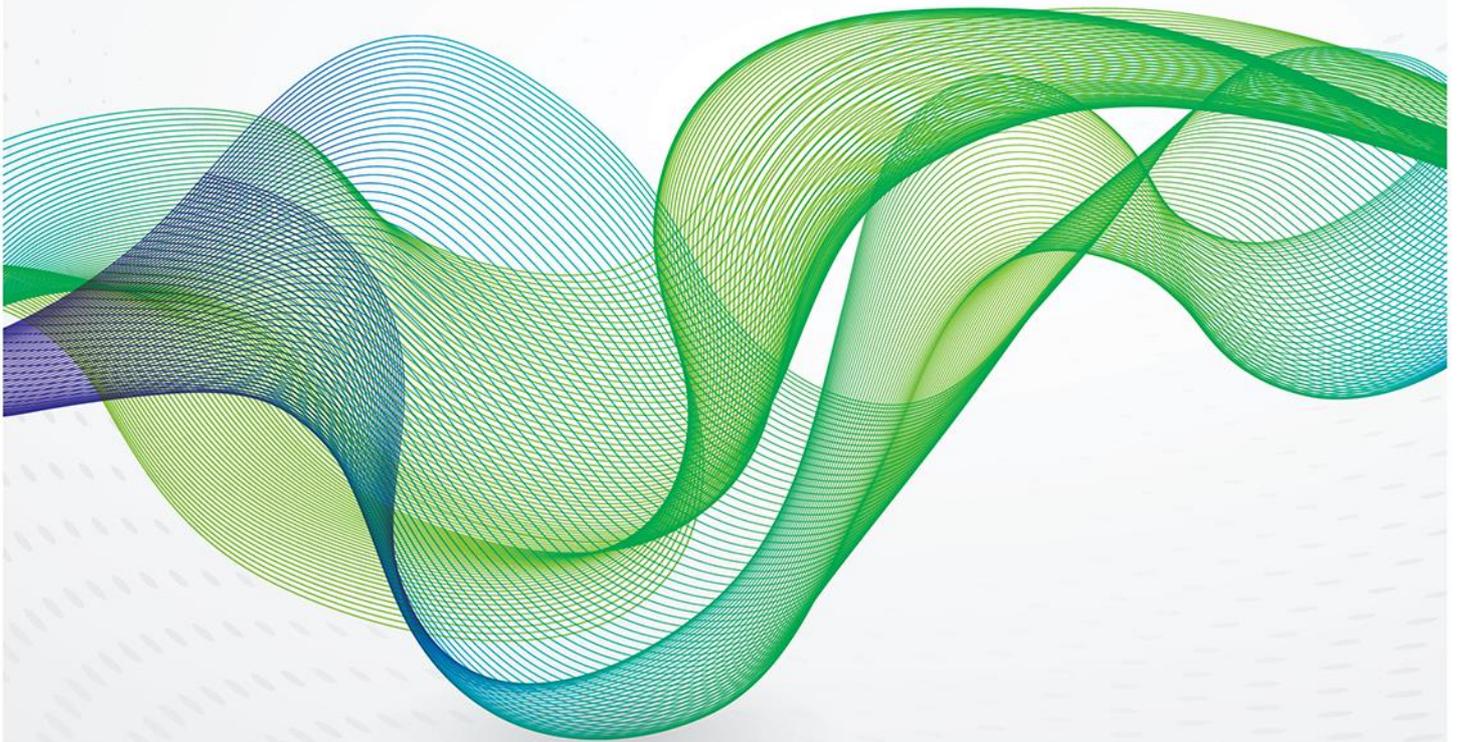




THE OXFORD
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Do we have aligned and reliable gas exchange prices in Europe?



Section 1. Introduction and methodology

This comment paper follows on from three previous publications by the Author¹ and assesses whether the main European energy exchanges² provide a reliable price reference for traded gas. After discussing the relevance of this research question (Section 2), it is addressed by adopting different but complimentary approaches, which are applied to the set of data presented in Section 3.

Firstly, the importance of exchange trading in natural gas is discussed, assessed and compared to OTC trading, with a special focus on short term products. Following the literature and industry practice³, we assess the importance of exchange trading by looking at a widely used liquidity indicator: total traded volumes by hub, as liquidity is one of the necessary conditions for reliable price signals. In particular, underpinned by seminal work carried out by the OIES Natural Gas Programme, Section 4 shows the development of exchange traded volumes over time at different locations (hubs) in Europe, compares it to that of OTC trading, and explains the possible reasons for the different growth patterns observed at the main hubs in Europe. Section 4 also looks at some nascent hubs at the current trading periphery, such as the Czech VOB, the Spanish and the Polish hub, where existing exchange trading could be instrumental in helping to develop hub liquidity⁴.

Secondly, we investigate whether day ahead gas is priced in a different way when traded on an exchange compared to OTC trading: Section 5 compares the evolution of spot exchange and OTC prices for the hubs where there is an active exchange offering day ahead products. We expect that reliable exchange prices should not significantly deviate from those quoted on the OTC market, when referred to the same delivery framework and hub⁵.

Thirdly, Sections 6 and 7 investigate the differences in the evolution over time of exchange day ahead prices for gas delivered at different locations. In particular, these sections assess how similar the daily exchange price movements are over time, using price correlation metrics, and whether we can observe any structural divergence. In other words, we check whether day ahead exchange prices react to the same supply/demand changes, in the same way and at the same time, therefore producing parallel price movements and a high correlation coefficient. Exchange price correlation is considered as one possible, although not an exhaustive, metric to assess the efficiency of exchange pricing⁶. More specifically, high correlation scores between the price time series of two adjacent markets suggest that both a) sufficient ability to transport gas across borders, and b) arbitrage forces, succeed in bringing prices “back in line with each other” very rapidly after a demand/supply shock occurs, driving down to zero any price difference above the transportation cost. In the light of this, if pricing for European exchange traded gas is efficient we expect to observe 1) tight structural correlation between exchange prices across different gas hubs, and/or 2) few periods of low correlation (if any) attributable to temporary physical disconnections between markets. Note that these are necessary, but not sufficient, conditions to confirm the existence of efficient pricing⁷. Further, it is worth noticing that price correlation is also an indication of the degree of integration

¹ Petrovich (2013, 2014, 2015).

² “The Exchanges are regulated markets where traders are secure in the knowledge that they are governed by the relevant financial regulator in each country and that the clearing house also financially guarantees all of the trades executed.” Source: Heather (2015), P.8.

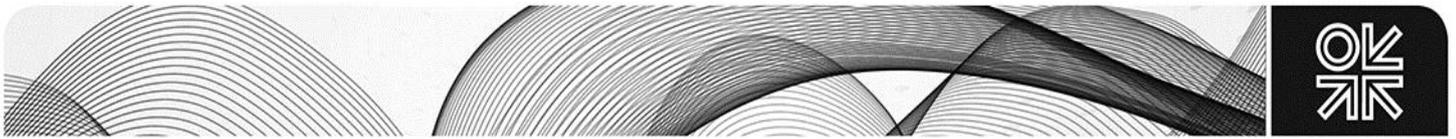
³ Heather (2015), P.75.

⁴ Other hubs are not covered in this analysis due to the absence of liquid exchange trading or the lack of information available. For example, at the Danish Gas Transfer Facility (GTF) the wholesale market is mostly based on bilateral OTC trading and according to the Danish Energy Regulatory Authority (DERA), the Danish gas exchange (Gaspoint Nordic, formerly known as Nord Pool Gas and created in 2007) in 2014 was not considered to be fully liquid. Source: Heather (2015), P.42-42.

⁵ As already demonstrated by Petrovich (2013) for TTF, ZEE, NCG, Gaspool (GSL), CEGH, PEGN and PEGS exchange prices, for the period from January 2007 up to June 2012. In this regards the present work constitutes an update both in chronological terms (data are up to December 2015 as explained below) and geographical terms (evidence for the Czech hub and ZTP is included in the sample).

⁶ For a discussion on the relevance and shortcomings of price correlation metrics please refer to Petrovich (2014) P. 9-10 and Petrovich (2013) P. 8-10.

⁷ A recently published study by Nick presents an alternative measure of efficient pricing, “informational efficiency”, applied to exchange gas prices in the October 2007-August 2012 period, for details see Nick (2016).



between European hubs, as strong price alignment suggests a breakdown of structural barriers to flowing gas across borders.

Summing up, the three research questions addressed by this comment paper are thus:

- 1) Have exchange traded gas volumes grown in recent years throughout Europe?
- 2) Do OTC and exchange prices at the same hub provide the same price signal?
- 3) Do exchange short term prices for gas delivered at different European locations show structural differences?

Section 2. Relevance of the research question

As clearly stated by Heather (2015): “Exchanges perform a vital role in the development of a traded commodity market and provide five important functions: price discovery, price transparency, supply/pricing flexibility, physical balancing and financial risk management”⁸. Based on this, if gas exchange trading activity exists and offers reliable price signals, we can conclude that these vital functions are provided at satisfactory level and therefore foster the development of a mature traded commodity market.

In particular, this holds true for some nascent hubs at the European trading periphery, where well-functioning exchange trading could be instrumental in helping to develop hub liquidity by offering new products on “easy-to-trade” electronic platforms and, perhaps more importantly, price transparency⁹.

Further, as far as transparency is concerned, as noted in Petrovich (2013), the correlation between OTC and exchange-based trading prices is indeed a relevant issue. If exchange prices - though representing relatively small traded volumes, (as will be demonstrated in Section 4) - did closely match OTC prices (which represent significantly higher volumes), this would indicate that transparent¹⁰ and accessible price signals expressed by exchanges can be trusted and used as a market reference price.

Well-functioning exchange trading also plays an important role in the design of gas balancing mechanisms as conceived by EU regulation. In fact, the European Network Code on Gas Balancing¹¹ assigns a pivotal role to exchanges: according to the Code a central counterparty platform for short term trading could be created and designed in order to be a suitable tool for the network users and the TSO to balance their positions.

Finally, reliable and transparent price signals expressed by every segment of the market (OTC, exchange) are important from an efficiency point of view as they should ensure an efficient allocation of the commodity across different locations and market participants¹².

The analysis in this paper focusses on day ahead gas price quotations, as spot price signals play an important role in the current market environment: as shown in Heather (2015)¹³, in the majority of the hubs that have active organized markets for gas, spot exchange volumes make the most of total exchange traded volumes. For this reason, the analysis in this paper focuses on day ahead exchange prices, as the day ahead product is the most liquid spot product traded on European gas exchanges, as well as on the OTC market. In addition, the short term horizon is typically the horizon over which

⁸ Heather (2015), P.31.

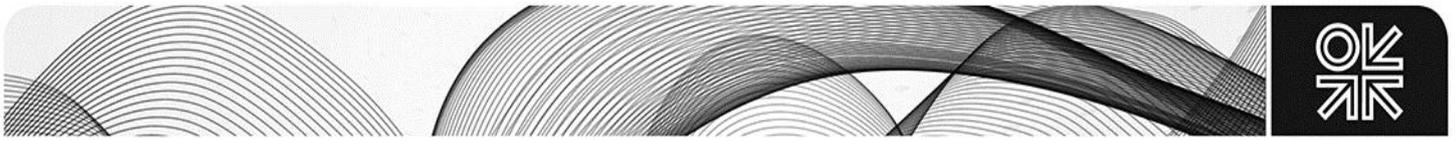
⁹ In fact due to their regulated nature exchanges have an obligation to be fully transparent in everything they do, as explained and discussed by Heather (2015), P.31-32.

¹⁰ As also noticed by Heather (2015), all the exchanges publish daily price indexes or real time price and volume data: “Because exchanges are regulated marketplaces, they have an obligation to be fully transparent in everything they do: the products traded, the volumes traded and the prices at which they were traded. This enables all gas market participants and outside observers to know the price of gas now and in the future (e.g.: up to six years ahead on ICE NBP and five years for ICE-Endex TTF). The current traded price is visible usually in real time, or occasionally with a slight time delay”. Source: Heather (2015), P.31-32.

¹¹ EU regulation 312/2014 establishing a European Network Code on Gas Balancing of Transmission Networks.

¹² In microeconomic theory this is actually the function that competitive prices perform in a free market economy, as also noted by Nick (2016), P. 6.

¹³ Heather (2015), P.73, Figure 33.



we would expect to see evidence of the strongest drivers of price differences across hubs (e.g. due to weather variations or local supply/demand issues). Consequently, observing structurally correlated day ahead prices suggests that the prices for more-distant-in-the-future maturities, if the liquidity develops over the curve, may be well correlated too.

In conclusion, the evolution and reliability of exchange prices at different hubs needs to be taken into consideration in addition to OTC prices, which were the main focus of the Author's previous papers.

Section 3. Data

The European exchanges that offered gas contracts in 2015¹⁴ are: ICE, ICE-Endex, EEX, Powernext, CEGH, GME, POLPX, CME (which entered the gas market in February 2015¹⁵) and MIBGAS (which went live in December 2015¹⁶). EEX and Powernext also signed a cross-market agreement and accordingly they market each other's contracts on a shared platform called PEGAS that became fully operational on 1st January 2015¹⁷.

Information on exchange prices and volumes is mostly transparent but building up a consistent dataset is not straight forward due to the different disclosure and dissemination practices and the presence of more exchange operators that offer central counterparty-cleared contracts for delivery at the same hub.

Exchange volumes by hub are based on the extensive research carried out by Heather (2015).

As far as prices are concerned, the focus of the analysis in this study is on the day ahead contract, which is the most frequently traded product for gas in Europe.

The exchange day ahead prices considered in this analysis are presented in Table 1.

¹⁴ For a review of types of gas contracts offered by each refer to Heather (2015) Appendix F, P.100.

¹⁵ Reuters, 27th January 2015, "CME Group launches six European natural gas contracts", <http://www.reuters.com/article/cme-contracts-gas-idUSL6N0V61YO20150127>; CME "European Natural Gas Futures", <http://www.cmegroup.com/europe/products/energy/european-gas-products.html>

¹⁶ Source: ICIS-Heren, 10th December 2015: "Iberian organised gas market launches", <http://www.icis.com/resources/news/2015/12/10/9952110/iberian-organised-gas-market-launches/>

¹⁷ Heather (2015), P. 33 and More information at: <http://www.pegas-trading.com/en/>

Table 1: Overview of the dataset for exchange day ahead prices

Exchange Day ahead price	Description and source	Availability
TTF (ICE ENDEX)	Settlement TTF DA prices published <u>since Jun 2015</u> by ICE ENDEX	free to download on ICE-ENDEX website
TTF (EEX)	settlement TTF DA price published by EEX	available subject to subscription
ZTP (ICE ENDEX)	Settlement ZTP DA prices published <u>since Jun 2015</u> by ICE ENDEX	free to download on ICE-ENDEX website
PEGN (Powernext)	Powernext PEGN daily average DA prices , daily price considered only when there are traded volumes on that day	free to download on Powernext website
PEGS (Powernext)	Powernext PEGS and (starting from April 2015) TRS daily average DA prices , daily price considered only when there are traded volumes on that day	free to download on Powernext website
GSL (EEX)	settlement Gaspool DA price published by EEX	available subject to subscription
NCG (EEX)	settlement NCG DA price published by EEX	available subject to subscription
AT VTP (CEGH)	CEGHIX index for delivery at the Austrian VTP in the working days and only when there are trades behind the index. The CEGHIX is basically the volume weighted average price of all day ahead trades of the whole trading day with delivery at the Austrian Virtual trading point	available subject to subscription
VOB (CEGH)	Czech Gas Spot Reference Price for DA contracts determined as volume weighted average of all trades concluded during the trading session on the CEGH Czech Gas Spot Market which is operated by PXE in cooperation with Central European Gas Hub. Note: daily price considered only when there are traded volumes on that day.	available subject to subscription
VPGZ (POLPX)	Volume weighted average price of day ahead transactions for GAS_BASE instrument for a given delivery day on the Polish Gas Day Ahead exchange POLPX, for delivery on the Polish hub VPGZ	free to download on POLPX website

Prices were converted to €/MWh using daily exchange rates for the trading day.

When day ahead exchange contract is not liquid or not offered, the balancing platform price is considered in order to make some general observations (Table 2).

Table 2: Overview of the dataset for balancing platform prices

Balancing platform price	Description and source	Availability
NBP (OCM)	UK OCM daily system average price (SAP) = average price of all gas traded via the OCM mechanism for the gas day. There is a single daily OCM price which <u>includes both day ahead and within day trades</u> done for the same delivery day	publicly available on National Grid website (NGG data explorer).
PSV (GME)	PBGAS G+1 session price ; PBGAS is the balancing platform operated by GME, purchase and sale offers are made in d-1 for delivery in d of gas in storage, rather than on the virtual trading point. There is a single price for each day computed as the <u>system marginal price in a daily auction</u> (no continuous trading).	publicly available on GME website

More specifically, as far as Italy is concerned, in 2015 there was no liquid trading activity for the day ahead product on the exchange managed by the GME (MGP-gas exchange)¹⁸. For this reason, in what follows, the daily price resulting from the G+1 session of the Italian balancing platform PBGAS is used as a proxy, although the functioning of the session G+1 of PBGAS, that consists basically in trading of gas in storage rather than at the virtual trading point, prevents any consistent comparison. Exchanges do not offer “pure” spot exchange trading for delivery at the NBP. The OCM daily average price may be used as a proxy of NBP exchange day ahead price, which however reflects more within day trading than day ahead trading. It is important that for this reason, results for NBP are not wholly reliable.

Data for OTC prices used in Section 5 are based on a dataset of over 4 million OTC trades which is provided to the OIES by three leading brokers, the Tankard Parties, under licence, for research purposes only¹⁹.

Section 4. The importance of exchange trading

As explained in Section 2, this paper extends the analysis of previous works by this Author, based on the OTC brokered trading market, to gas trading on the main European energy exchanges.

One motivation for this paper was the indication, from conversations with market participants that the volume of exchange trades is growing – partly driven by financial regulation requiring trades to be cleared. This was confirmed by extensive research carried out by the OIES: according to Heather (2015) exchange trading has gained in popularity since the financial crash of 2008, although OTC remains by far the prevalent way to trade gas in Europe: market share of exchange trading in 2014 was below 15% for all the hubs, with the significant exceptions being the NBP, where trading is almost equally distributed between OTC and exchange²⁰, and the French PEGs, where the exchange spot contracts are used by shippers to balance within month and optimize portfolios ahead of delivery²¹.

The growing popularity of exchange trading is supported by the fact that exchange liquidity has generally improved in the last three years for most of the main gas hubs (Figure 1), despite exchanges’ market size varying from country to country.

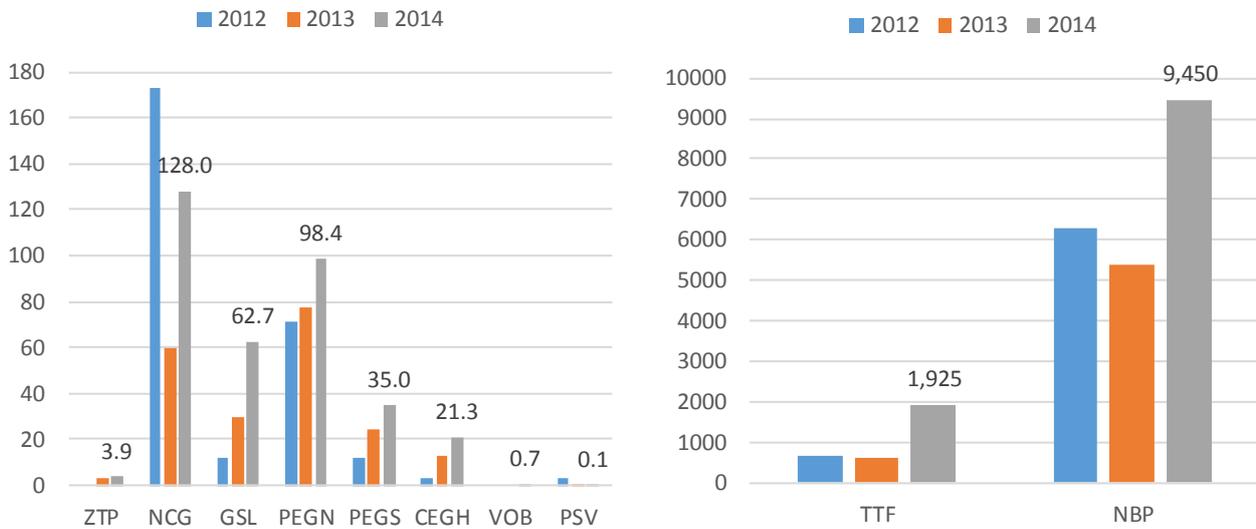
¹⁸ Source: GME data available at: <http://www.mercatoelettrico.org/It/Download/DatiStoriciGas.aspx>

¹⁹ For a detailed description of this set of data and data coverage: Petrovich (2013) and Petrovich (2015).

²⁰ The reason why NBP exchange trading share of total traded volume at NBP is at this level and has been growing in the past few years could be related to the way in which OTC gas trades in GB, where a party must be a Shipper registered with Ofgem to be allowed to transact, a requirement which may deter a number of participants. Source: Heather (2015), P.56-57.

²¹ Source: Heather (2015), P.34.

Figure 1: Total exchange traded volumes at each hub, all spot and future contracts (TWh)



Note:

The euro-quoted virtual hub ZTP, located in Belgium, was created in 2012; trading at ZEE was all OTC in 2013 and 2014

NBP: no spot exchange trading; although there is a centralized balancing platform (OCM) that can be considered as exchange trading

PSV: Spot and future exchange trading is possible, however exchange traded volumes were virtually zero in 2014; there is a centralized balancing platform (PBGAS) operated by the GME.

Source: Heather (2015), Appendix O and N, P.108-9, P. 45-46

One visible exception to this trend is gas exchange trading in Italy²², where, although the Italian market operator GME has been offering exchange contracts ranging from within-day to one-year-ahead since at least 2013, volumes in 2014 and 2015 were still virtually non-existent on the curve and still quite low on the shorter maturities (only 0.1 TWh traded in 2014, which concerned the within day contract, according to data published by GME). However, this situation could change as liquidity may receive a boost from the implementation of the new balancing regime²³, targeted for October 2016, and from the fact that other energy exchange operators, along with the Italian GME, in 2015 started offering PSV exchange contracts²⁴ (ICE-ENDEX²⁵ and PEGAS²⁶). In particular, the newly formed PEGAS platform (a merger of EEX and Powernext) started to offer PSV financial contracts in March

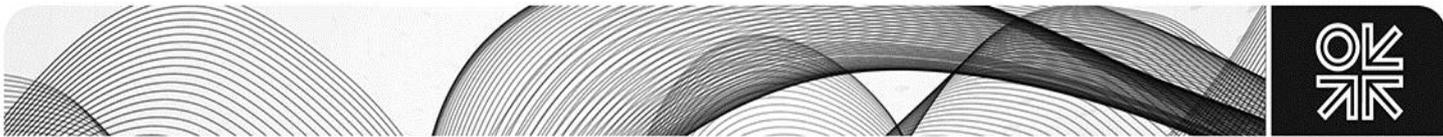
²² The marked year-on-year decline in NCG total exchange volumes in 2013 is entirely due to a drop in future volumes, down from over 150 TWh in 2012 to less than 25 TWh in 2013; futures exchange trading at NCG volumes recovered in 2014 to 67 TWh (Source: Heather (2015), Appendix N, P.109). One possible explanation of this pattern is that NCG had started to trade in its own right but then gradually there an increase in risk management being undertaken at the TTF, including possibly some LTCs having a small element of TTF hub indexation in them.

²³ See Section 2 for a discussion on the role of exchanges in the implementation of the European Network Code on gas balancing (EU Regulation 312/2014).

²⁴ It is worth noting that in Italy the GME has by law an exclusive right to operate the physical gas exchange in Italy (Italian legislative decree 93/11, art. 32.2) and hence exchange trading is formally operated only by GME. In 2015 a regulatory process started (AEEGSI res. 282/2015/R/gas issued in June 2015) aimed at extending natural gas exchange trading activities at the PSV to third parties (i.e. foreign exchange operators other than GME, such as EEX/PEGAS, ICE-ENDEX). The process was completed in September 2015 (AEEGSI resolution 436/2015/R/gas). In more detail, trading is operated by "third exchanges" and GME acts as "nomination agent" to record trade nominations on behalf of them on the PSV.

²⁵ Reuters, 4th June 2015: "ICE Endex Collaborates with GME and Snam to Introduce Italian Natural Gas (PSV) Futures Contracts in September 2015", <http://uk.reuters.com/article/ice-idUKnBw045497a+100+BSW20150604>

²⁶ EEX Press Release, 21st April 2015: "PEGAS: Launch of Physical Futures contracts for PSV market area on 17 June 2015", <https://www.eex.com/en/about/newsroom/news-detail/pegas--launch-of-physical-futures-contracts-for-psv-market-area-on-17-june-2015/86288>; EEX Press Release, 3rd February 2015: "PEGAS to enhance geographical offer with NBP, ZEE and PSV contracts - Launch of new contracts on 26 March", <https://www.eex.com/en/about/newsroom/news-detail/pegas-to-enhance-geographical-offer-with-nbp--zee-and-psv-contracts---launch-of-new-contracts-on-26-march-/84290>.



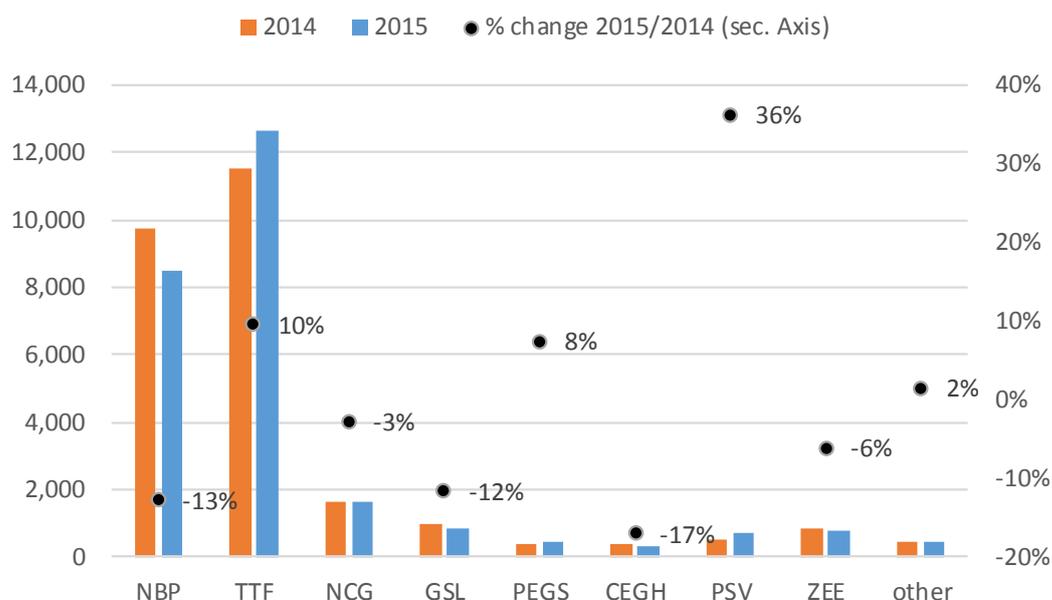
2015²⁷ and PSV physical contracts in June 2015, attracted several market participants and achieved in 2015 quite a large volume traded considering the very recent launch²⁸.

Signaling the growing interest towards gas trading on regulated organized markets, the CME group, one of the world's largest futures market operators, entered the gas market in February 2015²⁹, enlarging the group of European exchanges that currently offer gas contracts³⁰ (ICE, ICE-Endex, EEX, Powernext, CEGH, GME, POLPX).

It is worth noting that exchange trading has been increasing during a period when OTC traded volumes at some hubs have been on a slightly declining or level path (Figure 2). This is confirmed by LEBA³¹ data, with the most remarkable decline in net OTC volumes from 2014 to 2015 occurring at NBP (-13% in net OTC volumes) and at the Austrian VTP (-17%), a less steep decline in OTC liquidity occurred for Gaspool (-12%), Zeebrugge (-6%) and NCG (-3%). Increases, however, are shown by TTF OTC trades (+10%) and PSV, which continued to grow at a very rapid rate (36%, although this figure is aided by the relatively low starting level).

The reason for the downturn in OTC volumes may be related to an increase in the cost of OTC trading, possibly associated with new financial regulations.

Figure 2: OTC traded volumes at the main European gas hubs in 2014 and 2015 (TWh, % change 2015/2014)



Source: LEBA

The increasing role of exchanges is also underlined by the increase in cleared trades, that occur when traders 'give up' trading OTC and resort on the exchange to clear the deal to limit the counterparty risk (i.e. these are contracts arranged by the OTC brokers that are registered on the

²⁷ EEX Press Release, 21st September 2015: "Successful launch of Physical Futures contracts for PSV market area", <https://www.eex.com/en/about/newsroom/news-detail/successful-launch-of-physical-futures-contracts-for-psv-market-area/92112>.

²⁸ Source: Conversation with Patrick Heather, OIES.

²⁹ Reuters, 27th January 2015, "CME Group launches six European natural gas contracts", <http://www.reuters.com/article/cme-contracts-gas-idUSL6N0V61YO20150127>; CME "European Natural Gas Futures",

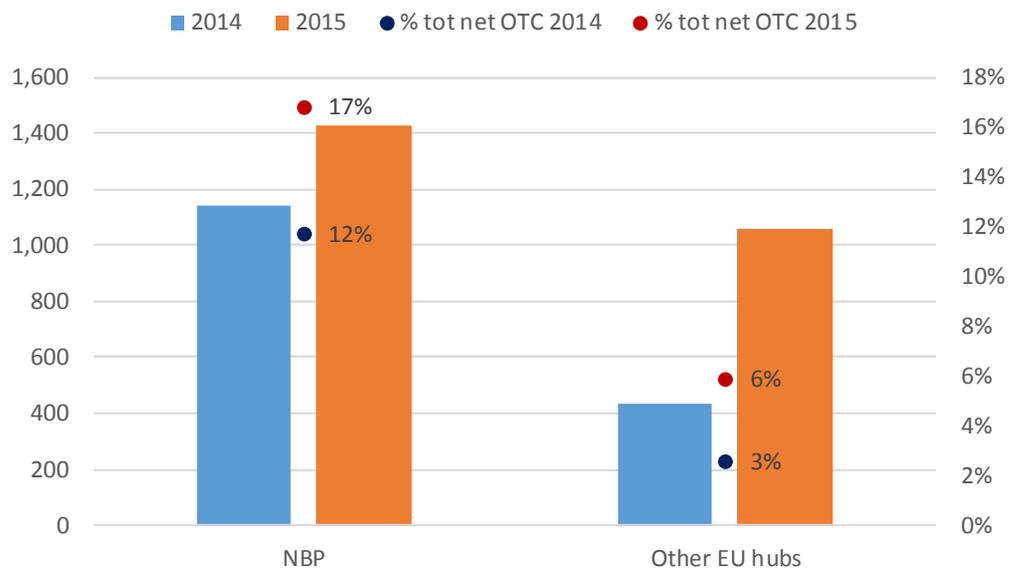
<http://www.cmegroup.com/europe/products/energy/european-gas-products.html>

³⁰ For a review of types of gas contracts offered by each refer to Heather (2015) Appendix F, P.100.

³¹ LEBA = London Energy Brokers Association.

exchange clearing platforms)³². Most of the active exchanges offer clearing services: ICE, ICE-ENDEX, PEGAS and CME. The increase in clearing activity is confirmed also by LEBA data (Figure 3) which show that total cleared volumes increased in 2015 in absolute figures as well as a percentage of total net OTC trades.

Figure 3: Total cleared volumes at the main European gas hubs (TWh, % of total net OTC trades)

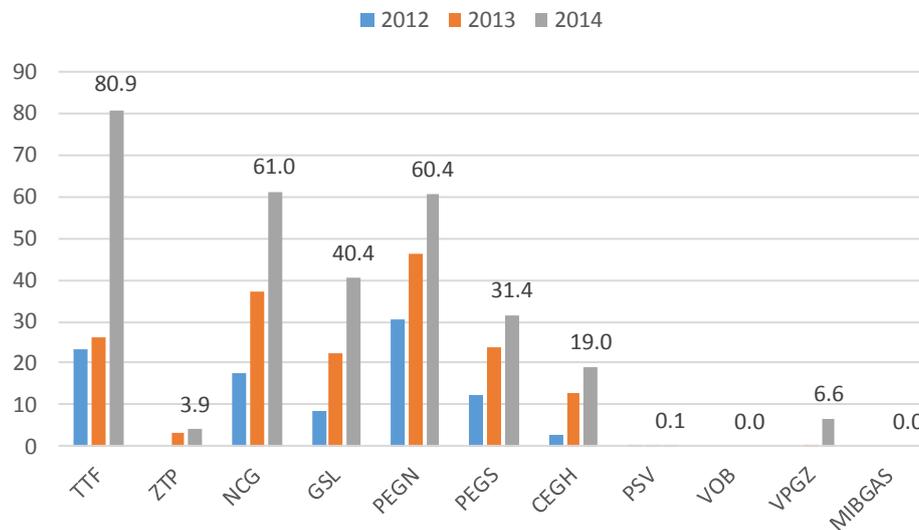


Source: LEBA volume report

Exchanges have also increased their role in terms of short term trading: spot volumes (mostly day ahead volumes) traded on the European gas exchanges have been increasing at a rapid rate since 2012 (Figure 4).

³² Based on Tankard data available to OIES, products that go to clearing are mostly curve trading products, no day ahead contract is cleared.

Figure 4: Spot exchange traded volumes at each considered gas hub (TWh)



Note:

- The euro-quoted virtual hub ZTP, located in Belgium, was created in 2012; trading at ZEE was all OTC in 2013 and 2014
- At NBP, there is no spot exchange trading; although there is a centralized balancing platform (OCM)
- At PSV there is no liquid spot exchange trading; although there is a centralized balancing platform (PBGAS) for trading gas in storage
- At Czech VOB, spot gas exchange launched in May 2015
- At the Polish VPGZ hub, the POLPX exchange started to offer spot gas products with delivery at the Polish hub in early 2013.
- At the Spanish hub, the spot exchange MIBGAS platform was launched in mid-December 2015.

Source: Heather (2015), Appendix O, P.109 and P. 45-46

Recently for some nascent hubs at the European periphery, exchange trading has been successfully established and may have helped to develop hub liquidity.

This is the case for the Czech VOB. It is in fact fair to say that the Czech VOB liquidity, which is in the early stage of development and already had active OTC brokered trading in 2014 accounting for 33 TWh³³, benefitted from the launch of spot exchange contracts by the CEGH exchange in May 2015³⁴. In fact, in the first 8 months of activity on the Czech Spot Exchange, total traded volume for the day ahead product (which is the most traded product) accounted for about 1.2 TWh (similar in size to the OTC day ahead market for PEG South for the whole 2014) and over 800 trades (a day ahead trade was executed almost every other day).

Another interesting case study is the Iberian Peninsula. As argued by Heather (2015) there is “very little or no OTC trading in Portugal and only a relatively small amount of ‘real’ trading at the Spanish virtual hub, the AOC”³⁵. Against this background, the spot exchange MIBGAS platform went live in mid-December 2015, almost two years after its initially scheduled launch of 1 January 2014³⁶; the

³³ As already noted by Heather (2015), Appendix M, P.107.

³⁴ The Austrian Central European Gas Hub AG (CEGH) and the Czech POWER EXCHANGE CENTRAL EUROPE (PXE) launched the CEGH Czech Gas Spot Market on 4 May 2015. The products that can be traded are the following: Day Ahead, Weekend and Weekend Days; these are physically settled product with delivery to the Czech Virtual Trading Point. Future contracts available on CEGH exchange since December 2013.

³⁵ For an excellent discussion see Heather (2015), P.35.

³⁶ Source: ICIS-Heren, 10th December 2015: “Iberian organised gas market launches”, <http://www.icis.com/resources/news/2015/12/10/9952110/iberian-organised-gas-market-launches/>

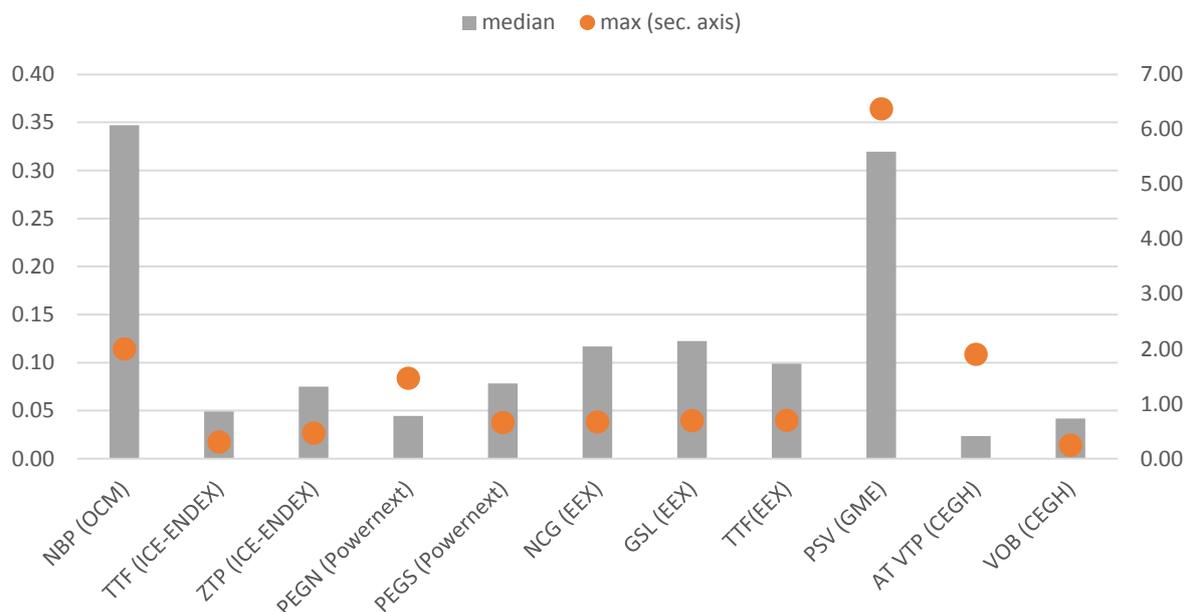
new organized market offers day ahead, within the day, balance of month, month ahead products with physical delivery in Spain; the medium term target is to extend MIBGAS platform's operation to the Iberian market, including Portugal. So far, the activity is very limited but within the industry there is an expectation that exchange trading activity will pick up significantly at the end of the 2016 due the increased penalties for imbalance and the consequent need to balance shippers' positions. This said, since MIBGAS exchange price and volume evidence is too limited for 2015, they are outside the scope of this study.

Finally, liquidity at the Polish hub (Virtual Point Gaz-System, VPGS), may benefit from the activity of the gas exchange (POLPX) which features a trade obligation ('gas release') for the incumbent³⁷. The volume traded on the Day Ahead gas exchange reached over 8 TWh in 2015, almost double the 4.4 TWh traded day ahead on the same exchange in 2014, possibly a consequence of the increase in the minimum quantity that the gas companies have to sell via exchange³⁸.

Section 5. Comparison between exchange and OTC day ahead prices

As expected, day ahead OTC and exchange daily price are almost identical³⁹ in North West Europe: in half of the days considered the absolute difference in daily prices is below 0.10 €/MWh for ZTP, TTF, PEGN, PEGS/TRS; and below 0.15 €/MWh for NCG and GSL. No OTC price data was available for the Polish hub, possibly related to the still limited openness of this market to traders other than the incumbent.

Figure 5: Median and maximum daily difference between OTC day ahead gas prices and exchange day ahead gas prices at each hub in 2015 (€/MWh)



Sources: Tankard Parties, exchanges: EEX, ICE-ENDEX, CEGH, Powernext, GME.

³⁷ For an excellent discussion on the evolution and main obstacles to the development of a liquid Polish gas hub see Heather (2015), P 45-46.

³⁸ Reuters, 3rd December 2013, "Poland's gas exchange chief says new products will fuel growth", <http://www.reuters.com/article/poland-gas-idUSL5N0JJ2BR20131205>

³⁹ The daily difference is computed with reference to daily average prices, whereby the daily average price for the OTC market is computed as the volume weighted average price over all day ahead trades executed in the corresponding trading day; the daily average price for the exchanges is the daily price as disclosed by the exchange operator. Most of the exchange operators publish a daily settlement price, that is a volume weighted average price over day ahead trades executed in a given "settlement window" in the corresponding trading day.

Exchange-OTC daily price differences are also low for the Czech and Austrian hub: the median daily difference is below 0.05 €/MWh. The highest absolute difference between exchange and OTC on a daily basis is the one recorded for day ahead trading at Austrian VTP (on the 5th of February the OTC price exceeded the exchange price by 2.5 €/MWh), followed by the one recorded for delivery at PEGN (on the 9th of February the exchange price exceeded the OTC price by 1.5 MWh). Such occurrences appear to be quite rare though and may be due to low liquidity where a player trades large volumes and chooses an exchange to trade anonymously rather than via OTC (or the contrary) and hence affects the price without sufficient other players to respond sufficiently to arbitrage between the OTC and the exchange markets. Some divergence may be also due to OTC prices being expressed as volume weighted daily average prices and exchange prices being, in most cases, available only as settlement prices. It might be the case that the prices closed in the settlement window at the end of the trading day are significantly different from daily average price for the same day, especially in markets with low liquidity⁴⁰.

As far as the PSV and NBP are concerned, where the exchange day ahead contract for gas is not liquid⁴¹ or not offered⁴², the difference between the OTC day ahead and the balancing platform price (PBGAS G+1 price and OCM system average price respectively) is on average higher and much more volatile. This is due to the special nature of the balancing price, in particular the OCM SAP includes within day and day ahead trades, while PB GAS G+1 price is the result of a system marginal price auction whose bids are submitted in the evening of the flow day and the clearing price is disclosed on the day after the flow day at 11 am.

Section 6. Exchange price correlation

Exchange day ahead prices moved in a rather parallel fashion in 2015, with very narrow price spreads between TTF, NCG, GSL, ZTP, VOB and PEGN (Figure 6). Price convergence seems to be higher during the spring, while in the first two months of the year 2015 prices range over a wider span of values.

From a visual inspection it is apparent that the Polish day ahead price is not structurally correlated to the other hub prices. The absolute difference in price levels between the Polish hub and the adjacent GSL and VOB hubs is significant and volatile.

Further, Austrian and Southern France prices sometimes diverge and feature a premium with respect to the others. For instance, in August and September 2015 the CEGH premium on the adjacent NCG was on average about 0.8 €/MWh compared to an average of 0.4 €/MWh in April- July 2015.

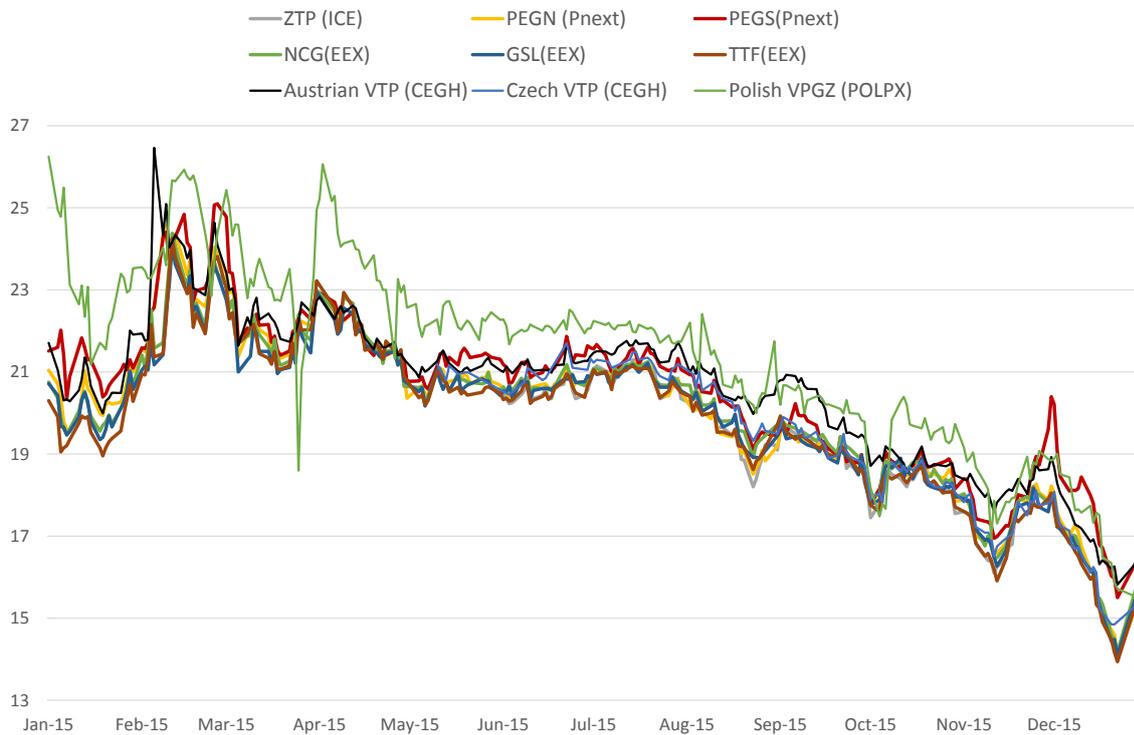
Prices in the South of France were at a premium with respect to the neighbouring PEGN in January and, more remarkably, in November-December 2015. In the last part of 2015, the quotation for PEGS day ahead gas traded at the Powernext exchange, as opposed to all the other exchange day ahead prices, spiked and maintained an average premium amounting to more than 1 €/MWh with respect to the price of gas delivered day ahead in the North of France.

⁴⁰ For an analysis on this point see Petrovich (2014), P.15-17.

⁴¹ The MGP-GAS exchange platform operated by GME, offering day ahead contracts, saw zero trades in 2015: <http://www.mercatoelettrico.org/En/Statistiche/Gas/StatMGP-GAS.aspx>

⁴² Exchanges do not offer day ahead contract with delivery at the NBP.

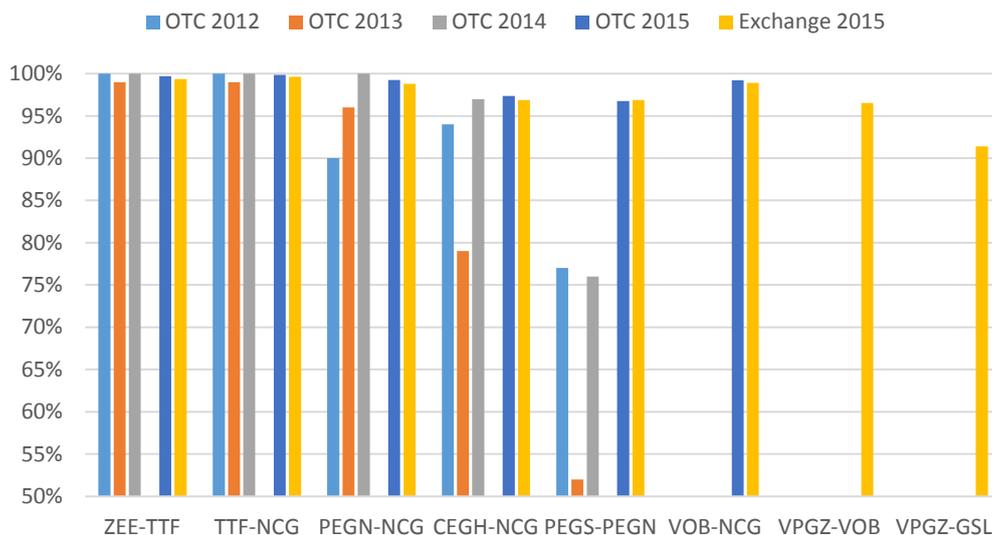
Figure 6: Exchange day ahead prices (€/MWh)



Sources: ICE-ENDEX, Powernext, EEX, CEGH, POLPX

2015 correlation scores for exchange day ahead prices are shown in Figure 7 and compared to the scores computed using OTC day ahead prices for year 2015, and also for previous years.

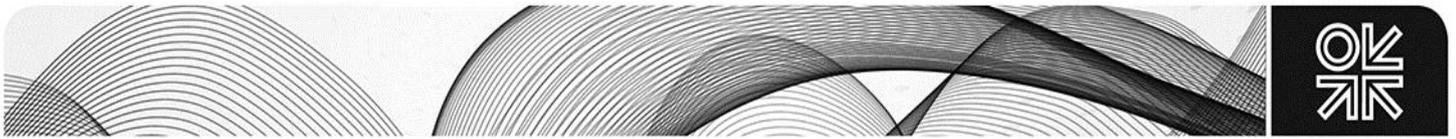
Figure 7: Pair-wise correlation coefficients between OTC day ahead daily prices and exchange day ahead daily prices (%)



Note:

- 100% = perfect positive correlation, 0% absence of any linear relationship
- "Exchange 2015" figure for ZEE in 2015 refers to ZTP exchange prices which are available starting from June 2015 up to December 2015; OTC data for VPGZ not available.

Source: EEX, Powernext, CEGH, POLPX, Tankard Parties



As expected, and consistent with findings in the previous Section, 2015 correlations are extremely close for both OTC and Exchange data for the hub pair comparisons.

The scores show that NCG/GSL/TTF continued in 2015 to be characterized by very high correlation and very low spreads.

Further, in 2015 there is generally good alignment between PEGN and PEGS (which becomes TRS starting from April 2015) and the NCG/GSL/TTF group; however the price alignment between PEGS and PEGN is weaker in December 2015.

The correlation between CEGH/NCG is still not perfect in 2015 and the Austrian gas is priced at a premium to NCG in 2015.

Finally, the Czech gas price is very closely correlated and has very good price convergence to the North West European prices, and in particular to the prices at the neighbouring NCG hub. This is consistent with the fact that the Czech market is physically well connected to Germany and therefore freedom to trade gas has led to price correlation⁴³. The result is also in line with Heather (2015) findings, which were based on the analysis of ICIS Heren price assessments for the month ahead contract for the 2012-2014 period.

Summing up, three cases of exchange price de-linkage were identified using 2015 exchange price data: VOB/GSL-VPGZ de-linkage, PEGS-PEGN de-linkage and NCG-Austrian hub delinkage. Note that the first is markedly more significant than the other two.

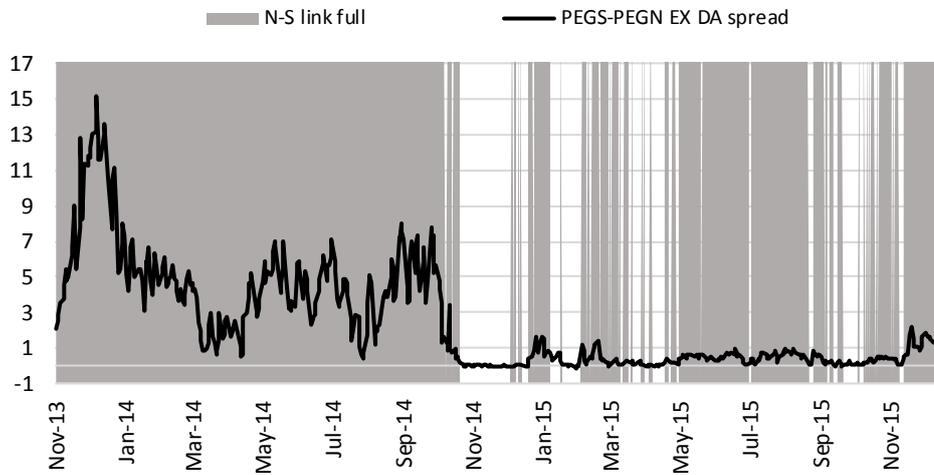
The analysis of cross-border transmission capacity utilization, as already discussed in Petrovich (2015), confirms that the driving factor of PEGS and Austrian hub price misalignment is physical disconnection between the adjacent hubs.

The delinkage between prices in France occurs at times when the physical congestion in the N/S link constrains supply from the North to the South of France (Figure 8). Further, the force behind the misalignment of the Austrian price is related to the persistence of a physical bottleneck preventing more gas to flow from NCG to the Austrian hub, reproducing exactly the same situation observed in 2014, discussed in Petrovich (2015): physical flows from NCG to Austria passing through the Oberkappel IP in 2015 were consistently above the firm technical capacity to exit Germany, which is lower than the corresponding firm technical capacity to enter Austria at the same IP (Figure 9).

The causes of physical congestions in 2015 are addressed in a forthcoming OIES paper by this Author.

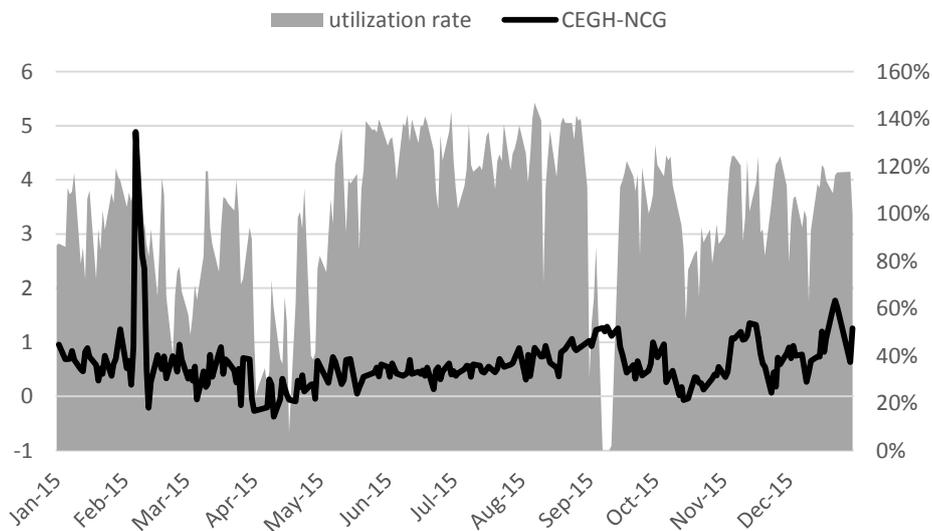
⁴³ This is in line with what we anticipated in the Oxford Forum issue on gas pricing: Oxford Energy Forum, Issue 101, August 2015.

Figure 8: North-South link utilization (%) and exchange day ahead price spread between PEGS (TRS since April 2015) and PEGN (€/MWh)



Note: N-S link full = utilization rate of the link > 90%
 Source: GRTgaz, Powernext

Figure 9: Transmission capacity utilization rate (%) at Oberkappel IP (NCG to Austria direction, exit from NCG) and exchange day ahead price spread between CEGH and NCG (€/MWh)

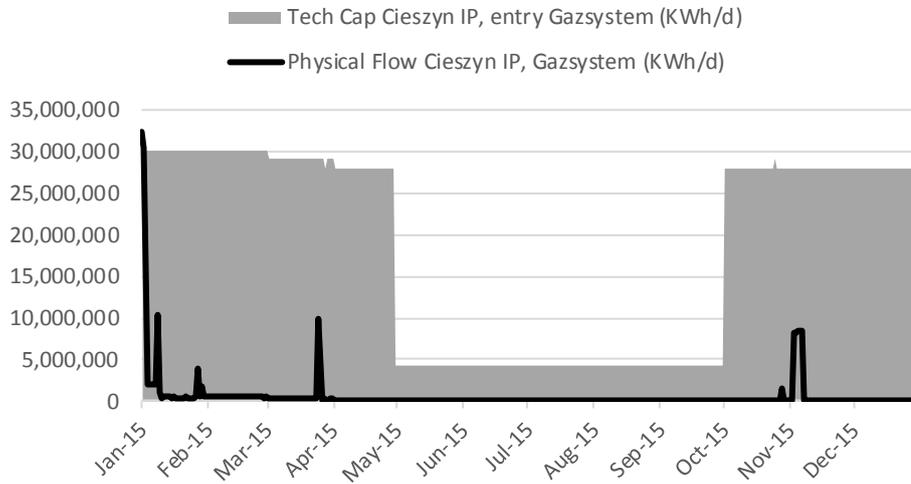


Source: ENTSOG Transparency Platform, EEX, CEGH

The story for the Polish gas price is somewhat different. The trading hub in Poland (VPGZ) is connected to GSL via the Lasów IP and to the Czech hub via the Cieszyn/ Český Těšín IP.

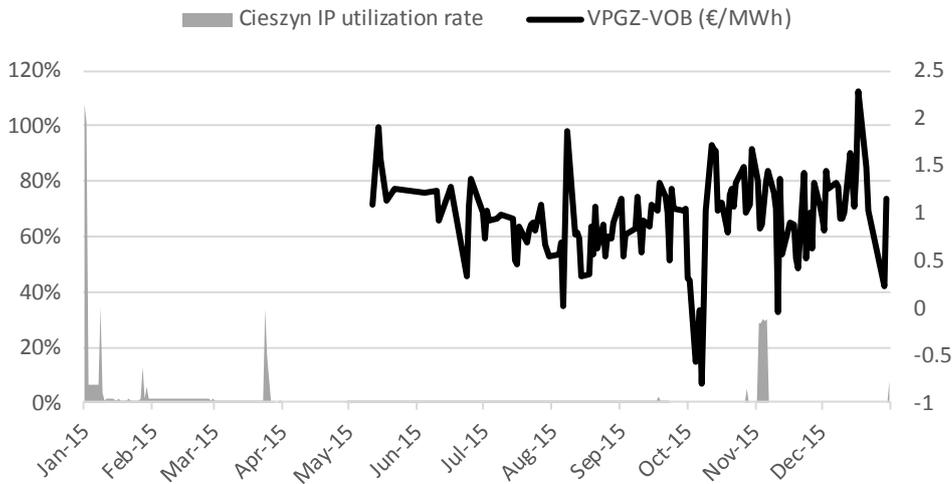
Notwithstanding the premium for day ahead gas quoted on the Polish exchange with respect to adjacent markets and the presence of ample spare cross border capacity (Figures 10-13), gas did not flow from the lower-priced Czech/GSL markets to the higher-priced VPGZ. This may signal the possible existence of non-physical barrier to trade gas across the Czech-Polish border and across the German-Polish border; Polish exchange prices may not therefore be result of supply-demand forces in an integrated European market, but rather the result of local dynamics possibly linked to market power and limited market openness in Poland.

Figure 10: Physical flows and technical capacity at Cieszyn IP (VOB to Poland direction, entry into Poland) (kWh/d)



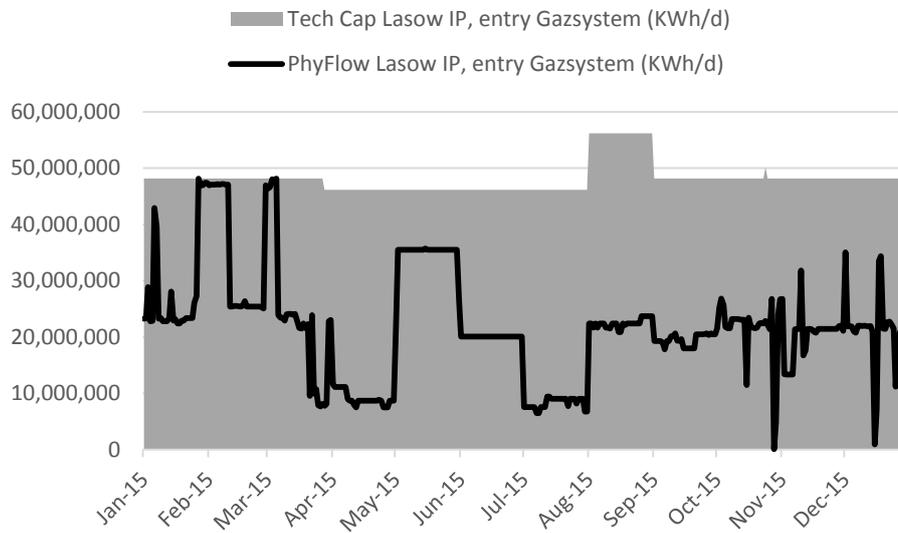
Source: ENTSOG Transparency Platform

Figure 11: Transmission capacity utilization rate (%) at Cieszyn IP (VOB to Poland direction, entry into Poland) and exchange day ahead price spread between VPGZ and VOB (€/MWh)



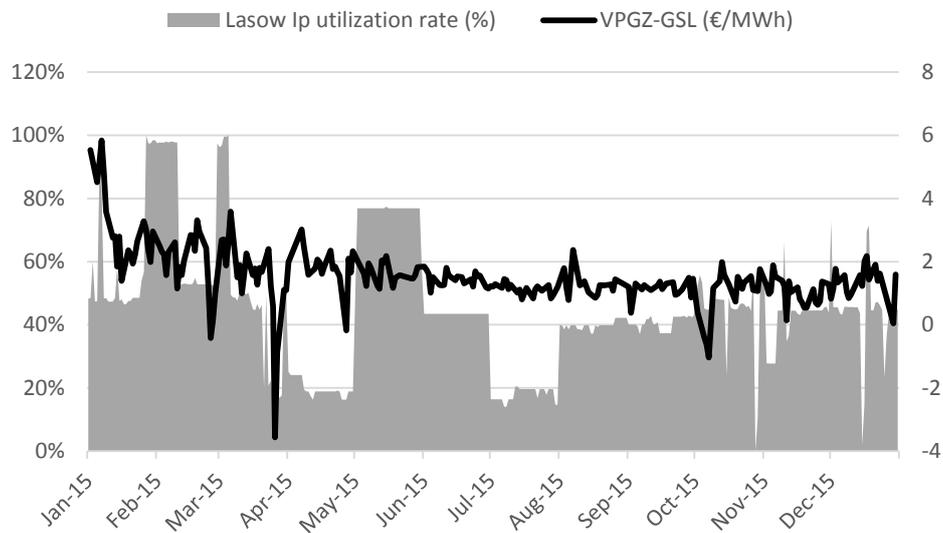
Source: ENTSOG Transparency Platform, CEGH, POLPX

Figure 12: Physical flows and technical capacity at Lasów IP (GSL to Poland direction, entry into Poland) (kWh/d)



Source: ENTSO Transparency Platform

Figure 13: Transmission capacity utilization rate (%) at Lasów IP (GSL to Poland direction, entry into Poland) and exchange day ahead price spread between VPGZ and GSL (€/MWh)



Source: ENTSG Transparency Platform, EEX, POLPX

Section 7. Conclusions

This comment paper assesses whether the main European Energy exchanges provide a reliable price reference for traded gas, in so doing addresses the following research questions:

- 1) Have exchange traded gas volumes grown in recent years throughout Europe?
- 2) Do OTC and exchange prices at the same hub provide the same price signal?
- 3) Do exchange short term prices for gas delivered at different European locations show structural differences? In other words: are exchange prices highly positively correlated and are periods of low correlation (if any) attributable to physical factors?

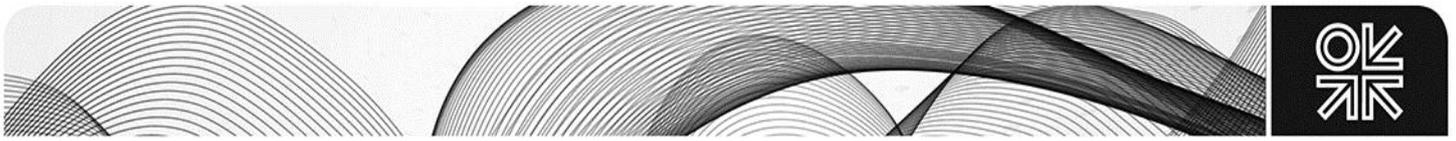
The aim of this paper is relevant as gas exchange trading activity is apparently becoming increasingly important for market players. If exchanges offer reliable price signals, this could foster the development of a mature traded commodity market, with transparent and reliable prices. Well-functioning exchange trading also plays an important role in the design of the gas balancing mechanism as conceived by EU regulation. In this paper, the analysis focuses mostly on spot exchange volumes and day ahead exchange prices, as the day ahead product is the most liquid product traded on European gas exchanges, as well as on the OTC market.

Turning to the first research question, the growing popularity of exchange trading is supported by the fact that exchange liquidity has generally improved in the last three years for all the main gas hubs, despite exchange market size varying from country to country. Lately, for some nascent hubs at the European periphery, spot exchange trading was established as part of a drive to improve liquidity and competition at a hub: this is the case for Czech Republic, Poland and Spain. One visible exception to the positive trend in exchange trading is Italy where, although the Italian market operator GME has been offering exchange contracts ranging from within-day to one-year-ahead, volumes in 2014 and 2015 were still virtually non-existent on the curve and still quite low on the shorter maturities. Although OTC still represents the majority of the traded volumes in Europe, exchange trading has been generally increasing during a period when OTC traded volumes at most of the hubs have been on a slight declining or level path.

The answer to the second question is also an affirmative. As expected, day ahead OTC and exchange daily prices are almost identical, it is very rare to observe significant differences. Exchange prices - though representing relatively small traded volumes- did closely match OTC prices (which represent significantly higher volumes), indicating that transparent and accessible price signals expressed by exchanges can be trusted and used as a market reference.

Turning to the third question, NCG/GSL/TTF continued in 2015 to be characterized by very high correlation and very low spreads. More interestingly, the Czech price is very closely correlated and has very good price convergence to the North West Europe, and in particular to the neighbouring NCG hub. This is consistent with the fact that the Czech market is physically well connected to Germany and therefore freedom to trade gas led to price correlation and prices responding to market forces in Czech Republic. Two cases of weak exchange price de-linkage were identified in 2015: the one between PEGS-PEGN and the one between NCG and the Austrian hub. The analysis of cross-border transmission capacity utilization, as already discussed in Petrovich (2015), confirms that PEGS and CEGH misalignments are due to physical congestion at the connecting infrastructure. The story for the Polish gas price is somewhat different. Notwithstanding the premium for day ahead gas quoted on the Polish exchange with respect to adjacent markets and the presence of ample spare cross border capacity, gas did not flow from the lower-priced Czech/GSL markets to the higher-priced VPGZ. This may signal the possible existence of non-physical barriers to trade gas across the Czech-Polish border and across the German-Polish border; Polish exchange prices may not therefore be result of supply-demand forces of an integrated European/regional market, but rather the result of local dynamics possibly linked to market power and limited market openness in Poland.

To conclude, we can state that most of the European Energy exchanges provide a reliable spot price reference for traded gas, and this holds true also for the relatively young Czech hub, where an active



OTC trading already exists and interconnections to North West European hubs appear to allow price arbitrage. Where hub development was still at a very early stage, as in Poland, or where exchange liquidity was virtually absent in 2015, as in Italy and Spain, exchange prices cannot be used yet as reliable market reference and may be out of line with more developed hubs. However, new interconnections accompanied by rules for market openness, can eventually be expected to produce reliable exchange prices in these markets and to align them with hub prices over the next several years.

Glossary

Broker: a party who intermediates and facilitates bilateral contracts to be concluded between a buyer and a seller.

CEGH: Central European Gas Hub. Here is used both for the Austrian hub and for the exchange operator. For the sake of easy comparison to previous papers by this Author we simply name the Austrian gas hub CEGH. However it should be noted that strictly speaking CEGH is only the name of the exchange operator now, not the name of the trading hub/point, which is VTP. More specifically, with the launch of the new Austrian Gas Act in January 2013, trading within the Austrian market changed from a flange-based system to an Entry/Exit regime and trading activities began to be centralized at the Virtual Trading Point (VTP), which is operated by CEGH. The market operator CEGH offers trading activities and services for different markets: CEGH OTC (over-the-counter) Market, CEGH Gas Exchange Spot Market of Wiener Boerse (Day-Ahead and Within-Day Market), CEGH Gas Exchange Futures Market of Wiener Boerse (Front Month, Quarter, Season, Year), CEGH Czech Gas Exchange in cooperation with PXE (Spot and Futures Market).

Cleared trades/clearing: Term used to indicate OTC bilateral trades that are 'given up' to the exchange for clearing. The counterparty risk is then transferred to the Clearing House.

Contract settlement: Resolution of a contract at its expiry. A contract may be settled through physical delivery, by cash settlement or by settling the payment and "giving up the volume" to an exchange, that is by tendering the quantity of gas on an exchange platform for whatever price it can be sold for.

Correlation: (see Pearson Product-Moment Correlation coefficient)

Day ahead (DA) contract/product: Contract for the purchase or sale of gas to be delivered the day after the trading date.

Delivery/net physical delivery: The moment when a player makes a nomination to the system operator, who in turn uses this input to compute the total volume to be injected/withdrawn into the grid. Nomination is made before gas has to be injected/withdrawn into the grid. In the UK nomination has to be made for gas to be injected/withdrawn into the grid the following day (day *d*). A player nomination is computed by netting off all the traded volumes relating to the day ahead.

EEX (European Energy Exchange): The German energy exchange, providing a market platform for trading in power, natural gas, CO₂ emission allowances and coal.

ENTSOG: association of European gas TSOs.

Exchange trade: Anonymous and regulated trade whereby the buyer and the seller of gas have the exchange operator as a central counterparty operating as a clearing house.

Exchange: the Exchanges are regulated markets where traders are secure in the knowledge that they are governed by the relevant financial regulator in each country and that the clearing house also financially guarantees all of the trades executed.

Financial trade: Trade which is settled without the actual delivery of gas but rather through a cash payment, normally of the difference between the agreed price and the outturn spot price.

Forward/future gas contract: Contract for the purchase or sale of gas to be delivered on a future agreed date (delivery date).

GFT: Danish Gas Transfer Facility, the Danish gas hub.

GME (Gestore Mercati Energetici): Italian energy exchange. It is the company established by Gestore della Rete di Trasmissione Nazionale S.p.A. (now Gestore dei Servizi Energetici-GSE S.p.A.) with the mission of organising and economically managing the Electricity Market; Law no. 99 of 23 July 2009 also assigned to GME, on an exclusive basis, the organisation and economic management of natural-gas markets, namely the Platform for the trading of natural gas (P-GAS), the Gas Market (MGPGAS and MIGAS) and the Gas Balancing Platform (PB-GAS). On 2 September 2013, GME also took over the management of physical forward gas markets (MTGAS).

Gross traded volumes (traded volumes): The total gas amounts that are traded on each hub which are usually a multiple of the physical quantity that is actually delivered on the grid. Traded volumes

can exceed consumed physical volumes in a commodity market as quantities can be bought and sold many times prior to delivery.

GSL: Gaspool, gas hub based in Germany.

GTM (Gas Target Model): Conceptual model for the single European gas markets originally developed by CEER in 2011, and updated in 2015.

Hub (gas hub): A virtual or physical location within the grid where the exchange of gas volumes takes place. In fact a gas hub is a market for gas, where the commodity is traded on a standardized basis between market participants. In this paper each hub represents a different price area.

ICE-ENDEX: energy exchange in continental Europe, which offers a regulated spot, futures and options trading platform, as well as gas balancing markets and gas storage services.

Interconnection Point (IP): Means a location, whether it is physical or virtual, between two or more EU Member States as well as between two adjacent entry-exit-systems within the same Member State, where the pipeline systems of the two adjacent Member States or entry exit systems join.

kWh: A unit of energy equivalent to a Kilowatt of power for the duration of one hour.

LEBA volume report: Regular monthly volume report covering the main gas, power, coal and emission markets, published by LEBA. LEBA volume data are available from January 2011.

LEBA: The London Energy Brokers' Association, is the industry association representing the FSA regulated wholesale market brokers in the over the counter (OTC) and the exchange traded UK and liberalised European energy markets. The major products that they deal in include crude oil and refined petroleum products, gas, electricity and emissions.

MIBGAS (Mercato ibérico del Gas): Spanish gas exchange which came online in December 2015

Month ahead (MA) or front month contract/product: Contract for the purchase or sale of gas to be delivered in the month after the trading date.

MWh: A unit of energy equivalent to a Megawatt of power for the duration of one hour.

NBP: National Balancing Point, gas hub based in Great Britain.

NCG: Net Connect Germany, gas hub based in Germany.

OTC (over the counter) trades: Bilateral non-regulated trade however involving standardized physical and financial deals. Such trades are based on standard agreements defining the point of delivery for gas along with other technical and legal terms. They can be for standard volumes of clip sizes of gas and multiples thereof.

Pearson Product-Moment Correlation coefficient (Pearson coefficient, r): Statistical metric which measures the strength of the linear relationship (linear correlation) between two data series. The correlation coefficient always takes a value between -1 and 1, with 1 or -1 indicating perfect correlation (all points would lie along a straight line in this case). A positive correlation indicates a positive association between the variables (increasing values in one variable correspond to increasing values in the other variable), while a negative correlation indicates a negative association between the variables (increasing values in one variable correspond to decreasing values in the other variable). A correlation value close to 0 indicates no association between the variables.

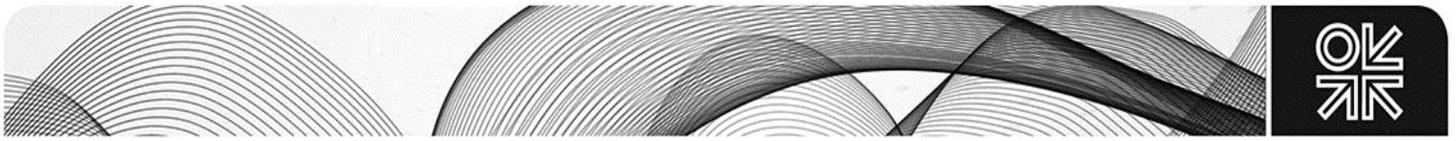
PEGAS: shared platform that became fully operational on 1st January 2015 where EEX and Powernext market each other's contracts.

PEGN: Point d'Echange de Gaz Nord (Peg North), gas hub based in the North of France, coinciding with GRTgaz network.

PEGS: Point d'Echange de Gaz Sud (Peg South), gas hub based in the South of France. On April 1, 2015, the PEG TIGF and PEG Sud hubs merged to form a single gas hub to be named Trading Region South (TRS).

PEGT: Point d'Echange de Gaz TIGF (Peg South), gas hub based in the South of France. On April 1, 2015, the PEG TIGF and PEG Sud hubs merged to form a single gas hub to be named Trading Region South (TRS).

Physical trade: Trade which is settled at expiry by the actual delivery of gas.



POLPX: Polish gas exchange which operates commodity exchange for trade in electricity, natural gas, emission allowances, property rights arising under the certificates of origin, property rights other than financial instruments, property rights arising under the energy efficiency certificates.

Powernext: the French energy exchange. Powernext SA is a regulated market operating under AMF supervision. Powernext manages the natural gas activities of the EEX Group under the PEGAS brand throughout Europe, and operates the National Registry for electricity guarantees of origin in France.

Price correlation: When prices move closely in parallel over time.

Price de-linkage: Period of low price correlation.

PSV: Punto di Scambio Virtuale, the Italian gas hub.

Tankard Parties: Tankard is an industry initiative created and developed by ICAP Energy Limited (ICAP), Marex Spectron Group (Marex Spectron) and Tullett Prebon Group Limited (Tullett Prebon).

Transmission System Operator (TSO): the company responsible for transmission system operation. Some countries have one gas TSO, others have several TSOs.

TRS: Trading Region South, French hub located in the South of France. On April 1, 2015, the PEG TIGF and PEG Sud hubs merged to form a single gas hub to be named Trading Region South (TRS).

TTF: Title Transfer Facility, gas hub based in the Netherlands.

VOB (Virtuální Obchodní Bod): Czech gas hub

VPGS (Virtual Point Gaz-System): Polish gas hub

WAP: Weighted average price.

ZEE: Zeebrugge, gas hub based in Belgium.

ZTP: Zeebrugge Trading Point. The Belgian entry-exit transmission model offering title trading.

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