). More recently, Neumann and Cullmann (2012) analysed the degree of integration of gas markets based on the prices of eight European hubs, finding a significant level of integration. Asche et al. (2013) analysed the degree of market integration between NPB, TTF and Zeebrugge, also finding a high integration. Petrovich (2013) analyses hubs integration verifying the "reliability" of hub prices as reference price signals. A large literature deals with the implications of the entry-exit model. Among others, it is worth recalling the works by Hunt (2008) that explores the implications of having an entry-exit model on integration and wholesale markets and by Vazquez and Hallack (2013) that identify the central significance that balancing markets assume within the entry-exit framework. A kindred work to ours is Heather (2012) that accurately describes and categorises the main European gas hubs and their liquidity. We move alongside this line of study, but focusing rather on balancing mechanisms and rules, and viewing liquidity as a result of the rules set by each country's regulator.

The paper is organized as follows. Section 2 presents an analytical framework to model the balancing issue and how it has changed with liberalization: a theoretical insight about balancing is offered, taking into account the importance of flexibility instruments and of market design and regulation, and a description of the regulation implemented by the European Commission is included. Section 3 reviews the balancing mechanisms and flexibility tools available for UK, the Netherlands, Germany, Belgium, France Italy, Austria and Spain, following the evolution of their respective hubs as trading platforms and evaluating their performance according to their liquidity. Section 4 compares the indexes computed for each country and concludes.

2 Analytical Framework

2.1 The balancing issue

The initial phase in the development of wholesale natural gas markets is linked to the balancing of individual positions in a liberalized market. From an operational point of view, natural gas flows in the transmission system from one point to another on the network by virtue of the differential in pressure existing between those two points. Pressure fluctuations stemming from market parties' injections and off-takes to and from the network can threaten the *system integrity*[2], and it is therefore crucial to design a balancing system that ensures that pressure in the system remains within the safe operational limits which guarantee the transport of natural gas through the grid. To understand why and how wholesale trade becomes a useful tool and is needed to efficiently run the system, we start from a description of the main inflows and outflows of a natural gas transmission system (GTS), and compare the case of a vertically integrated incumbent, that resembles the typical pre-liberalization setting, and the environment where the upstream and downstream segments in the gas industry are fragmented with many shippers and suppliers interacting.

[2] From Keyaerts et al. (p.2, 2008) "system integrity" is defined as "*each situation of a transport system where the pressure [and the quality of the natural gas] remain within the lower and upper limits set by the system operator such that the transport of natural Gas is guaranteed*".

2.1.1 Gas Transmission System: Inflows and Outflows.

The sources of inflows (I) in the system are imports, domestic production and withdrawals from the storage facilities, each characterized by some capacity constraint, that is an upper bound to the feasible flow per unit of time, possibly with some flexibility. More precisely, imports can be distinguished according to the transportation support: imports by pipelines (IM_{PL}) use the connections of the GTS to other systems or the production fields, and are subject to pipeline capacity (K_{PL}); in addition, we have imports by LNG terminals (IM_{LNG}), entry points for gas potentially being transported from any LNG liquefaction facility by LNG ships, that are subject to LNG capacity (K_{LNG}). The second source is domestic production (P) that feeds the GTS from gas fields located in the same territory, and is bounded above by the production capacity (K_P). Finally, gas can enter into the GTS through withdrawals from storage facilities (SW), that may be depleted gas fields, acquifers and salt caverns or, to a minor extent, storage infrastructures attached to the LNG regasification plants. Withdrawals are bounded above by the storage capacity (K_S). Then, we can write the amount of inflows that occur in the GTS per unit of time as:

$$I = IM_p + IM_{LNG} + P + SW \leq K = K_{PL} + K_{LNG} + K_P + K_S$$

Moving to outflows (O), corresponding to withdrawals from the GTS, they can take different forms: final demand by end users (D) directly connected to the GTS or to the distribution networks, exports to foreign GTS's by pipelines (EX_{PL}) or LNG (EX_{LNG}), and injections into storage facilities (SI). Hence, total outflows are

$$O = D + EX_{PL} + EX_{LNG} + SI$$

Inflow and outflow decisions are taken by a set of economic agents or institutional bodies and are clearly correlated. Outflows, for example, depend on the decisions of final users, who contract their gas provisions according to their predictable needs, and are mirrored by a corresponding decision of inflow (e.g. import) by upstream agents as shippers. Hence, the flows in the GTS depend on a large set of demand and supply decisions by different agents, and reflect their underlying decisions and unexpected shocks: inflows to meet demand requirements may experience unforeseen stops, and demand by final users typically displays random ex-post adjustments. Supply and demand shocks, therefore, may create imbalances between realized inflows and outflows as compared to the planned and contracted flows based on the ex-ante decisions of the agents involved.

In order to keep the GTS balanced, i.e. with the pressure into the system within given safety boundaries, the difference of inflows and outflows is to remain within certain thresholds. Imbalances, by making the inflows larger than outflows in case of unexpected negative demand shocks or positive supply shocks, or outflows in excess to inflows in the opposite cases, may threaten the equilibrium of the system, moving the pressure out of the security boundaries. Balancing inflows and outflows is therefore a crucial activity in the management of a GTS.

To illustrate in a very simple manner the balancing issue, let us consider this oversimplified example, corresponding to a market with four final clients that are served through four downstream contracts and four corresponding upstream contracts to cover their provision. Depending on the vertical and horizontal structure of the market, that we shall consider later on, the downstream contracts may be signed by a single or several suppliers, and the corresponding upstream contracts may be agreed upon by one or several shippers, that in turn may be vertically integrated or independent from the downstream shippers. At this stage, we want to analyse how the shocks in final demand may create imbalances between the ex-ante contracts and the ex-post provisions, in turn creating a gap between planned and realized inflows and outflows that threaten the system pressure and integrity.

Let us assume that final users' demand has a predicted component and a random shock, according to the expression:

$$D_i = d + \varepsilon_i$$

where the shocks are iid and may be positive or negative with equal probability, i.e. $\varepsilon_i = -\varepsilon/4$ or $\varepsilon_i = \varepsilon/4$. Hence, demand shocks have zero mean and standard error $\sigma_\varepsilon = \varepsilon/4$. Then, to cover the downstream contract a corresponding upstream contract for an amount equal to *d* is signed, the former implying a withdrawal and the latter an injection in the system equal to *d*. This way, the system is ex-ante balanced. Ex-post shocks, however, may create imbalances that require an adjustment. Table 1 reports some possible combinations of shocks, the aggregate imbalance and the amount of internal adjustments that may allow closing individual imbalances of different sign without calling for additional inflows or outflows from outside the system. These adjustments allow matching positive and negative imbalances due to opposite shocks of different end users, without any adjustment in the upstream provision to the system. Depending on the market structure, internal adjustments may take the form of compensations within a portfolio of contracts of the same operator or commercial trades involving different agents. If all these adjustments are concluded, any residual imbalance requires injecting more or less gas into the system than what originally contracted, an adjustment that involves the upstream providers.

However, if some of the individual imbalances are not adequately cleared through adjustments among market participants, balancing the system becomes more troublesome. Let us consider, as an example, the case $(-\varepsilon/4, \varepsilon/4, \varepsilon/4, \varepsilon/4)$, where three of the four final clients are hit by a positive shock and demand more gas than originally procured by their providers, with a fall in the pressure of the GTS. The net position at the system level requires to increase the total inflows by $\varepsilon/2$, while the first shipper, whose final client is demanding less than expected, would be able to deliver its excess supply of gas to the second shipper, that is short of gas, preventing this latter from triggering additional inflows from outside the system, overshooting the adjustment. If, however, for any reason, this internal compensation is not closed, the second shipper will require additional gas from outside, injecting gas to the system, with total injections equal to $3\varepsilon/4$ and an increase in the gas pressure in the system.

Table 1 - Demand shocks, aggregate imbalances and internal adjustments

Shocks	Aggregate imbalance	Internal adjustments
$(-\varepsilon/4, -\varepsilon/4, -\varepsilon/4, -\varepsilon/4)$	$-\varepsilon$	0
$(-\varepsilon/4, -\varepsilon/4, -\varepsilon/4, \varepsilon/4)$ $(-\varepsilon/4, -\varepsilon/4, \varepsilon/4, -\varepsilon/4)$ $(-\varepsilon/4, \varepsilon/4, -\varepsilon/4, -\varepsilon/4)$ $(\varepsilon/4, -\varepsilon/4, -\varepsilon/4, -\varepsilon/4)$	$-\varepsilon/2$	$\varepsilon/4$
$(-\varepsilon/4, -\varepsilon/4, \varepsilon/4, \varepsilon/4)$ $(-\varepsilon/4, \varepsilon/4, -\varepsilon/4, \varepsilon/4)$ $(-\varepsilon/4,\varepsilon/4, \varepsilon/4,- \varepsilon/4)$ $(\varepsilon/4, \varepsilon/4, -\varepsilon/4,- \varepsilon/4)$ $(\varepsilon/4, -\varepsilon/4, \varepsilon/4, -\varepsilon/4)$ $(\varepsilon/4, -\varepsilon/4, -\varepsilon/4, \varepsilon/4)$	0	$\varepsilon/2$
$(-\varepsilon/4, \varepsilon/4, \varepsilon/4, \varepsilon/4)$ $(\varepsilon/4,-\varepsilon/4, \varepsilon/4, \varepsilon/4)$ $(\varepsilon/4, \varepsilon/4, -\varepsilon/4, \varepsilon/4)$ $(\varepsilon/4, \varepsilon/4, \varepsilon/4, -\varepsilon/4)$	$\varepsilon/2$	$\varepsilon/4$
$(\varepsilon/4, \varepsilon/4, \varepsilon/4, \varepsilon/4)$	ε	0

It is clear from this example that balancing the system involves a crucial problem of coordination, in order to exploit first all the internal compensations between agents with individual imbalances of opposite sign, and then recurring to a net variation of inflows or outflows at the system level. How this task can be implemented, in turn, depends crucially on the horizontal and vertical market structure of the upstream and downstream segments.

To illustrate this crucial issue, we can start by considering the environment, typical of the gas markets until the late Nineties, with a vertically integrated monopolist running all the phases from the international transport to the sale services to final users. In this case, the incumbent deals with other operators upstream importing gas under particular contracting frameworks, and with the whole group of final users. Referring to the example in Table 1, the case of a vertically integrated incumbent corresponds to having all the four trades run within the same company. The incumbent in this case manages a very large portfolio of import and sale contracts. In this environment, individual supply shocks can be compensated internally, and the coordination issue underlying balancing is dealt with at the organizational level by the incumbent. In other words, if the incumbent in the pre-liberalization world is responsible for all the inflows and all the outflows, it faces the aggregate imbalances only, netting out through organizational, rather than commercial, adjustments most of the individual shocks that occur in the system. Only the net positions at the system level require dealing with other operators, as long as total realized inflows are different from realized outflows. In this case, the incumbent has to deal with different operators upstream (e.g. producers) or downstream (e.g. interruptible demand clients) to close the gap.

Individual shocks produce a completely different effect when many operators (e.g. shippers) are active in managing the inflows and many others deal with final customers (e.g. suppliers). This opposite case corresponds to each of the four trades in Table 1 being realized by a different pair of shippers-suppliers. In general, in a fragmented market structure, each of the agents in these two groups governs a subset of all the trades in the market, and therefore has a more limited ability to compensate within its portfolio the positive and negative shocks in trades it manages.

In this case, agents may act passively, without adjusting their individual positions, and forcing the transmission operator to act on their behalf, ensuring coordination by netting out short and long positions within the system. This result is achieved by purchasing gas from operators whose clients have a negative demand shock and selling it to those who are experiencing a shortage of gas given the unexpectedly high demand of their clients. Notice that in this case the transmission operator intervenes with gas trades to clear individual imbalances to a much larger extent than the aggregate gap at the system level would require. For instance, when shocks are $(-\varepsilon/4, -\varepsilon/4, \varepsilon/4, \varepsilon/4)$, although no aggregate imbalance occurs, the transmission operator should intervene to close the four individual imbalances in the system, buying from the first two operators and selling to the second pair of them.

Alternatively, if the agents are subject to the proper incentives and act within a market environment that allows dealing smoothly among them, they can close their imbalances by directly trading with other operators characterized by opposite positions. In this case, the transmission operator should take care only of the aggregate imbalances, leaving to the market operators to trade among them to clear their position as far as possible.

To sum up, demand and supply shocks require to adjust ex-post imbalances that may affect individual trades in the system. These adjustments may be in part closed by compensating individual imbalances of opposite sign and equal size, while aggregate imbalances require dealing with agents outside the system as producers or final users. In all these cases, the wideness of tools available for balancing (flexibility) greatly improves these adjustments. Since closing individual or aggregate imbalances entails both physical flows and commercial transactions, flexibility applies to both dimensions. Before analyzing how the development of a wholesale market can improve the functioning of the system, we therefore briefly review the main ingredients of physical and commercial flexibility.

2.1.2 Physical Flexibility Tools.

Consider first balancing at the level of the whole system and referred to keeping the physical volumes of inflows and outflows balanced (physical balancing). The subject in charge for this task can use several tools to affect the amount of gas injected and withdrawn from the system. Starting from injections, any imbalance between inflows and outflows can be adjusted through an increase or a decrease in the gas transported through the pipelines from outside the system, as long as there is remaining capacity available, and with line pack, realized by varying the amount of gas in the GST and, correspondingly, the pressure within the admitted boundaries. Although only small volumes of gas can be supplied through line-pack, it allows for a quick response to (hourly) flexibility requirements as a consequence of variations in gas flows. A variation in supply can also be realized through the LNG terminals or the production sites (production swings), with different time lags in the adjustment. As outlined by the IEA (2002), favourable economic conditions, such as the low required investments and proximity to the markets and geological characteristics (e.g. high pressure and high permeability) allow to easily vary the production rate without incurring in excessive additional costs making gas fields efficient sources of flexibility.

Finally, rebalancing the system can be managed through storage, beyond the programmed injections or withdrawals. From a physical point of view, depleted gas fields have a large storage capacity and a relatively low cushion gas requirement but have slower injection and withdrawal rate and are therefore best suited to respond to seasonal variations in demand for gas as opposed to salt caverns and LNG reservoirs. As a consequence, depleted fields, as aquifers[3], are best used for seasonal flexibility than for short-term gas requirements. As opposed to the previous facilities, salt caverns have the ability to respond quickly to variations in gas demand and therefore are best suited for daily and weekly flexibility requirements. In LNG storage sites, gas is stored as liquefied natural gas (LNG) and as such occupies 600 times less space than natural gas under gaseous form. LNG storage facilities are highly suited to respond to peak-day requirements as they have very high deliverability rates (though lower injection rates) and do not require any cushion gas. Nevertheless these facilities have usually small total capacities and the costs associated are very high.

Flexibility can also come from the demand side thanks to the so called "interruptible contracts" (otherwise contracts with interruption clauses) usually subscribed by large industrial consumer and power generation plants. Customers that signed an interruptible contract take on the obligation to interrupt gas consumption in a given timeframe, under given conditions, usually linked to weather temperatures (IEA, 2002). Interruptible demand is best suited to serve short-term flexibility needs and less appropriate for protracted periods (Frontier Economics, 2008).

2.1.3 Commercial flexibility.

So far we have briefly considered aggregate imbalances and the main ways to rebalance the system when the difference of total inflows and outflows exceeds certain boundaries, seriously affecting the pressure in the network. These sources of gas variation used to rebalance the system correspond to physical tools that allow reducing the gap between total inflows and outflows, achieving the physical balancing of the system. From our description of the different sources of inflow and outflow, it is evident that these gas exchanges involve different operators, and therefore they need a commercial counterpart to be executed. If, for instance, additional gas must be injected to cope with an unexpected increase in demand, and import by pipeline is the candidate source, the agent in charge for rebalancing needs to deal with producers or importers, according to the existing set of contracts and their rules, in order to provide

[3] Aquifers are similar to depleted gas fields in terms of storage capacity and withdrawal and injections rates, however the overall costs associated with aquifer storage facilities are slightly higher and a higher share of cushion gas is needed.

the extra gas needed to balance the system. It might happen that, although physical flexibility is available, because there is still free transmission capacity in the international pipelines, the contracts in place do not allow increasing the supply of gas at will, preventing the usage of this source to rebalance the system. Hence, if physical flexibility is a precondition, commercial flexibility is the second component needed to balance the system when aggregate imbalances arise due to unexpected shocks.

Commercial flexibility, that is the existence of commercial tools that allow to trade gas among agents, is also a key requirement for those internal adjustments that take place between agents with opposite imbalances, even when no aggregate imbalance occurs, to compensate their relative positions without modifying the total injections in the system. As argued above, the fragmentation introduced with the liberalization processes in Europe has moved these compensations from organizational adjustments within the same portfolio to commercial transactions between different agents, enhancing the importance of commercial flexibility to guarantee this trades be cleared

In this perspective, a wholesale market may become a very useful tool when individual excess supplies and excess demands of different operators can be cleared through transactions with no need of intervention by the system operator. The development of a wholesale market, in turn, requires to set up a complex and articulated set of rules that we consider in the next section.

2.2 The design and regulation of a wholesale gas market as a balancing tool

We move now to the analysis of the market design and regulatory measures that must be built in order to create an economic and commercial environment where the wholesale trades can be dealt with and the economic agents have the proper incentives to contract among them.

2.2.1 Transmission system models.

The first issue to address entails the definition of some basic rules that affect how the gas can be exchanged within the system. A certain amount of gas enters the system through a specific entry point, while serving a final user requires to deliver that same gas to a certain point of withdrawal where the user is located. Hence, when a shipper is willing to serve an agent located at a certain point in the system, she has to contract with the transmission system operator (TSO) in charge for the management of the system, in order to have the gas transported to that withdrawal point. In other words, each specific inflow and outflow of gas is associated with certain physical points within the NTS[4] and with associated routes on the system.

In an efficient and liquid wholesale market we would expect a certain amount of gas entered into the system to be sold at different exit points, whose destination might change over time due to new contracts that replace the previous ones, for instance due to the compensations between agents with opposite imbalances created by shocks. The routes that implicitly must be used to execute these trades, or, more precisely, the balancing of the system when managing these different trades, change therefore over time, modifying the agreements with the TSO on the usage of the system. It is therefore important that all these changes may be managed within a unified commercial framework to perform them as easily as possible. For instance, the possibility of changing the original nominations of the flows is crucial to redirect the gas provisions to the new origin or destination.

[4] National Transmission System

In order to facilitate the development of wholesale trade, different transmission system models have been proposed, namely: *postal* (or postage stamp), *point-to-point* and *entry-exit* capacity model[5]. In practice these three models incorporate each a different set of rights and obligations between the TSO and a shipper on the network access thereby defining three alternative types of transportation contracts. Following the definition provided by Lapuerta and Moselle (2002), in a postal model a shipper enters into a contract with the TSO that gives the former the right to inject and withdraw natural gas from any entry and exit point respectively on the grid. In addition the shipper is authorized to change entry and/or exit point without the need to sign a new contract with the TSO. In an entry-exit model the shipper is contractually bound by an entry capacity contract to inject natural gas at a given predefined entry point but has access to all exit capacity at any exit point on the grid. In case the shipper would want to inject natural gas from another entry point, a new transportation contract needs to be signed. Finally in a point-to-point model, network users have the ability to inject and withdraw natural gas from a specific pair of entry and exit point on the grid, *de facto* tying the contract to a specific route.

Hence, it is evident that the flexibility in managing a certain amount of gas, required to clear compensations between agents with different imbalances, is strongly affected by the transmission system model adopted. The entry-exit model has two important properties that make it fit to develop wholesale trade. It delivers most flexibility to network users by giving them the freedom to book independently entry and exit capacities and therefore fostering the entry of new participants in the market without suffering the competitive disadvantage of having a small portfolio of costumers as opposed to large existing network users[6].

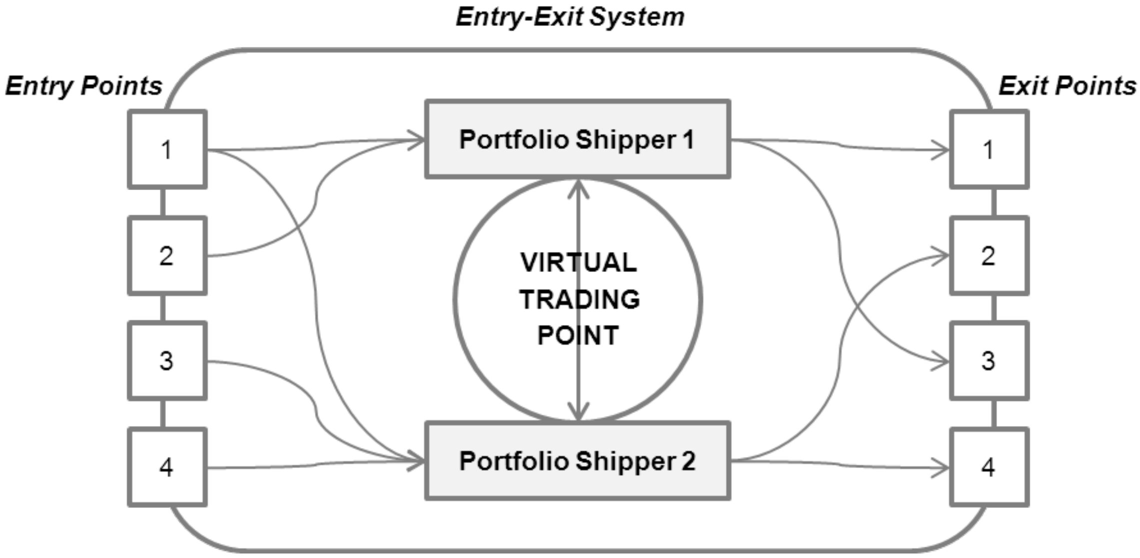
Secondly, the entry-exit model favours the emergence of a virtual balancing point by automatically creating a single entry-exit zone on which the “entry paid” natural gas can be either directly transported to an exit point or traded on equal terms by all network users. As a result, the virtual balancing point can both serve the purpose of balancing network users’ and the TSO’s portfolio and of trading natural gas in a given entry-exit market zone thereby becoming a proper virtual trading point. This double role is crucial in moving from the initial phase of development, driven by balancing needs, to a more mature phase where the hub serves also as an additional source of gas for downstream users.

---

[5] Models on capacity (or network access) shall not be confused with tariffs models (distance-based, entry-exit and postal) since it is possible that these models coincide or not. Given the scope of this paper we are going to discuss only the different capacity models and not the tariff ones. For a discussion on the latter see Lapuerta and Moselle (2002).

[6] As Lapuerta and Moselle (2002) explain, flexibility in terms of injection and withdrawal locations of natural gas on the grid is crucial for the development of competition since greater flexibility reduces the competitive importance of the shipper’s size. In fact, a point-to-point capacity model is the most inflexible model and shippers with a large customer base enjoy a competitive advantage from the fact that they can perform internal swaps and maximize the utilization rate of the defined routes for which they have contracts. On the contrary, the postal and entry-exit models deliver greater flexibility and are valuable to all shippers regardless of their size.

Figure 1 - Schematic Entry-Exit System



An entry-exit point model, therefore, allows to actually perform all those trades among upstream and downstream operators that are needed to clear the imbalances produced by individual shocks in a fragmented wholesale segment. At the same time, it is evident that the commercial framework permitted in this transmission system model is fit to facilitate any wholesale trade, motivated by short term balancing needs as well by the desire to exchange gas for other purposes. The adoption of an entry-exit model facilitates trading on the secondary market for capacity "*by creating a small number of homogenous commodities (one for each entry or exit point), rather than the hundreds or thousands that exist under point-to-point (one for each combination of entry and exit points)*" as stated by Lapuerta and Moselle (2002).

It is also consistent with the previous arguments that the potential for wholesale trades is larger the wider the area that is included into the system model. Indeed, the area delimited by the entry-exit model defines implicitly the set of trades that belong to the same virtual balancing point, and that can be easily adjusted to close the imbalances due to shocks. The larger this set of trades, the wider the opportunities to close individual imbalances through in-market trades rather than out of the system adjustments. If, therefore, the physical characteristics (i.e. no relevant regional bottleneck within the system) of the transmission system allow it, it is desirable to create a single national wide entry-exit capacity system in conjunction with a single balancing zone thereby allowing trade to take place at a single virtual trading point rather than at multiple points on the grid (KEMA, 2009).

While the adoption of an entry-exit model creates a commercial framework that facilitates the trade of imbalances of the operators, and the prerequisites for trading gas wholesale out of the strict balancing needs, it is necessary to create the proper incentives such that the operators do adjust their trading positions through the wholesale market, rather than leaving them at the responsibility of the TSO. For these reasons, the proper design of balancing rules, i.e. of a balancing regime, is a second building block in the creation of a wholesale market.

2.2.2 Balancing regimes.

Since any individual imbalance that is not cleared by the operators requires the TSO to intervene, purchasing or selling gas from other operators, either on the wholesale market or relying on external agents and sources as the storage facilities, production swings or line-pack deals, these interventions are costly to the system. The incentives provided to the operators to induce them to clear their individual imbalances, therefore, must be based on these avoided costs, i.e. they have to be market based. Moreover, the responsibility for balancing the transmission system has to be shared between shippers and the TSO, with the network users taking primary responsibility for balancing their inputs against their off-takes from the relevant *balancing zone* and within a given *balancing period* through the use of the *short-term wholesale gas market.* The rules of the balancing regimes are stated usually in the Network Code.

In a daily balancing setting, for instance, at the end of each day (so called *Gas Day*), for any residual deviation between gas injections and withdrawals, shippers incur *imbalance charges* for the imbalanced volumes accumulated throughout the day in a given balancing zone, and not timely compensated. These imbalance charges are designed to incentivize shippers to keep their positions balanced (to minimize their residual deviations) and have to be cost-reflective (i.e. reflect the actual costs incurred by the TSO to balance the system). The TSO, on the contrary, has only a residual role in balancing, i.e. assures that from a physical point of view the system is kept within safe operational limits by engaging in trading on the wholesale market (what are called usually *balancing actions*), or recurring to contracts with third parties to supply natural gas (the so called *balancing services*) through one of the balancing tools we have described above. Within this general approach, there are several specific solutions that can be designed, and we consider them when reviewing the balancing regimes adopted in some European countries in the second part of the paper.

From our discussion, it emerges that for the implementation of a market-based balancing regime it is necessary that in every balancing zone there is an easily accessible and sufficiently liquid traded market, based upon a virtual trading point in an entry-exit system, which allows both shippers to trade and to fulfil their balancing obligations, and the TSO to carry out its balancing actions.

2.2.3 Fundamental data transparency.

The majority of stakeholders in the natural gas market agree with the view that increased fundamental data transparency represents a crucial step for the development of liquid trading hubs[7]. *Fundamental data transparency* refers to the availability on an equal basis to all market participants of information regarding physical gas flows in the grid, storage and LNG facilities, and other relevant physical information mainly before trading[8]. Reminding the different ways in which balancing, and more in general, wholesale trade can be realized, using different flexibility tools and contracting with several sets of agents, the information that is potentially useful to the market participants to efficiently organize their activities is quite large. It involves both information on programmed and realized flows through the different facilities and on available capacities that are essential if ex-post balancing actions must be taken. This information should be released by the different agents and institutions active in the wholesale market and managing the flexibility tools that can be used to balance the system, including the TSO, the shippers and suppliers and those that manage the storage and LNG facilities.

[7] Among others IEA (2009), Ofgem (2009), Heather (2012) and EU institutions in several documents.

[8] Sometimes it is referred also to as "*pre-trade transparency*" since it is often delivered prior trading occurs. Nonetheless, fundamental data transparency within this paper refers to all "physical data" related to the natural gas market and which can be distinguished from pure financial data and information.

2.3 EU Regulation: From Physical Flexibility to market Flexibility

In the previous section we have discussed the main building blocks that must be set in order to promote a wholesale gas market as the primary instrument to manage the balancing of the system. The European Commission has moved in the last few years to promote these processes along coherent lines, setting a framework of rules and procedures that may guide the different member states in developing gas hubs within their gas systems.

Concerning the transmission system model, under Regulation 715/2009 (EU, 2009b) the European Commission has favoured and required by September 2011 the adoption of the entry-exit capacity model as a way to promote competition and the creation of an internal market for natural gas through the development of liquid wholesale gas markets as expressed in Recital 19:

"*To enhance competition through liquid wholesale markets for gas, it is vital that gas can be traded independently of its location in the system. The only way to do this is to give network users the freedom to book entry and exit capacity independently, thereby creating gas transport through zones instead of along contractual paths. The preference for entry-exit systems to facilitate the development of competition was already expressed by most stakeholders at the 6th Madrid Forum on 30 and 31 October 2002*" European Union (2009b).

The European gas market is currently fragmented in terms of balancing arrangements across Member States and with a multitude of balancing zones within and across countries. For this reason, the European Commission has included in the Gas Regulation provisions for the harmonization of balancing systems across Member States with the over-arching goal of creating a balancing regime that facilitates and promotes gas trading within and across European countries towards greater integration (ACER, 2011). Specifically, the Gas Regulation requires the European Network of Transmission System Operators for Gas (ENTSOG) to submit to the European Commission the Network Code on balancing based on the Agency for the Cooperation of Energy Regulators' (ACER) Framework Guidelines on Gas Balancing in Transmission Systems, published in October 2011[9]. In October 2012, ENTSOG submitted the final version of the Network Code on Gas Balancing in Transmission Systems (ENTSOG, 2012) to the European Commission which, after the *comitology procedure,* will be legally binding on all EU Member States that will need to implement all the necessary measures to comply with the provisions contained in the Network Code[10].

The final Network Code outlines the "Balancing Target Model", which can be summarized as follows. First, the Network Code requires Member States to implement a *market-based* balancing regime with shared responsibilities of the shippers and the TSO. A daily balancing period is adopted, instead of a shorter one, e.g. hourly interval which was used in some EU countries, with the aim of avoiding any further fragmentation of liquidity throughout the day and to impose unnecessary obligations on shippers, potentially harming entry of new parties. The TSO, burdened with residual obligations, adopts balancing action by buying or selling *short-term standardized products* on the wholesale gas market, giving priority to *Title Market Products*, i.e. non-physical products traded at a virtual trading point, or recurring to other types of standardized short-term products defined in the Network Code[11] (ENTSOG, 2012). When these interventions on the wholesale gas market cannot guarantee the system integrity (for example due to the

[9] Article 6 of Regulation 715/2009 lays out the procedure for the drafting and delivering of Network Codes based on the key areas identified in Article 8 (2) of the same Regulation (see European Union, 2009b).

[10] As outlined in Article 48 (1) of the Network Code: "*The TSOs shall comply with the provisions of this Network Code after the expiration of a twelve (12) – month period from the date of its entry into force except where and to the extent specific exemptions and interim measures are applicable*….". ENTSOG (2012).

[11] The *short-term standardized products include: Title Market Products, Locational Market Products, Temporal Market Products and Temporal Locational Market Products* (ENTSOG, 2012).

lack of liquidity on the wholesale market or when the response time of balancing services is faster as compared to the lead time of short-term products), the TSO may recur to *balancing services* trading with third parties.[12]

As already argued, setting the transmission system model and the rules of the balancing regime are fundamental steps in the implementation of a wholesale market. We have seen earlier that a third key ingredient that may greatly affect the ability and the incentives of agents in recurring to wholesale trade is the provision of complete and transparent information on market data needed to project and realize trades on the wholesale market. Regulators at the European level have included a set of provisions in the Gas Regulation concerning fundamental transparency requirements and related record keeping obligations. First, under Article 18 of the Gas Regulation (European Union, 2009b), transmission system operators are required to make public detailed information regarding the services they offer according to the network code and all appropriate information on capacities at all relevant entry and exit points on the grid and on supply and demand of natural gas based on the nominations received by market participants both ex-ante and ex-post along with actual and estimated future flows of natural gas in and out of the system. Second, within the same Regulation, Article 19 imposes similar transparency requirements on storage and LNG facilities operators and the obligation to publish information regarding the volumes of gas in each single or group of storage facilities, the volumes within LNG facilities, the available storage and LNG capacities and the relative inflows and outflows of natural gas (European Union, 2009b). Although binding transparency requirements are laid out in the Third Energy Package for all system operators, it has been highlighted by ERGEG (2010) that currently such requirements are far more detailed and comprehensive for TSOs than for storage and LNG facilities operators[13].

The importance of fundamental transparency has also been attested by the several voluntary initiatives undertaken by players in the market, complementing the European provisions. These pro-transparency voluntary initiatives share the willingness to increase transparency in the natural gas markets by implementing information disclosure requirements, by increasing accessibility through more frequent, time-effective and detailed information, by creating European-wise comprehensive data, by harmonizing formats and units and/or by using more user-friendly platforms which allow stakeholders to easily access and use the relevant data. These initiatives have been undertaken by several organizations (or associations of organizations) and system operators at the national or regional level. Among them, the *Transparency Platform* launched in 2009 by ERGEG represents an important step towards greater transparency in the EU natural gas market by providing an integrated information platform for data published by the individual TSOs across European countries.

2.4 From balancing to second sourcing and price risk management

In the previous sections we have analysed the potential role of gas hubs as a balancing tool in a liberalized market, and the regulatory and market design issues to be implemented in order to create an economic environment where commercial flexibility can exploit the physical flexibility potentials of the system, developing wholesale trade. As long as the gas hub becomes the central place where balancing trades are performed, liquidity increases, with the beneficial effects that larger volumes of trades bring in to make the prices a reliable signal of the demand and supply variations in the system. As such, the wholesale market may gain a further important role by providing a reference to the decisions of individual

[12] See Article 16 (1) of the Network Code (ENTSOG, 2012) for further details on the circumstances under which Balancing Services shall be used by the TSO.

[13] Therefore, ERGEG defined a set of non-binding transparency requirements under the Guidelines of Good Practice (GGP) both for storage and LNG operators to complement the Gas Regulation and Directive. Available at: http://www.energy-regulators.eu/portal/page/portal/EER_HOME

traders. Thereby, a liquid wholesale market may offer additional opportunities of trade to the upstream and downstream operators, as long as the prices that prevail in the hub correctly reflect the evolution of gas demand and supply. At this stage, therefore, the wholesale market can represent a second source of gas for suppliers, as opposed to long or medium term contracts with the shippers for the bulk of their needs (the *d* component in our toy model above), and can, as well, be an alternative place where shippers can realize a share of the sales that their long term contracts with the producers require to conclude according to take or pay obligations. In conclusion, the second phase in the evolution of the wholesale markets can be associated with the development of larger volumes of gas traded and with the use of the wholesale markets as a parallel source of gas, together with the long and medium term contracts with the upstream operators.[14]

A liquid wholesale market tends to reduce the variability of the prices, since a larger set of orders are closed through the market, allowing those compensations of individual shocks that we have discussed above. Still, some price variability remains, reflecting the underlying aggregate shocks of the system. Hence, relying on the gas hub to procure gas, for balancing or final usage purposes, leaves the operator exposed to some price risk, in particular when long term transactions coexist with short term trades. The creation of a portfolio of products and contracts, with different maturity and structures, then, can offer new tools for price risk management, satisfying an underlying demand for hedging.

The third phase in the development of wholesale gas markets, therefore, can be associated with the supply of a full range of products that are fit to price risk management, as futures and forward contracts. It is important to notice that while the first two phases, related to balancing and second sourcing, are strictly connected to the physical provision of gas, and therefore are naturally committed to take place within the gas system they serve, the development of financial instruments to manage the price risk is mostly unrelated to the physical delivery of gas, and therefore can take place in market venues different from those where the related physical deliveries occur.

This argument suggests that while it is likely that gas hubs driven by balancing and second sourcing needs will develop in all the European countries, with obstacles and incentives related to the structural features of the system, the availability of physical flexibility tools and the kind of regulation adopted, the emergence of market venues where the financial products will be traded may not necessarily follow the same pattern. The financial literature on security markets has highlighted the economies of scale and scope emerging from a concentration of trade in few large venues (Clayton et al., 1999) and it seems reasonable to extend these predictions to the trade of financial instruments related to the gas markets. Hence, the evolution of the gas wholesale markets in Europe may be characterized by the consolidation of national hubs focused on balancing and second sourcing and the prevalence of few focal market venues where the instruments for covering the price risk of gas contracts will be traded.

2.4.1 Market liquidity

Liquidity is a complex and somehow even vague concept. Financial literature includes several definitions, determinants and measures of market liquidity, with slight differences from author to author. In general, a market is considered liquid when a marginal transaction is made with no impact on the prevailing level of prices (Mazighi, 2005). In its renowned work on financial markets, Black (1971) defined a liquid market as one in which a "bid-ask price is always quoted, its spread is small enough, and small trades can be immediately executed with minimal effect on price." Grossman and Miller (1988) pointed out market liquidity can be measured by looking at "the ability of executing trades under the current price quotes price– and time-wise."

[14] For an analysis of the competitive effects of take or pay contracts v. wholesale market provision see Polo and Scarpa (2013)

The seminal literature on liquidity (Garbade, 1982 and Kyle, 1985) identifies three main dimensions of liquidity: breadth, depth and resiliency. From the very definition of liquidity follows that the number of players in the market should be large enough to guarantee that demand and supply always meet, without the need of any discount price. A market with a low number of buyers and sellers is called a thin market, while a market in the opposite condition is called broad. Also the volumes traded and the number of trades that take place within the market are positively correlated with the level of market liquidity. Under this respect, a market able to sustain relatively large market orders without impacting the price of the security is called a deep market. The difference between depth and broadness is quite subtle, to the extent that in financial literature there is often reference only to the former. Resiliency is the speed with which pricing errors caused by uninformative order-flow shocks are corrected or neutralized in the market (Dong et al., 2007). Some authors (IMF, 2002) highlight further desirable features of liquid markets, namely tightness and immediacy. In a tight market, transactions and implicit costs are low. Immediacy refers to the speed of execution and settlement of orders; it can be seen as a measure of the efficiency of trading, clearing and settlement systems. Much attention has been recently devoted to the characteristic of market transparency as a desirable feature of a liquid market (among others see Mazighi, 2005 and Ofgem, 2007). According to these authors, the level of transparency intended as a continuous display of information available to players and the absence of any discrimination or privileged access to information, positively influences liquidity in gas markets. Since liquidity basically means being able to trade at market prices, price transparency and reliability is essential. Furthermore, this is also in line with the predictions of Kyle (1985) and Glosten and Milgrom (1985) models, which show that trading costs should be increasing in the degree of the potential information asymmetry between the market maker and informed investors. The European Union appears to share this view, having devoted many efforts to improve transparency in energy markets (EU, 2011). Other factors positively affecting liquidity are the frequency of trades, i.e. the number of trades in a given market over a given time horizon (Ofgem, 2009), range of products available to market players, which allows them to meet the different liquidity needs and energy requirements and the presence and development of forward trading that reflects the ability of market players to hedge.

Macroeconomic variables play an important role in wholesale markets and affect their liquidity. Such variables may be structural, like for instance a country's external dependence from gas due to scarce or absent internal production, but also shocks like an unanticipated fall in consumers' demand. Also the legislative framework matters, since it defines the rules that will determine the type and the number of players (IMF, 2002). Regulatory credibility and political stability are factors that positively influence market performance, because players are encouraged to actively participate in the market and require a lower risk premium.

The most commonly used liquidity measures in gas markets are the churn ratio and the bid-ask spread, although they are not the only ones, and are not always computed in a unique way. Based on the classification proposed by IMF (2002) a first distinction should be made between volume-based measures and transaction cost-based measures of liquidity.

Among volume-based indicators the most used are traded volumes and the churn ratio. Traded volumes of a product on a given market provide a rough measure of liquidity of the market. As highlighted by Fleming (2001) traded volumes are a popular measure of liquidity in light of its simplicity and of the fact that, based on empirical evidence, liquidity improves as the trading activity on a given market measured by its traded volumes increases. Nevertheless large traded volumes are often associated with increased volatility which on the other hand might impair market liquidity (Karpoff, 1987 via Fleming, 2001) and therefore the effects on increased trading volumes on market liquidity might not always be so straightforward.

Table 2 - Determinants and dimensions of market liquidity

Dimension	Description	Measured by:
Tightness	Low transaction costs	Bid-ask Spread
Immediacy	Speed at which orders are executed and settled	Churn Ratio
Depth	Existence of abundant orders	Volumes traded Number of traders Churn Ratio
Breadth	Orders have a minimal price impact	Churn Ratio
Resiliency	Speed at which new orders flow into the market to correct order imbalances	Bid-ask Spread
Transparency	Display of information available to players and the absence of any discrimination or privileged access to information	Bid-ask Spread
Range of products	Ability of market players to hedge	Futures market
Macroeconomic variables	Exogenous, country specific factors that may affect liquidity	Internal production Demand

The churn ratio is defined as the ratio between the traded volumes to physical gas deliveries after trades on a given market. Its meaning is quite intuitive: as it measures the number of times a commodity is traded on the market before it is actually delivered to a final buyer, the churn ratio is an indicator of the dynamism of the market[15]. As such, the higher it is the higher is market liquidity. The advantage of the churn ratio as a measure of liquidity as opposed to the traded volumes is that is allows carrying out a comparison across different geographical areas and markets and even across different commodities (Ofgem, 2009). Usually in liquid markets the traded volumes are several times the physical consumption of the traded commodity and according to the vast majority of literature and operators (see among others Stern, 2011) a churn rate of 10 can be considered a minimum value for markets to be considered liquid[16].

[15] In fact, it is derived from the English verb *to churn,* meaning "to agitate" or "to stir".
[16] Nonetheless, some criticize hat a churn rate of 10 is too low threshold for a market to be considered liquid and a higher one should be defined.

Within transaction cost-based indicators the most commonly used measure is the bid-ask spread[17], i.e. the difference between the prices quoted for an immediate sale (ask) and an immediate purchase (bid), which provides an estimate of the implicit trading cost sustained by market players. As such, the bid-ask spread is both a measure of liquidity and of the entity of the transaction costs of the market. According to the characteristics of the markets, the products and the availability of data different price measures can be applied and methodologies to calculate the bid-ask measures seem to vary. The most common spread measures used in the gas markets are:

- Quoted spread: measured as the absolute difference between the quoted ask price (PA) and the quoted bid price (PB): S(quoted) = PA - PB

The quoted spread can be normalized with respect to the mid-price m= (PA + PB)/2 to obtain the

- Relative quoted spread: S(relative quoted)= (PA - PB)/((PA + PB)/2)

Usually, for the values of PA and PB are chosen among the highest bid and lowest ask prices in the market in a given reference time or otherwise among the most recently available quotations.

An alternative is to use the weighted average of actually executed trades over a given time horizon since it may be that some trades do not take place at quoted prices. The bid-ask spread calculated in this fashion is defined the realized spread.

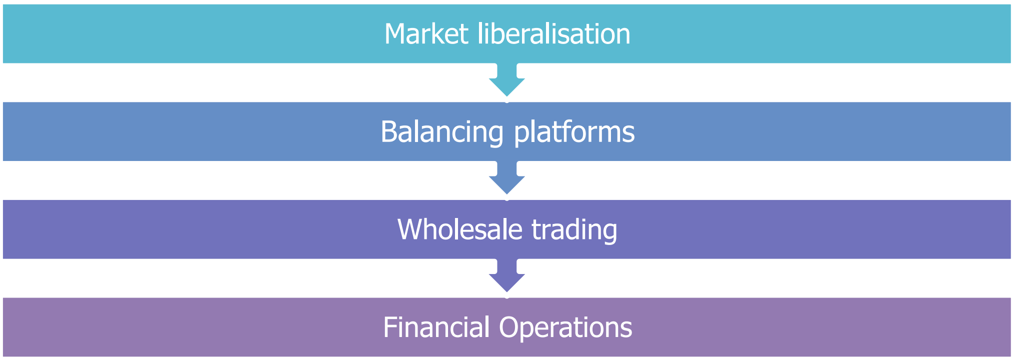
In the next section we review in detail the evolution of the most important gas hubs in Europe, focusing in particular on the regulatory regimes adopted and the progresses in their liquidity indicators, illustrating the present state in particular with respect to the initial driving force of balancing needs provided by gas hubs.

[17] Pagano (2012) defines the bid-ask spread as the "*gap between the execution price and a benchmark that is deemed to approximate the price obtainable in a perfectly liquid market*" (p.2 chapter 2).

3 Case studies

In this section we examine the balancing system in place in eight selected European countries. In our view, they represent each a stage in the development from early liberalization towards liquid gas markets with a strong and relevant financial side. Figure 2 shows the scheme that we discussed in the previous sections, starting from an early stage (post vertical integration) towards an advanced stage (with relevant financial dimension).

Figure 2 – Stages of market development.



As pointed out in Wright (2011), it is important to always keep in mind that gas balancing is ultimately a physical matter; markets are useful as long as they allow a more efficient allocation of physical balancing and yield prices that reflect demand and supply. As just seen in the previous section, a market that yields such prices is typically a liquid market. The market organization within which trade occurs may impact on some dimensions rather than others, fostering or slowing down the development of trade and liquidity. For example, a dealer or brokered market will typically need high volumes of transactions to be efficient; if traded volumes at the hub are scarce, an over-the-counter market is likely to be inefficient and less liquid than a market that shows less transaction costs (Garbade, 1982). Finally, as above mentioned, the availability of financial instruments for hedging is a good indicator of market performance and maturity, and as such deemed to increase liquidity.

All these factors considered the market that shows the higher level of development in terms of liquidity and regulatory efficiency is the UK National Balancing Point (NBP). The country has set the standard and developed a model that has profoundly inspired the regulation pictured by the EU. The Dutch TTF follows closely, and, as we will see further on, may be to the point of catching up. Germany, particularly the hub Net Connect Germany (NCG), and the Belgian Zeebrugge follow in terms of volumes traded at great distance from the first two. The other countries stand at an earlier stage; they have been ordered in terms of volumes of gas traded at the hub. From a regulatory perspective, there are two interesting cases to be highlighted.

Belgium has gone through an intense phase of reforms, but the effects of such reforms have just brought stability in prices and volumes, without that liquidity boost that the reform anticipated. The cause may be the division of the market into three submarket areas, but also the (uneven) competition of the neighbouring markets of TTF and NBP.

Italy has experimented a reverse process with respect to the other countries, starting with a goal to develop wholesale gas trade as a second source of gas provision while not yet setting properly the regulation of balancing services. The development of gas trade has resulted in a poor performance, until a new balancing platform has been introduced. Following this reform, that has restored the rational sequence of phases to the development of wholesale trade, gas volumes and market liquidity have steadily increased. In this sense, Italy offers a (unsuccessful) counterfactual to the sequence of steps we are using to analyse the efficient development of wholesale gas trade, confirming our approach.

3.1 UK: National Balancing Point

UK began the extractive activity of natural gas in the mid-1960s, in the region of waters surrounding the United Kingdom called UK Continental Shelf (UKCS). Since then, gas has become a fundamental component of energy mix, making the UK a net exporter of natural gas for a long time. Natural gas comprises about 40% of the UK total energy slate, and about 35% of the natural gas used in the UK goes to the production of electricity. The majority of production activity takes place in the North Sea, although smaller volumes are produced both onshore and in the Irish Sea. Domestic production peaked in the year 2000 and the UK became a net importer of gas only 4 years later, at the end of 2004 (Business Insights, 2012).

Most reserves are in the form of non-associated gas located in three distinct areas - the central North Sea, the northern North Sea and the Southern Basin. The UK is also seeing considerably reduced its proved gas reserves. Recently, new opportunities seem to arise from the exploitation of shale gas; The UK government has encouraged shale gas drilling despite protests from citizens and environmental associations in a quest for new, cheaper sources of energy amid declining reserves from the North Sea, but the amount of gas and the success of the entire operation are difficult to predict (The Guardian, 2013).

Table 3 - Natural Gas Balances - UK. Source: IEA (2013)

								Million cubic metres
	2011	2012	4Q2012	1Q2013	2Q2013	aug 2013	%Change Current Month	%Change Year to Date
United Kingdom								
Indigenous Production	47433	40989	10038	10143	10312	2577	-14.2	-9.0
+Imports (Entries)	52838	49100	14724	16686	12023	2233	-26.6	4.1
-Exports (Exits)	16012	11971	1831	1975	3212	792	-55.0	-24.6
=Gross Consumption	82215	78091	23348	28496	16632	3365	-12.3	3.1

UK's NBP is Europe's leading and most active gas hub and the British market accounts for the bulk of European wholesale market liquidity. The virtual hub, National Balancing Point (NBP), is the most developed and most liquid of all EU. Although the Dutch TTF is catching up, NBP has been for long time the only market place considered as a mature market by traders (IEA, 2009). Thanks to its liquidity and to the two gas lines connecting the British market to continental Europe (Interconnector and BBL), the NBP exerts a high degree of influence on continental hubs. The system operator, National Grid Gas (NGG), is a public limited company that owns and operates electricity and gas networks. National Grid plc's ordinary shares are listed on the London Stock exchange. NGG shares are largely diffused to the public; at 31 March 2012, the total shareholders were around1.05 million, and of these, approximately 88% own 500 or fewer shares.

The main onshore transmission pipeline system is owned and operated by National Grid, which has around 7,400 kilometres of gas lines that serves about 40 power stations and large industrial customers. Regional gas distributors are privately owned. UK is physically connected to continent by two gas lines, Interconnector (connecting Bacton in Norfolk with Zeebrugge) and BBL (connecting Bacton with Balgzand in the Netherlands). The offshore pipeline system to mainland Europe is owned by the licensee Gas Interconnectors and the pipelines to Ireland are owned by private companies. UK has five regasification plants and other projects in course. In Milford Haven, South Wales there is the largest LNG regasification plant in Europe: the South Hook LNG terminal. It has a capacity of 21 bcm/year and it is 70% owned by Qatargas and 30% by ExxonMobil (Business Insights, 2012).

The UK National Transmission System (NTS) is owned and operated by National Grid, formerly TRASCO. Ofgem oversees the regulation of the NTS through the use of price controls. Gas enters the NTS at various coastal terminals around the UK, called the Aggregated System Entry Points (ASEPs). Gas may come from British gas fields (the UK Continental Shelf – UKCS that we mentioned earlier) and British storage facilities, but also from imports of gas through pipelines or terminals of liquefied natural gas (LNG). Entry capacity to the NTS is auctioned in monthly tranches. Gas is taken directly from NTS exit points by the NTS itself and by the shippers on behalf of a number of large transmission connected customers (TCC) such as heavy industrial, combined cycle gas turbines (CCGT), energy generators and gas storage facilities. In total, NTS has 30 points of entry and over 200 exit points and other interconnectors (Ofgem, 2010).

Users of the NTS are obliged to obtain a shippers' license from Ofgem and are directed by the terms of the Network Code, a set of rules governing use of the system. Shippers must balance their deposits to and withdrawals from the NTS on a daily basis. Short-term wholesale gas prices are heavily influenced by the shipper's efforts to keep the system in balance, and the regulator has moved to stabilize off-take mechanisms to avoid violent fluctuations in supply and wholesale costs, as we will see in the next section.

3.1.1 Balancing

NBP has been the first European gas hub. Following the wave of liberalizations in the 80s and 90s, and the subsequent entry of many firms in a once monopolistic market, controlling gas flows and their balancing into the British gas pipelines became challenging. The solution identified by the energy regulators and policymakers was to introduce a mechanism coherent with market liberalization, in which every economic agent would be responsible for its own balancing. The aggregate balancing of all agents reduces the amount of total balancing required by the system level and consequently decreases the cost of balancing and improves the security of the system. Indeed, the primary goal in setting up the NBP was to ease the management of balancing needs of market operators. Shippers are entitled to participate in an auction, offering on a daily basis all of the gas not previously allocated, in order for it to be used for balancing purposes. This system, called *Flexibility mechanism* heavily relied on the physical balancing tools available; if a shipper had nominated capacity that was not allocated, another shipper could buy such capacity to balance its opposite position. The Transmission Operator (TRASCO at the time) stacked the offers in merit order taking into account the technical limitations and the marginal price (Heather, 2010).

Introducing the exchange of physical flexibility tools in the market has been a first successful step in helping the development of competition. In the space of only few years, the NBP worked so well to be used also for other purposes; shippers began to exchange gas for trading purposes and not only for balancing. After only three years from its birth, NBP required already a change in regulation. In 1999, the flexibility mechanism has been replaced by the so called *New Gas Trading Arrangements* (NGTA), characterized by more reliance on market-based tools for balancing, in order primarily to improve prices as signals of demand/supply conditions, and also to reduce the cost of balancing. NGTA has been introduced also to reduce the cost of balancing and to create incentives on the operators to clear their positions, by making the TSO (National Grid) balancing residually the system at a price related to the System Average Price (SAP). Rules on balancing are established via a Uniform Network Code which is published and managed by the Joint Office of Gas Transporters (Joint Office of Gas Transporters, 2012a). The main market instrument to acquire the resources for balancing is the *On-the-day Commodity Market* (OCM). OCM is a platform of continuous and anonymous exchange managed 24/7 by ICE-Endex. Exchanges can either refer to the virtual point (NBP), or be physical exchanges related to precise locations in the network (Ofgem, 2009). The price set on the OCM is used as a reference for the SAP[18]; subsequently, the System Marginal Buy Price (SMBP) and the System Marginal Sell Price (SMSP) are computed. The SMBP is the price paid for gas in case of a negative imbalance, and the SMSP is the price paid in case of a positive imbalance. In the former case, the Code states that the price paid by the shipper to the System Operator (SMBP) must be the highest between the System Average Price plus 0.0287 pence/kWh[19] and the highest balancing action offer price in relation to a market balancing action taken for that day. Otherwise, if the imbalance is positive, i.e. the TSO has to buy gas from the shipper, the SMSP is the lowest between the System Average Price less 0.0324 pence/kWh and the lowest balancing action offer price in relation to a market balancing action taken for that day (Joint Office of Gas Transporters, 2012b).

This system, therefore, is conceived to pass on to the shippers the cost of (residual) balancing, and to give them incentives and responsibility for balancing their own positions. National Grid has at its disposal a wide range of instruments for physical balancing: line-pack is the most used, but as the UK's own gas supplies diminish, storage capacity is steadily increasing and becoming more and more important (KEMA, 2009). Being a gas producer, the UK can also count on production swing as an additional source of physical flexibility[20]. Finally, the UK can count on imports both via pipeline and LNG terminals.

3.1.2 Trading

As we have seen, initially introduced as a simple balancing platform, NBP has soon become a reference for wholesale gas trading. Nowadays, more or less half of the gas consumed in the UK is traded via NBP, and the remaining half through bilateral contracts, typically long-term (Heather, 2010; DG Energy, 2012). Players in NBP are primarily gas shippers, but there are also producers, power generators and financial institutions. Necessary condition to trade at the NBP is to obtain a shippers' license from Ofgem. The most common form of trading is over-the-counter (OTC); almost all of the trades entail gas delivery within the NTS, only few are still transacted at the Entry Points, and some others are of financial nature; these are traded at the NBP, but although linked to the physical trade, do not require actual delivery.

ICE-Endex Gas UK OCM[21] plays the role of an organized exchange and is the central counterpart to spot trading and it basically operates through locational, physical and title products, always on the NBP. Hence, NBP can be distinguished into three different platforms, according to the product that is traded:

[18] The System Average Price for a day is the price in pence/kWh calculated as the sum of all balancing transaction charges divided by the sum of the market transaction quantities and non-trading system transaction quantities for all balancing transactions respectively effected in that day (Joint Office of Gas Transporters, 2011).

[19] This amount is the so called "Default System Marginal Price", expressed in pence/kWh. It is computed following a methodology that can be retrieved in Joint Office of Gas Transporters, 2012b, 1.1.2.h.

[20] Very recently, new opportunities seemed to arise from the exploitation of shale gas; the British government decided to incentivize the exploration by fracking companies, but the amount of gas and the success of the entire operation are difficult to predict (The Guardian, 2013). Should this strategy be successful, the implications for the European market could be dramatic; therefore it is important to monitor its evolutions.

[21] Formerly, APX Gas UK OCM. APX-ENDEX was an Anglo-Dutch energy exchange operating the spot and derivatives markets for electricity and natural gas in the Netherlands, the United Kingdom, and Belgium. Established in 1999, APX-ENDEX provided exchange trading, central clearing and settlement. The company has undergone dramatic changes, and has given itself a brand new organization. Starting from March 1st 2013 APX-ENDEX has separated into two companies: the power spot exchange APX and the gas spot, gas derivatives and power derivatives exchange ENDEX. At the end of the same month, ICE and Gasunie further transformed ENDEX, entering in its shareholding and launching ICE Endex. The new platform has only ICE and Gasunie as shareholders; ICE owns 79.12% and Gasunie 20.88% of the shares.

- NBP Locational is a single entry/exit point at which gas is traded. Locational trades results in an obligation to change physical gas flows at entry/exit points around the hub;
- NBP Physical: the physical exchange of gas at a selected location, after the trade has happened;
- NBP Title: the trade is a transfer of title of gas between market participants. This trade is the most frequent and may result or not in a physical change of gas flow.

Contracts referred to two different time spans are tradable at any one time: within-day and day-ahead, according to the time at which trade occurs. OCM yields two reference prices: the bid price, defined as the highest price that a buyer is willing to pay for traded gas, and the ask price, corresponding to the price a seller accepts for gas. OCM prices are also used as a reference for within-day trades which are used to correct shippers' imbalances; as a matter of fact, the OCM is the main channel through which balancing occurs (see Figure 3).

NBP is also the pricing, delivery point and clearing for futures both OTC and via exchange. The exchange is the ICE (Intercontinental Exchange) platform for natural gas futures contract. Here trading is anonymous at all times, and it can entail or not physical delivery, although in practice actual physical delivery occurs only for a very small percentage of trades. While the futures market is operated by the ICE's subsidiary ICE Futures Europe, exchange clearing is provided by another subsidiary, ICE Clear Europe (Heather, 2010; ICE website). Futures OTC clearing happens on another exchange, EEX, European Energy Exchange which provides month, quarter, season and year futures.

Currently, NBP is the most liquid market in Europe, but its predominance shows a declining outlook, in favour of the Dutch TTF. UK trades on NBP more or less half of all the gas consumed in the country. Figure 4 compares traded and physical volumes, and Figure 5 shows the difference between gross and net churn ratios, computed following Heather (2012): the gross churn ratio is computed dividing total traded volumes at NBP with country's demand of gas, and as such expresses the relative weight of trading as a means to purchase gas. The net churn ratio is computed dividing traded volumes at NBP with an estimate of the total volume of gas physically delivered at NBP. Fig. 6 shows the daily number of trades on NBP; it is evident from these figures that both the volumes of energy traded and the number of transactions are declining. This is only partly explained by the declining demand; it is more likely the effect of the increasing relevance acquired by the competitor TTF, which is becoming the new reference for natural gas transactions in Continental Europe (see Petrovich, 2013 and next section for details on TTF). As for bid-ask quotes, they are steadily declining.

3.1.3 Data summary and graphs

Figure 3 – Daily System Average Price of OCM market (September-November 2013), in €ct/kWh – conversion €/£≈0.833. Source: ICE-Endex Website

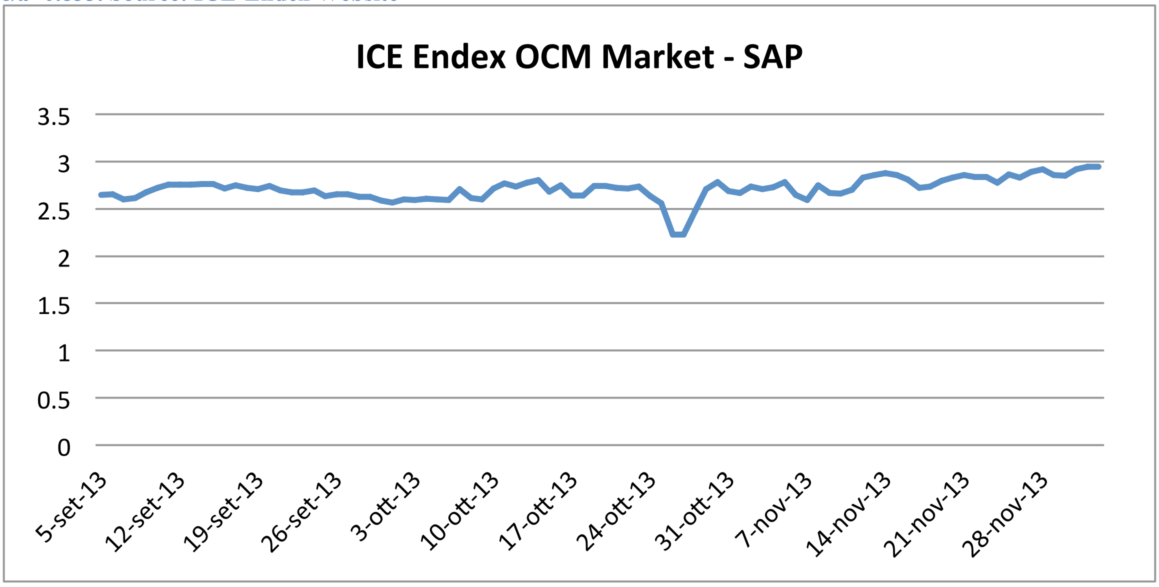


Figure 4 - Traded and physical volumes at NBP (in bcm). National Grid and LEBA report different figures for traded volumes.

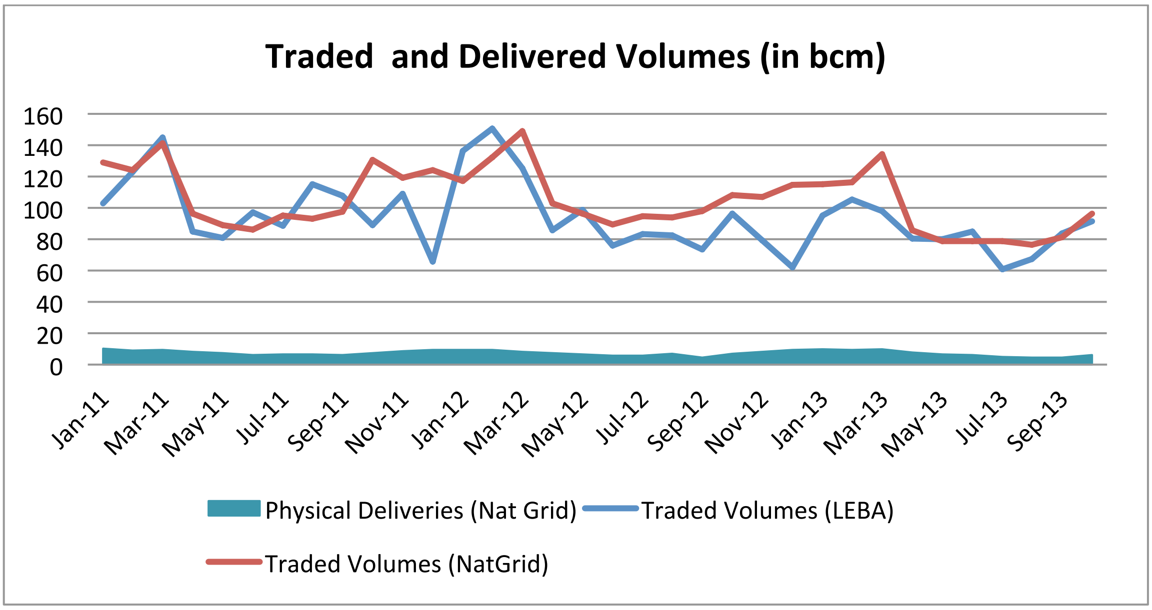


Figure 5 - Gross and net churn ratio at NBP.

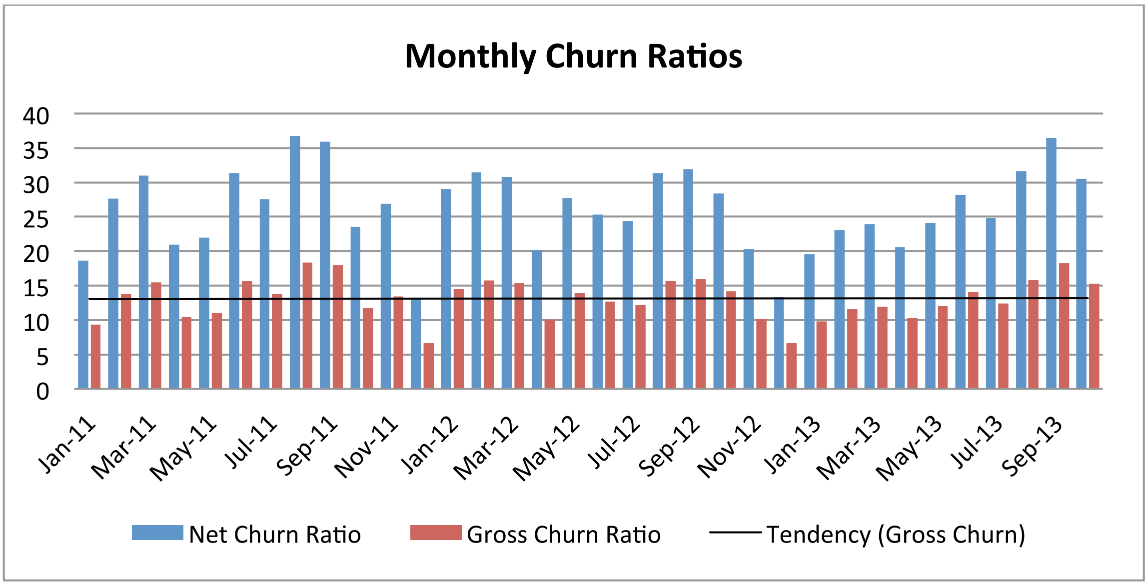


Figure 6 - Number of trades. Source: National Grid.

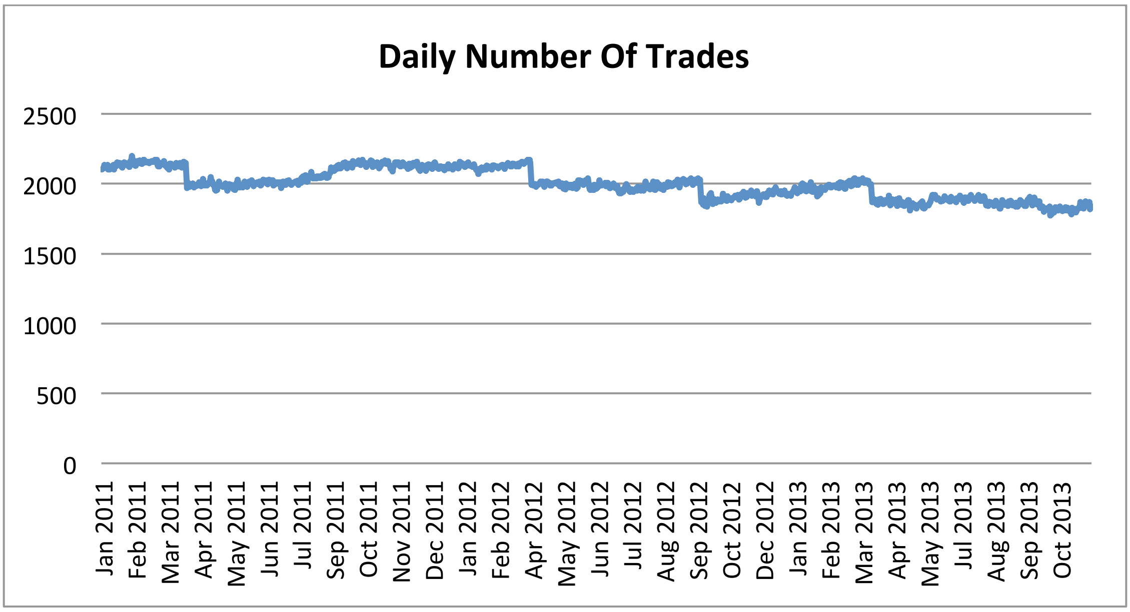


Figure 7 - Bid-Ask prices at NBP (in €/MWh). Source: Bloomberg.

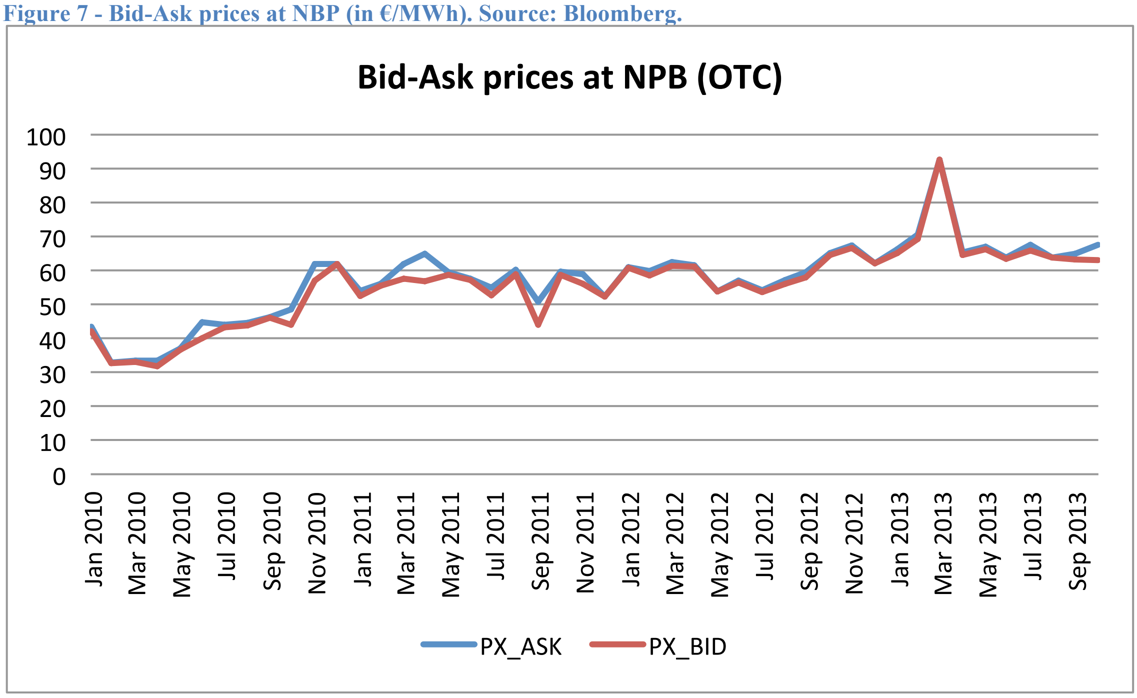
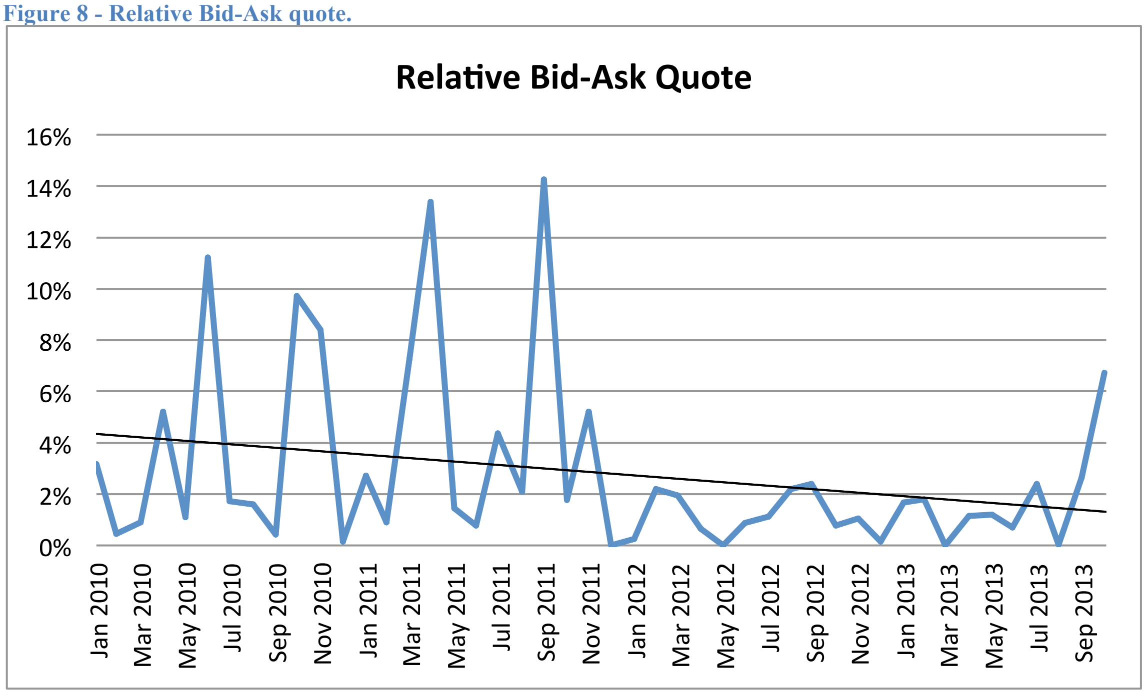


Figure 8 - Relative Bid-Ask quote.



3.2 The Netherlands: Title Transfer Facility

The Netherlands are a main producer and exporter of natural gas in Europe. Production coming from the Groningen field and smaller fields amounted to 81 bcm in 2011, whereas exports of natural gas to neighbouring countries accounted for 54,8 bcm. However, as indigenous production of gas has been steadily decreasing over the last years, imports acquired a growing weight. Gross consumption in 2011 accounted for 48 bcm, slightly lower than in 2010 when consumption reached 53,1 bcm, with the bulk of consumption being concentrated in the commercial and residential sectors together with the transformation sector. In 2012 consumption further declined, while in 2013 the outlook is towards an increase. Whereas consumption in the commercial and residential sector and industry sector has been decreasing due to technological improvements and efficiency savings, natural gas consumption has been increasingly consumed in the power generation sector (IEA, 2009).

Table 4 - Natural Gas Balances - Netherlands. Source: IEA (2013)

								Million cubic metres
	2011	**2012**	**4Q2012**	**1Q2013**	**2Q2013**	**aug 2013**	**%Change Current Month**	**%Change Year to Date**
Netherlands								
Indigenous Production	80574	80145	24273	33634	15776	4001	7.2	10.0
+Imports (Entries)	23012	26086	7157	7127	7062	1957	6.8	5.7
-Exports (Exits)	55851	60411	17969	23504	13553	3586	10.9	12.1
=Gross Consumption	47735	45820	13461	17212	9285	2372	1.7	4.6

The Dutch national transmission network is operated by Gas Transport Services B.V. (GTS), a 100% affiliate of Gasunie which owns and operates the 11,800 kilometers of high pressure pipelines in the country. N.V. Nederlandse Gasunie (Gasunie in short form) is a Dutch natural gas infrastructure and transportation company operating in the Netherlands and Germany (where it owns approximately 3,000 km of network). Gasunie is 100% state owned, and the Dutch Ministry of Finance represents the Government's shareholder interest. In 2004 GTS introduced an entry-exit capacity system and the virtual trading point TTF. The Dutch gas transportation system comprises 52 entry points (37 from the indigenous gas fields and 17 feeding points from neighbouring countries' networks), approximately 1,110 delivery stations supplying gas to the Dutch customers and 25 cross-border stations. Gas is moved within the pipelines through 11 compressor stations all over the system and in order to balance the system GTS can also exploit the five storage facilities available on the network: two non-depleted gas fields, one LNG peak shaving, one depleted gas cavity and one salt cavity.

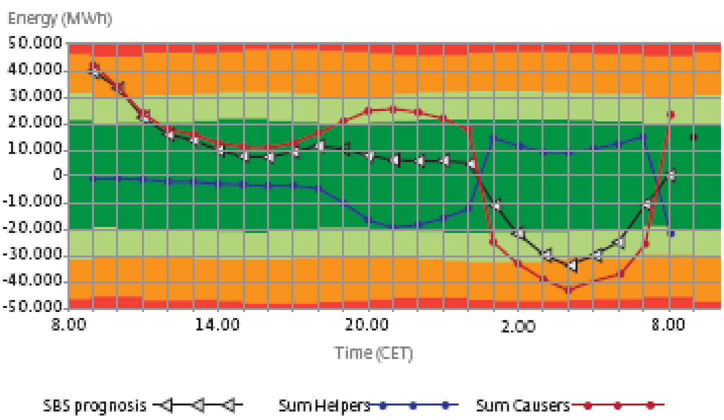
3.2.1 Balancing

In 2005 the ownership unbundling of Gasunie into a trading company (GasTerra) and a transportation company (Gasunie), has been implemented. In 2011 a "new market model" (in Dutch, Nieuw marktmodel) has been introduced in order to facilitate and strengthen the functioning of the gas market and increase security of supply. With the new market model since April 1st, 2011 the Title Transfer Facility (TTF), the Dutch virtual trading point, has become the central trading point for all natural gas in the Dutch transmission system. In addition the amendments to the Gas Act also introduced a new balancing regime in the Netherlands in line with the guidelines outlined by ACER. With the new balancing regime every market party is responsible for keeping its own portfolio balanced through buying and selling gas on the TTF, implying that the TTF has become the central balancing platform for all natural gas in the Dutch transmission system. GTS acts only as a residual responsible for balancing the system.

From an operational point of view every day all shippers, defined as Program Responsible parties (Dutch initials, PV) send in their entry, exits and trading plans for the day ahead by using a so called damping formula. The submission of the programs is done at the Virtual Point for Transfer of Program Responsibility (VPPV) which consists of the sum of all trades on the TTF and the transfer of a shipper's own entry program to its own exit program. Based upon almost real time information about the single portfolio positions of shippers GTS publishes the Program Imbalance Signal (POS) which is the accumulated balancing position of every PV. Thereafter by summing up the individual POSs, GTS calculates and publishes the System Balance Signal (SBS). A system imbalance occurs when the SBS deviates from zero, scoring either a shortfall in gas supply (negative imbalance) or an excess of gas (positive imbalance). Given the figures of the SBS, GTS publishes also the POSs of the helpers (PVs with POS of the opposite sign of the SBS) and the causers (PVs with POSs with the same sign of the SBS) of the SBS. As illustrated in Figure 9, imbalances are classified into zones (dark green, light green, orange and red zone) and are calculated based on estimated gas loads from the hourly PVs programs. When the SBS leaves the Dark Green Zone (DGZ) a market based correction mechanism called the Bid Price Ladder (BPL), comes into action. Specifically, GTS will buy or sell gas on the BPL if respectively the system is short or long. In order to guarantee that the system is physically balanced, GTS will only accept bids on the BPL for physically available flexibility tools with a deliverability time varying with the zone.

The damping formula to be computed by the shippers constitutes an ex-ante, short-term and individual device that contributes to system balancing. Through this formula provided by GTS, shippers reduce and delay their hourly entry flows. On a daily basis the sum of all hourly entries and sum of all exits must be equal, but on an hourly basis entry and exit may not balance exactly. The damping formula is used to adjust shippers' short term individual position according to the daily congestion of network capacity. The formula has two parameters, alpha and beta, which are adjusted every day. The alpha parameter is used to maximize the amount of line-pack available every day. By changing the beta parameter, the intention is to make entry flatter and smoothly distributed during the day. However, proceeding this way flattens the Green Zone in parallel, and so the beta parameter can only be applied when there is sufficient line-pack available. The formula and the parameters are published daily at 09:00 on the day prior to the day of transport.

Figure 9 - Imbalances zones. Source: GTS.



As a residual balancing actor, GTS is financially neutral with respect to the balancing actions eventually undertaken. In light of the rationale behind the new balancing regime, in the case of system imbalances shippers can support the TSO in balancing the system by:

- Making offers or bids for gas to GTS on the Bid Price Ladder and GTS will buy/sell at the marginal price (buy or sell).
- Provide "Assistance Gas" by balancing their own POSs to support the system and according to GTS (2011) they can use "their physical means, trade on the TTF or enter into commercial balancing relations and receiving/paying the marginal price in the case of settlement". The provision of assistance gas is meant to give an additional incentive to shippers to keep the overall system balanced. Specifically, the accumulated volume of the helpers is bought or sold at the marginal price and their balances are restored (i.e. POS restored to zero) whereas a pro-rata of the involved volumes of gas will be allocated to the POS of the causers (GTS, 2011; GTS, 2012).

In order to maintain the physical balance of the gas grid, GTS, as well as National Grid in the UK case, can rely on a wide variety of flexibility tools. Besides line-pack, a particular source of flexibility for physical balancing comes from the production swing possible at the Groningen field. The Groningen field is a key source for responding to short-term gas requirements on the grid in light of unforeseen variations in demand; furthermore, by varying production over the course of the year, gas fields comply also easily with seasonal requirements. Flexibility through storage is provided both by domestic storage facilities and by plants located in Germany and connected to the GTS transmission system (Frontier Economics, 2008). Together the domestic storage facilities accounted in 2010 for approximately 5,4 bcm of working gas and represent a key flexibility source together with the production swing. The largest share of gas storage in the Netherlands is concentrated in depleted gas fields used mainly for seasonal flexibility given their relatively low ability to respond quickly to variations in demand and supply of gas. On the contrary, the LNG peak shaving facility at Maasvlakte and the salt cavern of Zuidwending allow for a quick provision of flexible gas into the system although having a smaller total working gas capacity. The Dutch transport network is directly connected to four European countries via 25 interconnections. Gas can be both exported and imported via connections with Belgium and Germany. Gas can only be exported via the BBL pipeline, connected with the United Kingdom and only be imported via the connection with Norway. In the Netherlands two types of gas are moved on the national gas network: high calorific gas (H-gas) used mainly to supply large industrial consumers and power plants and low calorific gas (L-Gas) intended for small and residential consumers. According to Frontier Economics (2008), gas conversion stations have the ability to respond very quickly to flow variations of L-Gas and H-Gas, and can therefore be considered as a source of flexibility.

3.2.2 Trading

Since the unbundling of Gasunie into GasTerra, as trading company, and Gasunie as transportation company in 2005, TTF has notably improved in terms of traded volumes and number of market participants, thanks to the efforts of the Dutch government. Indeed, in its first phase, TTF development was sluggish due to structural factors, such as lack of import infrastructure and storage facilities, and organizational factors, such as a poor utilization of the transport infrastructure, problems with quality conversion, poor transparency and an outdated balancing regime (NMa, 2007). The government strategy focused on improving competition, market integration and trading by increasing gas transport capacity, interconnections with neighbouring countries and promote market coupling initiatives; by increasing import capacity and storage facilities in light of the decreasing indigenous production; and by adopting a new market model for wholesale natural gas including a new balancing regime. The elimination of the two types of gas quality traded at the TTF (H-gas and L-gas) in 2009 represented another positive change. Before 2009, shippers had to reserve quality conversion capacity with GTS to convert H-gas to

L-gas for supplying end-consumers, and this created a barrier to entry to other shippers and was detrimental to the development of the TTF. Following the amendment to the Gas Act, quality conversion is now part of GTS's system services with cost being socialized over all entry and exit points on the grid.

Nowadays, after NBP, TTF is the best developed hub in Europe, and it serves as a reference market for continental Europe. The reference price at the TTF has not always been very stable compared to other hubs, but this is also a signal of the dynamicity of this hub, which should allegedly follow demand and supply trends. Furthermore, prices at TTF are among the lowest in continental Europe. On top of that, in these last few months prices have looked increasingly stable, also due to the series of changes introduced by the Dutch regulator.

Spot trading is implemented via the platform ICE-Endex, on the basis of two price indexes called TTF Spot (formerly APX Gas NL): day ahead and within day. The Within-Day Index is a volume-weighted average price of all orders which are executed and delivered on the same gas day on TTF. The Day-Ahead Index is a volume-weighted average price of all orders which are executed on the gas day proceeding the day of delivery and consists of two indices. Gas in the TTF can also be exchanged on the EEX Spot Market. Here spot contracts of different types are traded. Products for delivery and/or procurement of natural gas with a constant rate for day base load deliveries (Natural Gas Day Contracts) and weekend base load deliveries (Natural Gas Weekend Contracts) as well as for variable delivery capacities for intraday products (Natural Gas Within Day Contracts). Delivery is possible at the virtual trading hub in the market area of Gastransport Services for the Dutch Title Transfer Facility (TTF Natural Gas Contracts) in H-gas or L-gas quality. Natural Gas Day Contracts and Natural Gas Weekend Contracts can each be traded with two different delivery volumes - with 1 MW or 10 MW.

TTF is a liquid market; as can be noted from the Figures 11 and 12, the churn ratio and traded volumes show an increasing tendency. Moreover, a comparison of traded volumes at TTF and the British NBP shows that the gap between the two hubs is constantly reducing (Figure 13). Figures 14 and 15 display the bid-ask prices, highlighting a decreasing tendency.

3.2.3 Data summary and graphs

Figure 10 - Reference price at TTF (day ahead). Figures in €cent/kWh. Source: Gaspool Data Service.

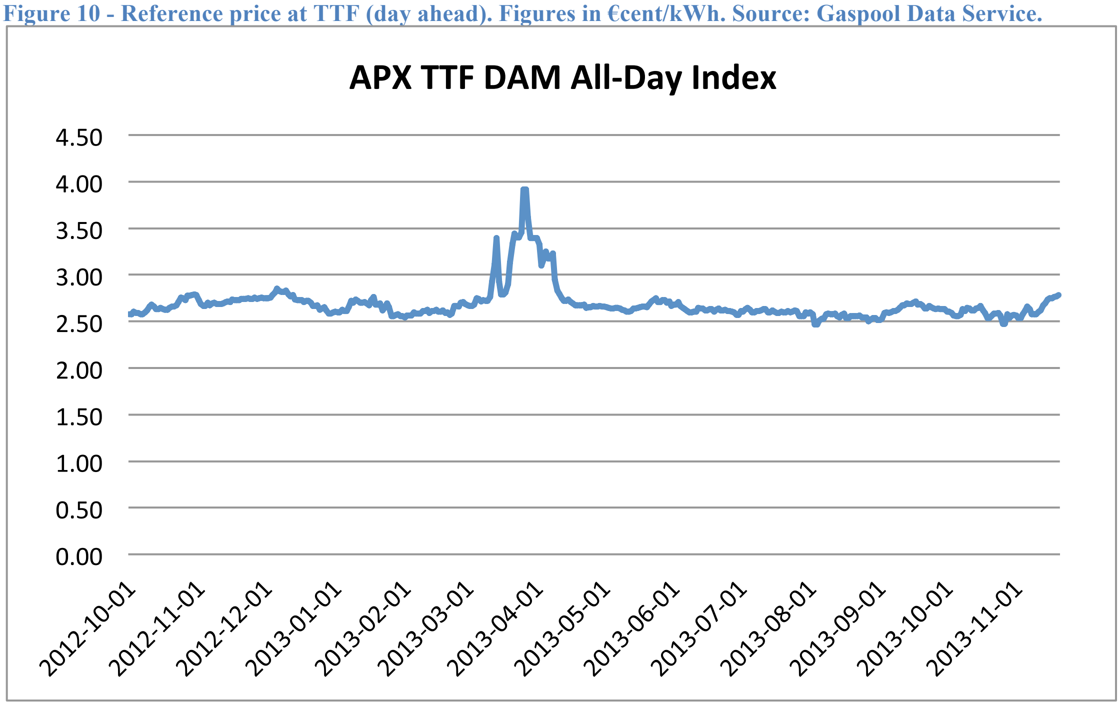


Figure 11 - Churn Ratio at TTF.

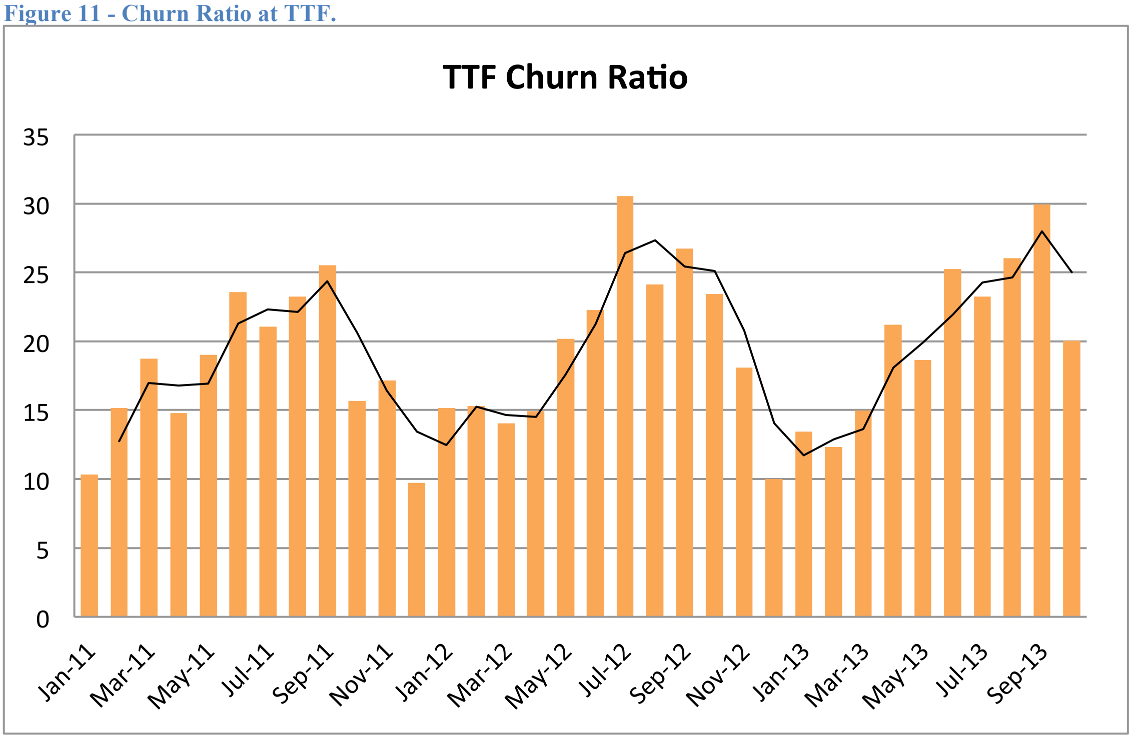


Figure 12 - Physical and traded volumes. Source: GTS and LEBA.

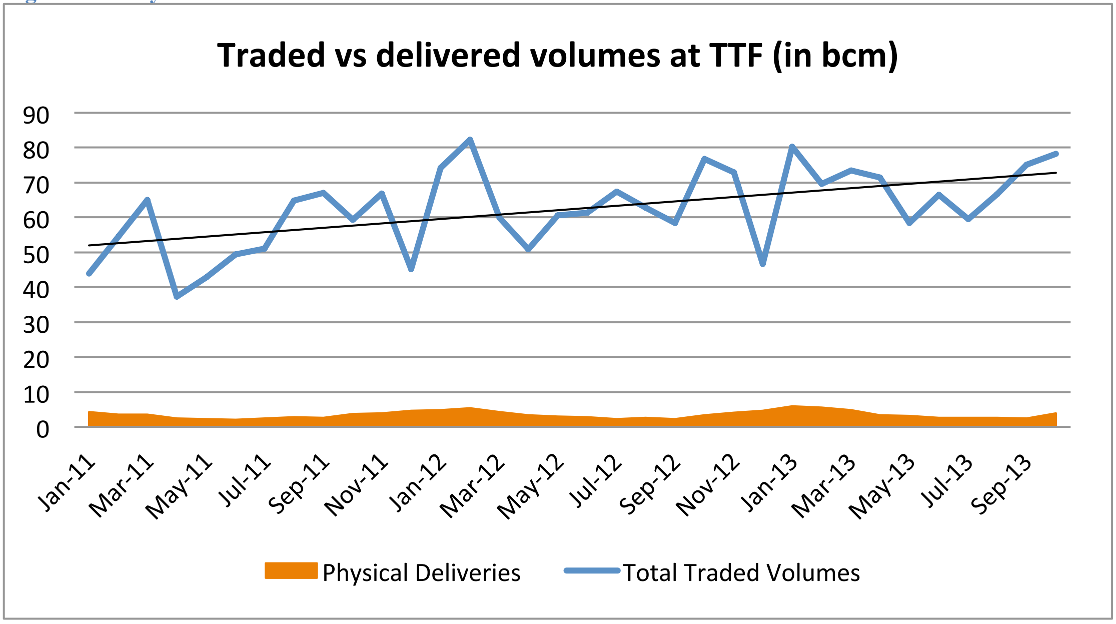


Figure 13 - Comparison between traded volumes at NBP and TTF (in bcm). Source LEBA, GTS.

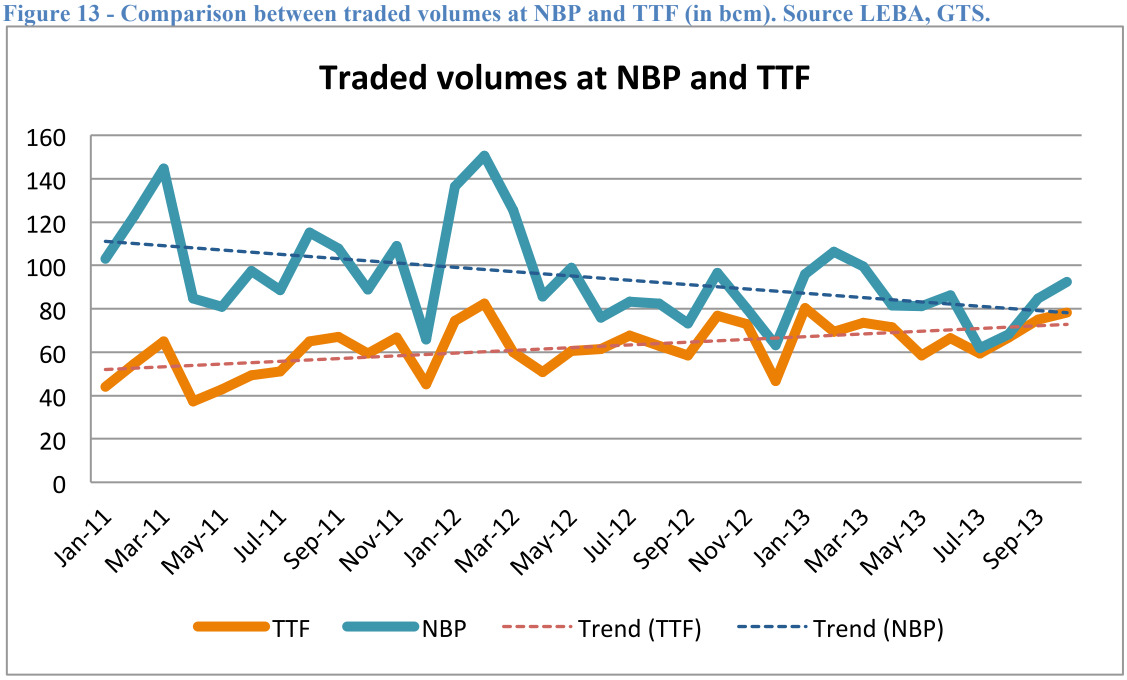


Figure 14 – Bid-Ask prices at TTF (in €/MWh). Source: Bloomberg.

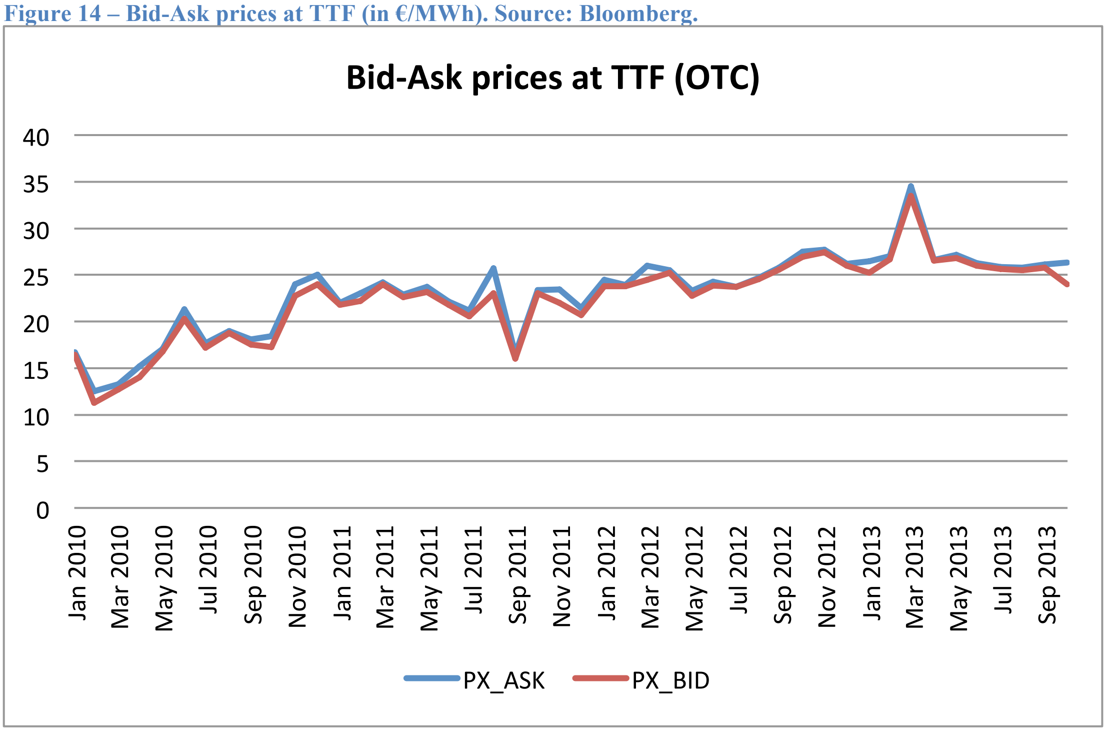
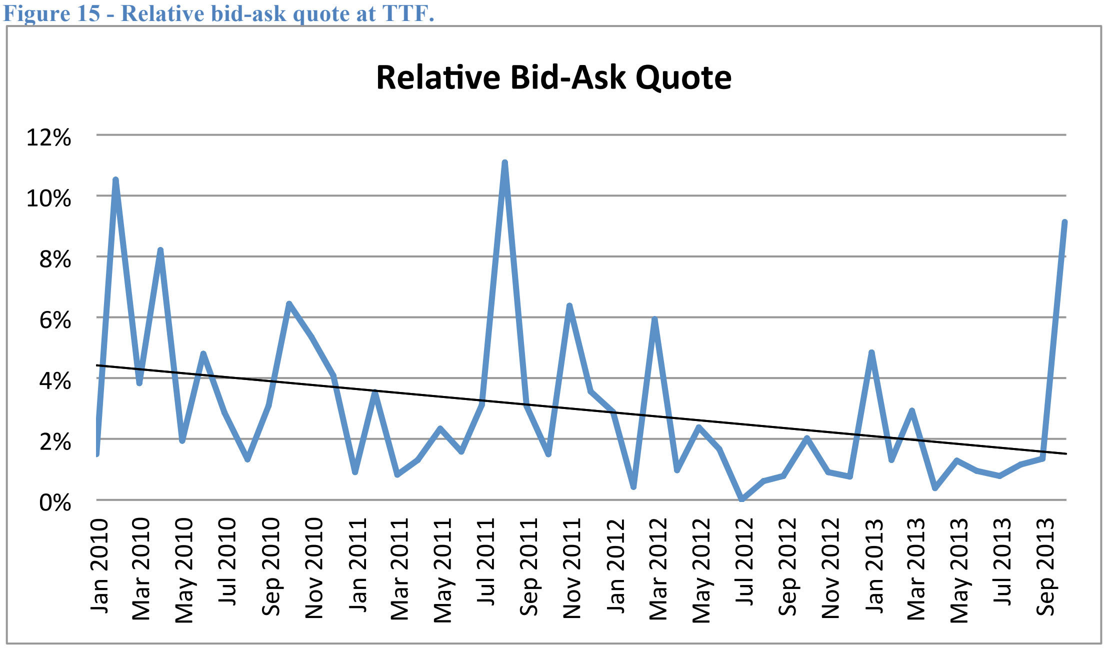


Figure 15 - Relative bid-ask quote at TTF.



3.3 Germany: Net Connect Germany and Gaspool

Germany is one of the world's largest players in the natural gas sector, being a major consumer, providing a fair amount of gas storage and serving as a transit country for gas, mainly to France, Italy and the UK. Furthermore, contrary to what is happening to the rest of the European Union countries, its gas demand is expected to rise, due to the decision of dismantling the existing nuclear plants in favour of a more secure and environmentally sensitive energy policy (WEO, 2011). Despite the effects of this decision have been partially offset by the reduced demand for power, mainly due to an increased attention to energy efficiency and a growing share of renewables in the technology mix to generate power, gas consumption in the country is showing a tendency to increase in 2013 (see Table 5).

Table 5 - Natural Gas Balances - Germany. Source: IEA (2013)

								Million cubic metres
	2011	2012	4Q2012	1Q2013	2Q2013	aug 2013	%Change Current Month	%Change Year to Date
Germany								
Indigenous Production	14060	12299	3248	3500	2843	894	0.6	-0.5
+Imports (Entries)	87571	87964	23177	26222	23314	7569	39.6	10.2
-Exports (Exits)	19745	18173	4510	5703	4155	1136	18.3	-4.2
=Gross Consumption	79774	82277	24705	34036	17837	4888	45.8	16.4

The German gas transmission system is organized in a combined system of pipelines for domestic supply and large bulk transport pipelines connecting important cross-border entry and exit points, storages, owned and operated by altogether 14 TSOs (Table 6).

Germany started wholesale gas trading in 2002, with the creation of the Bunde-Oude hub on the Dutch/German border. This first attempt was indeed not particularly successful: difficulties in obtaining third-party access to pipelines and the complex network ownership situation, together with competition with the neighbour Title Transfer Facility (TTF) market in the Netherlands caused trading activity at Bunde to have indeed little impact and lacking liquidity. In October 2006 three new German hubs were launched - the BEB hub, the E.ON Ruhrgas hub and the Gaz de France Deutschland (GDFDT) hub. In July 2005 the new German Energy Law, Energiewirtschaftsgesetz (EWG), came into force following the EU Directive 2003/55/EC7. 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 Federal Regulatory Authority (Bundesnetzagentur, BNA) discussed issues concerning network access with the stakeholders, but the rules for network access were defined by representatives of network operators, and in July 2006 a Cooperation Agreement was released, which sought to standardise the grid access scheme in Germany. Germany was divided into 19 entry-exit zones, called "Marktgebiete", i.e. "market areas"; at the end of 2008 the areas were reduced to 12 and now they are only three, two for H-gas, NetConnect Germany (NCG) and Gaspool, and one for L-gas. This process has been strongly encouraged by BNA, that starting from September 2010, through the Gas Network Access Ordinance (GasNZV) explicitly required TSOs to reduce the market areas for L-gas to one and for H-gas to two by April 1, 2011 (BNA, 2011). The two H-gas market areas are NetConnect and Gaspool. NetConnect became operational in October 2008 as the former areas of E.ON and Bayernets were combined. In October 2009, GRTgaz Deutschland, ENI and GVS joined NCG. In April 2011, Thyssengas, the former RWE gas TSO, joined NCG. Finally, in December 2012 Fluxys TENP acquired 10% of NCG shares following its acquisition of ENI's stakes in TENP and Transitgas pipelines. While NCG since then covers the South and West of Germany, Gaspool as the second major market zone is located in the northern part of Germany. Gaspool resulted from a cooperative arrangement between BEB, StatoilHydro and DONG Energy. In July 2008, Gasunie, operating the Dutch transmission network, has taken over the transportation services of BEB. In October 2009, ONTRAS and Wingas Transport joined GPL. The entry-exit system requires that the natural gas shippers book capacity at the relevant entry and exit points separately; hence, the fees to be paid for the transportation of natural gas (entry and exit charges) are no longer based upon the distance between the entry and exit points (Growitsch et al., 2012). Germany's TSOs are divided in two large groups, according to their belonging to the NCG or Gaspool area. They have all chosen the form of the ITO, and most of them are subsidiaries of gas suppliers or large energy groups. The basic system currently in place in Germany for balancing the system is based on the "GABi Gas" model (Grundmodell der Ausgleichsleistungs- und Bilanzierungsregeln im Gassektor) that was implemented in May 2008. However, this system is experiencing a series of profound changes, e.g. EEX reference prices as a new basis for calculating compensation energy, instead of the method originally entailed in GABi (Germany Energy Blog, 2011). BNA has explicitly declared that within 2013 the whole system is going to be reformed to comply to the EU Network Code, thus the system that we are going to describe may change soon.

Table 6 - Gas TSOs in Germany. Sources: ENTSO-G, companies websites.

Name	Group	Market Area
1. *bayernets* GmbH	It is entirely owned by Bayerngas GmbH, active in exploration, transportation, storage and retail	NCG
2. Fluxys TENP GmbH	TSO in the TENP pipeline; commercializes 60% of the system's capacity. It is part of the Fluxys group. On 30 November 2011 the Fluxys group acquired Eni's stakes in TENP and Transitgas pipelines (49% in TENP KG and 46% in Transitgas AG).	NCG
3. GASCADE Gastransport GmbH	It is a subsidiary of Wingas, half owned by Wintershall (a company belonging to the chemical BASF), half owned by the Russian Gazprom.	Gaspool Balancing Sevices
4. Gastransport Nord GmbH (GTG)	It is a subsidiary of EWE AG, a multi utility company that operates also in gas production, retail and storage.	Gaspool Balancing Sevices
5. Gasunie Deutschland Transport Services GmbH	Affiliated to Gasunie B.V.,the Dutch public firm that owns the gas transport network in the Netherlands. Gasunie is also shareholder of APX-ENDEX.	Gaspool Balancing Sevices
6. Gasunie Osteeanbindungsleitung GmbH (GOAL)	Shareholder of NEL	Gaspool Balancing Sevices
7. GRTgaz Deutschland GmbH	It is a subsidiary of GRTgaz France, that is in turn a subsidiary of GDF Suez	NCG NetConnect Germany
8. jordgasTransport	jordgasTransport is the new name of the former Statoil Deutschland Transport GmbH (Independent Transmission System Operator), entirely owned by the Norwegian Statoil.	Gaspool (not a shareholder; jordgas operates within Gaspool through Gasunie)

9. Nordeuropäische Erdgasleitung (NEL)	Network operator of the North European Natural Gas Pipeline	
10. Nowega GmbH	Ex Erdgas Münster Transport GmbH & Co. KG, Nowega from February 2012	Gaspool Balancing Sevices
11. ONTRAS - VNG Gastransport GmbH	It is a subsidiary of VNG – Verbundnetz Gas AG (VNG) , one of the main gas importers, wholesalers and suppliers in Germany. The VNG group owns also storage facilities. Its main shareholders are: EWE Aktiengesellschaft: 47,90% A trustee of 10 utilities and municipalities: 25,79% Wintershall Holding GmbH: 15,79% GAZPROM Germany GmbH: 10,52%	Gaspool Balancing Sevices
12. Open Grid Europe	Formerly E.ON Gastransport, Open Grid Europe belongs to the E.On Group	NCG
13. terranets bw GmbH	It is 100% controller by EnBW Eni Management Company Ltd.	NCG
14. Thyssengas GmbH	Formerly belonging to RWE, from 2011 it is owned by the Australian banking group Macquarie	NCG

3.3.1 Balancing

Gaspool and NCG are the responsible for balancing within their market area. The basic balancing system in Germany operates on a daily basis. The relevant volumes for balancing are the nominated hourly volumes at the entry and exit points of market areas, border points, connection points to storage and virtual trading points. For non-metered customers (SLP-customers, where SLP stands for “standard load profiles”) the relevant volume is determined with a time-lag of 48 hours. Trading partners who have a balancing group at their disposal in the Gaspool or NCG market area can conduct trading transactions at one of the two hubs. Sellers and buyers nominate the volume of gas from their balancing group for a determined period; the balancing operators facilitate matching of offers, and in the event of a mismatch, the lower of the two values in a transaction is allocated.

The responsible for balancing carries on two sets of operations: the physical procurement of gas for balancing purposes (so called “control energy”), and the allocation of all or part of such energy to balance the system differences between in-takes and off-takes of each balancing group account. There are two types of control energy products: commodity and flexibility products. Commodity products consist in the purchase and selling of gas quantities for medium-long term balancing actions in the market area. The two commodity products available are “Day-Ahead”, which can be used for one gas day only, and “Long-Term”, which can be offered for one or more gas days. For each gas day, all of the control energy contracts are stacked in a merit order list according to the price offered, which determines their call-off by the balancing operator, prepared for each gas quality (H-Gas or L-Gas). Flexibility products refer instead to short-term balancing services, and consist in delivery ("parking") or acceptance ("borrowing") of quantities of gas in the market area, kept in a gas account. The positive / negative account balances can be equalized at any time, and must be equalized at the latest by the end of the contract period.

The prices for balancing gas are computed based on the day-ahead reference price published on EEX and ICE-Endex (Gabigas). Group network operator shall pay a charge amounting to the second lowest selling price among the reference prices GP's One Day-Ahead Settlement Price, NCG'S One Day-Ahead Settlement Price, TTF or Zeebrugge, multiplied by 0.9 to the balancing group manager in case of negative balancing energy. In case of positive balancing energy, the balancing group manager shall pay a charge amounting to the second highest purchasing price of the reference prices abovementioned, multiplied by 1.1 to the balancing group network. The prices in €/MWh at the following trading points shall apply as reference prices for the respective gas day.

The main instruments used in Germany to meet load variations are gas storage and line-pack, and, to a lesser extent, interruptible demand, apart from the volumes produced and imported via pipelines (KEMA, 2009 and BNA, 2011). Line-pack is probably the first flexibility tool in Germany, being the privileged instrument to settle the system balance. The TSO is obliged to use its own line-pack first, and only afterwards it will be possible to exchange balancing gas between market areas. After both line-packs are exhausted, TSO will be able to use other sources of flexibility. Germany has the largest storage capacity available in Western Europe, with a capacity of more or less 20 bcm and 47 storage points recognized on the GSE map (GIE, 2011), and together with France and Italy, holds more than 70% of the EU storage capacity. Most of the working gas volume is concentrated in the hands of the major incumbents, and of course their incentive to release storage volume to third parties is limited. Although storage access is possible, the terms of such access are defined by various SO such as EON Gas Storage, RWE, Wingas, EWE and others, making it difficult for third parties to utilise the storage commercially. However, the rapid growth of gas trading is expected to boost the use of storage as a trading tool and increase the demand for storage even further (EFET, 2009). Access to storage capacity is not regulated; according to the EnWG (2005, par. 28) only bilateral agreements with "reasonable terms" are needed. Storage capacity allocations occur either on a first-come/first-served basis or through an auction. Usually, the time-frame for storage allocation contracts is 1 to 3 years. Secondary trading of storage capacities happens via an internet platform called store-x, in which storage package are offered to the public through an auction or at a fixed price. However, store-x platform is still in development, and often does not provide regular storage capacities. Germany does not have LNG, although the implementation of LNG terminals has been in the policy debate for a while; agreements to import Liquefied Natural Gas have been made with the Middle East and increasingly from the USA (BNA, 2011). LNG became a source of interest for Germany since its decision to switch away from nuclear power after the March 2011 Fukushima accident. RWE Gas Midstream announced that it planned to build an LNG regasification terminal in northern Germany (Wilhelmshaven) with two partners, US-based Excelerate Energy and Germany's Nord-West Oelleitung GmbH in 2007, but the project has been suspended. There is also a project to build a regasification terminal at Rostock (Business Insights, 2012).

3.3.2 Trading

Besides ordinary brokered and OTC operations at the hubs, in Germany there is also the opportunity to trade gas via exchange, namely via the European Energy Exchange AG (EEX)[22] the German gas

[22] The European Energy Exchange (EEX) was founded in 2002 as a result of the merger of the two German power exchanges European Energy Exchange in Frankfurt and LPX Leipzig Power Exchange Leipzig where it is now settled. Clearing activities are managed by the subsidiary European Commodity Clearing (ECC). In 2008, EEX entered a close cooperation with Powernext in the field of power trading. In the framework of this cooperation, both partners integrated their power spot and derivatives market. EEX holds 50% of the shares in the joint venture EPEX SPOT which operates the spot market for Germany, France, Austria and Switzerland. The power derivatives market for Germany and France is operated by the EEX subsidiary EEX Power Derivatives. EEX operates a spot and

exchange platform since July 2007. In the initial phase exclusively futures were traded in the H-gas market area of Open Grid Europe, but already from October 2007 the EEX offerings were extended to include day-ahead products on the spot market, and one year later gas exchange trading was expanded to cover the virtual trading point of NCG and Gaspool's joint H-gas market area.

According to data on the price of gas imports at the German border released by the German Federal Office of Economics and Export Control (BAFA), prices in Germany are on the European average, or slightly lower, though there is a significant difference between the price at the border and at the hub. DG Energy (2012) has estimated such difference to be on average 5 €/MWh higher than either of the two German hub prices. Germany however benefits from favourable terms relative to a number of its Central and Eastern European neighbours, (although UK and Belgium, which are very closely correlated to hub prices traded there, are even more favourably treated than Germany). As an example, DG Energy estimates that in the first quarter of 2012 Germany paid on average 27.7 €/MWh for Russian gas, with respect to a Platts NWE GCI oil-indexed average price for the same period of 34.3 €/MWh.

Figures 16 and 17 show the reference prices at the two hubs; it can be noted that the pattern of prices at NCG and Gaspool has been not significantly different for a long period, but is lately showing some signals of divergence.

The recent evolution of the German market can be appreciated in the performance of volume-based indicators, particularly the churn ratio of NCG. Figures 18 and 19 show volumes and churn ratios: net churn ratio shows an increasing trend for both NCG and GP, but such increase is decidedly more marked for NCG. Bid-ask spreads are showed in Figures 20 and 21. Futures contracts to trade on German hubs are listed on two exchanges: EEX and ICE. On EEX, besides the spot exchange, there are also derivatives available for future physical deliveries at both NCG and GP. Such futures are monthly, quarterly, seasonal and yearly contracts. On the ICE are available contracts for physical delivery through the transfer of rights at the NCG and have a trading period of months, quarters, seasons, and years, like the ones on EEX. As it occurs nearly everywhere in Europe, there is an overwhelming prevalence of the OTC trading with respect to the exchange. Within the exchange trading, futures contracts are the most traded, while the spot trading is less relevant.

In conclusion, the picture of the German gas system shows an evolving market, with scope for improvement. To improve the system performance in the future, it may be advisable to proceed to a further merger of the two market areas. This could lead to better performances in terms of liquidity, for many reasons. First of all, because of the higher volumes resulting from the union of the two, secondly because of the lower transaction costs due to process integration and economies of scale. Third, having one single market would be more attractive for traders, especially foreigner ones, because of the lower search costs to understand the differences and the functioning of the two, and would result in a higher degree of transparency.

derivatives market for the German market areas Gaspool and NCG as well as a spot market for the Dutch TTF market area. EEX holds 20 percent in EMCC GmbH (European Market Coupling Company), a company which executes the congestion management at the German-Danish border. In addition, EEX holds an interest in store-x GmbH (Storage Capacity Exchange), an internet platform for secondary trading in storage capacities for natural gas, and in trac-x GmbH (Transport Capacity Exchange GmbH), an internet platform for natural gas transport capacities.

3.3.3 Data summary and graphs

Figure 16 - Reference prices at German hubs. Source: Gaspool data service.

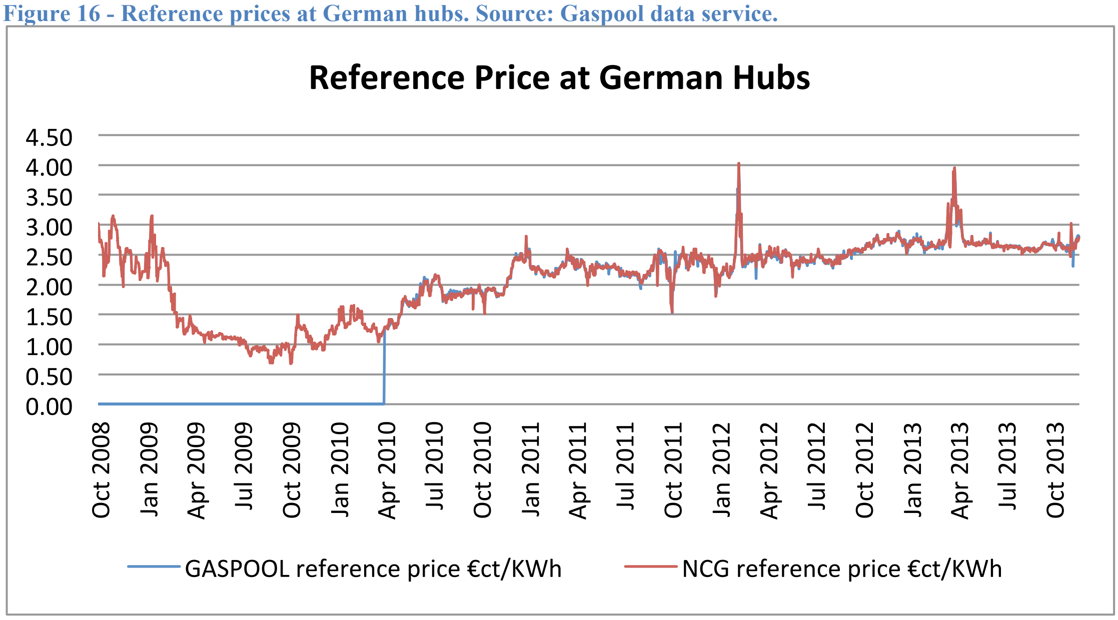


Figure 17 - Reference prices in Germany - detail of the year 2013. Source: Gaspool data service.

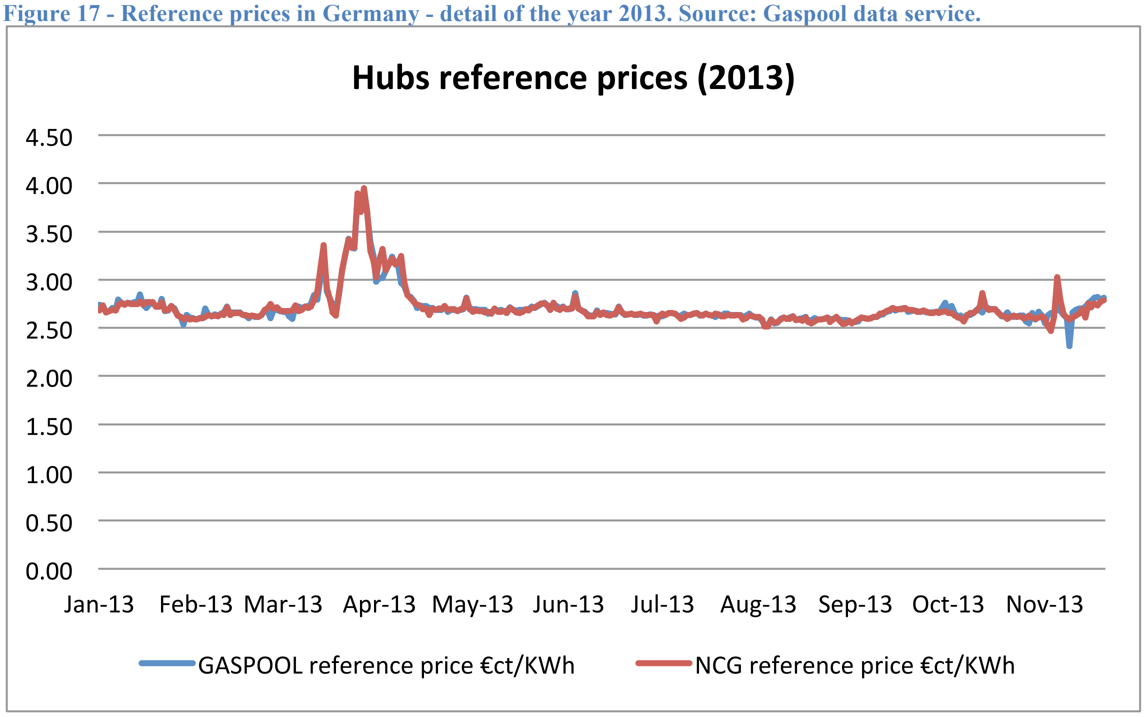


Figure 18 - Traded volumes at NCG and GP, compared with total traded volumes at German hubs. Sources: Gaspool, NetConnect Germany

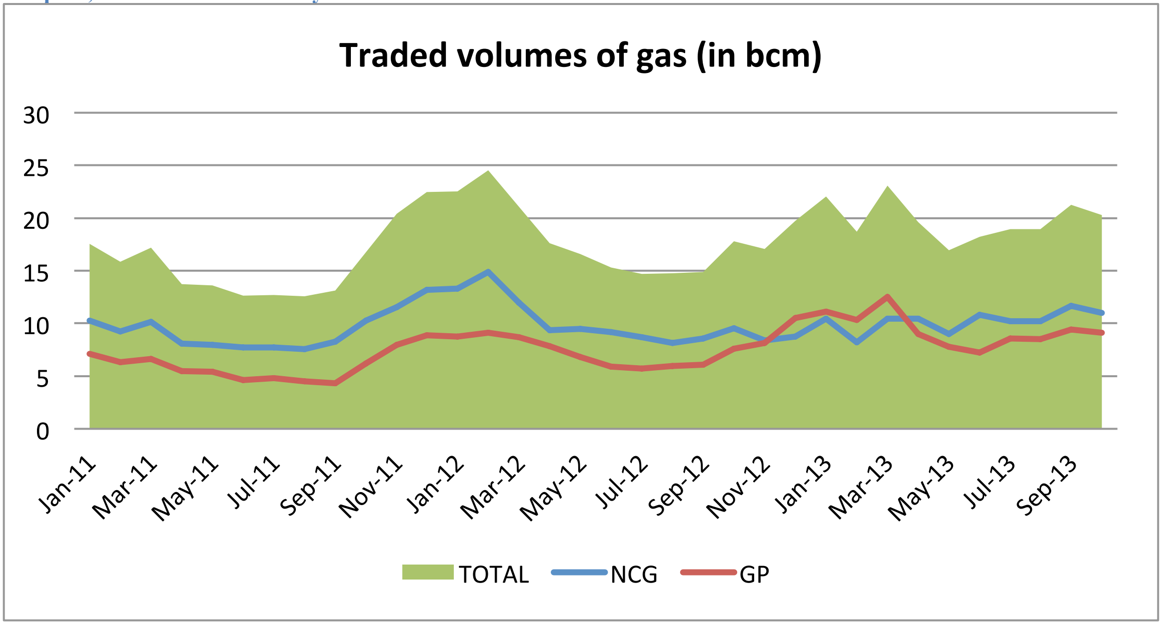


Figure 19 - Churn Ratio. Data Source: Gaspool, NCG

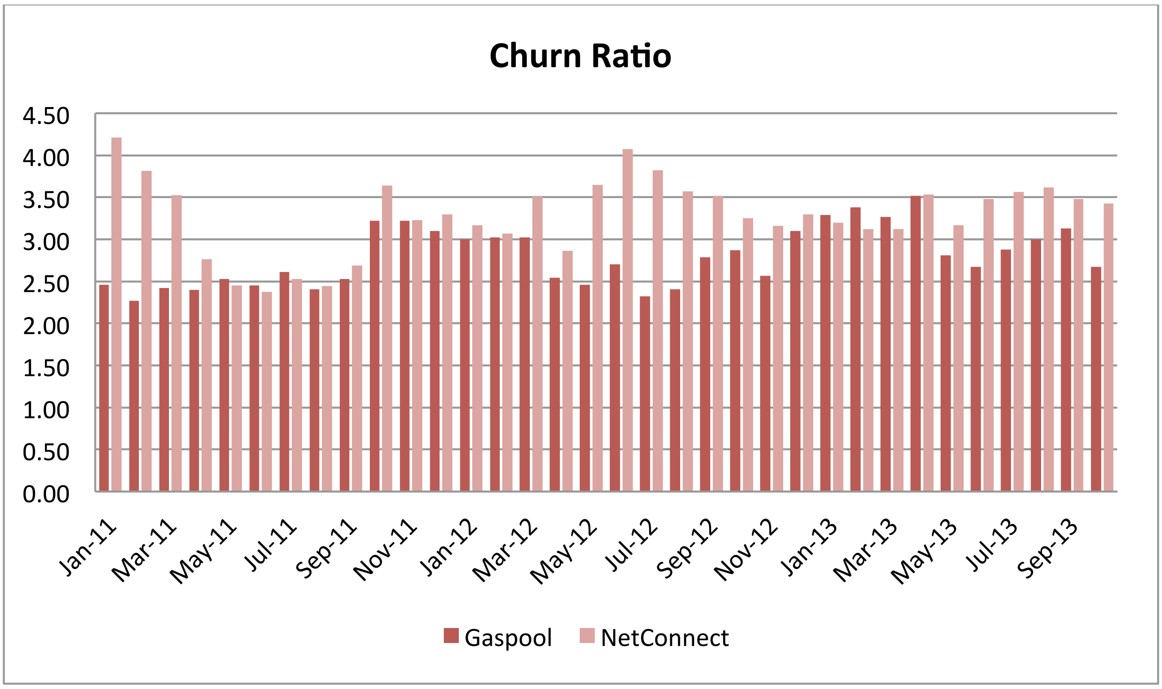


Figure 20 - Bid-Ask prices at NetConnect (in €/MWh). Source: Bloomberg.

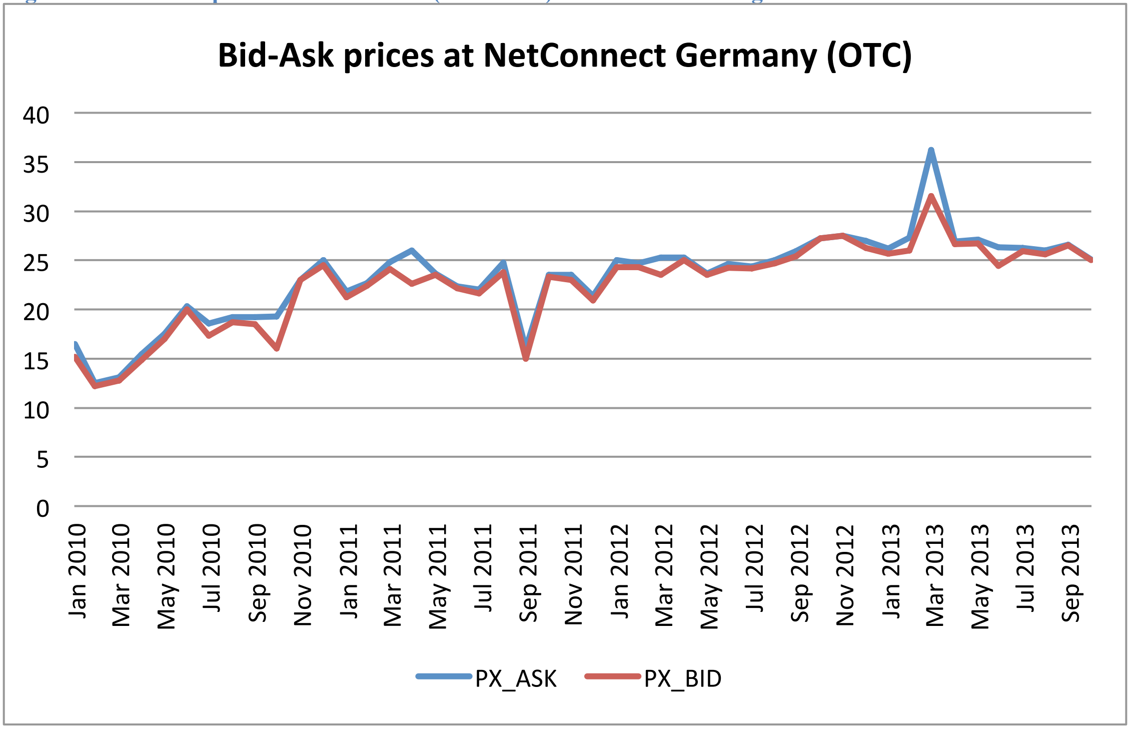
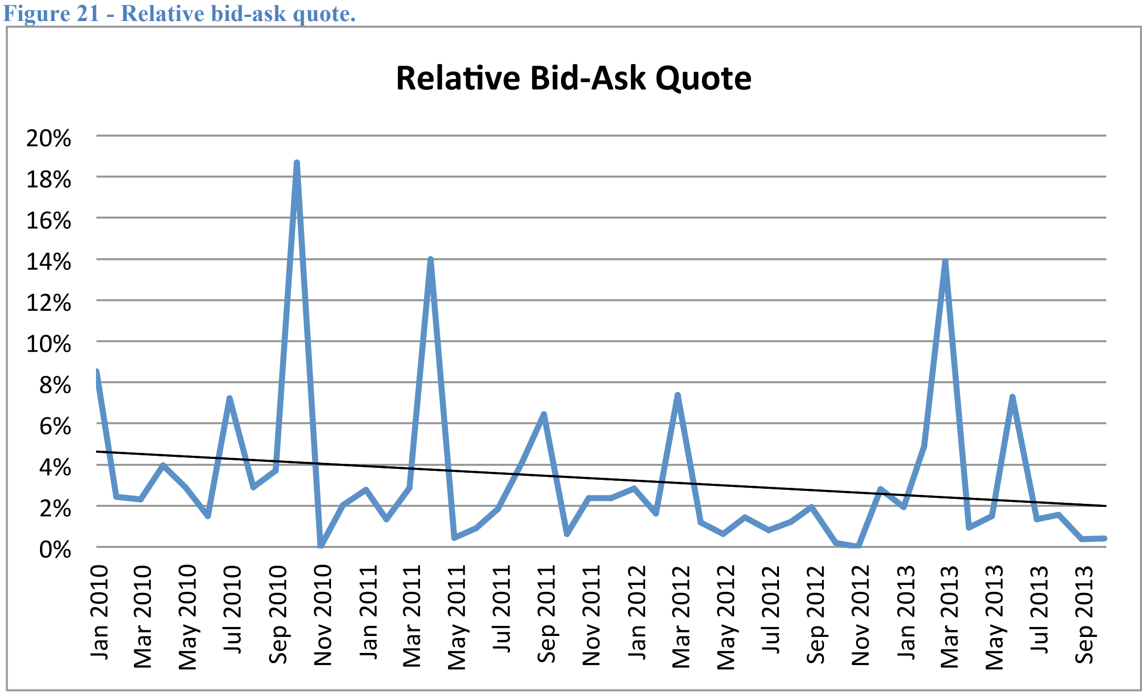


Figure 21 - Relative bid-ask quote.



3.4 Belgium: Zeebrugge

Belgium does not possess any natural gas among its natural resources, hence the country relies for the totality of its supply of natural gas on imports. Given its geographic position, Belgium is a nodal country for gas transit in Continental Europe, receiving gas coming from Algeria (through the Zeebrugge Beach LNG Terminal) Norway, the Netherlands and UK and flowing it to France, Italy, Spain, UK, Luxemburg and Germany. Natural gas has acquired an increased importance in Belgium with respect to other fossil fuels and accounted in 2010 for approximately 31% of total primary energy supply. Gas consumption is almost equally distributed across the industrial, transformation and residential and commercial sectors (IEA, 2011).

Table 7 - Natural Gas Balances - Belgium. Source: IEA (2013)

							Million cubic metres	
	2011	2012	4Q2012	1Q2013	2Q2013	aug 2013	%Change Current Month	%Change Year to Date
Belgium								
Indigenous Production	-	-	-	-	-	-	-	-
+Imports (Entries)	41723	38903	10746	14086	9768	2658	-11.5	15.2
-Exports (Exits)	24623	21184	5851	7558	5823	1814	-9.4	23.4
=Gross Consumption	16637	16833	4907	6782	3683	770	-12.4	10.4

The Belgian independent operator of the gas transmission system and storage infrastructure is Fluxys, which is a public limited company under Belgian law, owned for 80% by Publigas SCRL23 and for 20% by the Caisse de dépôt et placement du Québec, while the Belgian State owns one golden share of the company. Fluxys is listed on Euronext Brussels market and operates also the Zeebrugge LNG Terminal and the Zeebrugge trading hub, through its subsidiary Huberator. The Belgian network comprises 4,100 kilometers of underground pipelines used to transport gas within the national borders targeting the Belgian consumers and for transit purposes towards neighbouring countries. As seen above, Belgium relies totally on natural gas imports coming from UK, Norway, the Netherlands, Russia and various LNG producing countries which enters the transmission grid through 18 Entry Points. Pressure in the system is maintained through five compressor stations whereas four blending stations allow for the High calorific gas (H-gas) to be transformed into Low calorific gas (L-gas) flowing from the H-transmission grid to the L-transmission grid. The transmission network comprises also 90 delivery stations connected with 17 Distribution System Operators (DSO) which distribute gas to homes and small-medium enterprises and to about 260 industrial consumers, power stations and cogeneration plants that are directly connected to the grid. Furthermore about 180 pressure-reducing stations link the high-pressure pipelines with low-pressure ones which are operated by Fluxys or a DSO. The Belgian grid comprises also an underground storage facility at Loenhout and the Zeebrugge LNG Terminal where liquefied natural gas can be temporarily stored and can be regasified to be either injected in the transmission network or loaded back on LNG vessels.

Transmission and distribution, storage of natural gas and LNG's terminal activities in Belgium are regulated and are under the supervision of the Commission for Electricity and Gas Regulation (CREG). Specifically the Federal Act of 12 April 1965 (the Belgian Gas Act) on the transmission of gaseous and other products by pipelines, regulates all the activities carried out by Fluxys together with the two royal decrees on tariffs and the Code of Conduct. The Code of Conduct has been adopted through the Royal Decree of 4 April 2003 and establishes all the conditions for access to the natural gas infrastructure. In January 2011, based upon the Royal Decree of 23 December 2010, a new Code of Conduct was implemented guaranteeing non-discriminatory access to the infrastructure, in order to comply w EU's requirement on network access. In the framework of the new code of conduct, Fluxys jointly with the

[23] Publigas is owned by a number of Belgian municipalities and intercommunales.

CREG is bringing about major changes to the gas market in Belgium in order to strengthen its functioning and enhance its' competitiveness with respect to other European countries. In light of this objective, Fluxys submitted for approval on March 15th, 2012 to the CREG a set of documents24 through which it aimed to radically change the Belgian transmission system by introducing an entry/exit transmission model, a market based balancing regime together with the creation of one single trading hub, the Zeebrugge Trading Point (ZTP), with both virtual and physical services. CREG approved almost entirely the documents submitted by Fluxys and as a result the latter published an adjusted version of the documents on April 26th, 2012 for re-approval by the CREG. The new entry/exit transmission model and the related rules entered into force in the autumn 2012. The new entry/exit model that Fluxys has implemented to offer its transmission services is structured as follows. The transmission system has been divided into two entry/exit zones corresponding to the High-calorific subgrid (H-zone) and the Low-calorific subgrid (L-zone). The gas can enter both zones through an interconnection point and may leave the grid through a domestic exit point or another interconnection point or can be traded within the system. The entry/exit model allows for independent and decoupled booking of entry and exit transport capacities by market parties, and puts on shippers a legal obligation to offer their unused capacity in the secondary market organized by Fluxys[25].

3.4.1 Balancing

In line with the objectives of the Third Energy Package, the market-based balancing system adopted in Belgium aims at giving grid users the primary responsibility for balancing the system whereas assigning to Fluxys a residual role of intervention only when the overall system imbalance moves out of a given predefined zone.

Shippers are responsible for balancing inflows with outflows in the grid on a daily basis following the hourly allocation information provided by Fluxys. Specifically, Fluxys publishes the hourly cumulative Grid user Balancing Position (GBP(h,z,g)) for every shipper in a considered zone calculated as the difference between all entry allocations and all exit allocation and the net title transfer on the relevant notional trading point (Fluxys, 2012)[26.] Alongside, Fluxys publishes the hourly cumulative Market Balancing Position (MBP(h,z)) calculated as the sum of all individual shippers GBP(h,z,g) in a considered zone. For both balancing positions GBP(h,z,g) and MBP(h,z), Fluxys provides grid users with a forecast for the remaining hours of the considered gas day (see Figure 22).

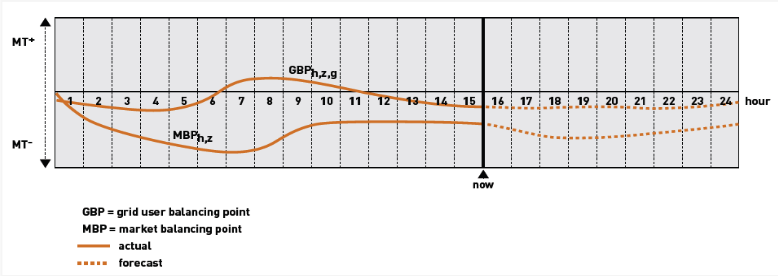
The system is considered to be balanced as long as the MBP(h,z) remains within the predefined upper and lower threshold MT+ and MT-. When the MBP(h,z) exceeds the upper or lower threshold in the H-zone or L-zone, Fluxys will immediately settle the imbalance by starting a buy or sell operation on the commodity exchange market for the quantity of gas that exceeds the threshold MT+ or MT-. The settlement will be proportional to the shippers causing the excess or shortfall in the system through their GBP and the residual actions undertaken by Fluxys will define a Buy or Sell price that is used for charging or refunding the shippers who caused the market imbalance. To this financial settlement, Fluxys under the authorization of the CREG applies also an incentive in order to foster shipper's effort in keeping their portfolio balanced and thus the overall market as well.

[24] These documents include: standard transmission agreement (contractual terms and conditions), access code for transmission (access rules and procedures) and the transmission programme .

[25] Details about the secondary market for capacity in Belgium can be found in the Transmission Programme (2012-2015) published by Fluxys on its website (www.fluxys.com) on April 26th, 2012.

[26] The net title transfers need to be confirmed by Huberator on the relevant notional trading point (ZTP and/or ZTPL, respecitively for the low and high calorific gas).

Figure 22 - Balancing positions and forecast. Source: Fluxys (2012).



At the end of the gas day the individual shippers' GBP is set to zero through a cash settlement taking into account the balancing incentive. Specifically as reported in the Transmission Programme for the 2012-2015 period published by Fluxys, the settlement at the end of the day for every GBP in both balancing zones comprises the following steps:

- Definition of the market imbalance, i.e. the quantity of gas in excess or shortfall on the last hour of the gas day;
- Definition of the gas quantity per grid user, equal to the GBP(h,z,g) of the last hour;
- Initiation of transactions by Fluxys on the commodity market in order to set each GBP(h,z,g) equal to zero, i.e. purchase or sale of gas on the market.
- Financial settlement: at the end of the transaction Fluxys will have defined a proportional quantity of gas to be received or given to each shipper and the price of this transaction. Also in this case an incentive may be applied[27].

The creation of the virtual trading point ZTP and a gas exchange has been useful both for grid users and the TSO. On one hand grid users are able to balance efficiently their inflows and outflows of gas in system by buying and selling gas in the exchange for the ZTP. On the other hand, the TSO can carry out residual balancing actions via ICE-ENDEX (see next section) when there are system imbalances. In case of within-day or at the end-of-day imbalances, Fluxys accepts bids (offers) for a defined TSO physical product available on the exchange. There are two physical TSO products: one for balancing actions on the L-zone and another for the H-zone. The balancing actions carried out by Fluxys on the exchange determine the reference price for the abovementioned settlements and the respective quantities.

3.4.2 Trading

Gas trading in Belgium is mainly realized at the Zeebrugge Hub, based in the homonymous town in Northern Belgium. The Belgian wholesale market for gas is deeply changing as we write, therefore it will be difficult to fully evaluate its status, but we will try to describe its most important features and the possible directions that it is taking. Access and associated services to the Zeebrugge Hub are provided by Huberator SA, a subsidiary of the Belgian TSO Fluxys that fully owns and operates the Belgian transmission grids. Huberator SA facilitates natural gas trading at ZTP or shipping through the Fluxys grid for delivery into the Belgian market or redelivery at the borders for onward transmission to the United Kingdom, the Netherlands, Germany, Luxembourg, France, and Southern Europe. Its services comprise title tracking, back-up, physical and financial trading, and transaction conclusion services. Gas may enter in the Zeebrugge area primarily for three purposes:

[27] As outlined in the Transmission Programme for the 2012-2015 period Fluxys (2012, p.25), the end-of-the-month settlement may be needed when: "At the latest the 20th day after the relevant month, the final allocations are compared with the provisional allocations. If the final allocations differ from the provisional allocations, this results in a financial settlement between Fluxys and the grid user to compensate for the difference between the final and the provisional allocations. This settlement is financially handled during the next invoicing cycle".

- Intra hub trading: trading without shipping natural gas to or from the hub;
- Shipping natural gas into the hub for selling, in which case the ZTP serves as an exit point in the Fluxys system;
- Buying natural gas at the hub for onward delivery into Belgium or elsewhere in Europe, in which case the ZTP serves as an entry point into the Fluxys system.

Originally, Zeebrugge was born as a physical hub, but in time Fluxys and CREG have taken steps to integrate its services with creation of a virtual trading point, the Zeebrugge Trading Point (ZTP), and a gas exchange, ZTP Gas Market. This change has been completed with the introduction of the new balancing system just described. As a result, at ZTP transactions may be concluded: Over-the-Counter (OTC) or via exchange, also called screen-based trading. Grid Users can nominate OTC deals on Zeebrugge Beach, ZTP, and ZTP-L to Huberator, where Zeebrugge Beach is the physical trading point for LNG, ZTP is the virtual trading point for high calorific gas (H-gas) and ZTP-L is the trading point for low calorific gas (L-gas),(Fluxys, 2012).

Fluxys, together with ICE–Endex (APX-Endex at the time of launch), launched the Belgian exchange to boost market liquidity and price transparency in the Belgian gas market on September 27, 2012. With the new rules, grid users may balance efficiently their inflows and outflows of gas in the system by buying and selling gas in the exchange for the ZTP, while the TSO carries out residual balancing actions via ICE-Endex when there are system imbalances. The gas exchange operator is responsible for bringing together the gas required or being offered for sale, and for the financial transaction. The pattern of the reference price at the hub prior the implementation of the new exchange is showed in Figure 24: prices are, on average, slightly lower with respect to other continental hubs. A detail of the day ahead prices and volumes traded post reform is displayed in Figure 23. A peculiarity of Zeebrugge is that, contrary to the other Continental hubs, trading happens in pence per therm, i.e. with the British measurement unit (we have converted the figures in €cent/kWh for the sake of comparability with the other hubs). This is due to the strong bond that has always linked Zeebrugge with NBP, thanks to the Interconnector pipeline that brings British gas directly from Bacton, UK to Zeebrugge.

Imports play an important role in the system's security and flexibility, and in Belgium there is little difference between the price of gas imported from Norway, ZEE-Day Ahead price and LNG price (DG Energy, 2012). Belgium is also among the countries that pay the lowest price for imported LNG and, together with UK, the lowest price for long term contracts. This convergence in prices is a reflection of the integration of natural gas infrastructures (interconnectors, pipelines, terminals). The country is endowed with a very efficient interconnection and pipeline system and that is probably the key factor that has lead to this unusual convergence in prices.

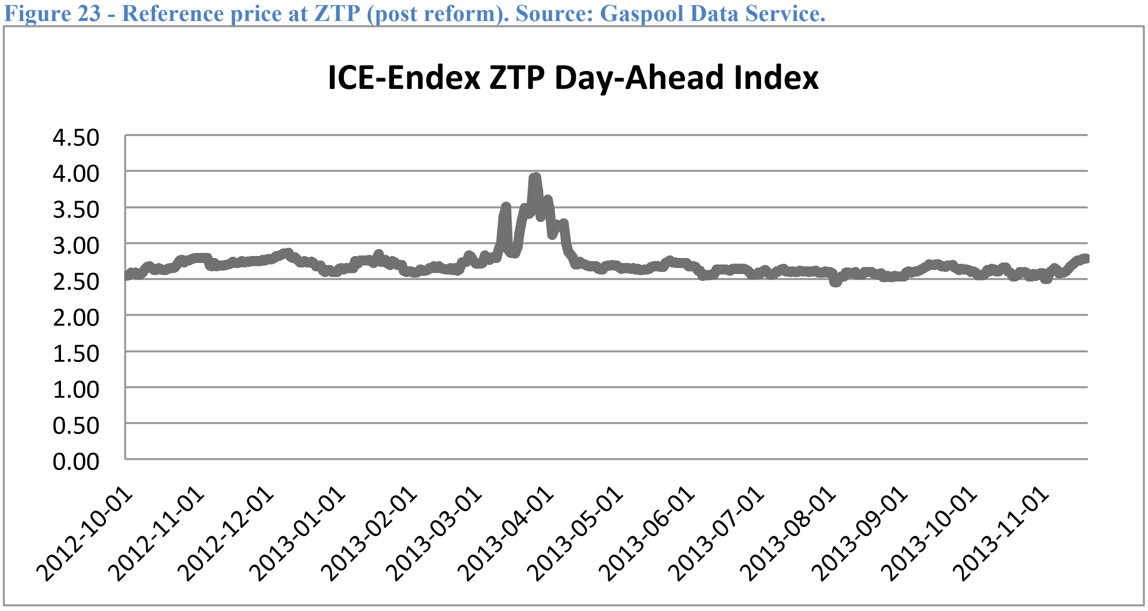
Figures 25, 26 and 27 show the pattern of volume-based liquidity indicators. From Figure 26 it can be noted that the performance of the churn ratio is worsening, because the growth in physical supplies has overtaken the growth in traded volumes. Transaction cost-based measures reveal a past instability in spreads followed by a current, more stable phase, with lower spreads starting from mid-2012, as can be appreciated in Figures 28 and 29. The occasional negative bid-ask spreads are a signal of the cross-market trading that happens at ZTP.

Physical flexibility is primarily guaranteed by means of line-pack, storage (underground and LNG), imports and interruptible demand and supplemented by the ZTP. Line-pack as a physical flexibility tool is implicitly incorporated in the predefined thresholds MT+ and MT-, calculated per balancing zone. In general terms, these predefined thresholds are based on the peak imbalances in the Belgian gas market for each zone over a period of 3 years[28]. Nevertheless, since line-pack can only serve for small and short-term variations in gas demand, a crucial role is played by storage. The most important storage facility is the Loenhout underground storage, an aquifer storage for H-gas that mainly provides seasonal storage. The facility at Loenhout has a working capacity of 700 mcm of high-calorific natural gas with a withdrawal capacity of 625 mcm per hour and an injection capacity of 325 mcm per hour. Alternatively the Zeebrugge LNG Terminal, owned and operated by Fluxys LNG, has a storage capacity of 380 mcm and a send out capacity of 9 bcm/ year. As a consequence, the LNG facility has a higher ability to respond to peak-day requirements in case of unforeseen variations in demand. Finally, although transparent and reliable information is not provided, it is reasonable to assume that Belgium may also rely on flexibility from import contracts and interruptible demand.

As a supplementary mean of flexibility, Belgium has a secondary market for capacity where grid users make available the capacity that they subscribed but do not need any more. Trading is again organized by Fluxys, through an electronic platform, capsquare.eu, in which users can exchange capacity and entry or exit services that they has previously booked and that they no longer require. Trading can happen anonymously or OTC.

3.4.3 Data summary and graphs

Figure 23 - Reference price at ZTP (post reform). Source: Gaspool Data Service.



[28] "These thresholds are defined per zone and can vary on a seasonal basis, as described in the access code for transmission. For information, the market thresholds level is determined for each zone based on the peak imbalances of the Belgian market (total final customers connected on the considered zone, either directly or through distribution networks) observed over an historical period of 3 past years and assuming a profiling of the gas entering the transmission grid of 102/9615 for the H zone and 105/90 for the L zone.)". Fluxys (2012).

Figure 24 - Reference price from Oct 2008 to Sep 2013 (pre-reform). Source: Gaspool Data Service.

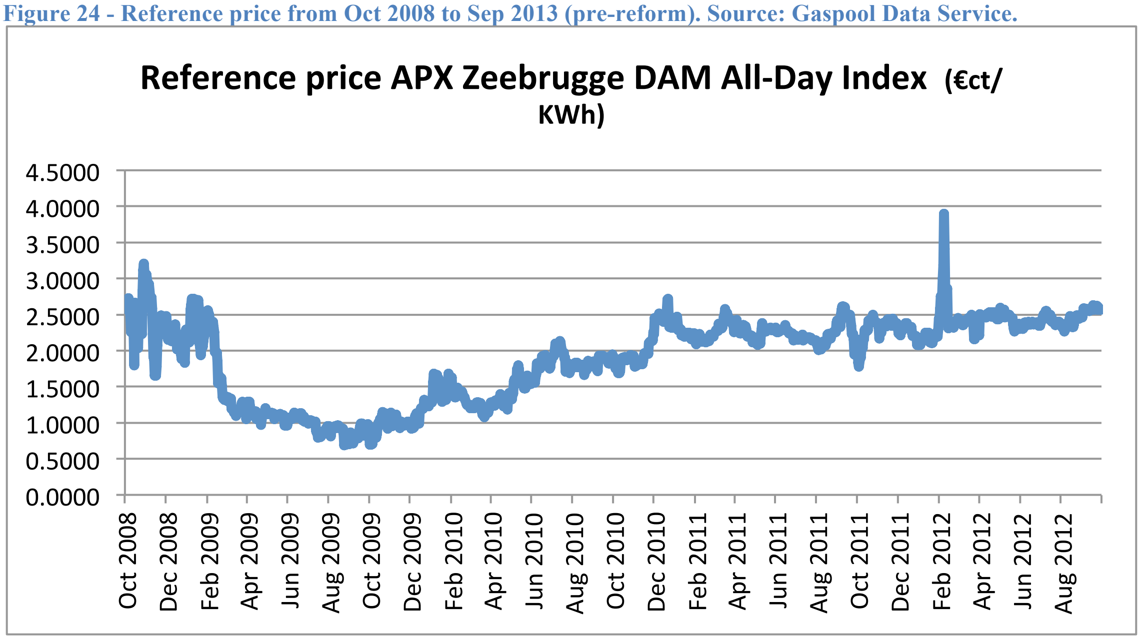


Figure 25 - Traded and physical volumes at ZTP. Source: Huberator.

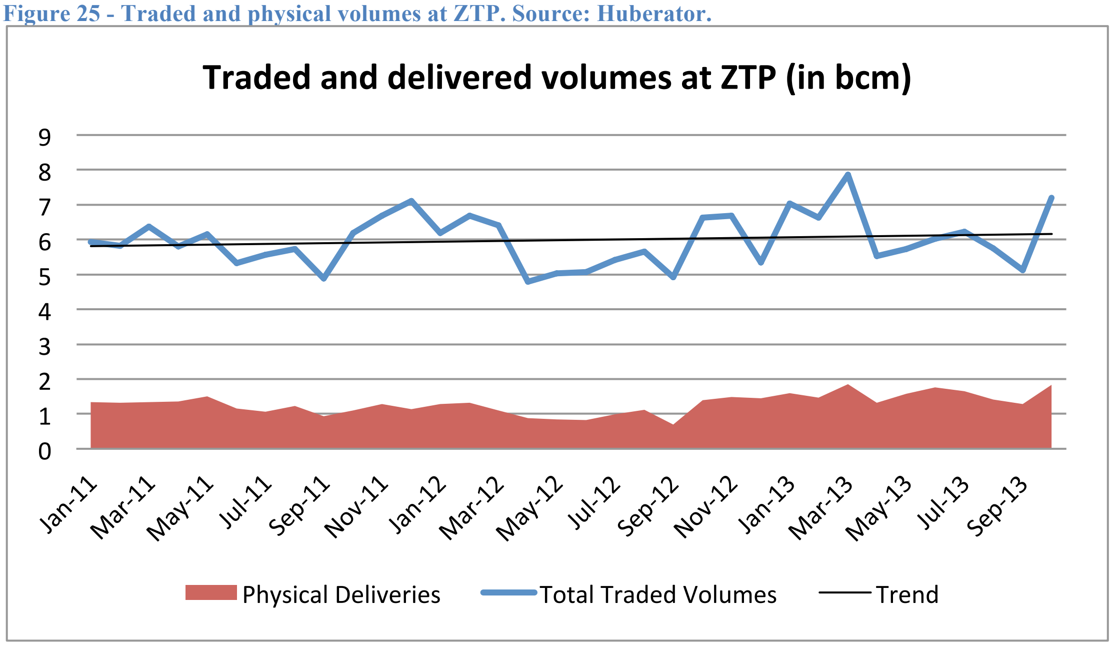


Figure 26 - Gross and net churn ratios at ZTP. Source: Huberator.

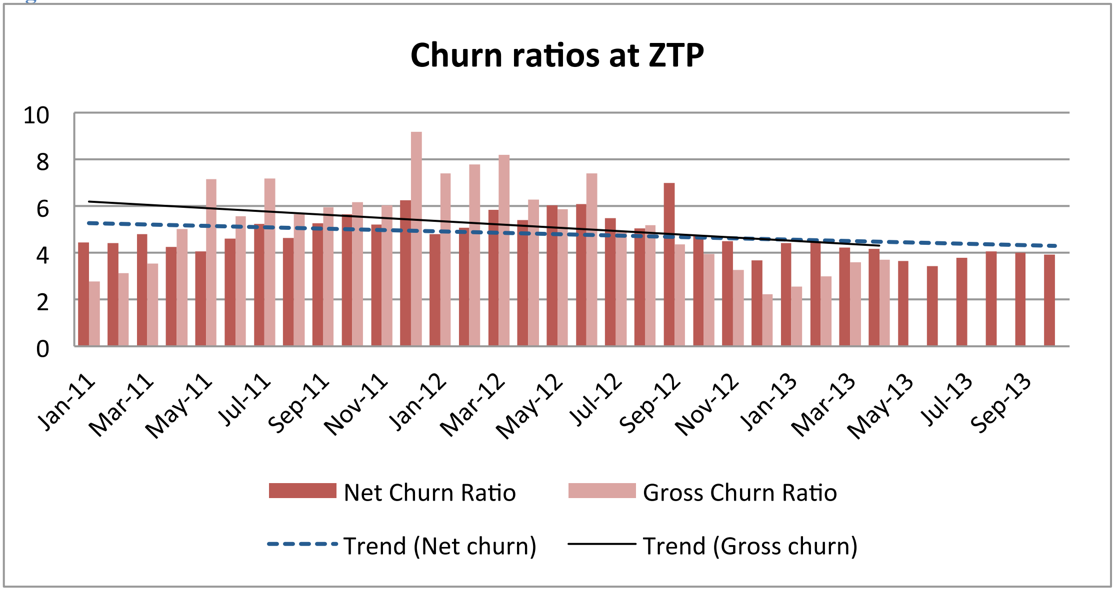


Figure 27 - Churn ratio split for market area – Source: Huberator.

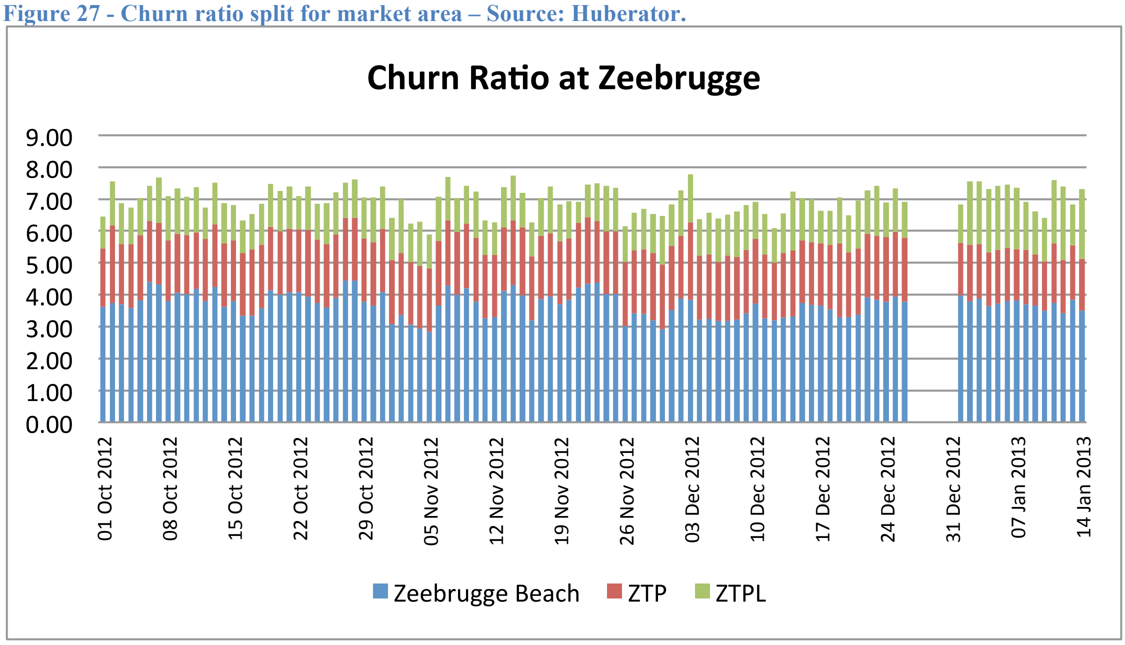


Figure 28 - Bid-Ask prices at ZTP. Source: Bloomberg.

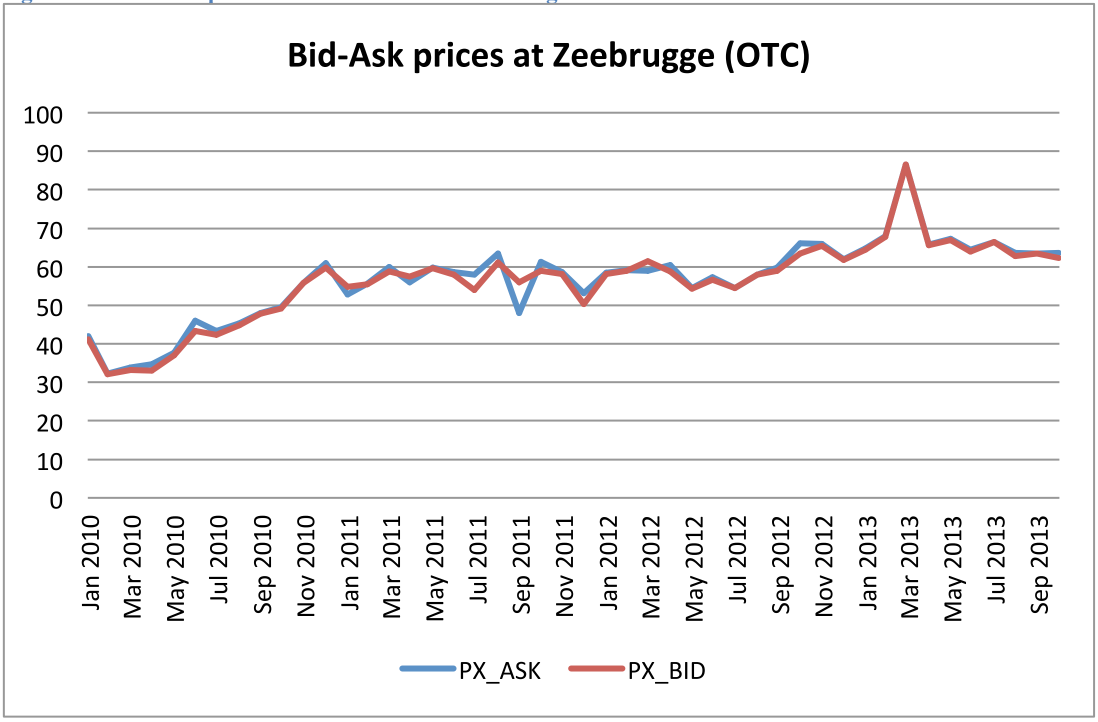
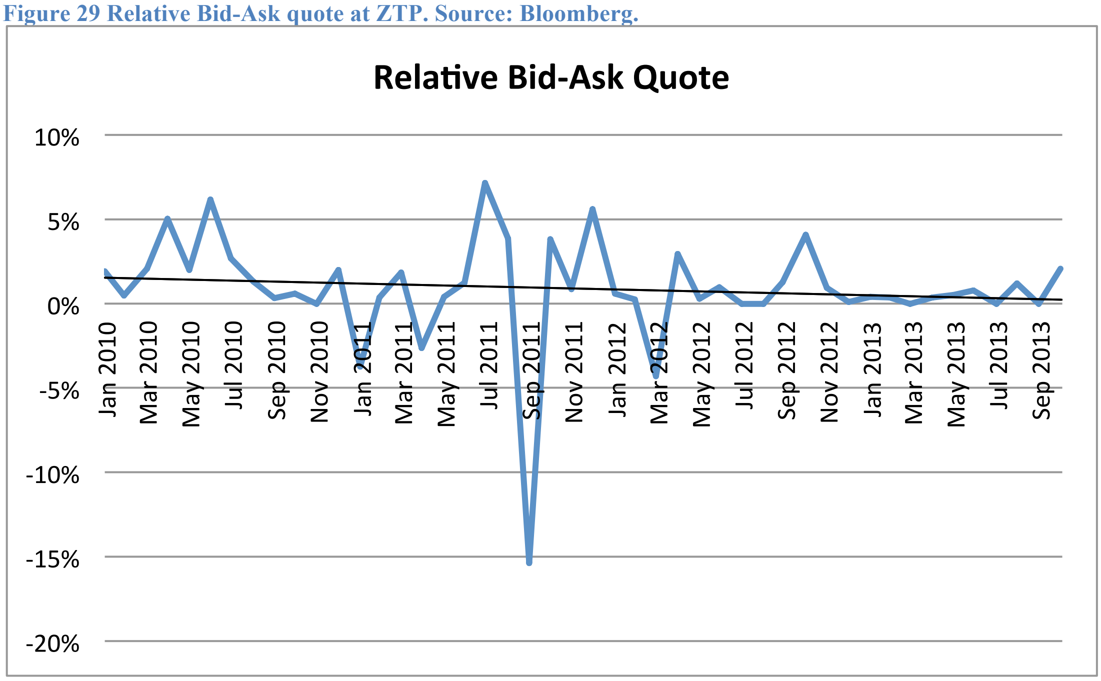


Figure 29 Relative Bid-Ask quote at ZTP. Source: Bloomberg.



3.5 France: PEGs

Given the important role played by nuclear energy for power generation, the share of natural gas in the French technology mix is less relevant with respect to other EU countries (IEA, 2009). France imports natural gas both via pipelines and LNG terminals coming from a well-diversified set of countries around the world. Indigenous production is very small in France: in 2011 it amounted to only 5,87 bcm and it has declined in 2012. The French government expects that production will cease in the short-term (IEA, 2009).

Table 8 - Natural Gas Imbalances. Source: IEA (2013)

								Million cubic metres
	2011	2012	4Q2012	1Q2013	2Q2013	aug 2013	%Change Current Month	%Change Year to Date
France								
Indigenous Production	587	508	120	112	112	29	-32.6	-17.1
+Imports (Entries)	49589	47708	11748	12453	12149	3431	-11.5	-2.7
-Exports (Exits)	6483	5994	987	1112	905	458	4.6	-36.5
=Gross Consumption	41519	42586	13301	17597	7915	1383	-1.4	3.2

Gas gross consumption in France in 2011 amounted to 41,5 bcm, more than 8% less than the previous year, and has experienced a slight recover in 2012, continued in 2013.

The gas transmission system in France is operated by GTRgaz, 100% subsidiary of GDF Suez, and TIGF, 100%, a former subsidiary of Total S.A. that has been now sold to a consortium lead by the Italian Snam (45% shares), and formed by Singapore sovereign fund Gic (35%) and Edf (20%). GTRgaz operates about 32,000 kilometers of pipelines wherein approximately 7,000 kilometers belong to the main network (réseau principale) which allows gas to flow between the interconnection points connecting the transmission grids of neighbouring countries for transit, links storages and LNG terminals in France and is connected with the 25,000 kilometers of regional network (réseau régional). The regional network instead is connected directly to large industrial consumers and to the distribution grid which supplies gas to end consumers. Alongside, TIGF operates 5,000 kilometers of pipelines in the south-west of France comprising pipelines both of the national and the regional network. Moreover twenty-five compression stations in the GTRgaz network and six in the TIFG network allow gas to move from one point to another in the grid at an average speed of 30 km/h. Russian, Norwegian and Dutch gas enters the French transmission system at the interconnection points in Obergailbach, Taisnières, Dunkerque and Biriatou whereas exports to Spain and to Italy of Norwegian gas are carried out from the interconnection point at Larrau and Oltingue respectively. Alternatively gas coming from Algeria, Egypt, Nigeria and Qatar is supplied via LNG vessels at the Fos-Cavaou, Fos-Tonkin and Montoir-de-Bretagne regasification terminals. France's storage capacity, which is operated and developed by Storengy and TIGF, is among the largest in Europe. Storengy is a subsidiary of GDF Suez and operates nine aquifer facilities, three salt caverns and one depleted field with a total working gas of around 10 bcm. TIFG instead operates two underground storage facilities (Lussagnet and Izaute) with a working gas volume of approximately 2,6 bcm (GIE website).

Briefly following the European Directives on liberalization, the demand-side of the gas market has been fully liberalised: since July 2007 consumers can freely choose their supplier and legal unbundling of the regulated activities from the competitive ones along with third party access to the gas infrastructure have been adopted. Furthermore, the French National Energy Regulator (Commission de Régulation de l'Energie, CRE) in conjunction with GRTgaz and TIGF is gradually implementing a market-based balancing regime in light of the EU Directive 715/2009 and the related network codes. To this end, the creation in 2008 by French gas and electricity market operator (Powernext) of an organized spot and futures gas market at the three French virtual trading points Nord, Sud and TIGF PEGs[29] should favour the emergence of a liquid and efficient wholesale gas market through which the market-based balancing regime could unfold. As will be outlined in the following paragraphs, different balancing regimes exist on the GRTgaz and TIGF networks, creating a fragmented environment that impairs trade among the different zones and hinders the smooth access to the market. For this reason, a path towards a balancing regime based upon market mechanisms started in 2006 and evolved in the definition of a target model for balancing outlined in the Deliberation of September 30th, 2010 by the CRE. Lately in 2011, following market consultations the CRE in its Deliberation of December 1st, evaluated the proposals submitted by GRTgaz and TIGF regarding the implementation of improved balancing rules in order to achieve a uniform balancing regime in line with the European requirements.

3.5.1 Balancing

In France there are three balancing zones: GRTNord[30], GRTSud and TIGF for which the transmission system operators GRTgaz and TIGF are responsible for the physical balance between entries and exits of gas. The availability of storage facilities, line-pack coupled with the ability to buy or sell gas on the market allow the TSOs to intervene when the system is imbalanced. Alongside, shippers are responsible for balancing on a daily basis their inflows and outflows of gas from a given balancing zone while having the possibility to score imbalances, within defined tolerances bands, without incurring in penalties. As a result, a daily balancing regime allows minimising the cost on the final consumer of those flexibility tools used to balance the system.

Figure 30 - Gas balancing zones in France. Source: GRTgaz website.

GRTgaz and TIGF regimes are currently slightly different. As we write, CRE is leading a balancing task force that has been working on the balancing issue for some years to meet the EU regulations by 2015. By then, the two operators GRTgaz and TIGF will have to use the same balancing rules (ICIS, 2013).

The current GRTgaz balancing regime requires shippers to balance on a daily basis their gas flows on the Nord H-gas, Nord L-gas and Sud Balancing zones but have the possibility to accumulate part of their imbalances over a longer period. Specifically the balancing regime entails the calculation at the end of the gas day for every balancing zone the Daily Imbalance of a shipper, given by the difference between the

[29] The PEGs (*Point d'Echange de Gaz*) referred to the three balancing zones in France as described in the next paragraph.
[30] In the Nord GRTgaz balancing zone there is a distinction between low and high calorific gas and therefore there is a H-Nord and L-Nord balancing zone.

total quantities delivered and the total quantities of gas taken-off from a given balancing zone. Furthermore, GRTgaz calculates a daily tolerance as a percentage of the total delivery capacity of a shipper – so called standard tolerance - with the opportunity to pay for an additional tolerance - optional tolerance. Consequently, a mid-range of cumulative imbalances is calculated as a percentage of the daily tolerance (standard and optional). Imbalances within the mid-range of cumulative imbalances are not cashed-out and shippers do not incur in penalties but the imbalances are aggregated on a daily basis into a Cumulative Imbalance Account for which a maximum level is set at five times the mid-range of cumulative imbalances (GRTgaz, 2011a). Given these imbalance zones, the following balancing rules apply:

The quantity of gas within the cumulated mid-range and the tolerance band is cashed out at a daily balancing market price, P1. Specifically, GRTgaz buys or sells the daily imbalance quantities at the price defined by the day-to-day market transactions on the "Powernext Gas Spot" market by GRTgaz. The quantity of gas within the maximum cumulative imbalance and the tolerance band is cashed out at a penalty price. Specifically, GRTgaz buys or sells the daily imbalance quantities at a price P2 defined as P1 plus a surcharge or discount if GRTgaz sells or buys respectively from the shipper. Gas quantities exceeding the maximum cumulative imbalance are subject to a penalty but are not cashed out. The price penalty P3 is set as P1 plus a surcharge. By recurring to market mechanisms to cash out shippers imbalances, the balancing regime is financially neutral for GRTgaz, meaning that the TSO will not incur any profits or losses by intervening in the market to balance the system but will pass on surpluses or penalties to shippers.

The TIGF balancing regime has not yet evolved towards a market-based model such as GRTgaz. As a result, TIGF balances its network physically through storage. The balancing rules are designed as to allow shippers some tolerances with respect to the settlement of imbalances at the end of the gas day allowing shippers to carry on imbalance and clearing them only at the end of month. Specifically, when the shipper imbalance is within the Daily Discrepancy Tolerance (DDT) no transaction occurs. When the daily cumulated imbalances are in excess of the Total Discrepancy Tolerance (French initials, TEC), TIGF intervenes by buying from or selling to the shipper the imbalanced quantities of gas at a penalty price P1. At the end of each month, the imbalances of a shipper are cleared to zero at a non-penalty price P2. Nowadays P1 is defined by the Powernext Gas Spot End-Of-Day PEG South price Day-Ahead and Weekend products for delivery on the day of the imbalance including a penalty of +/- 50% whether it is a purchase or a sale and a surcharge corresponding to the transport cost between the GRTgaz Sud zone and TIGF zone. Alongside P2 is defined as "the average of Powernext Gas Spot EOD PEG South references for DA or WE products for delivery over the last seven days of the month" (TIGF, 2011) to which a surcharge for transportation costs is applied. In order to incentivize shippers to optimize their daily balances on the grid and thereby contributing to the overall balance of the system, TIGF offers shippers a Daily Balancing Service (French initials, SEJ) to adjust withdrawals and injections from and into the storage facilities.

As reported by GRTgaz (2011a) in its prospective study about the needs for intra-day flexibility, in order to manage the physical balance of its network GRTgaz can rely on the following flexibility tools: market interventions, storage flexibility contracts, LNG terminals, line-pack alongside flexibility coming from the TIGF network. As outlined in the target model for balancing, GRTgaz shall increasingly rely on the wholesale gas market for balancing purposes and thus for acquiring flexible gas. Therefore, GRTgaz intervenes on the spot market organized by Powernext for H-gas with delivery at the virtual trading points PEG Nord and Sud for Within-day, Day-Ahead and Weekend contracts. From a physical point of view, GRTgaz can recur to within-day storage flexibility from the aquifer and salt reservoirs of Storengy. The within-day flexibility service offered by Storengy is interruptible and is based on the availability of unused withdrawal and injection capacity for a given day. As estimated by GRTgaz, on average the storage facilities belonging to Storengy can offer an average of 15 GW/h (1.4 mcm and 51 billion Btu)[31] of flexibility (GRTgaz, 2011b). Along the underground storage facilities, GTRgaz can rely on intra-day flexibility coming from the LNG terminals of Fos-Tonkin operated by Elengy (subsidiary of GDF Suez) and Fos-Cavaou owned by Fosmax LNG. Under a contract stipulated with Elengy from April 1st 2011, GRTgaz estimated an average available flexibility of 1,5 GW/h (0.14 mcm and 5.1 bi. Btu) coming from the Fos-Tonkin terminal at least till the end of 2014. Also according to GRTgaz, the intra-day flexibility coming from the Fos-Cavaou LNG Terminal is estimated to be on average of 3,5 GW/h (0.325 mcm and around 12 bi. Btu) from 2012 until 2020. It should be noted that although these sources of flexibility satisfy intra-day needs, they may also be used to respond to variations in gas flows on a longer period. Storage plays a crucial role on the TIGF transmission grid for responding to variations in gas flows. It has been estimated by TIGF that during 2009 on average 85 percent of intra-day flexibility requirements were met by withdrawals and injections from the storage facilities at Lussagnet and Izaute, whereas only 15 percent from line-pack (GRTgaz, 2010).

In order to respond to intra-day variations of gas flows on the grid, GRTgaz can also rely on line-pack. The availability of line-pack is a function of the daily consumption of gas, the overall load of the grid and the repartition of gas across the entry and exit points. Overall, the maximum available line-pack is given by the difference between the minimum amount of pressure needed to move the gas within the pipelines and the maximum pressure at which we can exploit them. As reported by GRTgaz, in 2011 during the summer the average available line-pack on the network amounted to 110 GW/h (10.2 mcm) whereas during the winter due to higher consumption of gas it amounted to 65 GW/h (6 mcm). Finally, as reported by GRTgaz (2011a), TIGF will be able to supply intra-day flexibility for the 2012-2014 period at the Cruzy Point for about 1,5 GW/h (0.14 mcm) on average. As explained more extensively below, the flexibility supplied by TIGF to GRTgaz derives mainly from the storage facilities located in Lussagnet and Izaute since pressure on the TIGF grid is almost at its maximum level therefore allowing the TSO to recur marginally to line-pack for within-day flexibility. To conclude, since 2006 GRTgaz has been gradually converging towards a market-based balancing system. Nevertheless, as mentioned earlier in this section, according to the French energy regulator in order to fully comply with the principles outlined in the Third Energy Package further changes have to be made. Specifically, in order to develop a balancing regime based upon the primary responsibility of shippers for balancing the national transmission system whereas a residual role played by the TSOs, GRTgaz will need to increase incentives for shippers to daily balance their portfolio, increase its participation in the market and more importantly allow for daily cash outs of imbalances, thereby eliminating the ability to cumulate imbalances over time. Along these changes, increased availability of qualitative and quantitative information on the status of the network to shippers and their single portfolio position will increase transparency and efficiency in the management of gas flows in the French transmission system and ultimately reduce the need for interventions by the TSO. Also TIGF will have to eliminate by 2014 the cumulated imbalances with settlement at the end of the month to introduce daily cash out of imbalances at market prices which will reflect the cost of the intervention by TIGF on the PEG Sud-Ouest. Furthermore, TIGF will provide in the short-medium term increased and transparent information on the status of gas flows on the network and define a path for intervening on the within-day market for balancing purposes while maintaining the Daily Balancing Service for shippers through storage.

3.5.2 Trading

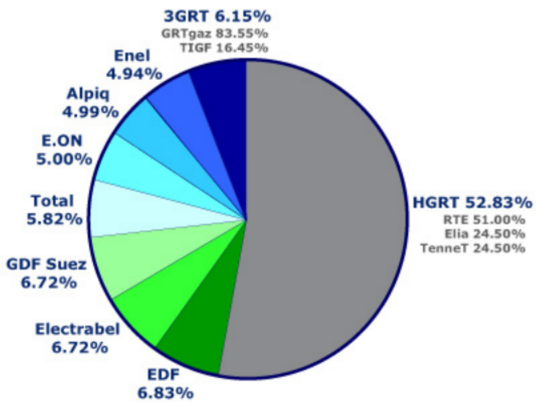
To each of the three balancing zones, GRTgaz Nord, GRTgaz Sud and TIGF there is a corresponding virtual trading point: PEG Nord, PEG Sud and PEG TIGF. On the PEGs market parties have the possibility to exchanges quantities of gas either via OTC bilateral agreements or via the gas exchange

[31] The report by GRT Gaz reports figures in GW/h; to render the figures comparable with the other countries we have converted them in mcm (million cubic meters) and Btu (British Thermal Units) in the parentheses.

operated by Powernext. In November 2008 Powernext launched an organised spot and futures market where market parties can buy or sell standardized products for delivery at the PEGs.

Powernext is held by a group of European transmission system operators in electricity and natural gas, and European energy utilities (see Figure 31 below). Powernext SA and European Energy Exchange AG (EEX) that manages natural gas exchange trading in Germany and spot market for the Dutch TTF market area, have recently agreed to combine their natural gas market activities and pool their respective expertise to create a pan-European gas market, PEGAS, which has been launched in May 2013. Clearing and settlement of all transactions will be provided by the EEX clearing arm, European Commodity Clearing (ECC) that also manages part of the British NBP clearing services for OTC derivatives.

Figure 31 - Powernext's capital structure. Source: Powernext website.



Although if this cooperation with EEX will be successful, the number of contracts available for trading will increase, at the moment on the Powernext Gas Spot market it is possible to trade at the three PEGs by buying and/or selling the following contracts:

- Within-Day contract which allows intra-day arbitrage and balancing:
- Day-Ahead contract which allows to trade gas for the next gas business day;
- Week-end Contract which allows to trade gas for the coming week-end;
- Spread contract PEG Sud/ PEG Nord for all the three maturities outlined above.

Instead, on the Powernext Futures market it is possible to trade futures contracts only for the PEG Nord and PEG Sud for the maturities: next three months, two quarters and three gas seasons.

Volume-based liquidity measures show that traded volumes are stable. Bid-ask spreads show many little irregularities, suggesting that transaction costs at PEGs are still not negligible, and that there is room to increase transparency. It is also interesting to note that, on average, prices have been fairly stable in the last two years, hence the difference in bid and ask prices cannot be ascribed to volatility or shortage concerns. It is equally interesting to note that future prices have been quite stable too in more or less the same period (Powernext website). The range of products offered by Powernext is quite wide, although it applies only on the PEG Nord area.

France is an importer of energy, but its imports are not of the order of magnitude of similarly populated countries, like Italy or Germany, because of France baseload of nuclear energy.

GRTgaz can rely on several flexibility tools: storage flexibility contracts, LNG terminals, line-pack alongside flexibility coming from the TIGF network and from the exchange.

3.5.3 Data summary and graphs

Figure 32 - Traded volumes at PEGs. Source: Powernext.

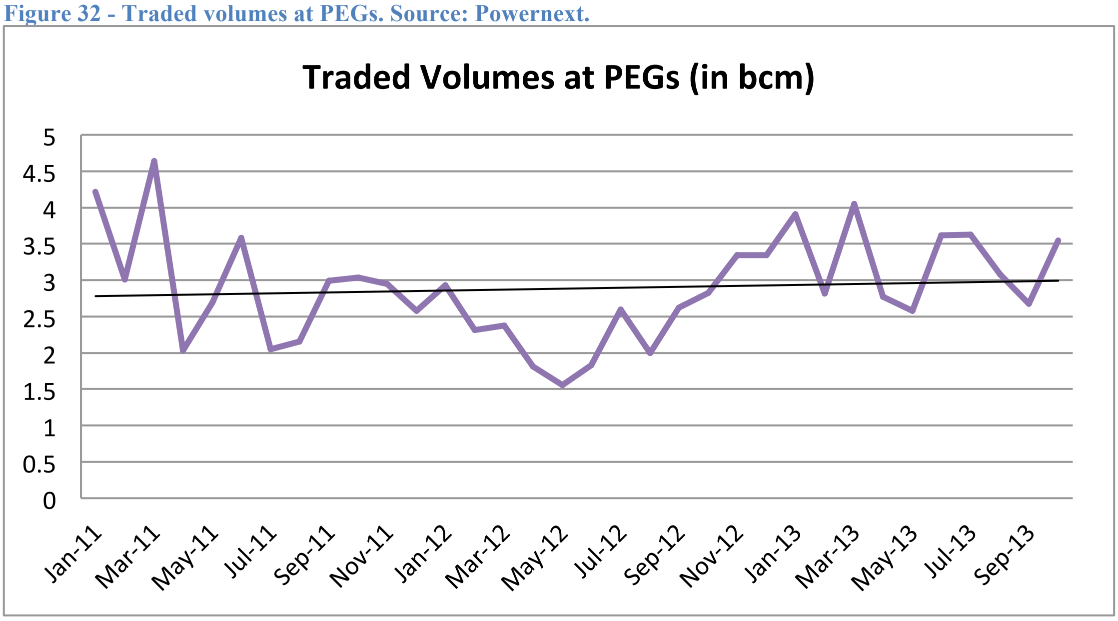


Figure 33 – Churn ratios at PEGs.

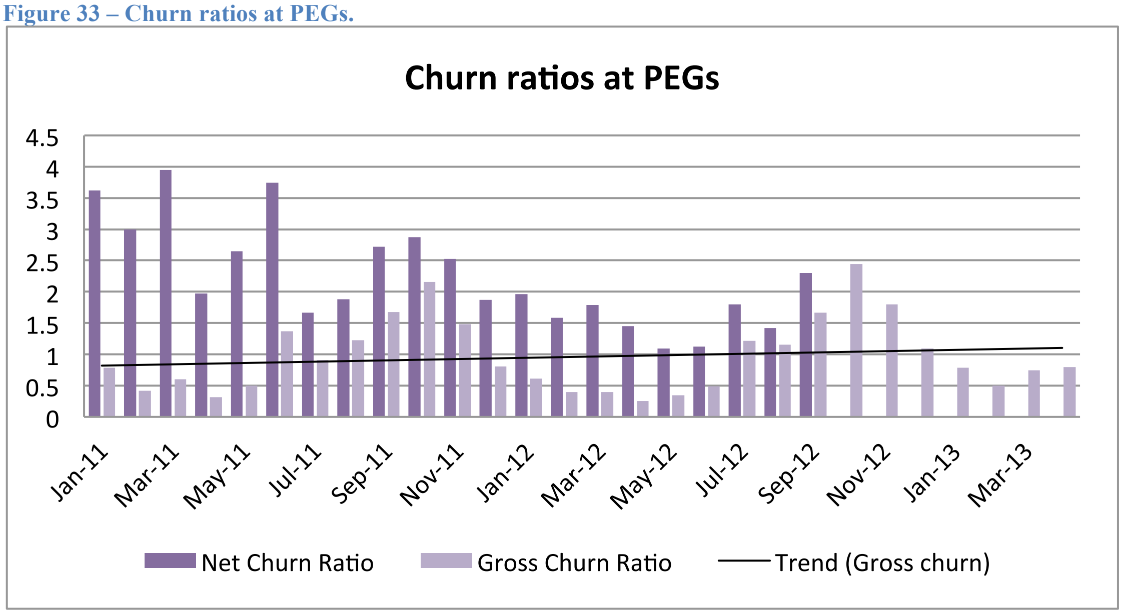


Figure 34 - Bid-ask prices at PEGs (in €/MWh). Source: Bloomberg

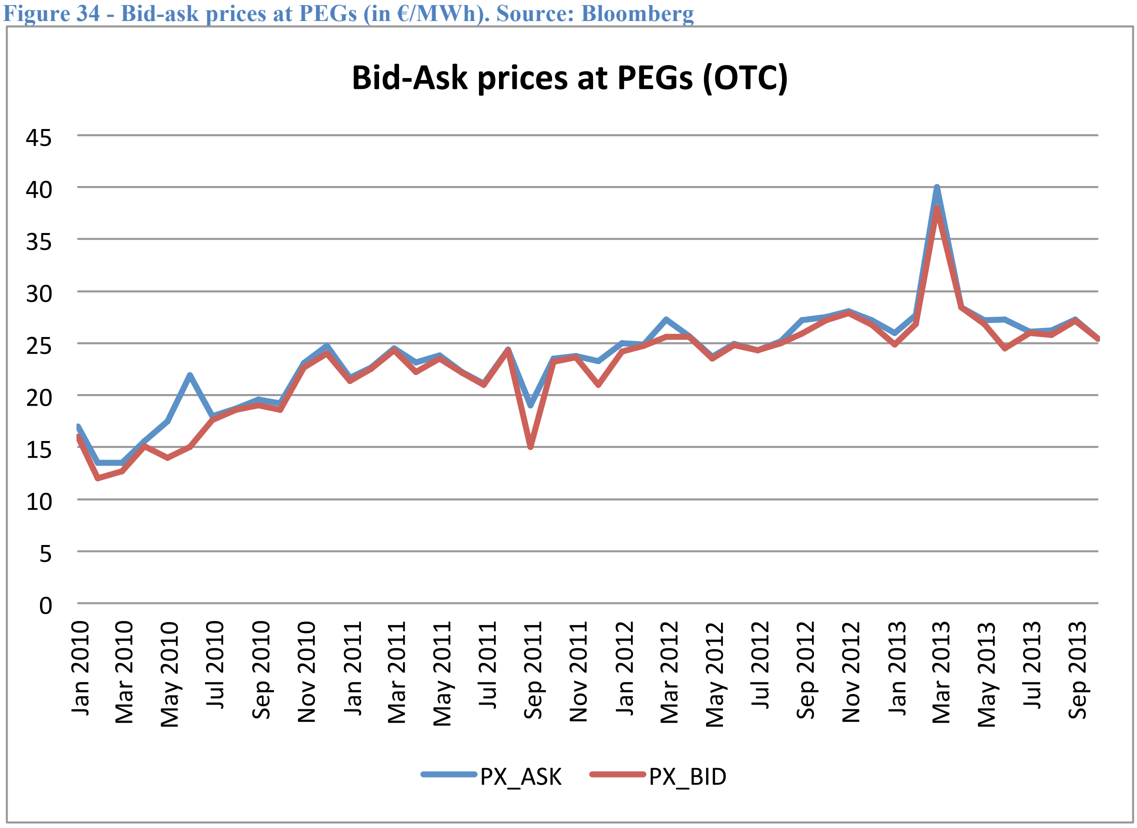
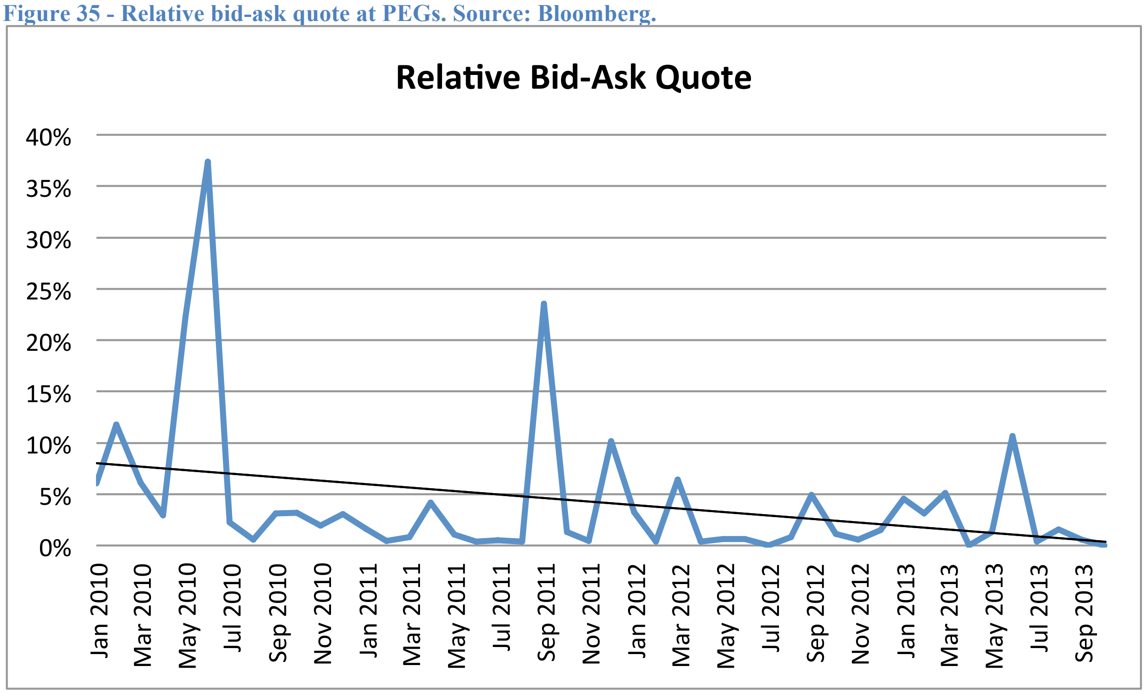


Figure 35 - Relative bid-ask quote at PEGs. Source: Bloomberg.



3.6 Italy: Punto di Scambio Virtuale

The Italian natural gas market is one of the most dynamic in Europe. Italy is the fourth importer of gas worldwide, and it can rely on a well-developed transmission network to receive gas from abroad. Domestic production of natural gas has been constantly decreasing in the last years, whereas imports have steadily acquired importance and amounted to approximately 90% of gas supply in the country in 2011. Italy imported approximately 70 bcm of natural gas in 2011 of which 88% arrived via pipelines and the residual part has been imported via the two LNG terminals in Rovigo and Panigaglia. Gross consumption of natural gas in 2011 decreased with respect to the previous year by 7,8% and amounted to 77 bcm. This negative trend continued in 2012, with a gross consumption of 74.9 bcm (see Table 9) The fall in consumption can be explained in light of the economic recession currently unfolding alongside the use of renewable energies for the generation of electricity (especially photovoltaics). The industrial sector and the civil sector consumed in 2012 respectively 15 bcm and 31 bcm whereas the power generation sector recorded a dramatic decrease in gas consumption, falling from 28 bcm in 2011 to 25 bmc (AEEG, 2013). Exports account for a negligible part of the exchanged gas.

Table 9 - Natural Gas Balances - Italy. Source: IEA (2013).

							Million cubic metres	
	2011	**2012**	**4Q2012**	**1Q2013**	**2Q2013**	**aug 2013**	**%Change Current Month**	**%Change Year to Date**
Italy								
Indigenous Production	8364	8605	2123	1972	1951	654	-11.4	-9.2
+Imports (Entries)	70597	67802	16390	16856	14049	4424	-3.4	-13.5
-Exports (Exits)	373	324	53	83	42	12	-33.3	-40.6
=Gross Consumption	77832	74925	20540	26265	12170	3242	-21.3	-8.6

3.6.1 Balancing

Italy is the fourth importer of gas worldwide, and it can rely on a well-developed transmission network to receive gas from abroad. Domestic production of natural gas has been constantly declining since the 90s[32]; as a consequence imports have steadily acquired importance and amount nowadays to approximately 90% of gas consumption. Gas is imported mainly via pipelines, and sales are dealt with through long term contracts, or via the wholesale market by means of the virtual hub PSV (*Punto di Scambio Virtuale*). Natural gas is traded on the PSV principally over-the-counter, while the gas exchange is not yet fully developed, in spite of being in function since October 2010. PSV is managed by the system operator Snam Rete Gas, while the energy exchange operator GME (*Gestore Mercati Energetici*) organizes and manages the natural gas markets in all their aspects.

Starting from the 1st of December 2011 Italy implemented the new balancing system (SBMS) with the aim of creating a competitive, transparent and efficient gas market and of boosting liquidity and flexibility. The SBMS has entailed the creation of a balancing platform (PB-GAS), organized and operated by the GME on behalf of Snam Rete Gas, which is the sole counterpart of the transactions of the PB-GAS and is ultimately responsible for the overall physical balancing of the Italian gas system, guaranteeing the system integrity and security of supply. The PB-Gas is organized as a daily auction, in which authorized players have to submit daily demand bids and supply offers for the storage resources that they have available. Likewise, Snam Rete Gas may - as balancing operator - submit demand bids and supply offers for a volume of gas corresponding to the overall imbalance of the system, with a view to procuring the resources offered by participants and needed to keep the gas system balanced.

[32] AEEG reports a slight increase in domestic production in the years 2011 and 2012, but it has not been sufficiently high to alter the country's external dependence.

From an operational point of view, starting from the fourth gas-day preceding the gas-day to which bids/offer refer (D-4), market parties have the obligation to make offers on the PB-GAS to increase (or decrease) the injected or withdrawn quantities of gas from the storage facilities connected to the Italian grid with the aim of keeping their own portfolio balanced and to contribute to the system's overall balance. Snam Rete Gas on the day following the gas day to which bids and offers refer (D+1) makes an offer corresponding to the total system imbalance (SBS, Sbilanciamento Complessivo del Sistema) which is calculated as the difference between the shippers' programs and the actual gas withdrawn or injected at the storage facilities. Bids and offers on the PB-GAS are selected on a daily basis through an auction mechanism; bids are stacked on a merit order up to the point where the SBS is covered . Finally imbalances are cashed out at a balancing market price, where the price is cost reflective of the price paid by Snam Rete Gas to procure balancing resources and corresponds to the price of the last accepted offer[33].

Currently, storage represents the major flexibility tool available to Snam Rete Gas to physically balance the system along with the availability of line-pack in the national pipeline grid. Stogit, of the Eni group, owns 96.5% of storage capacity. Italian storage facilities consist only of depleted gas fields and as a result have a lower ability to respond quickly to variations in demand with respect to other types of gas reservoirs. Italy also imports LNG through two LNG terminals.

3.6.2 Trading

Along the obligations related to the PB-GAS, shippers have the possibility to buy or sell gas at the PSV, the Italian virtual trading point, engaging in OCM bilateral agreements or to trade on the gas exchange operated by GME. Specifically, in August 2010 GME launched the spot market for gas (M-GAS) wherein market parties can exchange Day-Ahead and Intra-Day products with delivery at the PSV and where the GME takes the role of central counterparty in the transactions. In the M-GAS, that we can consider the Italian gas exchange, market participants may make spot purchases and sales of natural gas quantities. The M-GAS has a day-ahead gas market (MGP-GAS, Mercato del Giorno Prima), and an intra-day gas market (MI-GAS); in both trading happens under the continuous-trading mechanism[34].

Market participants can also trade on the P-GAS on the Import and Royalties Segment where they can offer their gas import quotas and royalties owed to the State respectively. Moreover, the GME opened a new segment (Legislative Decree 130/10 Segment) where market participants can make bids for "gas quantities made available by the virtual storage operators". As opposed to the spot market, on the P-GAS the GME acts as a "broker" and not as a central counterparty in the transactions. As a result, through the OTC market, gas exchange, and most of all through the balancing platform PB-Gas, shippers have the ability to support the overall daily balancing of the system by resorting to commercial flexibility to balance their portfolios. All the transactions on these markets are dealt through the PSV, therefore all players of these markets must obtain authorization to be able to carry out transactions at the PSV.

The implementation of PB-Gas has been extremely beneficial both for liquidity and for price alignment with other European exchanges. The increase in the volumes of traded gas subsequent the implementation of the balancing platform is straightforward (see Figure 37). However, volume-based indicators deliver a mixed message on the liquidity situation at PSV. Despite the number of transactions and the volumes traded have been substantially increasing starting from 2010, most notably in correspondence to the institution of M-Gas, and they have kept an increasing tendency notwithstanding the dramatic drop in gas

[33] Note the similarities of the functioning of the PB-Gas with the British "Flexibility Mechanisms", i.e. the early framework for balancing used in the UK.

[34] On the day-ahead market trades used to take place in two successive stages, one under the continuous-trading mechanism, the other under the auction-trading mechanism, but the Italian regulator has decided to suppress the final auction because it was practically never used. Actually, after the introduction of the balancing platform, volumes on the whole M-Gas have almost dropped to zero.

demand (see Figure 36), the churn ratio at the hub has improved just slightly throughout the same period (Figure 38).

An issue in the country's political debate is the higher cost borne by Italian importers to buy gas via pipelines, especially regarding natural gas coming from North European countries, whose gas is traditionally cheaper with respect to gas coming from extra-EC countries like Russia. During the first half of 2012, for example, Italy has recorded the highest increase in gas contracts for imports from the Netherlands and Norway. Italy also paid a premium for LNG averaging 6 €/MWh more than the price of the natural gas available on the PSV (DG Energy, 2012). Furthermore, according to the DG Energy quarterly report, the PSV hub reference price, although lower with respect to LTC and LNG imports, has systematically been higher with respect to the other countries that we examine in this study (on average 27,5 €/MWh for the first half of 2012, against an average of 25 €/MWh in North-Western Europe). During 2013 the situation seemed to improve: in June, Eni announced a 7% price reduction from Gazprom and an agreement with Sonatrach to import less Algerian gas until the end of 2014. Meanwhile, at the end of April, Italy's second largest gas importer Edison won an arbitration case against Sonatrach to have its long-term gas contract price lowered (DG Energy, 2013). To sum up, Italian importers are paying a little less for imported gas, but they are not yet experiencing the price convergence among LTC, hub and LNG that other countries possess. This suggests that the structure of the wholesale market is still largely linked to long term contracts, both for pipeline gas and for LNG. Such arrangements, made before the market became more liberalized and integrated, guarantee a reliable and stable supply to the country, but in turn are an obstacle for the creation of a price for gas that may truly reflect demand and supply.[35]

The Italian government has recently repeatedly stated the goal to make Italy a so called "Mediterranean Hub", i.e. a nodal hub for gas imported from south. Also the European Union has recognized the need to potentiate infrastructures to create a southern corridor for gas (EU, 2013). However, such proposal will need enormous efforts to be realizable in the near future. The market has still problems of liquidity and is characterized all in all by a certain structural rigidity that is difficult to overcome in the short run. Italy has a newly-born futures market. Following GME announcement that a new platform for futures market would be starting from autumn 2013 (GME, 2012), the market started in September, operating under the M-GAS platform. The resulting M-GAS is now divided in two macro-areas: MP-GAS and MT-GAS, respectively spot market (mercato a pronti) and futures market (mercato a termine). On the MT-GAS traders will be able to trade one month, seasonal, six months and BoM (Balance of Month) contracts; however, no transactions have been recorded yet on the new platform. Actually, since the PB-Gas has started to have sufficiently high volumes traded, the whole M-GAS platform has been almost totally abandoned by traders, and no gas transaction has been recorded since March 2013.

[35] At the moment, Italy can rely on the following gas suppliers: Russia, through the TAG (Trans Austria Gasleitung) pipeline, that brings gas in the country from the North East, in Tarvisio; The Netherlands, through TENP (Trans Europe Naturgas Pipeline) and Transitgas, at passo Gries; Norway, again with Transitgas; Algeria, with the submarine pipeline Transmed that brings gas from the south at Mazara del Vallo, Sicily, and Libya, through Greenstream pipeline, again in Sicily, at Gela.

3.6.3 Data summary and graphs

Figure 36 Volumes traded at PSV. Data Source: Snam Rete Gas.

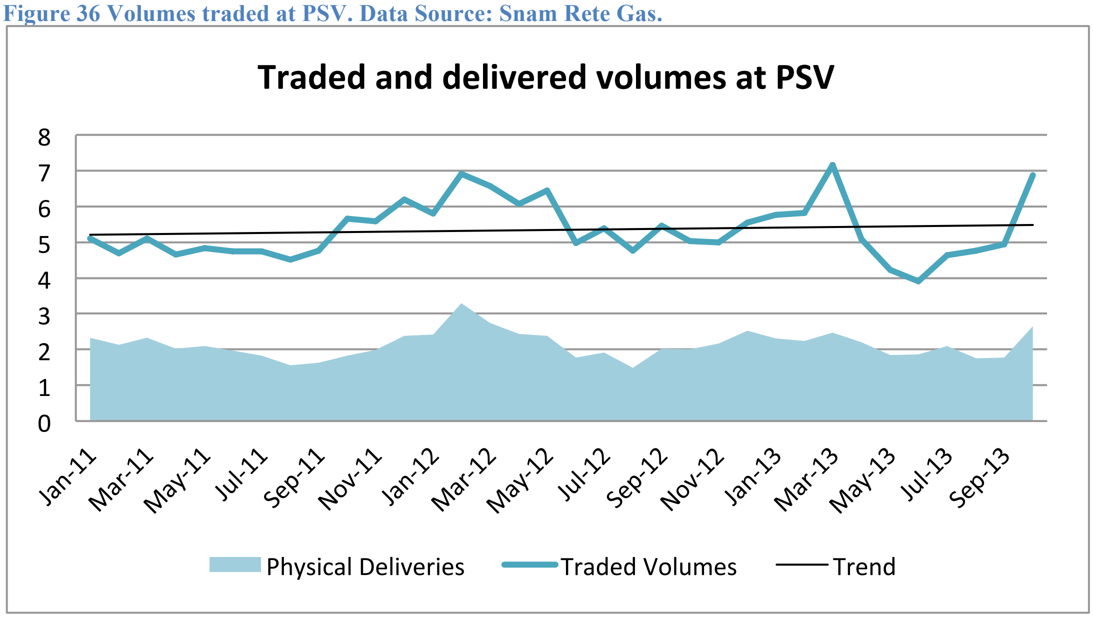


Figure 37 - Exchanged Volumes at PB-Gas. Data Source: GME.

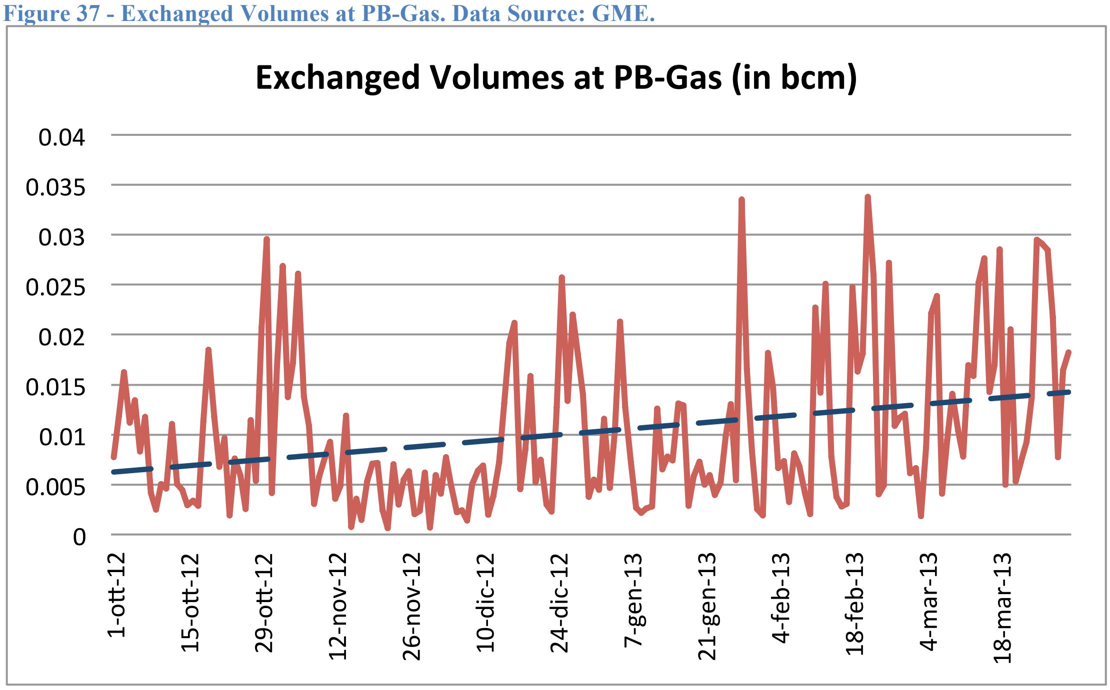


Figure 38 - Net and gross churn ratio at PSV. Data Source: Snam Rete Gas, IEA.

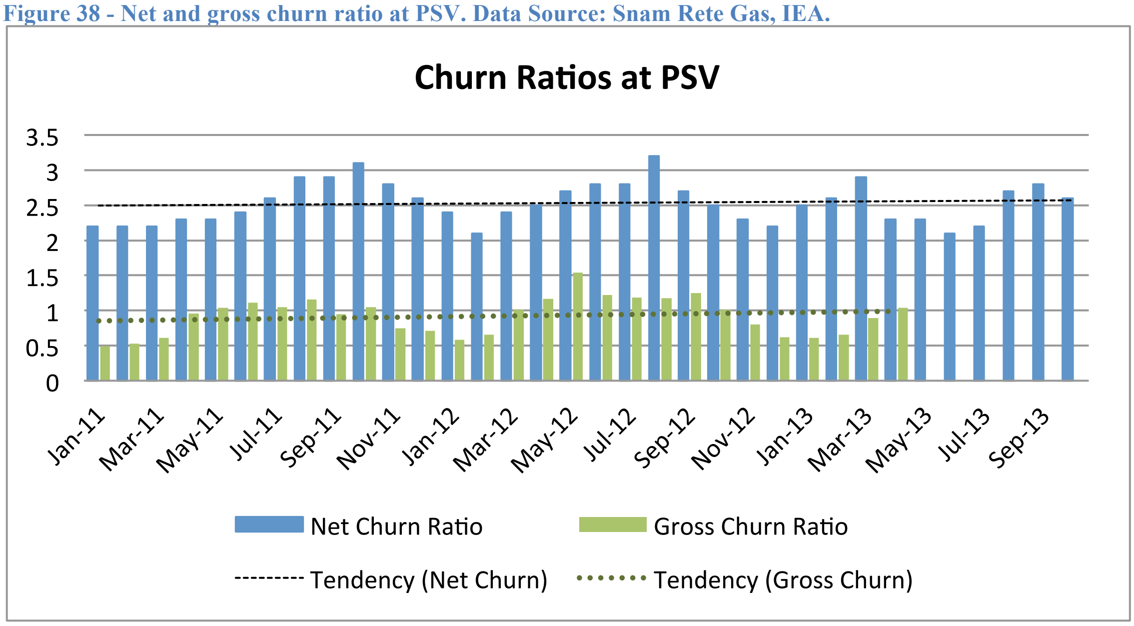


Figure 39 - Bid-ask prices at PSV in €/MWh. Source: Bloomberg.

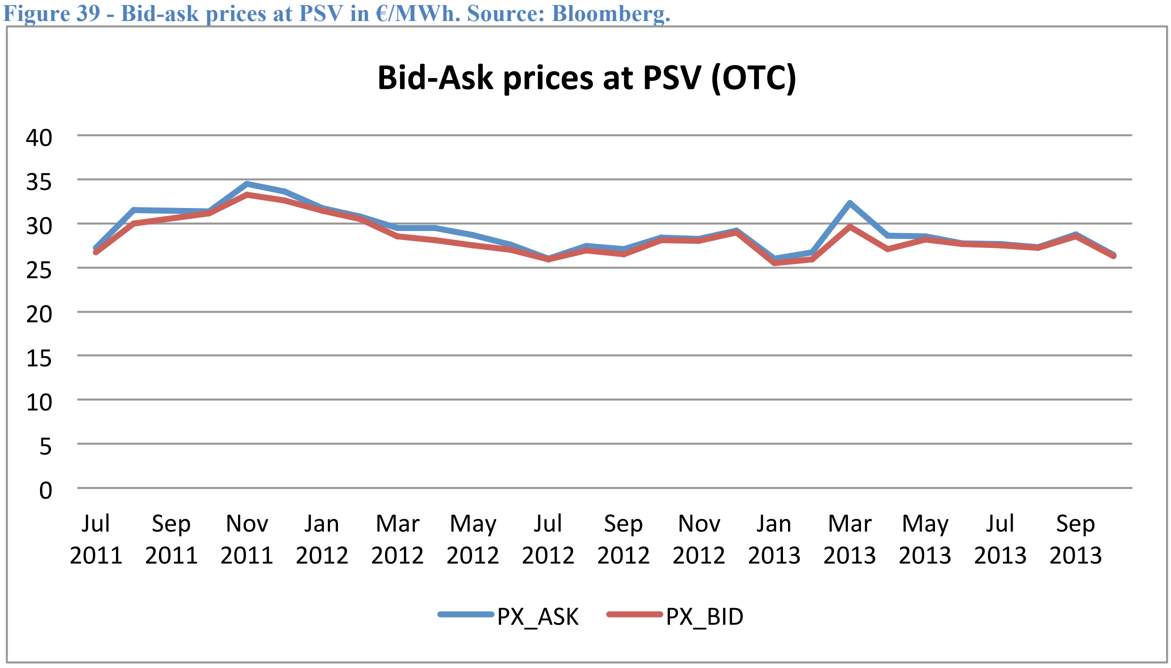
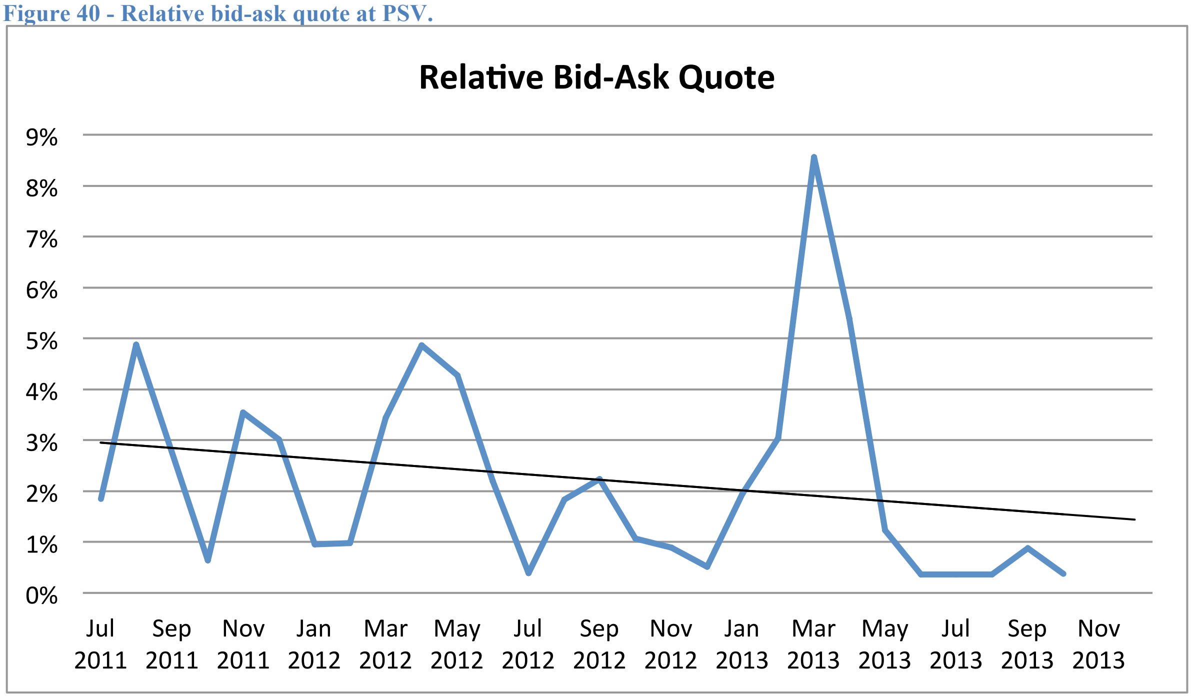


Figure 40 - Relative bid-ask quote at PSV.



3.7 Austria: CEGH

Austria is a transit country for natural gas. Its domestic production is constantly decreasing over time, and the country is able to meet only around one fifth of its internal demand for gas. Consequently, Austria is heavily dependent on the import of natural gas, mainly from Russia, Norway and Germany. However, being a transit country, it is also an relevant exporter of gas, as can be noted in the table below.

Table 10 - Natural Gas Balances: Austria. Source: IEA (2013)

								Million cubic metres
	2011	2012	4Q2012	1Q2013	2Q2013	aug 2013	%Change Current Month	%Change Year to Date
Austria								
Indigenous Production	1777	1906	421	380	373	112	-31.3	-26.7
+Imports (Entries)	46022	42564	11317	10992	11823	4396	33.1	15.3
-Exports (Exits)	36243	34752	10004	12188	10045	2949	21.0	27.9
=Gross Consumption	9448	9004	2835	3271	1531	353	-11.1	-3.8

Natural gas accounts for approximately 24% of total primary energy supply. Considering that over 60% of electricity in Austria is produced through renewables (mainly hydro-power plants), the role of gas in the energy mix is not negligible at all. The Austrian energy supply is based on a balanced mix of energy sources. Although the importance of fossil energy sources has been declining in favour of renewable energy sources, data of the Austrian Energy Agency for 2010 showed that the share of fossil energy sources in Austria's energy portfolio is still very high, with oil, gas and coal accounting for about 70% (www.energyagency.at).

The Austrian natural gas market has been fully liberalised since the year 2002. The three system operators are the owners of the natural gas network and are responsible for the construction, expansion, maintenance and operation of the network. Specifically, the TSOs are Gas Connect, BOG and TAG. Gas Connect Austria GmbH operates the infrastructure that acts as the central hub in the European natural gas grid. Formerly OMV Gas GmbH, from October 2011 the company has been separated from OMV to comply the requirements of the EU to become independent transmission system operator and the Natural Gas Act provision to separate the areas of production and trade from network operations at an organisational level. Gas Connect Austria hence is independent company and wholly owned subsidiary of OMV. OMV is an integrated international oil and gas company, headquartered in Vienna. OMV's main business is in Exploration & Production (E&P), Gas & Power (G&P) and Refining & Marketing (R&M). BOG, Baumgarten-Oberkappel Gasleitungsgesellschaft GmbH is the transmission system operator of WAG (West-Austria-Gasleitung). WAG is a 245 km-long gas pipeline running from the Slovak-Austrian border at Baumgarten an der March to the Austrian-German border at Oberkappel. WAG is a very important East-West transit route for Russian natural gas to Western Europe; from the European natural gas interconnection point at Baumgarten most of the Russian natural gas transits through WAG in its way to Germany and France.WAG has three compressor stations at Baumgarten, Kirchberg and Rainbach and can be operated bidirectionally. BOG is a joint venture of OMV (51%), GDF Suez (34%) and E.ON Ruhrgas (15%). Following the creation of Gas Connect, the stakes of OMV Gas have been transferred to Gas Connect that is now the majority shareholder. TAG GmbH, Trans Austria Gasleitung GmbH is a natural gas undertaking responsible for the transportation of natural gas as well as the acquisition, construction, expansion and operation of the required transportation systems and especially for the conclusion of Transportation Contracts as well as the accomplishment of related activities. The shareholders of the Trans Austria Gasleitung GmbH were ENI International B.V. (89%) and OMV Gas GmbH (11%). As per 22.12.2011 the share of ENI International B.V. (89%) was acquired by Cassa Depositi e Prestiti (CDP). Again, since January 2012 the stakes of OMV Gas GmbH have been transferred to Gas Connect Austria GmbH (source: TAG website). The TAG Pipeline System consists of three lines, five compressor stations, auxiliary equipment and several Intake and Offtake Points and leads from the Slovakian - Austrian border near Baumgarten an der March to the Austrian-Italian border near Arnoldstein covering a length of about 380 km. The TAG Pipeline System is used for supplying domestic customers in Austria as well as for the transit of natural gas to Italy. Via the SOL Pipeline System (Süd-Ost Leitung) of OMV Gas GmbH, which diverges at Weitendorf from the TAG Pipeline System, transit to Slovenia is also possible.

3.7.1 Balancing

Austria's gas network is divided into three Control Areas, the biggest and most important of which is in the centre-east of the country. The Austrian natural gas hub is CEGH, Central European Gas Hub, owned by CEGH AG (formerly known as Gas Hub Baumgarten) founded in 2000. CEGH is a physical hub, comprising six tradable locations, of which Baumgarten is the most important. Central European Gas Hub provides a trading platform at the gas hub in Baumgarten an der March, close to Slovakian and Hungarian borders. The CEGH AG, settled in Vienna, is the operator of the Austrian Virtual Trading Point. It was created in October 2005 and provides services for both the Over-The-Counter (OTC) market and the gas exchange of Wiener Boerse. CEGH shareholding is divided among OMV Gas & Power GmbH, which holds 65% of the shares, Wiener Boerse AG holding 20% since June 2010 and Eustream a.s. holding 15% since September 2012. CEGH started in 2005 as an OTC Market trading platform, to which added up the Gas Exchange Spot Market segment in December 2009 and the Gas Exchange Futures Market segment in December 2010. CEGH is the major transit point for the Russian natural gas imported by Western Europe; approximately one third of all gas exports from Russia to Western Europe passes through the OMV natural gas junction in Baumgarten (IEA, 2012). Baumgarten lies at the eastern end of the 380 kilometres long Trans Austria Gas Pipeline (TAG) that traverses Austria from north to south. Besides the TAG, Baumgarten also is the starting point of other important pipelines, such as the West-Austria-Gas-Pipeline (WAG) that runs west and the Hungaria-Austria-Gas-Pipeline (HAG) as well as the Kittsee-Petrzalka-Gas-Pipeline (KIP) that runs south-east.

The implementation of the 3rd EU Energy Package has brought about new changes in the market structure, with the introduction of an entry-exit regime starting from 1st January 2013. The new regime entails executing physical movements of gas via entry and exit points, instead of point-to-point transportation. The aim is to have eventually a single market area with the collapsing of the separated trading locations throughout Austria into one Virtual Trading Point operated by CEGH. This will in turn bring new regulations for balancing markets, requiring non-discriminatory trading of balancing energy. The new structure authorizes the Market Area Manager to balance, on behalf of and for the account of the Balance Group Representatives, the imbalances that will not be re-nominated in time. Accordingly CEGH has launched a new instrument, the Gas Exchange Within-Day Market, started on 1st January 2013, to allow for transparent trading based on the exchange price (CEGH website). An organised balancing market has been established in the Eastern control area to provide and price physical balancing energy. Balancing in Austria is based on so called "balancing group systems", and it is regulated by the Gaswirtschaftsgesetz (Natural Gas Act), which defines balancing energy as the difference between supply and offtake in a balancing group. A balancing group consolidates wholesalers, retailers and consumers into a virtual group, within which natural gas supply and demand are balanced. Every system user that is connected to the Austrian gas grid and is supplied from it or feeds gas into it must belong to a balancing group or form one of its own. Suppliers and sometimes large consumers that have direct contractual relationships with their balancing group representatives are referred to as "direct" balancing group members, while most consumers are "indirect" members of their suppliers' balancing groups, by means of their supply contracts. Balancing group representatives are responsible for the business management of their balancing groups, and for representing them. Under the Gaswirtschaftsgesetz the regulator E-Control is responsible for licensing balancing group representatives.

The calculation, allocation and settlement of balancing energy are one of the duties of clearing and settlement imposed to market agents by the Natural Gas Act. To enable them to perform this function, the clearing and settlement agents receive all the import, export, production, storage movement and trading schedules from the balancing group representatives, and the system operators send them all the meter readings for handovers of shipments at network exit points and for quantities of gas consumed by suppliers active in the network. The clearing and settlement agents thus have a complete set of data for the control area. During the monthly clearing procedures carried out by the clearing and settlement agents, the latter compute the net quantity of balancing energy per hour and balancing group, and finally bill it. A competitive mechanism for the procurement of balancing energy has been created by means of an organised balancing market. This market is run by the clearing and settlement agent, Gas Clearing and Settlement AG (AGCS), as a day-ahead market. The quantities of gas that the control area manager, Austrian Gas Grid Management AG (AGGM), physically injects into the transmission grid or withdraws from it to maintain network stability are bought and sold on the balancing market. The prices paid on the balancing market yield an hourly clearing price which the clearing and settlement agent applies as the price of each hour of accrued balancing energy.

3.7.2 Trading

CEGH offers trading activities and services for different markets: CEGH OTC, CEGH Gas Exchange Spot Market (Day-Ahead and Within-Day Market) and CEGH Gas Exchange Futures Market. The CEGH OTC Market allows the settlement of bilateral trades in the Austrian new entry/exit system combining a number of transmission pipelines, storage sites, the domestic Austrian grid and conjunctions to neighbouring systems. This entails that customers can rely on CEGH for supervision of the operational completion and, in cooperation with the adjacent network operators, for taking care of the actual physical availability of natural gas volumes. In fact, CEGH is in charge of delivering final matching values to all customers and of carrying out the physical allocation of the confirmed quantities, after the physical gas flow.

The CEGH Gas Exchange of Wiener Boerse is operated in cooperation with Wiener Boerse AG (the Vienna Stock Exchange) and European Commodity Clearing AG (ECC), a 98.5% subsidiary of the EEX clearing department while the rest of the share are held by Powernext (1.5%) and APX-ENDEX (1 share). CEGH, as the Gas Exchange Market operator, provides physical settlement and interacts with customers. Wiener Boerse is the commodity exchange license holder and operates the fully developed Austrian securities exchange, granted by the Ministry for Economic Affairs and the Austrian Financial Market Authority. ECC is the commodity exchange clearing house and offers clearing and settlement services for both exchange and OTC transactions. CEGH Gas Exchange is divided into two segments: the spot market (CEGH Gas Exchange Spot) and the futures market (CEGH Gas Exchange Futures). Trading members in the Austrian gas exchange spot market are currently 42, while those participating in the gas exchange futures market are 22. In the CEGH Gas Exchange system when traders generate a transaction Wiener Boerse distributes selected information to ECC and CEGH. ECC is the central counterpart for all exchange trades concluded on the CEGH Gas Exchange. It is responsible of the financial and physical clearing and settlement of all trades concluded or registered and provides protection against default risk and guarantees secure and efficient settlement of the transactions of spot exchange products. CEGH, as the Gas Exchange market operator and OTC platform operator provides settlement services and has to match the gas flows generated from gas exchange deals with the corresponding OTC gas flows. CEGH also publishes a spot index (CEGHIX), which serves as reference price for the Gas Exchange Spot Market of Wiener Boerse. CEGHIX guarantees a daily reference price based on the volume weighted average price of all transactions, which illustrates price signals and supports the increase of liquidity on the Austrian market (see Figure 41). The Austrian system is very complex and traditionally focused on the physical aspects of gas exchange. However, also thanks to the intense reform put in place by the Austrian regulator, this market is experiencing many changes and is evolving rapidly. Volume-based liquidity indexes show an improvement of market performance from 2010 to present, with a churn ratio that, though quite variable in the past, has averaged 3.5 in 2012 (Figure 45). Volumes traded on the OTC market (see Figure 42) accordingly have shown an improvement from 2010 to present, with more or less constant physical supplies, but are now experiencing a downward tendency. On the contrary, volumes traded on the gas exchange are less consistent and far more variable, although they are showing a tendency to increase (see Figures 43 and 44).

We do not report transaction-cost based liquidity measures for the Austrian OTC market due to the high frequency of missing data, particularly for bid prices. The Quarterly Report on European Gas Markets by DG Energy (2012) notices that Austria shows a significant price differential, of the order of magnitude between 1 and 2 Euro/MWh, between Day-Ahead and Spot prices at the hub, meaning that the hub is not a reliable price reference. As pointed out by Heather (2012) the Austrian hub is the most complex in all Europe, although the new market model should overcome some of these intricacies, by, for instance, reducing and merging market areas. The picture we have taken, nonetheless, suggests that this process is not yet started, and that transaction costs appear to be relevant.

On CEGH are also available secondary market services through the ECC (European Commodity Clearing) platform. Currently there are only twelve trading members (see CEGH Exchange website). The delivery point for Natural Gas Futures Contracts is the Integrated Trading Area Baumgarten (ITAB) and the range of products offered is not wide, as there is just one type of contract available, the CEGH Natural Gas Futures, available for different maturities.

Austria has at its disposal two main tools for physical flexibility: storage and line-pack. For what concerns storage, the country has a quite large total available capacity, which exploits almost entirely. Linepack is mostly used network balancing. Due to its geographically internal position, Austria cannot rely on LNG, but only on pipeline imports.

3.7.3 Data summary and graphs

Figure 41 - CEGHIX Reference price. For the period September-November 2013. Image source: CEGH Market data.

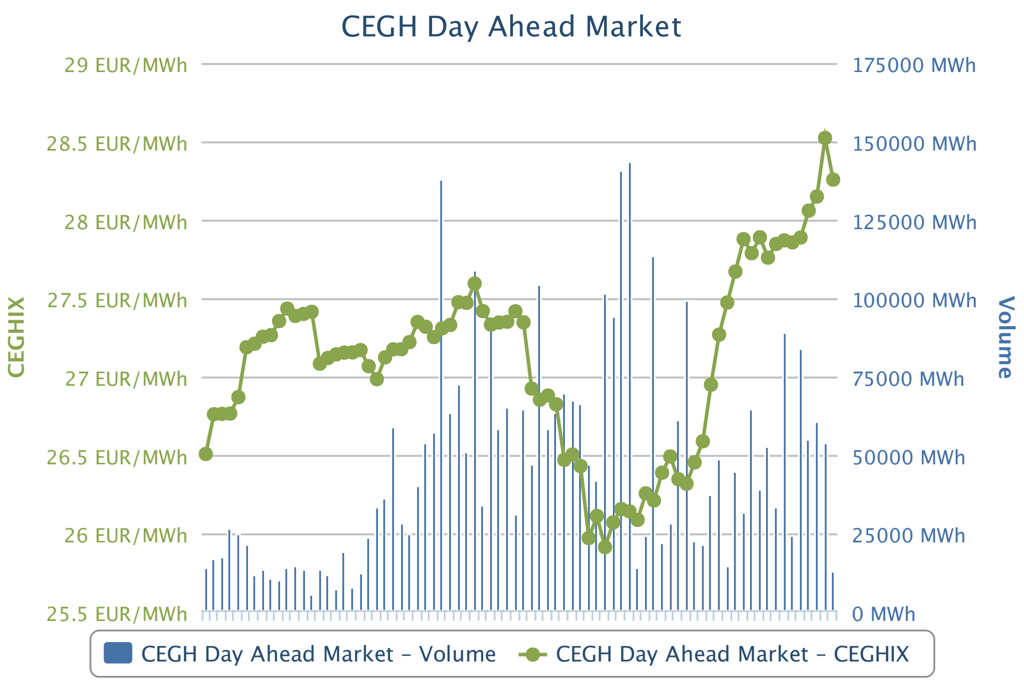


Figure 42 - Traded and delivered volumes at CEGH. Source: CEGH Market data

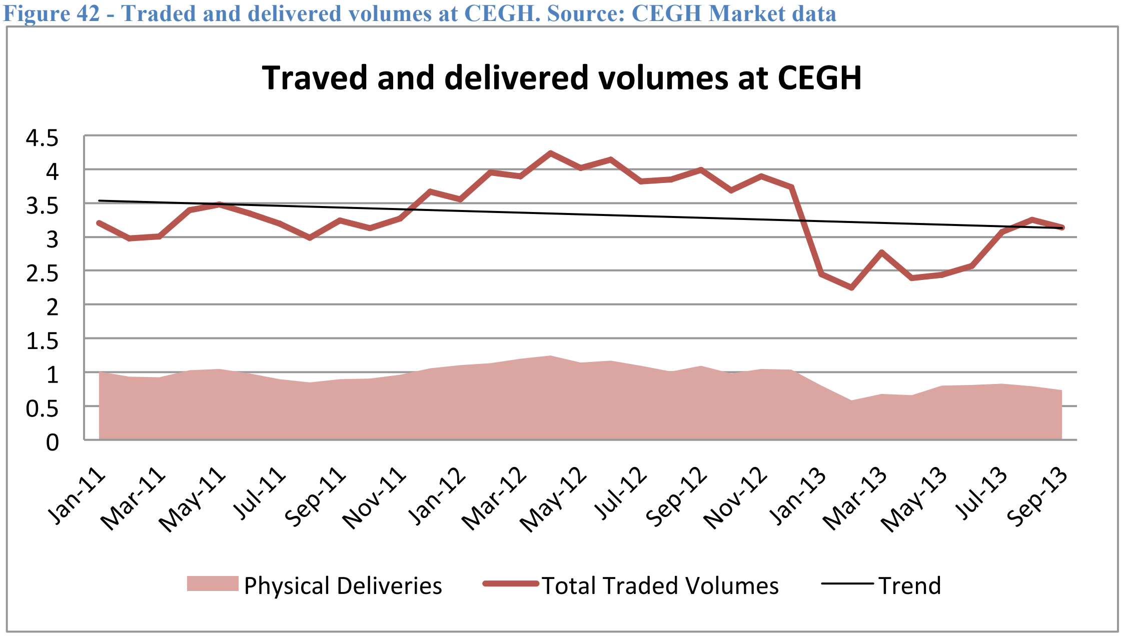


Figure 43 - Volumes exchanged at CEGH Gas Exchange.

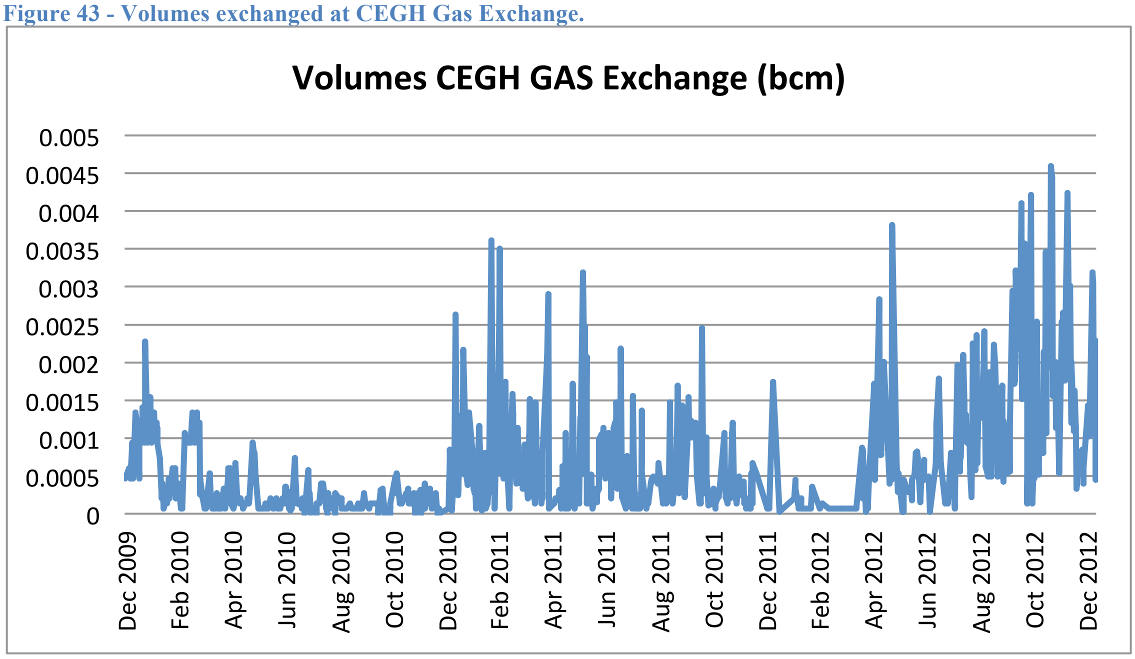


Figure 44 - CEGH Exchange volumes. Source: CEGH GAS Exchange website

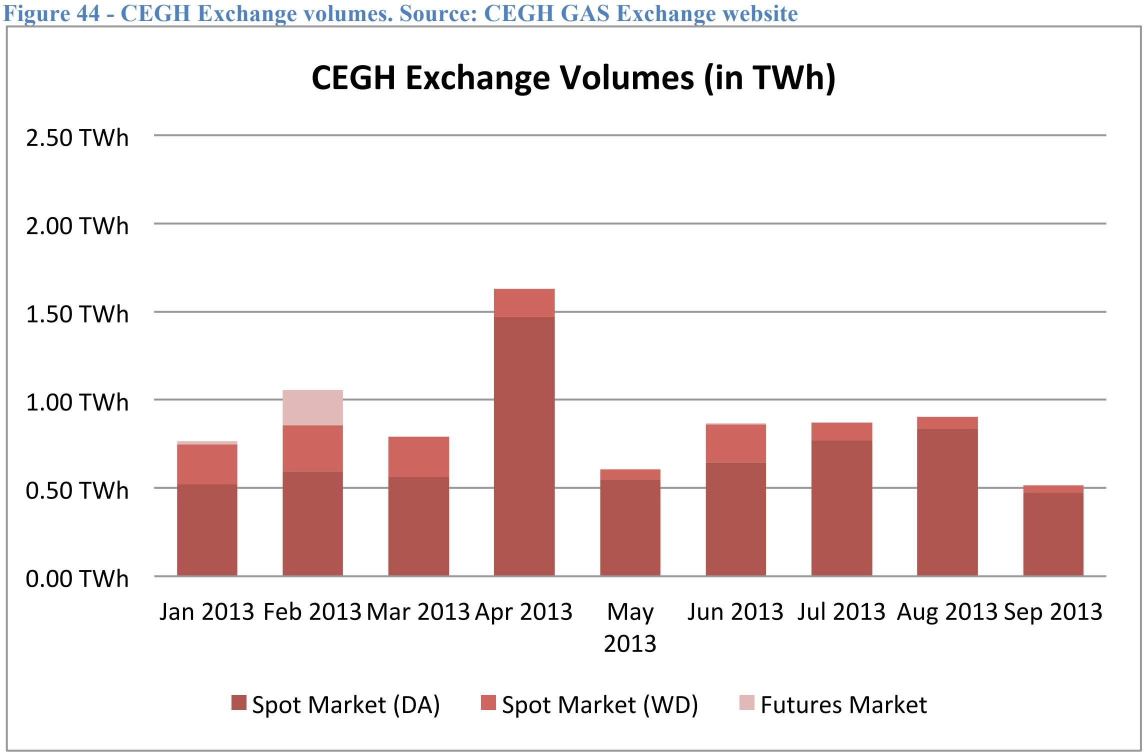
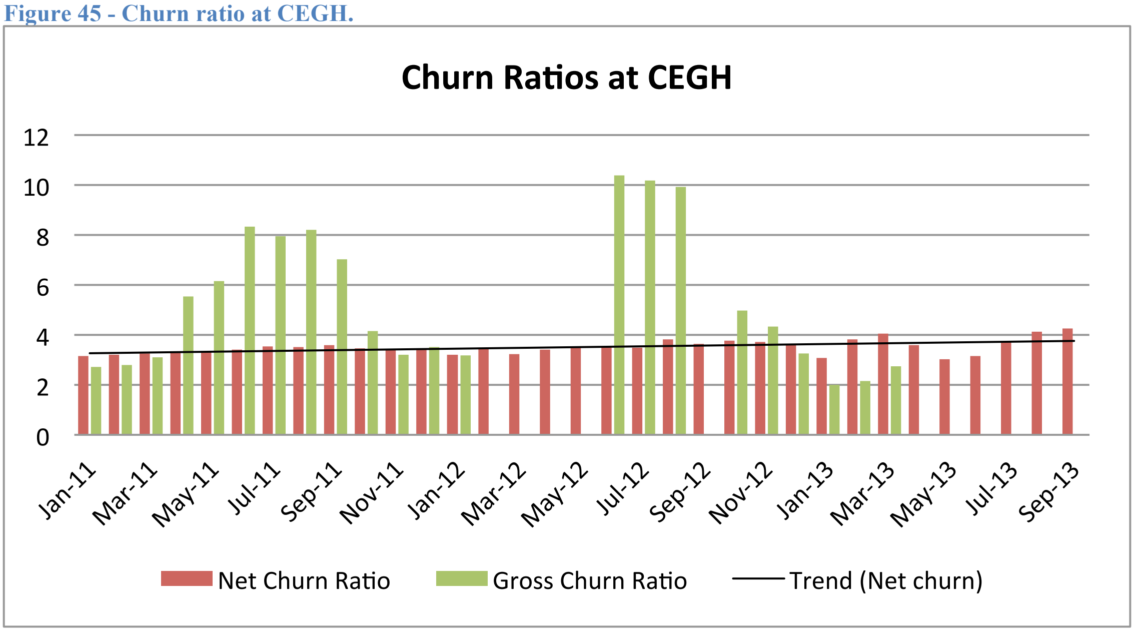


Figure 45 - Churn ratio at CEGH.



3.8 Spain

Spain's gas sector has been fast growing over the last ten years, though a recent downward pressure due to the economic recession. Mainly driven by a strong demand in the power generation sector, gas consumption increased by 65 per cent over the 2003-2008 period (IEA, 2009) and amounted in 2011 to 35.5 bcm. The bulk of gas consumption is concentrated in the industrial sector with 48.5% of gas sales in 2010 (Honoré, 2011), followed by the power sector (33.9%) and residential and commercial sector (16.1%).

Spain imports the vast majority of gas from a well-diversified set of countries worldwide. This has been facilitated by relying for the bulk of its gas imports on LNG cargoes as opposed to pipelines, predominant in other European countries. As a result, Spain is the 3rd largest LNG consumer in the world and the first one in Europe, with 75% of total imports supplied via LNG (26.8 bcm) whereas only 25% via pipes (8.7 bcm) in 2011. Another distinguishing feature of the Spanish gas market is that the country has been able over the last years to attract many spot LNG cargoes by dedicating almost 25% of the regasification, storage, transportation and distribution capacities to short-term contracts (IEA, 2009).

Table 11 - Natural Gas Balances - Spain. Source: IEA (2013)

	2011	2012	4Q2012	1Q2013	2Q2013	aug 2013	%Change Current Month	%Change Year to Date
Spain								
Indigenous Production	52	61	18	18	14	4	-33.3	8.1
+Imports (Entries)	36322	36754	9465	9271	8499	2685	-5.3	-5.4
-Exports (Exits)	3098	4414	1113	1060	1450	641	137.4	21.4
=Gross Consumption	33555	32496	8529	8858	6729	1872	-13.5	-9.7

The national transmission system in Spain entails more than 10,000 kilometers of high pressure pipelines, where Enagas owns and operates about 90% of the grid. The transmission grid transports gas to large industrial consumers and power plants and is connected to the distribution system which entails 60,000 kilometers of low-pressure pipelines. Alongside, three small gas fields located in the south-west are connected directly to the transmission grid held by Enagas and accounted for 0,052 bcm of gas supply in the country. Being the largest LNG importer in Europe, Spain holds six LNG terminals that give the country the possibility to import gas from diverse countries around the world (Algeria, Qatar, Nigeria, Peru and others). The terminals in Barcelona, Cartagena and Huelva are operated by Enagas whereas the other three by BBG (Terminal de Bilbao), Reganosa (Terminal de Mugardos) and Saggas (Terminal de Sagunto). International interconnection points allow for gas to flow into the Spanish grid via pipelines: from Algeria directly at the entry point of Almería and Tarifa (through Morocco) and from France at the Larrau entry point. The Tuy and Badajoz interconnection points export gas to Portugal whereas a bidirectional interconnection point at Irun in the northern-east links Spain and France. Gas flows from one point to another in the grid through 18 compressor stations and in order to respond to variations in demand and supply the Spanish gas network can rely on three underground storage facilities together with the storage available at the LNG terminals. The offshore depleted field of Gaviota and the onshore one at Serrablo are operated by Enagas with a total working gas capacity of approximately of 2,2 bcm in 2011 whereas the underground storage facility at Marismas is owned and operated by Gas Natural Fenosa with a capacity of 3,6 bcm. Enagas expects to put into operation in the short-term a new storage facility at Yela (Guadalayara), in the inland parts of Spain, with an expected working gas capacity of approximately 1 bcm.

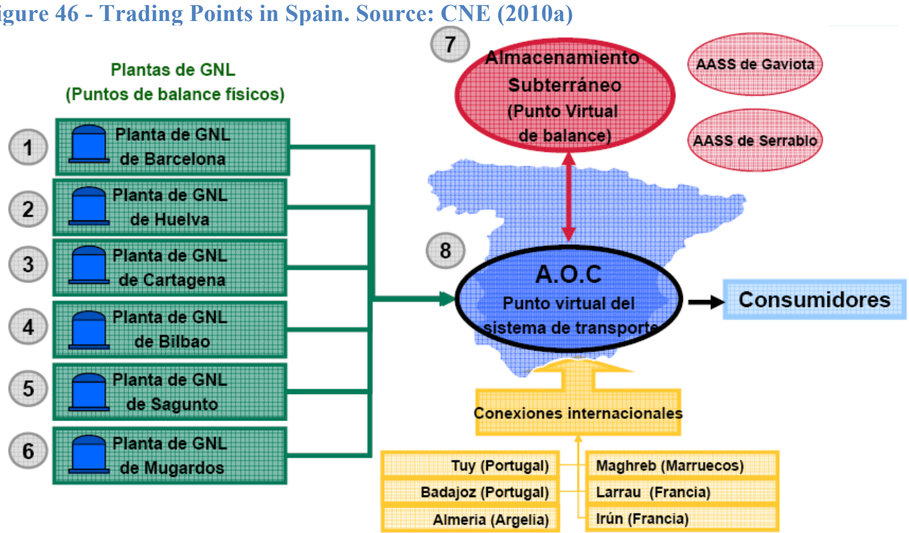
With respect to other European countries, the gas sector in Spain has significantly changed over a short period of time in light of the European Directives for the creation of an internal gas market. The 1998 Hydrocarbons Law (Law 34/1998, on hydrocarbons, dated October 7th, 1998) implemented the European Directive 98/30/EC and started the process of liberalization of the gas market in Spain. Thereafter the

Law 12/2007, amending the 1998 Hydrocarbons Law and implementing the European Directive 2003/55 introduced new requirements in terms of unbundling. Overall the Law 12/2007 brought about minor changes to the gas sector since the Hydrocarbons Law applied already regulated TPA to gas infrastructure and required legal unbundling of all regulated activities such as LNG terminals, storage, transmission and distribution activities from the competitive ones (CNE, 2010a). Overall in 2003 the gas market in Spain was considered already fully liberalized with consumers being free to choose their supplier (Honoré, 2011). Given this general introduction of the Spanish gas legislation, we discuss the developments of the regulatory framework for balancing later in this section and we focus in the next paragraph on the current functioning of the balancing system in Spain.

3.8.1 Balancing

Spain has adopted an entry-exit model with one balancing area. As opposed to the other European countries analysed in this report, Spain has currently no spot market for gas whereas a secondary market for gas exchanges was set up by Enagas in 2005. Negotiations on the secondary market occur by the means of an electronic platform (MS-ATR) where market parties can engage in OTC bilateral transaction, balancing relations with the TSO and negotiations of gas prices on an anonymous basis (Enagas, 2008). On the MS-ATR market parties define their bids and offers in terms of price and volumes for every infrastructure, i.e. for every trading point on the grid. There are eight trading points on the Spanish grid which corresponds *de facto* with the balancing points on which shippers must match their inflows and outflows of gas. These trading and balancing points include the six LNG terminals listed previously, a virtual balancing point (*Almacenamiento de Operación Comercial,* AOC) and a virtual storage point as illustrated in the Figure 46. As stated by Federico (2010, p.28), the fact that trades take place at different points implies "*that the secondary gas market does not act as an effective gas hub*".

Figure 46 - Trading Points in Spain. Source: CNE (2010a)



On the only virtual balancing point, the AOC, shippers have the opportunity to trade gas in order to balance their gas positions within the day. Shippers are considered balanced as long as their gas volumes are within given tolerance bands for the various facilities on the grid and therefore can score five types of imbalances36. The tolerance band is a function of the daily contracted capacity in the network for a given shipper and more specifically a shipper is entitled a tolerance band between 0% and 50% of contracted capacity and "up to five days of the contracted capacity in case of LNG facilities" as outlined in CNE, ERSE and ACER (2012). If a shipper's gas volumes on a given day exceed the upper or lower tolerance bands a penalty is applied.

Box - Calculation of Penalties on the Enagas Grid

According to CNE, ERSE and ACER (2012, p.9), *"the penalty on network imbalances outside the tolerance are as follows (T = 0.02098 €/MWh/day):*

- *If the daily stock level is above 50% and below 70%, the penalty is 1.1 T*
- *If the daily stock level is above 70% and below 100%, the penalty is 1.5 T*
- *If the daily stock level is above 100%, the penalty is 15 T*
- *If the daily stock level is below 0%, and the network user has a stock of LNG inside the Spanish system, the penalty is 1.1 T*

If there is no market price in Spain, the reference price is equal to the arithmetic average of the Henry Hub gas price and the National Balancing Point (NBP) gas price of the 7 preceding days.

- *Bids and offers should be order in terms of volume and price for every infrastructure*
- *Shippers having access to MS-ATR trading platform are able to choose the infrastructure where they want to trade gas and to accept or refuse offers from other users.*
- *MS-ATR allows to organize the OTC bilateral exchanges*
- *MS-ATR allows GTS to receive offers to manage the imbalances*
- *MS-ATR allows the negotiation of gas prices between users, on anonymous basis."*

In order to balance the system the TSO can rely on the following physical tools available on the Spanish gas network: pipeline line-pack, storage (underground and LNG) which allow to satisfy both short-term and seasonal variations in gas flows. The three underground storage facilities are depleted gas fields which have a relatively slow ability to respond to gas demand variations in the short-term and as a result serve mainly the purpose of responding to deviations on a seasonal basis by withdrawing gas during the winter months (November-March) and injecting gas during the remaining months. On the contrary, line-pack is used to accommodate variations in gas flows within the day alongside the LNG facilities.

The underground storage facility of Gaviota, is located off-shore in the Cantábrico Sea in the Bay of Biscay at 8 kilometers from Cabo Matxitxako, in the northern-east of Spain. The Gaviota storage has a working capacity of approximately 1600 mcm and an injection and withdrawal capacity into and from the depleted field of 5,7 mcm/day and 4,5 mcm/day respectively. In the short-term Enagas plans to increase the injection and withdrawal capacities to 14,2 mcm/day and 9,6 mcm/day respectively. The Serrablo storage facility located on-shore in northern-east part of Spain has a working capacity of 680 mcm and an injection and withdrawal capacity into and from the depleted gas field of 4,4 mcm/day and 6,7 mcm/day respectively. The Marismas phase I underground reservoir operated by Gas Natural Fenosa, started to operate in 2011 and has currently a small working gas capacity of 360 mcm and an injection and withdrawal capacity into and from the depleted gas field of 1 mcm/day and 2 mcm/day respectively. It is expected that through the Marismas phase II, Gas Natural Fenosa will double the working gas capacity by the end of 2013.

[36] From CNE, ERSE and ACER (2012, p.9) we have that shippers can score five types of imbalances that are: "*excess/deficit of stock level in LNG tanks; excess / deficit stock level in storage for commercial operation and deficit stock level operational reserves (line-pac*k)".

Table 12 - Natural Gas Storage Facilities in Spain. Source: Enagas (2011), CNE (2010b) and companies' website.

Terminal	Storage Capacity		Regasification Capacity	Operator
	Mcm of LNG	*N. of Tanks*	*Mcm/hour*	
Barcelona	840	8	1950	Enagas
Bilbao	150	2	800	Enagas*
Cartagena	587	5	1350	Enagas
Huelva	610	5	1350	Enagas
Mugardos	300	2	412,8	Reganosa
Sagunto	600	4	1150	Saggas

*40% held by Enagas and 60% by BBG

In light of the large LNG capacity in Spain, the system can rely both on LNG storage and regasification capacity to quickly respond to variations in supply and demand of gas. On one hand, LNG storage can cover variations in supply coming from the discontinuous arrival of LNG carriers. In 2011, the total storage capacity of LNG on the Spanish grid amounted to approximately 3 bcm. On the other hand, the large LNG regasification capacity is used to respond to daily and weekly fluctuations in gas demand on the Spanish grid.

Alongside the physical tools present on the Spanish grid, the TSO organizes daily auctions on the secondary market (MS-ATR) to restore the system's overall balance. Finally, the MS-ATR gives shippers the possibility to manage efficiently their gas inflows and outflows across the different Spanish balancing points in order to minimize their imbalances and avoiding penalties while reducing the need for interventions by the TSO.

In March 2012, the Comision National de Energia (CNE) released an information document (CNE, 2012) describing the measures that Spain expects to adopt to improve the functioning of the gas market in order to comply with the EU requirements.

The major measure that Spain will be adopting in the short-term is the creation of a gas hub through an organized spot market where market players can buy and sell gas on the balancing point (AOC) and thereby allow the formation of a Spanish spot price for natural gas. As reported by the information document, the large number of competitors in the wholesale gas market, the well-diversified set of import sources and the large consumption of gas in the country make it feasible for the creation of liquid and transparent spot market in Spain. As a result, the CNE proposed to the Ministry of Industry, Tourism and Commerce a path towards the implementation of the organized spot market which can be summarized in the following steps:

1. Modification of the Hydrocarbons Law in order to introduce the organized market.
2. Creation and implementation of the rules concerning the functioning of the market.
3. Measures to foster market liquidity comprising:
    i. Gas purchase obligations on some market players to be carried out on the organized market in order to foster liquidity and the formation of reliable price signals.
    ii. Introduce a market-based balancing system by eliminating the current system based on imbalance penalties. Market players will be able to buy and sell gas on the market to balance daily their portfolios whereas the residual imbalances at the system level will be adjusted through market interventions by the TSO.

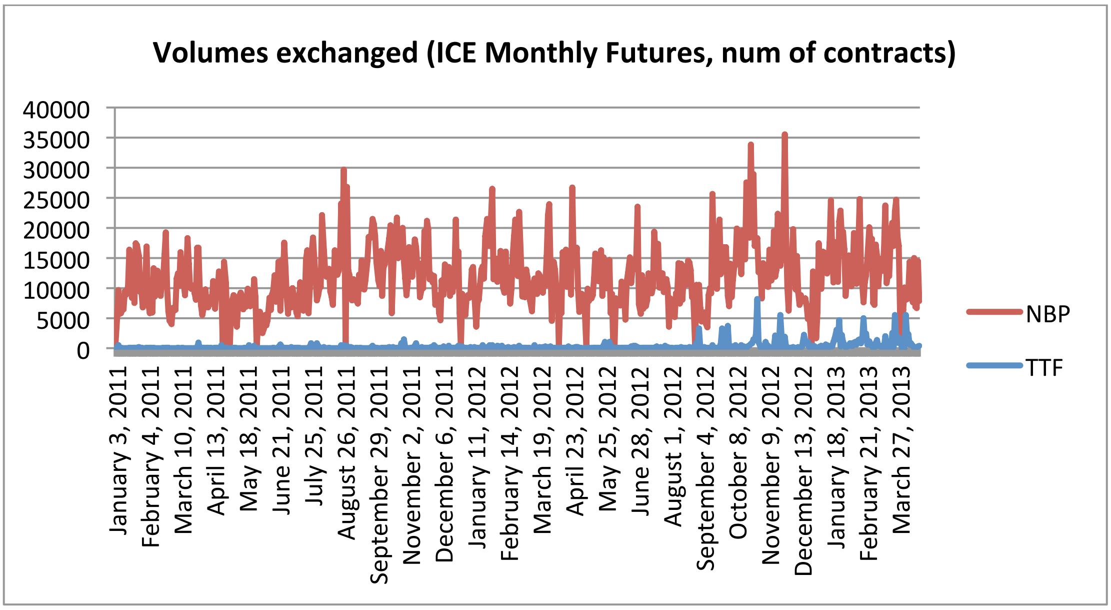
iii. Foster the emergence of market makers to foster liquidity, i.e. market players committed to simultaneously offer and sell gas on the market with the obligation to maintain ascertain bid-ask spread when defining their prices.

4 Concluding remarks

Wholesale gas trading has been a consequence of market liberalization. Not by chance, the first country which introduced a wholesale market has been the UK that is also the first European country that liberalized its energy markets. The emergence of many fragmented market operators which needed to balance their positions has given impulse to the creation of the National Balancing Point and the creation of the Flexibility Mechanism. In few years, NBP has been transformed from a simple balancing platform to a gas trading point, where shippers can purchase and sell gas for sourcing purposes, and not only for balancing. As we have seen, a liquid wholesale market should yield a price that reflects supply and demand conditions, as opposed to the price certainty faced with long term contracts. Nonetheless price volatility that has been experienced also in the UK (Alterman, 2012), calls for the introduction of financial instruments for managing and hedging the price risk. The UK gas system and the NBP offer along their evolution clear evidence of these three steps in the evolution and maturity of a wholesale gas market.

TTF has begun only recently its race to become the reference hub for Continental Europe, but thanks to natural advantages like gas availability in the Netherlands, an appropriate market regulation and a strong push from the Government, it is nowadays closing the gap with NBP, at least in terms of traded volumes (see figure 13). Although TTF has employed only few years to go successfully from phase 1 (balancing) to phase 2 (wholesale trading), it does not yet compete with NBP in terms of financial trading. Instruments available for hedging at TTF are as wide as for NBP, and TTF title are listed on all the main European energy exchanges, but the volumes of financial instruments exchanged, although increasing, are far below those of NBP (Figure 47).

Figure 47 - Exchanged volumes of futures on ICE.



Germany is managing the passage from balancing to sourcing, updating its regulation and trying to improve its balancing mechanism. Starting from the reduction of market areas to the new rules for market-based balancing, it appears that Germany's effort is bringing good results. At first the NCG hub seemed the most promising one, but trading volumes and other liquidity indicators of the two German hubs are now converging (Fig. 28). In general, the market division in two areas reduces the total liquidity and may create barriers for market entry. Furthermore, the German system is still under revision, and it might be difficult to predict if new rules will be implemented to complete the passage to a sourcing platform.

Belgium has undergone important changes in its regulatory framework. Such reforms have not brought yet sensible improvements in the liquidity indicators, but this might be partly due to a decrease in demand. The certainty in the regulatory setting has caused nonetheless price stabilisation (also helped by the market integration with TTF and NBP), and improvement in bid-ask spreads, even though volumes traded are sluggish.

France is the only country of our study that is experiencing an increase in internal gas consumption. Since the market reform makes is still ongoing, it is difficult to draw conclusions. All liquidity indicators are rather stable.

Italy lies at an early stage of market development; it has only recently implemented a balancing platform, and peculiarly has done so only after the creation of an OTC market at PSV and an exchange, to encourage trading, reverting by regulation what it is generally considered the natural path of a gas hub from balancing to second sourcing. The increase in volumes and market liquidity seems to have received a decisive boost once the rules for balancing through the PSV have been set, restoring the rational sequence of steps that we are suggesting.

Austria has been so far a country heavily linked to the physical side of gas trading, due to its strategic position. It is now experiencing, in line with many European countries, a decreasing consumption, but unlike most of the countries object of our study, its traded volumes are decreasing. Nonetheless, such decline is mostly attributable to OTC transactions, while an increasing tendency exchange transactions partly offset the decrease.

Spain does not have a proper hub; its market structure is heavily linked to LNG, but the country has a penalty system for unbalances in line with the requirements of the EU network code.

To show the differences in market performances as measured by market liquidity, figures 48 an 49 show traded volumes and figures 50, 51 and 52 compare the churn ratios of the markets object of our study, computed as the ratio between traded volumes and physical deliveries within the hub. Figure 53 shows the gross churn ratio, computed using the demand instead of physical deliveries. To express the amount of gas traded relative to the total amount of gas consumed in the country, we have computed a "availability index", that is computed as the ratio between the volume of gas physically delivered within the hub area and total consumption. The availability index is related to the churn rate as follows:

Gross Churn Ratio = Net Churn Ratio * Availability Index

$$\frac{Traded\ Volumes}{Total\ Consumption} = \frac{Traded\ Volumes}{Physical\ Deliveries} \times \frac{Physical\ Deliveries}{Total\ Consumption}$$

As such, it expresses the degree of reliance on market prices (fig. 54); if the volumes traded are sufficiently high (i.e. the index is close to 1), then we can assume that there is enough trade going on in the hub to reflect the resource scarcity. If this index is low, then the amount of gas traded at the hub is not representative of market conditions, and therefore hub reference prices are not reliable signals. The results confirm that while in the UK and the Netherlands the wholesale gas markets plays a central role in the overall transaction of gas, and the NCG shows a promising performance in this sense, Gaspool and, notably, the PSV are still trading a small fraction of the overall gas consumed in the system, that for the most part is still operated through long term contracts. Hence, also this availability measure confirms the relative ranking among European gas hubs that this study has documented.

4.1 Data summary and graphs

Figure 48 - Comparison of traded volumes.

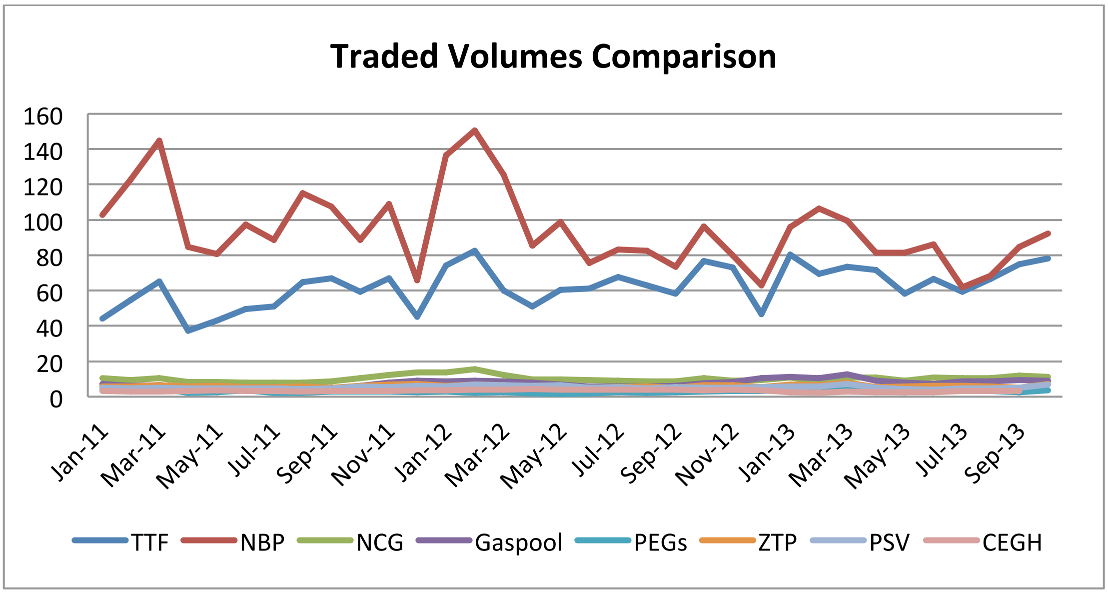


Figure 49 - Trade volumes of European hubs (without NBP and TTF)

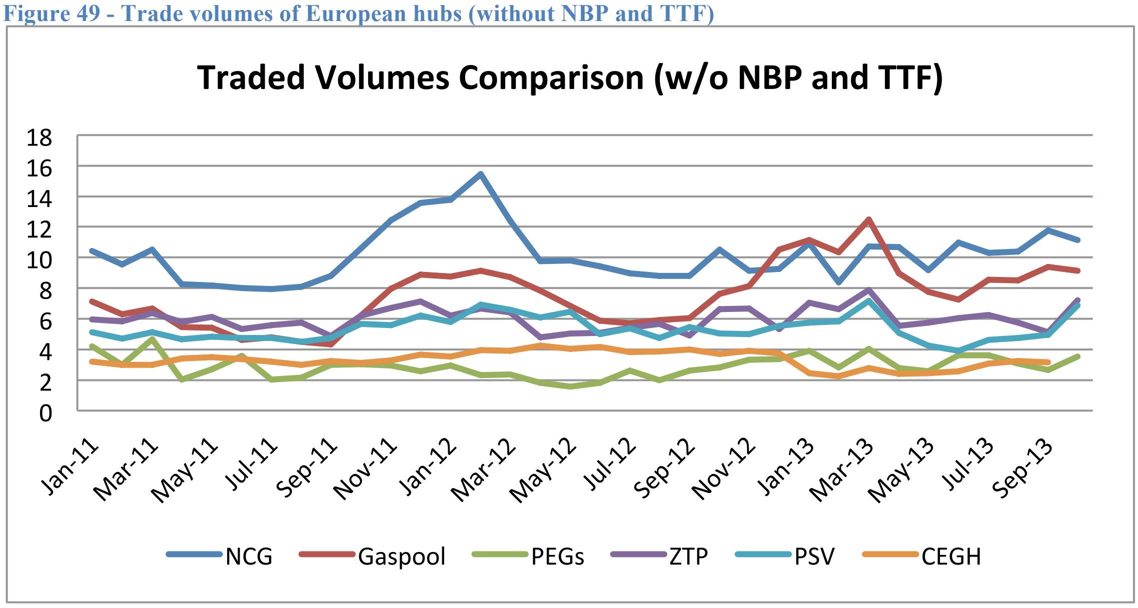


Figure 50 - Comparison between TTF and NBP Churn Ratios.

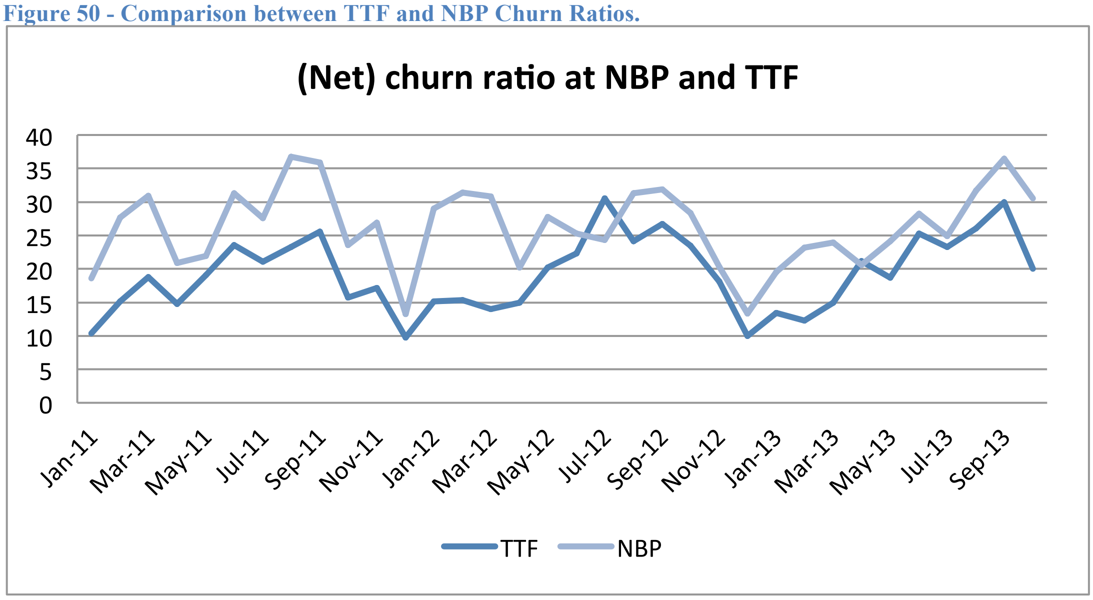


Figure 51 - Comparison of Churn Ratios.

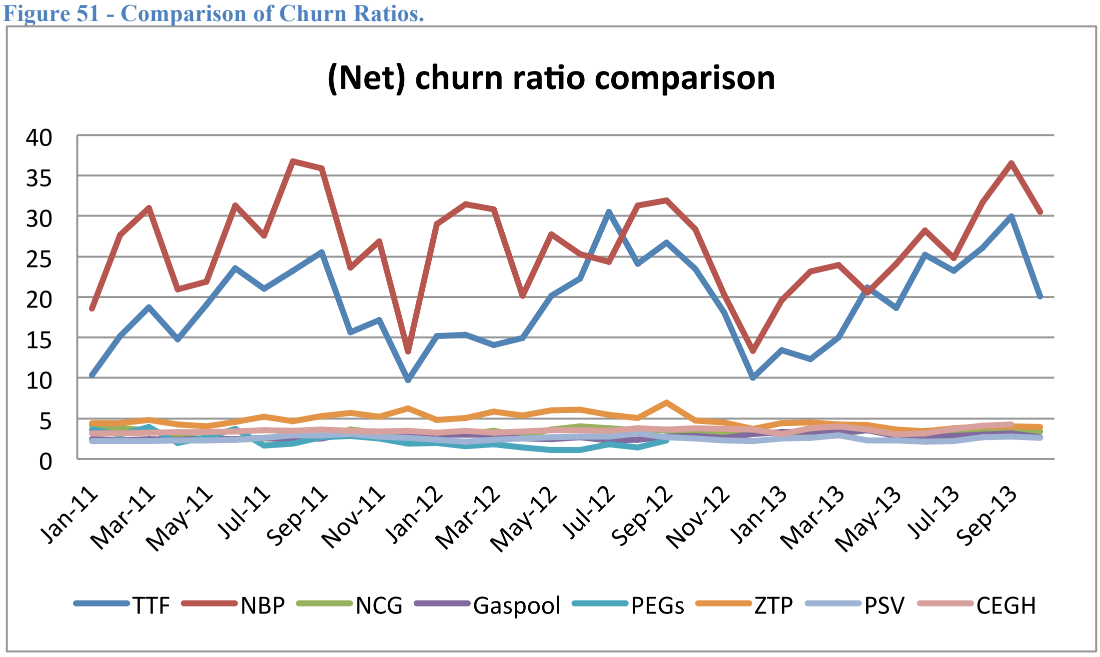


Figure 52 - Comparison of Churn Ratios without NBP and TTF.

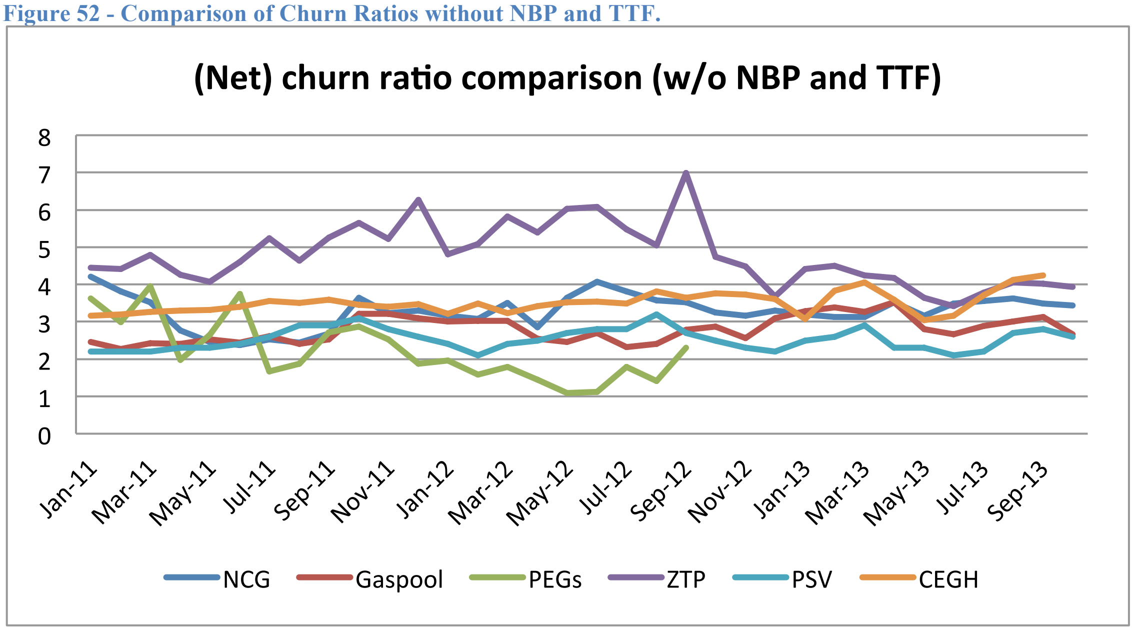


Figure 53 - Comparison of gross Churn Ratios.

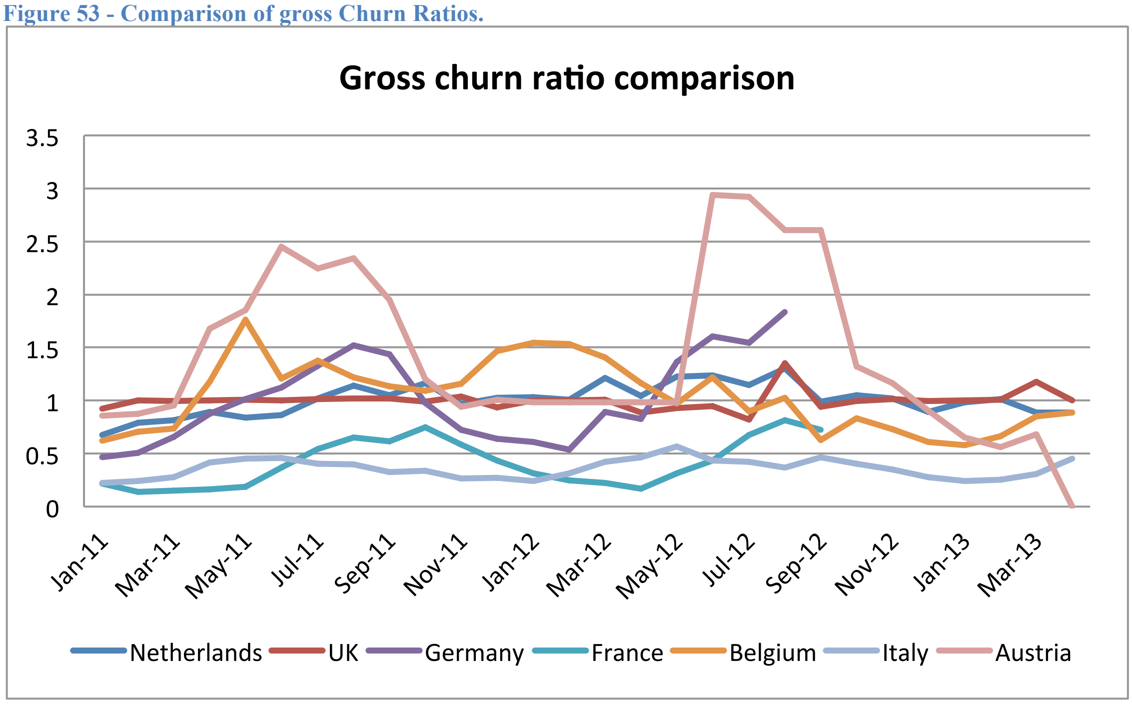
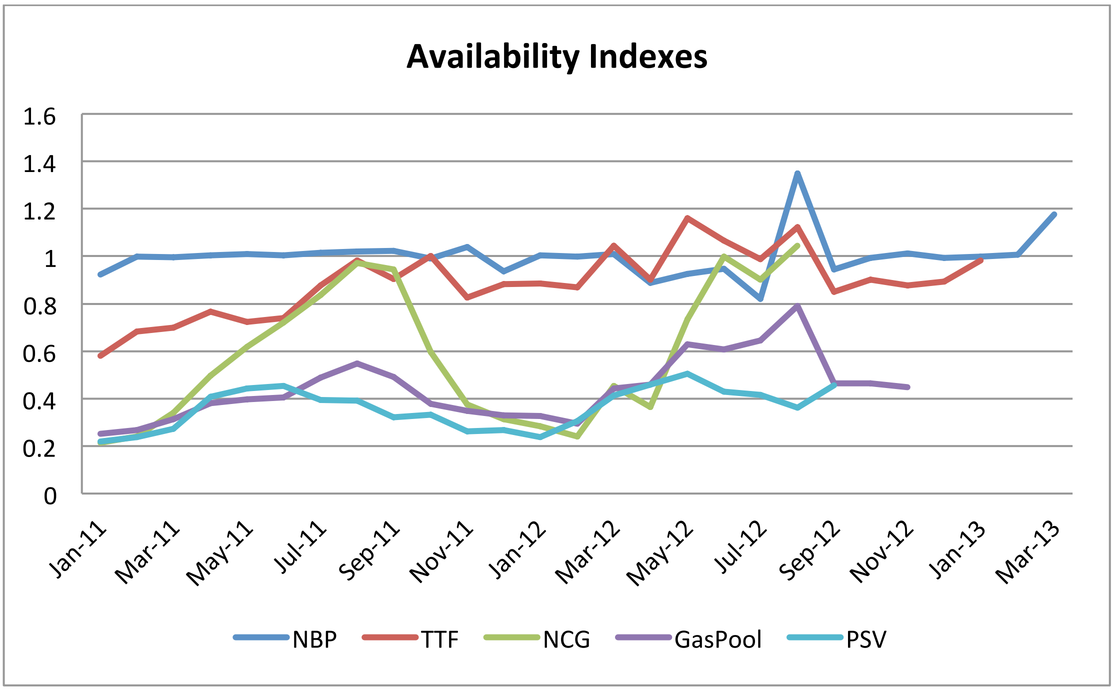


Figure 54 - Comparison of Availability Indexes



References

ACER, 2011. Framework Guidelines on Gas Balancing in Transmission Systems. Published on 18 October 2011.

Alterman, S., 2012. Natural gas price volatility in the UK and North America. OIES, NG 60, February 2012.

Asche, F., Misund, B., Sikveland, M., 2013. The relationship between spot and contract gas prices in Europe. Energy Economics 38, pp. 212–217.

Asche, F., Osmundsen, P., Tveteras, R., 2002. European market integration for gas? Volume flexibility and political risk. Energy Economics 24, pp. 249-265.

Autorità per l'Energia Elettrica e il Gas (AEEG), 2013. Relazione Dell'autorità per l'Energia Elettrica e il Gas sullo Stato dei Mercati dell'Energia Elettrica e del Gas.

Autorità per l'Energia Elettrica e il Gas (AEEG), 2011. Annual Report to the European Commission on Regulatory Activities and the State of Services in the Electricity and Gas Sectors. July 31, 2011.

Black, F., 1971, Towards a Fully Automated Exchange, Part 1, Financial Analysts Journal, 27, 29-34.

Bundesnetzagentur (BNA), 2011. Monitoring Benchmark Report.

Business Insights, 2012. Gas Infrastructure in Europe. 27 April 2012

Cavaliere, A., 2011. Efficient Mechanisms for Access to Storage with Imperfect Competition in Gas Markets. Quaderni di Dipartimento # 151 (07-11), Università di Pavia.

Clayton, M. J., Jorgensen, B. N., & Kavajecz, K. A., 1999. On the formation and structure of international exchanges.

Comisión Nacional de Energía (CNE), 2012. Informe Sobre El Sector Energético Español. Parte IV - Medidas Sobre El Mercado Mayorista De Gas Natural. March 7, 2012.

Comisión Nacional de Energía (CNE), 2011. Supervisión De Los Abastecimientos De Gas Y La Diversificación De Suministro. November 2011.

Comisión Nacional de Energía (CNE), 2008. The Spanish Wholesale Gas Market.

Comisión Nacional de Energía (CNE), 2010a. Spanish Energy Regulator's Annual Report to the European Commission 2010. Published on 22 July 2011.

Comisión Nacional de Energía (CNE), 2010b. Capacidades actuales de las plantas de regasificación. Available at: http://www.cne.es/cne/doc/mer_ener/capacidadesgasistas.pdf

CNE, ERSE and ACER (2012) Analysis Of Cross Border Transmission Gas Tariffs Between Portugal and Spain. Public Hearing. Published in January 2012.

Cretì A., editor, 2009. The Economics of Natural Gas Storage: A European Approach. Springer Verlag.

DG Energy, 2013. Quarterly Report on European Gas Markets. Volume 6, issue 2: Second quarter 2013.

DG Energy, 2012. Quarterly Report on European Gas Markets. Volume 5, issues 2 & 3: April 2012 – September 2012.

Dong, J., Kempf, A., Yadav P.K., 2007. Resiliency, the Neglected Dimension of Market Liquidity: Empirical Evidence from the New York Stock Exchange. Available at SSRN 967262.

EFET, 2009. Gas Storage in Europe-Adding Security through Flexibility.

Ejarque, J. M., 2011. Evaluating the economic cost of natural gas strategic storage restrictions. Energy Economics, Volume 33, Issue 1, January 2011, Pages 44–55.

Enagas, 2008. MS-ATR: The Secondary Market for Gas Exchanges in Spain. Presented to EFET in Madrid, 23th July 2008.

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

European Network of Transmission System Operators for Gas (ENTSOG), 2012 Network Code on Gas Balancing of Transmission Networks. Published on 26 October 2012.

European Regulators' Group for Electricity and Gas (ERGEG), 2010. Gas Hub Monitoring Report.

European Union (EU), 2013. Regulation No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009. Official Journal of the European Union L 115/39, 25/4/2013.

European Union (EU), 2011. Regulation (EU) No 1227/2011 of the European Parliament and of the Council of 25 October 2011 on wholesale energy market integrity and transparency. Official Journal of the European Union L 326/1, 8/12/2011.

European Union (EU), 2009a. Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC, L211. Official Journal of the European Union, pp.94-136.

European Union (EU), 2009b. Regulation EC 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for the access to the natural gas transmission networks and repealing Regulation EC No. 1775/2005, L211. Official Journal of the European Union, pp.36–54.

Federico G., 2010. The Spanish Gas and Electricity Sector: Regulation, Markets and Environmental Policies. Reports of the Public-Private Sector Research. IESE Business School.

Fleming, M.J., 2001. Measuring Treasury Market Liquidity. FRB of New York Staff Report No. 133. Available at SSRN.

Fluxys, 2012. Transmission Programme – Service Offer Description 2012-2015. Published on April 26th, 2012.

Frontier Economics, 2008. Research into Gas Flexibility Services. A Report Prepared for DTE. Final Report, May 2008.

Garbade, Kenneth, D., 1982. Securities Markets. MacGraw-Hill Series in Finance.

Glosten, L. R., and Milgrom, P. R., 1985. Bid, ask and transaction prices in a specialist market with heterogeneously informed traders. Journal of Financial Economics 14, 71–100.

Grossman, S.J., and Miller, M.H, 1988. Liquidity and Market Structure. Journal of Finance, American Finance Association, vol. 43(3), pages 617-37, July.

Gas Infrastructure Europe (GIE), 2011. GSE Map. August 2011. Available at: http://www.gie.eu.com/index.php/maps-data/gse-storage-map

Gas Transport Services (GTS), 2012. Services included – services, balancing, tariffs. Published in January 2012.

Gas Transport Services (GTS), 2011. The 2011 Balancing Regime and Market Model. Version 1.0.

Germany Energy Blog, 2011. BNetzA: New EEX Gas Reference Prices to Determine Compensation Energy Prices. July 19, 2011. Available at: http://www.germanenergyblog.de/?p=6830#more-6830

Gestore Mercati Energetici, 2012. Mercato a termine fisico del gas naturale, Documento di consultazione n. 04/2012, published on October 2012.

Growitsch, C., Stronzik, M, Nepal, R., 2012. Price Convergence and Information Efficiency in Germann Natural Gas Markets. EWI Working Paper, No 05/12.

GRTgaz, 2011a. Règles d'équilibrage sur le réseau de transport de gaz de GRTgaz au 1er Mai 2011.

GRTgaz, 2011b. Répondre aux besoins de modulation intra-journalière. Adéquation offre-demande de la flexibilité intra-journalière. Étude prospective 2012-2020.

GRTgaz, 2010. Etude De La Capacite Des Infrastructures Gazieres A Repondre Aux Besoins Des Centrales Prevues. Document GRTgaz et Document TIGF N°/DDC/DEV_10-0009.

Heather, P. 2012. Continental European Gas Hub: are they fit for purpose? OIES NG 63.

Heather, P., 2010. The Evolution and Functioning of the Traded Gas Market in Britain. OIES NG 44.

Honoré, A., 2011. The Spanish Gas Market: Demand Trends Post Recession and Consequences for the Industry. The Oxford Institute for Energy Studies. N55.

Hunt, P., 2008. Entry–Exit Transmission Pricing with Notional Hubs: Can it Deliver a Pan-European Wholesale Market in Gas? OIES NG 23, February.

ICIS, 2013. Update: EU states press on with new gas balancing rules ahead of network code. Published on 30 May 2013. http://www.icis.com/heren/articles/2013/05/30/9673854/update+eu+states+press+on+with+new+gas+balancing+rules+ahead+of+network.html

International Energy Agency (IEA), 2013. Monthly Natural Gas Survey. OECD/IEA Publications.

International Energy Agency (IEA), 2011. Natural Gas Information. OECD/IEA Publications.

International Energy Agency (IEA), 2009. Natural Gas Market Review. OECD/IEA Publications.

International Energy Agency (IEA), 2002. Flexibility in Natural Gas Supply and Demand. OECD/IEA Publications.

International Monetary Fund (IMF), 2002. Measuring Liquidity in Finance Markets. Working Paper. December 2002.

Joint Office of Gas Transporters, 2012a. Uniform Network Code.

Joint Office of Gas Transporters, 2012b. Uniform network Code - Transportation Principal Document Section F – System Clearing, Balancing Charges and NeutralityIMF, 2002

KEMA, 2009. Study on Methodologies for Gas Transmission Network Tariffs and Gas Balancing Fees in Europe. Report for the European Commission DG-TREN, December 2009.

Keyaerts, N., Hallack, M., Glachant J-M, D'Haeseleer, W., 2011. Gas market distorting effects of imbalanced gas balancing rules: Inefficient regulation of pipeline flexibility. Energy Policy 39, Pag. 865–876

Keyaerts N., Meeus L., D'Haeseleer W., 2008. Natural Gas Balancing: Appropriate Framework and Terminology. TME Working Paper series: EN2008-003. University of Leuven (K.U.Leuven) Energy Institute.

Kyle, A., 1985, Continuous auctions and insider trading, Econometrica, 53, pp.1315-1335.

Mazighi, A. E. H., 2005. Henry Hub and national balancing point prices: what will be the international gas price reference?. OPEC review, 29(3), 219-230.

Lapuerta, C., 2010. Gas Balancing (The Brattle Group). Presented at Florence School of Regulation on 24 March 2010

Lapuerta, C., Moselle, B., 2002. Convergence of Non-Discriminatory Tariff and Congestion Management Systems in the European Gas Sector", The Brattle Report, London.

Migliavacca, G., 2009. Il mercato del bilanciamento del gas: metodologie adottate in Europa e riflessi sul mercato elettrico. CESI Ricerca. February 2009.

Nederlandse Mededinginsautoriteit (NMA), 2007. Versnelling van de ontwikkeling van TTF en de groothandelsmarkt voor gas. The Hague.

NERA and TPA Solutions, 2005. Gas Balancing Rules in Europe: A Report for CREG. 23 December 2005.

Neumann, A.; Cullmann, A., 2012. What's the story with natural gas markets in Europe? Empirical evidence from spot trade data, European Energy Market (EEM), 2012 9th International Conference, May 2012.

Ofgem, 2010. Update consultation on National Transmission System (NTS) flexibility capacity. 16 December 2010

Ofgem, 2009. Liquidity in the GB wholesale energy markets. 8 June 2009

Ofgem, 2007. Updated Securing Britain's Gas Supply. Factsheet 32.

Petrovich, B., 2013. European Hubs: How Strong is Price Correlation?, OIES NG 79, October 2013.

Pollitt, M., 2011. The Single Market in Electricity (and Gas): Success and Failures. Talk to CERRE, Brussels, 24th March 2011.

Polo M., Scarpa C., 2013. Liberalizing the Natural Gas Market: Take-or-Pay Contracts, Market Segmentation and the Wholesale Market, International Journal of Industrial Organization, 31(1): 64-82.

Roller, L.-H., Delgado, J. and Friederiszick, Hans W., 2007. Energy: Choices for Europe. Bruegel blueprint series/March 2007.

The Guardian, 2013. Budget 2013: George Osborne commits to UK shale gas boom. Online edition, 20 March 2013. http://www.guardian.co.uk/environment/2013/mar/20/budget-2013-george-osborne-shale-gas-boom

TIGF, 2011. Proposition de TIGF sur l'évolutions de son système d'équilibrage nécessaires pour se conformer aux principes de la 3ème directive.

Vazquez, M., Hallack, M., 2013. Design of auctions for short-term allocation in gas markets based on virtual hubs. EUI RSCAS; 2012/43.

World Energy Outlook (WEO), 2011. International Energy Agency, December 2011.

Wright, P., 2011. Gas Balancing, Markets and the System operator. Presented at Jornada Tecnica Bogotà, 29 March 2011.

Websites:

www.apxendex.com
www.capsquare.eu
www.cegh.at
www.ceghex.com
www.ceghotc.com
www.e-control.at
www.eex.com
www.enagas.es
www.energyagency.at
www.energy-regulators.eu
www.fluxys.com
www.Gaspool.de
www.gasunietransportservices.nl
www.germanenergyblog.de
www.gie.eu.com
www.grtgaz.com
www.iceendex.com
www.leba.org.uk
www.mercatoelettrico.org
www2.nationalgrid.com/uk
www.net-connect-germany.de
www.powernext.com
www.snamretegas.it