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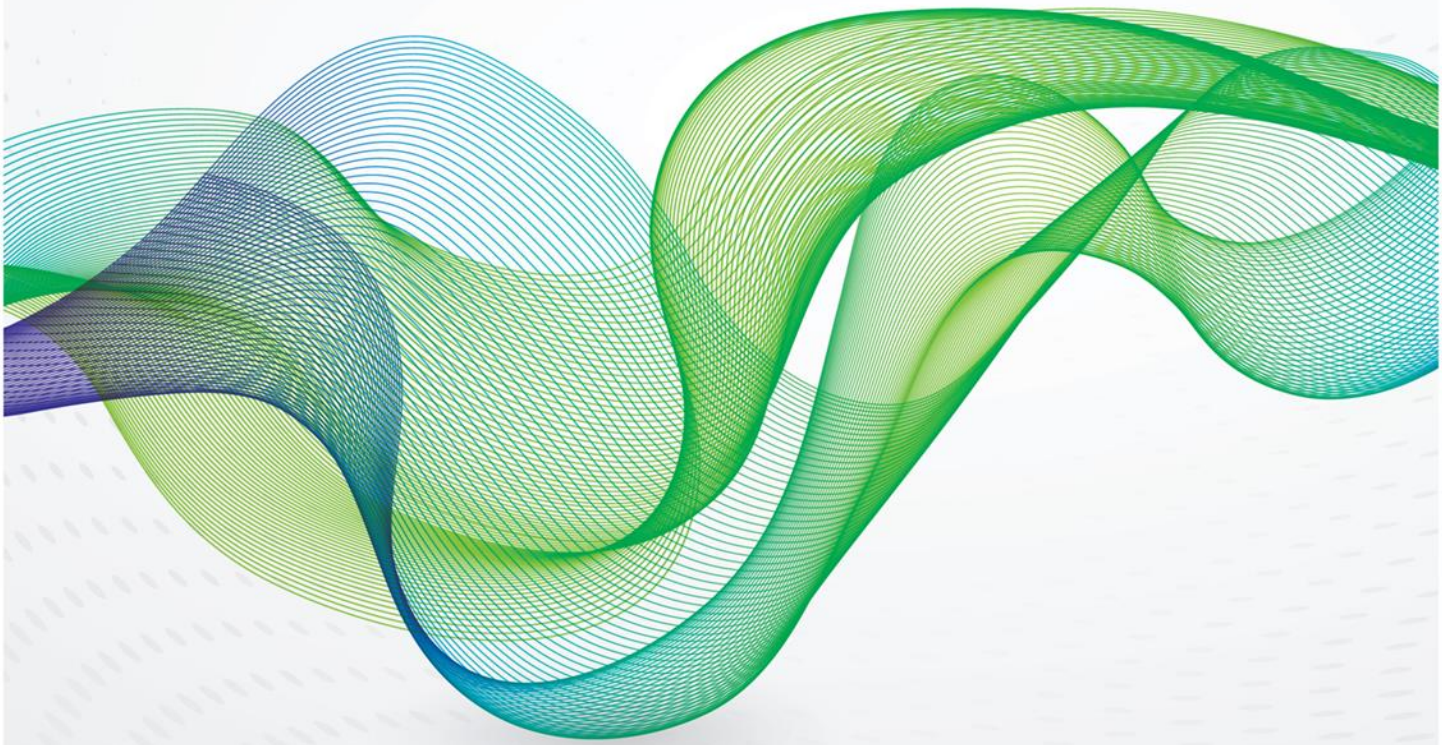
European Traded Gas Hubs: their continued relevance



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Executive Summary

The European gas markets have experienced a very turbulent ride over the past three years which has resulted in a severe readjustment of the European traded gas markets. There have been ongoing political and energy industry debates regarding not just the future of natural gas in the energy mix, but also how to resolve the immediate problem of 'replacing' Russian gas for Europe's demand needs now and for the next few years?

Politically, there have been a number of interventions suggesting that the traded gas markets and the Dutch Title Transfer Facility (TTF) hub in particular, are no longer representative of the price of natural gas in the grid.

The purpose of this Paper is to analyse the results of the trading data in 2022 for the European traded gas hubs, in order to be able to assess whether these hubs continue to be relevant, or not, in the pricing of long term physical gas contracts? It will look at the TTF in particular, as this hub has for several years now been the most liquid by far in Europe, and has been widely used as the reference price for physical wholesale gas contracts.

Despite the extreme trading conditions over the past 2 years, trading across all the European hubs has remained relatively buoyant and very much in line with the underlying physical volumes in each country. When comparing the 2021/22 year on year difference, all countries had lower total traded volumes, except for Germany, France, Belgium (ZTP), Spain, and Bulgaria.

From the summary of the 5 Key Elements, TTF is now the only mature 'tier one' hub. NBP went from mature to an active 'tier two' hub in 2021 and has remained there in 2022. There is then a progressive drop in scores for the next three active hubs - THE, TRF, and VTP;

Of the four poor 'tier three' hubs the PSV slipped lower in both 2021 and 2022 to just 7/20; the ZTP improved 3 points to 7/15; the PVB has dropped 2 points from its 2020 and 2021 scores; and finally in this category, the VOB has eased just one point from its 2020 and 2021 scores.

The very poor relation of the European hubs in 2022 was the Belgian ZEE hub, which is now in the new inactive 'tier four' category with a score of just 1/15. The remaining European hubs are all classed as inactive.

This leads to the question whether traded gas hubs, and the TTF in particular, are still relevant today and can genuinely provide a reliable representative price of the gas flowing in the grids? Of course, the most important function of the hubs is to provide a safe and effective means of balancing the high pressure network. There is no doubt that they all do perform this role.

The question then is whether any of the European hubs can provide reliable pricing signals and provide the means by which market participants can risk manage their portfolios?

From the analysis carried out in this paper, there is no doubt that several of the European hubs do provide the right pricing signals in their respective markets, and even provide the ability for market participants to risk manage some of their portfolio exposures.

TTF has become a contract that is highly liquid and which has, since the 2010s, been used to price physical contracts not only in its own Market Area but much wider, across the neighbouring west-European countries, and some other European countries as the reference price used in physical supply contracts; and even globally as the reference price used in a number of LNG contracts.

On the ICE exchange the TTF contract can be traded up to 13 years forward, which is comparable to the crude oil market, and therefore can reliably indicate a price curve into the future. These gas forward curves are used to price and evaluate large projects with regard to potential price exposure and returns, in the same way that oil forward curves did when there was oil indexation in gas contracts. Crucially, the big difference is that they should necessarily reflect the supply/demand structure of the gas market, and not that of oil transposed to gas.

In response to the EU's gas market correction mechanism, which would prevent trading above a certain price, the ICE exchange launched parallel Dutch TTF futures and options contracts on its ICE Europe platform based in London in February 2023 and will serve as a back-up for all market participants currently using the ICE Endex platform based in the Netherlands.

This will no doubt give great reassurance to all gas market participants as to the reliability of the TTF contract and will firmly see it continue as the reliable benchmark on which to price LTCs, including LNG contracts. Indeed, this appears to already be happening: in the first five months of 2023, the ICE exchange has reported having record market participation in both the TTF futures and options contracts, with the traded futures volumes rising 17% yr/yr, traded options volumes rising 179% yr/yr, and open interest rising 68% yr/yr.

On a global level, the analysis shows that the TTF is truly *the* leading pricing benchmark for North-West Europe and indeed many other European countries also, as well as being used to price some LNG cargoes destined for Europe. It has become an investment asset class in its own right and there are signs that it has become a global benchmark too.

The final conclusion of this paper is that all European traded gas hubs are most definitely still relevant, if only to enable the safe and efficient balancing of the gas grids; but they can also be much more than that. Some are relevant for actual local market pricing, whether wholesale or retail, and possibly for limited (mainly short term) risk management purposes.

The Dutch TTF though is all those things, and is also used by a great many market participants, from all around the world, as a reliable price marker for several surrounding European countries, as well as on a wider scale across Europe, and even globally.

Yes, the TTF in particular does continue to be relevant in the pricing of long term physical gas contracts and, yes, it is still representative of the price of gas in the Dutch, and wider European, grid network at any given time and, yes, this Author believes that it will continue to be so.

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1. Introduction

The Author has been following the development of the European traded gas hubs over many years and has already published a number of Papers and Insights on the subject.[1] He is now also following the development of traded gas markets in Asia and the relative importance of global gas pricing benchmarks.

The European gas markets have experienced a very turbulent ride over the past three years: firstly, the demand for gas was greatly reduced by the global Covid-19 pandemic of 2020 then, as global demand started to rise again in mid-2021, prices started to rise to unprecedented levels[2] followed, in early 2022, by the Russian invasion of Ukraine; these factors[3] directly or indirectly led to a series of events that resulted in a 56% drop[4] in Russian pipeline gas supplies to Europe.[5] Russian pipeline supply is likely to fall even further during 2023, as estimated from the actual flows in Q1-2023 and early Q2-2023, and could be as low as just +/-20bcm for the full year.[6] Furthermore, all this has been happening against the backdrop of the ongoing debate about the Green Transition and the potential phasing out over time of all carbon sources of energy, including natural gas.

These events resulted therefore in a severe readjustment of the European traded gas markets, at all levels from international trade, to European wholesale and retail sectors too. There have been ongoing political and energy industry debates regarding not just the future of natural gas in the energy mix, but how to resolve the immediate problem of 'replacing' Russian gas for Europe's demand needs now and for the next few years?[7]

Politically, there have been a number of interventions and in particular by EU Commission President, Ursula von der Leyen[8], and US President Biden[9] suggesting that the traded gas markets, and the Dutch Title Transfer Facility (TTF) hub in particular, are no longer representative of the price of natural gas in the grid; furthermore, the US is willing to supply Europe with more Liquefied Natural Gas (LNG)

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[1] All of which are listed in the Bibliography and are available to download from the OIES website: https://www.oxfordenergy.org/authors/patrick-heather/

[2] For a detailed explanation of the action and reaction in the traded gas markets, see Heather (2022).

[3] For a detailed explanation of European gas demand, see Honoré (2020) Pandemic effect, Honoré (2022) high prices impact, Honoré (2023) Ukraine war result.

[4] Total Russian pipeline supplies to Europe were 142bcm in 2021 and 63bcm in 2022 (source: ENTSOG Transparency Platform). See the OIES Quarterly Gas Reviews for more detail, in particular, QGR-20 (January, 2023), Figure 1.3, p.5.

[5] For a detailed explanation of the six factors that caused Russian gas flows to decline in 2021 and 2022, see Sharples (2022), pp.2-7.

[6] See QGR-21 (April 2023): Figure 1.4, p.6 and last paragraph p.8.

[7] For a detailed review of the demand/supply balance of natural gas in Europe, see Fulwood, Honoré, Sharples (July 2022).

[8] See CNBC report, 14th September 2022, 'EU chief von der Leyen promises overhaul of energy markets, tax on fossil fuel profits': https://www.cnbc.com/2022/09/14/eu-chief-von-der-leyen-promises-overhaul-of-energy-markets.html
Reporting on President von der Leyen's annual State of the Union speech, delivered at the European Parliament, CNBC wrote that:
"In her annual State of the Union speech, […] von der Leyen also said there had been a shift from pipeline gas to increased use of liquefied natural gas, but the benchmark used in the gas market, TTF, had not adapted"; and
"She said the commission would work on developing a more representative benchmark for trading that reflects this change, and also ease liquidity pressures on energy suppliers by amending rules on collaterals and taking measures to limit intraday price volatility".

[9] See Whitehouse Press Release, 25th March 2022, 'Joint Statement between the United States and the European Commission on European Energy Security': https://www.whitehouse.gov/briefing-room/speeches-remarks/2022/03/25/remarks-by-president-biden-and-european-commission-president-ursula-von-der-leyen-in-joint-press-statement/
The press release reports President Biden as stating that:
[The US is*] helping Europe reduce its dependency on Russian gas as quickly as possible*; and
[The US is] *going to work to ensure an additional 15 billion cubic meters of liquefied natural gas — LNG — for Europe this year* [2022].

deliveries in order to counter the dependence on Russian pipeline supplies, and it is this change from pipeline to LNG supplies that purportedly makes the TTF unrepresentative.[10]

The purpose of this Paper is not to analyse or comment on these political statements,[11] which are set out here in summary to explain its main reason, which is to analyse the results of the trading data in 2022 for the European traded gas hubs, in order to be able to assess whether these hubs continue to be relevant, or not, in the pricing of long term physical gas contracts? It will look at the TTF in particular, as this hub has for several years now[12] been the most liquid by far in Europe, and which has been widely used as the reference price for physical wholesale gas contracts.

2. An overview of the European traded gas hubs

Map 1 shows all the European gas hubs[13] that were operational at the end of 2022. The colour scheme indicates which hubs are categorised[14] as 'Mature', 'Active', 'Poor' and 'Inactive'. There is now just one Mature hub, the Dutch TTF; the British NBP lost it's 'mature' status in 2021 and is now classified as Active, alongside three other hubs, the German THE, the French TRF, and the Austrian VTP; and three Poor hubs, the Italian PSV, the Spanish PVB, and the Belgian ZTP; all of the remaining hubs are classed as Inactive, and now also include the Belgian ZEE.

Map 1: European gas regions, markets and hubs: 2022

[10] Although the shift from pipeline supplies to LNG was the underlying cause but much of the actual price rise was also due to infrastructure constraints in getting the regasified LNG into the national grids and across borders, especially into Germany. For a full account of the infrastructure constraints, see Fulwood (September 2022).

[11] For an analysis on the European Commission's proposals to cap the price of TTF, see Fulwood (October 2022).

[12] The Dutch TTF hub overtook the British NBP in terms of total traded volumes in 2016 and, in 2022, represented very nearly 76% of all European traded gas volumes.

[13] Appendix 11.1 lists all of the European gas hubs, their name and year of inception.

[14] As defined by the Author, following his 5 Key Elements analysis; see Chapter 3.1 of this Paper.

The Portuguese virtual hub (PVN[15]) became operational during 2021 and has started to trade some balancing and short term volumes on the exchange. This means that virtually all of Europe does now have a virtual hub, although some still trade very little volumes, in particular Croatia and Slovenia.

There is no traded market as such in Croatia, no OTC trading and no exchange trading. Balancing is performed by the Transmission System Operator, Plinacro, having received any balancing offers from 'Balance Group Leaders', through the intermediary of the Croatian Energy Market Operator (CEMO).[16]

In Slovenia, a virtual trading point was established in late 2015 "for exchanging natural gas quantities on the Slovenian transmission system, which also comprises the services of a Trading Platform and Bulletin Board, all of which have been made jointly accessible to the users of the system through a web application".[17] However, the Author was unable to find any sources referring to actual trading, whether OTC or Exchange, balancing, spot, or curve trading.

In the Baltic States, the vision of creating a single Baltic Market Area has faltered: following the merger of the Latvian and Estonian hubs into one Market Area, Finland joined them in a single entry-exit system in January 2020, albeit with a separate balancing zone and with certain rules, contracts, invoices and billing; a decision for full integration has still not been taken. Lithuania has not yet joined the grouping, despite previous statements saying that it wished to, because it is not ready to join on the same terms and conditions as were agreed by Finland, Estonia and Latvia.

In Greece, the HEnEx[18] gas platform finally went live in March 2022 and recorded 2.87TWh of spot trades; there is still no OTC trading recorded in Greece.

Despite the extreme trading conditions over the past 2 years, trading across all the European hubs[19] has remained relatively buoyant[20] and very much in line with the underlying physical volumes[21] in each country. All countries had lower total traded volumes compared to 2020, except for five (France, Belgium (ZTP), Spain, Hungary, and Bulgaria), of which all but Hungary had higher physical volumes too. When comparing the 2021/22 year on year difference, all countries had lower total traded volumes, except for five (Germany, France, Belgium (ZTP), Spain, and Bulgaria), of which all but Germany also had higher physical volumes.[22]

At a European level, there was a large 45% decrease in OTC trading and a small decrease (just 2%) in exchange futures and options trading; exchange spot trading saw a massive rise of 66%. However, there were some wide variations from country to country: apart from the three countries[23] that do not report any OTC trades, the drop in OTC trading varied from -4% in Britain, to c.-40% in Germany, Czech Republic, France, Denmark, and Hungary, and to -85% in Slovakia.

Every country, except three,[24] saw an increase in spot trading, from just +5% in Italy, to +89% in the Netherlands, and +97% in Spain.

More detail will be given in Chapter 3.2 below but the Dutch TTF is still firmly ahead of all the other European hubs, in every criterion reviewed in the 5 Key Elements.

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[15] Ponto Virtual de Negociação (PVN).
[16] Balance group leaders deliver balancing energy offers to the Croatian Energy Market Operator (CEMO).The CEMO prepares a balancing energy offer list on a daily basis and delivers it to the transmission system operator. The transmission system operator uses offered balancing energy volumes when necessary, respecting the order specified in the delivered list. For more information, see: https://www.plinacro.hr/default.aspx?id=603
[17] An outline of the balancing and virtual hub services can be found on the TSO website: https://www.plinovodi.si/en/network-access/
[18] Hellenic Energy Exchange S.A.: https://www.enexgroup.gr/web/guest/energy-markets
[19] Fifteen countries surveyed: GB; NL; DE; FR; BE; AT; IT; CZ; ES; DK; PL; RO, HU; BG; SK.
[20] Total volumes, including OTC and exchange spot and futures trades: 57,010TWh, a fall of 15% on the previous year.
[21] Total physical volumes: 6,996TWh, a fall of 12% on the previous year.
[22] All the traded (OTC and Exchange) and physical (net and gross) volumes appear in summary table 11.2 in the Appendix.
[23] Poland, Romania, Bulgaria.
[24] Spot volumes were unchanged in Denmark, 15% lower in Hungary, and 31% lower in Poland.

3. Review of the 5 Key Elements in 2022

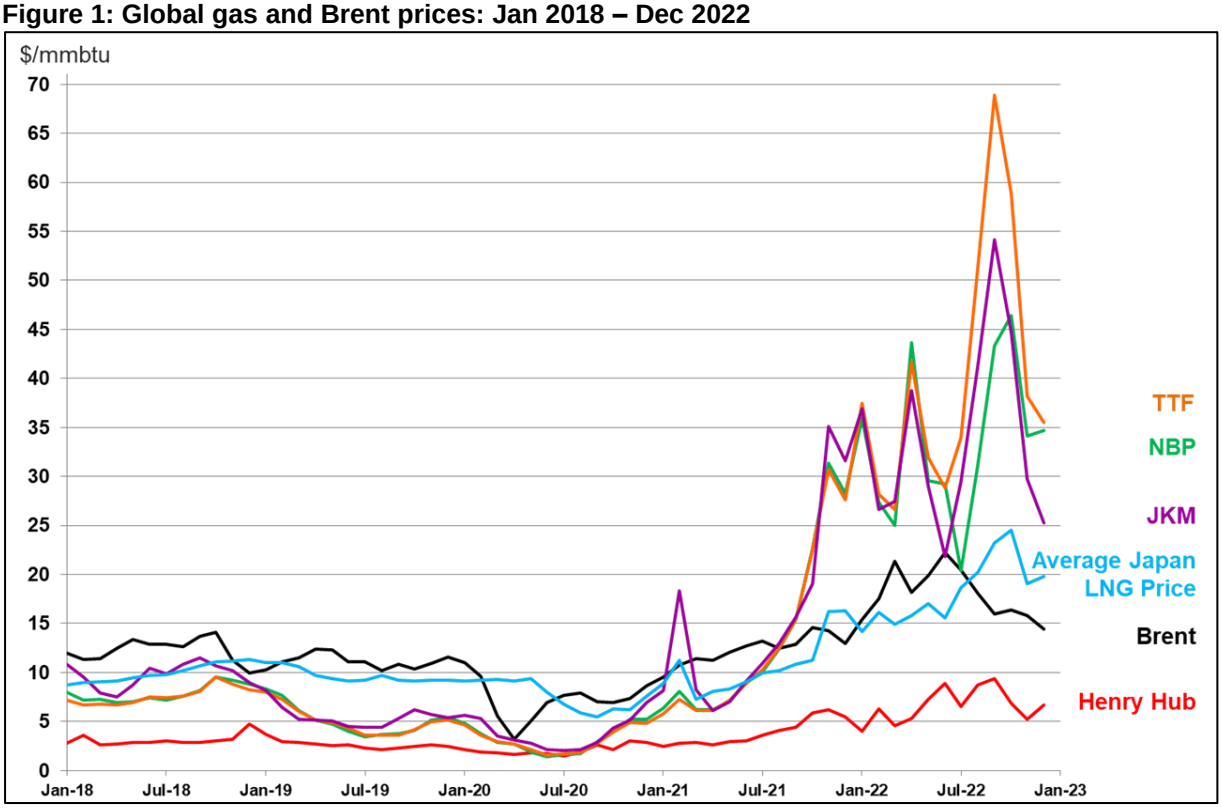
Before we review the 5 Key Elements pertaining to European gas trading, it is useful to place European gas in the context of its global equivalents, and the crude oil market.

The Covid-19 pandemic, the ensuing energy 'crisis' that started in summer 2021, and the war in Ukraine in 2022 all contributed to a disruption in the global economies generally; this quickly led to higher commodity prices, including agri-commodities, metals, and energy, especially the price of natural gas.[25]

Market volatility was extremely high in the gas market[26] although somewhat less so in the crude oil market. This did create some temporary distortions in the market but, by the end of 2022, they appear to have largely been ironed out, for now at least.

Figure 1 shows the relevant global gas and Brent oil prices over the five year period from January 2018 to December 2022. Although the period from 2015 is not shown here to give better clarity, in the six years to the end of 2020, there was a gradual convergence of hub prices, including JKM, whilst oil and oil indexed prices remained mostly dearer; then came the summer 2021 price surge and the 2022 war in Ukraine that saw that convergence tested.

Figure 1: Global gas and Brent prices: Jan 2018 – Dec 2022



Sources: S+P Global Platts, EIA, Argus, CME; M. Fulwood, P. Heather

The gas hub prices of TTF, NBP, and JKM were all aligned in their volatile price moves but the LNG long term contracts that were mainly oil indexed followed the less aggressive rise in the crude price, and eased back lower in 2022, albeit with a time lag.

[25] For a detailed explanation, see Heather (2022).
[26] Ditto.

The North American gas benchmark, Henry Hub, did also see a sustained price rise from July 2021 onwards, even more than doubling in price, but of course, this was from a much lower base price; the primary reason for the increase there was due to the rapid increase in demand for US LNG.

It is clear from Figure 1 that the oil price has continued to ease lower and that the hub prices fell sharply from Q4-2022; this has continued into 2023.

The extreme gas market volatility and the exceptional, unprecedented, high gas prices following the energy crisis and the war in Ukraine have necessitated a total 'rethink' of gas imports into Europe, with flows from Russia decreasing by 56% last year: there have been some additional pipeline supplies from existing suppliers such as Norway and Algeria, but there has also been a substantial increase in extra LNG imports, as well as the construction of new LNG import capacities; these are examined in Chapter 4 below.

This, as well as the Belgian ZEE and Czech VOB hubs recording lower traded volumes in 2022, and some of the emerging hubs significantly increasing their volumes, has led the author to rethink the methodologies used in his analysis of the 5 Key Elements.

3.1 A note on methodology

The new methodologies will be more precise and will help the reader better understand the variations in maturity and development across the now many traded gas hubs in Europe. These have been applied to the data from 2021 onwards.

The main difference is the addition of a new 'lowest' category in each of the elements, represented by a pale brown colour, to the previous 'traffic light' Green, Amber, Red colours in the tables: the full methodologies are shown in footnotes to each of the tables.

As previously, each Element will have its own scores, and then they will be amalgamated in the Summary of the 5 Elements, in order to determine the overall ranking, which will also have a revised lowest banding that will determine the 'Inactive' hubs.

For Key Element 1 'Active Traders', the new brown category will be where the number of active traders is less than 10, and if the hub score is less than 10.

For Key Element 2 'Traded Products', the new brown category will be where the hub score out of a total of 56, is less than 8.

For Key Element 3 'Traded volumes', the new brown category will be where the total traded volumes are less than 100TWh.

For the 'Traded volumes - emerging hubs', the same methodology will now apply.

For Key Element 4 'Tradability Index', the new brown category will be where the score is less than 5/20.

For Key Element 5 'Churn rates', the new brown category will be where the net or gross churn is less than 1.

The Summary of the 5 Key Elements table will show the new colour scheme for each of the elements and there is a slight change to the two lowest categories: 'Poor' hubs will now be for scores of 4-7/15 (previously 5-7/15), shown in amber on the Map; and 'Inactive' hubs will now be for scores of 1-3/15 (previously 1-4/15), shown in red on the Map.

3.2 Results of the 5 Key Elements in 2022

Following the tumult in traded gas markets in 2021, trading activity returned to more normal conditions in 2022. This meant that having seen a large fall in market participants in 2021 most returned to trading in 2022 and in many markets exceeded the number trading in 2020. Table 1 shows the number of 'active'[27] participants at each of the selected hubs; the more active participants there are, the more liquidity there will be in a market. The methodology recognises the importance of curve trading over spot, as it is this that is most often used to risk manage a participant's portfolio and to hedge physical contracts.

In 2022, all but the British NBP (-11%) and Belgian ZEE (-35%) hubs saw an increase in market participants. For Britain, this is despite the significant increase in LNG imports but could be seen as simply a mitigating factor in slowing the decline of this once Mature hub.

Once again, the Dutch TTF is way ahead of all the other hubs with a calculated 'score' of 275, but also with almost as many 'active' curve traders as there are spot/prompt traders, the only hub with this characteristic; as the other Key Elements will show, TTF is by far the leading gas hub in Europe and attracts not only physical traders but financial, institutional and speculative traders also.

Table 1:[28] Key Element 1: Market participants: 2022

2022	OTC Active Traders*				
HUB	Hub Score^		S/P/M**	Q/S/Y***	Hub Score^
	2020	2021	2022	2022	2022
TTF	225	164	95	90	275
THE (NCG up to 2020)	126	110	81	53	187
NBP	166	142	61	33	127
VTP	110	70	55	35	125
GPL	99				
TRF	46	40	50	33	116
PSV	112	92	40	28	96
ZTP	32	26	35	21	76
PVB	55	45	20	16	52
VOB	41	27	20	15	50
ZEE	45	20	9	2	13

*** The estimated number of traders who regularly trade.**
**** Spot / Prompt / Months contracts; *** Quarters / Seasons / Years contracts.**
^ Hub score calculated as (1xS/P/M) + (2xQ/S/Y).

Sources: 2020: based on survey results from 2 traders (large companies) and 2 brokers;
2021: based on conversations with 3 market participants (very difficult to get responses given the market conditions);
2022: based on survey results from 3 market participants, with 1 broker input.

[27] The criterion used in the survey is how many traders trade at least once per week; the spot/prompt includes the Month Ahead contract.
[28] The methodologies used in this table are: (S/P/M): Green: =/>60; Amber: <60; Red: <25; Brown: <10; (Q/S/Y): Green: =/>20; Amber: <20; Red: <10; Brown: <5; (Hub) : 1xSPM/2xQSY: Green: =/>100; Amber: <100; Red: <45; Brown: <10.

The next best hub is the newly formed German THE[29] with a score of 187, reflecting the urgent need for that country to find alternative gas supplies during 2022. Historically, data have shown that there were substantial volumes of NCG/GPL spreads with TTF in the curve contracts, indicating that German shippers were hedging at the Dutch hub, using the German hubs for near curve portfolio adjustments and spot balancing. There are still very large volumes of spot trading today at the THE hub. Unlike the German THE, the Austrian VTP also saw an increase in its overall score but this was due primarily to an increase in the number of spot traders.

France and Belgium (at the ZTP hub) saw impressive rises in their scores, and to a lesser extent Spain also; this is most probably due to the large increase in LNG imports[30] and subsequent regasification and distribution through their national grids. If the cargoes were priced based on the destination hub, this would potentially involve LNG sellers hedging their side of the transaction at that hub; even if they were not priced at the destination hub, the sellers and buyers would be trading at the national hub as it would necessarily be 'delivered at the hub' once regasified.

A good measure of a hub's maturity is the types of products available to trade and their traded volumes, which are a good indication of whether a market is used for balancing or risk management. Table 2 shows all the traded products for each of the hubs, both OTC trading on the left and Exchange trading on the right.

At a glance, it can be observed that in 2022 TTF is yet again top with a score of 49/56, the same as it had in 2020. Most of the individual products categories are shown as 'green', meaning that the OTC volume of that product is greater than 600TWh, and greater than 500TWh for the exchange volumes.

All of the remaining hubs, except for ZEE, stay in the same colour band as they were in 2020, and all but three hubs (NBP, PSV, ZEE) achieved a higher hub score. The Belgian ZEE hub fell from a score of 12/56 in 2020 to just 7/56 in 2022. Only three hubs (TTF, NBP, THE) have a score higher than the mean, with the TRF, PSV, and VTP just below that number.

There are some interesting product splits across the hubs, as shown in Figure 2. All the hubs, with the exception of TRF and NBP saw a marked increase compared to 2020 in spot/prompt/months as a percentage of their total traded volumes. NBP was about the same, whereas TRF recorded a reduction from 57% in 2020 to 49% in 2022; this can in part be attributed to the increase in LNG imports and the need for shippers to trade more along the curve.

However, it should be noted that these are percentages of the total traded volumes; when looking at the actual volumes traded, the result could appear rather different: for example, whereas the British NBP and the French TRF recorded the highest percentages of Seasons[31], as shown in Figure 2, the absolute volumes traded in the seasons at the NBP was 1935TWh and at the TRF was 413TWh. By contrast, the Dutch TTF recorded a lesser percentage[32] of Seasons trading, but the actual traded volume was 9256TWh, some 5 times that of NBP, and 22 times that of TRF.

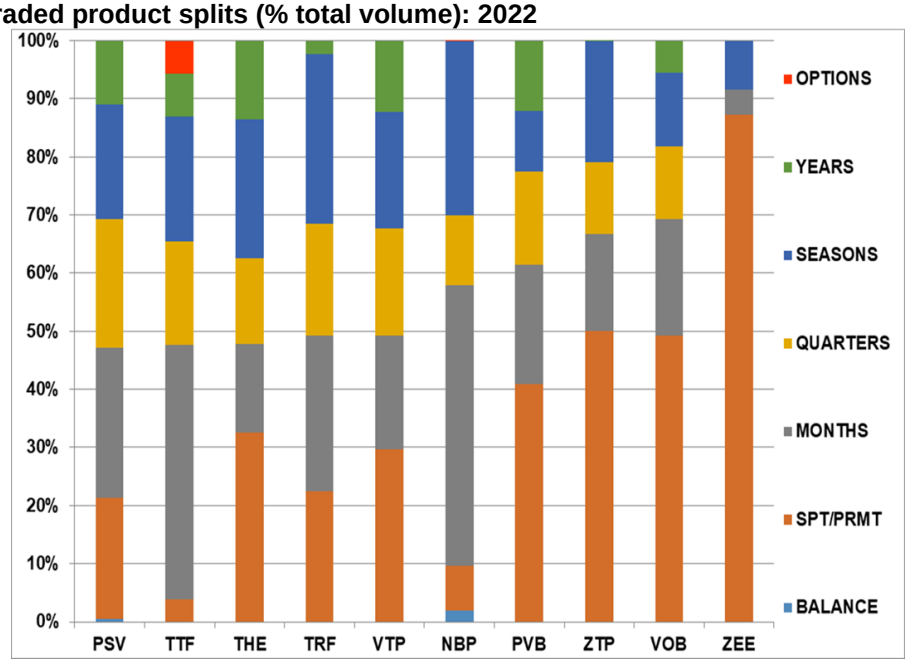
[29] Trading Hub Europe (THE), the merger of the previous two hubs, NCG and GPL, commenced trading on 1st October 2021.
[30] Belgium saw an increase in 2022 of 175% yr/yr and France 102%. See Chapter 4 below for details.
[31] 29.95% and 29.17% respectively, the highest percentages of all the hubs in this product.
[32] 21.46%.

Table 2:[33] Key Element 2: Traded products: 2022

2022 Product evaluation based on absolute volumes* / HUB SCORE/56		OTC	SCORE / 28	CLEARING	WD DA	BOW W/E WDNW BOM	MA MONTHS	QUARTERS	SEASONS	YEARS (CAL + GAS)	EXCHANGE	(% SHARE)	SCORE / 28	BALANCING TRADES	SPOT PROMPT	FUTURES MONTHS	FUTURES QUARTERS	FUTURES SEASONS	FUTURES YEARS	OPTIONS MONTHS
TTF	49	Y	24	Y	Y	Y	Y	Y	Y	Y	ICE PGS CME	<91 9 <1	25	Y	Y	Y	Y	Y	Y	Y
NBP	36	Y	18	Y	Y	Y	Y	Y	Y	Y	ICE PGS CME	99 <1 0	18	Y	Y	Y	Y	Y	Y	Y
THE	32	Y	16	Y	Y	Y	Y	Y	Y	Y	PGS ICE	95 5	16	N	Y	Y	Y	Y	Y	N
TRF	23	Y	13	Y	Y	Y	Y	Y	Y	Y	PGS	100	10	N	Y	Y	Y	Y	Y	N
PSV	22	Y	13	Y	Y	Y	Y	Y	Y	Y	GME ICE PGS	45 42 13	9	Y	Y	Y	Y	Y	Y	Y
VTP	22	Y	11	Y	Y	Y	Y	Y	Y	Y	PGS ICE	99 <1	11	N	Y	Y	Y	Y	Y	N
ZTP	15	Y	9	Y	Y	Y	Y	Y	Y	Y	PGS	100	6	Y	Y	Y	Y	Y	Y	N
PVB	15	Y	7	Y	Y	Y	Y	Y	Y	Y	MIB PGS	63 37	8	N	Y	Y	Y	Y	Y	N
VOB	12	Y	6	Y	Y	Y	Y	Y	Y	Y	PGS	91 9	6	N	Y	Y	Y	Y	Y	N
ZEE	7	Y	5	Y	Y	Y	Y	Y	Y	Y	PGS	100	2	N	Y	Y	Y	Y	Y	N
*KEY:		GREEN: =/>600TWh		AMBER: <600TWh		BLUE: <250TWh		RED: <50TWh			GREEN: =/>500TWh			AMBER: <500TWh		BLUE= <100TWh		RED: <30TWh		
GREY: No volumes		Hubs column based on OTC + Exchange 'score'/56; OTC column based on 'score'/28; Exchange column based on 'score'/28																		
		ICE=ICE or ICE/Endex		PGS=PEGAS (EEX)		CME=CME Europe					MIB=MIBGAS			Y=AVAILABLE				N=NOT AVAILABLE		

Sources: OTC: LEBA, ICIS; Exchange: ICE, ICE-Endex, EEX, CME, GME; MIBGAS; P. Heather

Figure 2: Traded product splits (% total volume): 2022



Sources: OTC: LEBA, ICIS; Exchange: ICE, ICE-Endex, EEX, CME, CEGH, GME; MIBGAS; P. Heather

[33] The methodologies used in this table are: (Products): as per Key in table; (Hub score/56): Green =/>42; Amber <42; Red <16; Brown <8.

Similarly, when looking at the Quarters, the Italian PSV recorded the highest percentage, followed by the French TRF, the Austrian VTP, and the Dutch TTF, as also shown in Figure 2. The absolute traded volumes however paint a different picture: TTF traded a total of 7643TWh, some 28 times that of TRF, 37 times that of PSV, and 60 times that of VTP.[34]

In the Years, TTF traded 3224TWh, some 4.5 times more than all the other hubs put together, despite in percentage terms the German THE, Austrian VTP, and the Spanish PVB all recording higher splits than TTF.

Finally only two hubs, the Dutch TTF and the British NBP, recorded exchange financial options trading in 2022, although the volumes were lower than in both 2020 and 2021. Interestingly, there has been a surge in TTF options trading in the first part of 2023.[35] The options contracts are listed on the ICE exchange and totalled 2436TWh on TTF and just 3TWh on NBP, representing 6.78% and 0.06% respectively of exchange trading.[36]

It is clear from the traded products table and the product splits that both TRF and ZTP traded more along the curve, mainly due to the higher LNG imports; PSV has slightly improved its ranking in the splits, by default as other hubs have slightly less curve trading; ZEE is now 87% spot/prompt; with the other hubs more or less unchanged. The Dutch TTF is the 'mature' risk management hub, including options trading.

High absolute traded volumes are usually indicative of a liquid market with a large number and varied range of participants; depending on the size of the underlying physical market, this will likely also indicate a large churn rate. In Table 3, mature hubs are shown in green; the active hubs, with developing depth, liquidity and transparency in amber; the poor hubs, which cannot yet be considered as deep, transparent or liquid, in red; and the illiquid hubs in Brown.

Even from a summary glance at Table 3, it is evident that the Dutch TTF hub has by far the largest traded volumes, including as described above, in all products across the whole curve. Despite the fall in the total compared to both 2021 and 2020, that is still over three times more than all of the other hubs put together; that is nearly 7 times more than the next most traded hub, the British NBP; 13 times more than the German THE hub, in Europe's largest gas consuming country; and over 30 times more than the French TRF, which saw a 'surge' in traded volumes in 2022.

The greatest increase in total traded volumes was at the Belgian ZTP hub, rising 138% to 560TWh; however, this was offset somewhat by the hub with the biggest drop in total traded volumes, the Belgian ZEE hub, falling 56% to just 35TWh. To put these Belgian figures into perspective, only 11 years ago, ZEE alone traded 870TWh, more than the two Belgian hubs together in 2022.

Figure 3 shows the traded volume development for all the main hubs from 2015 to 2022. In order to be able to show comparative trends better on the chart, the TTF line represents that hub's total volumes divided by ten and the NBP line represents that hub's total volumes divided by five.

[34] 274TWh, 209TWh, and 127TWh respectively.
[35] The ICE exchange reported that in May 2023, the TTF options volumes exceeded the total for 2022: 4158TWh. See: https://mondovisione.com/media-and-resources/news/ice-announces-record-traded-volumes-in-ttf-natural-gas/
[36] Equivalent to 5.65% and 0.04% respectively of total exchange and OTC trading.

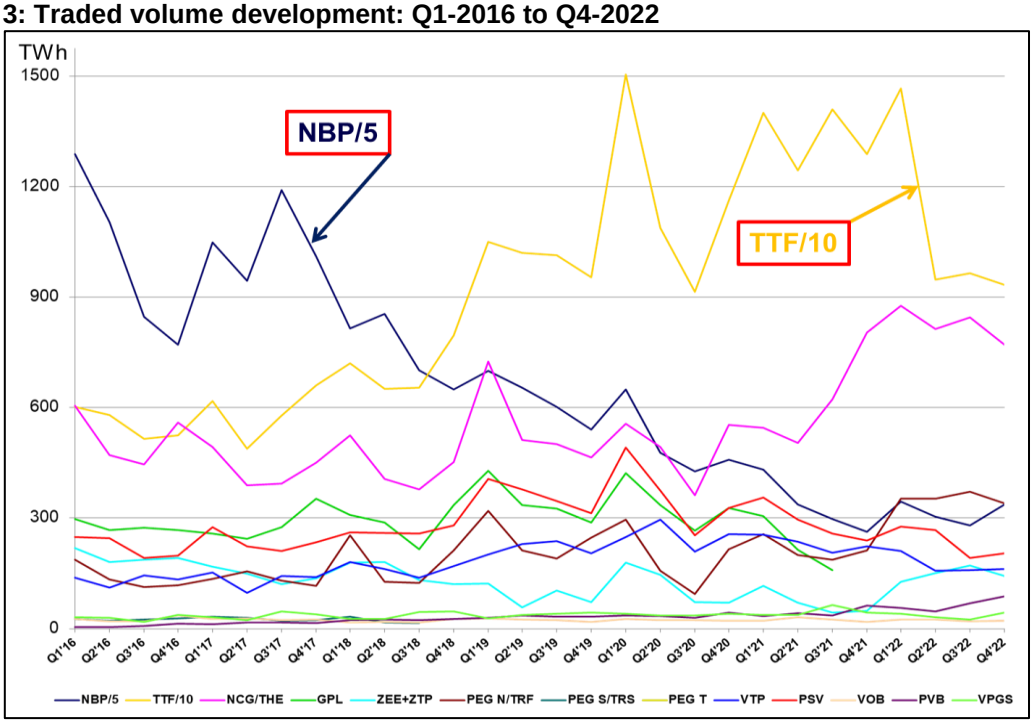
Table 3:[37] Key Element 3: Traded volumes: 2022

2022		TOTAL TRADED VOLUMES* (TWh)						
HUB		2008	2011	2020	Δ% =>	2021	Δ% =>	2022
TTF		560	6295	46690	+14	53430	-19	43135
NBP		10620	18000	10060	-34	6640	-5	6335
NCG	THE	EST.215	880	1965	-5	3155	+5	3305
GPL	THE	EST.145	310	1350				
TRF		PEG N 185	PEG N 430	890	-4	855	+66	1415
PSV		160	185	1455	-21	1155	-19	940
VTP		CEGH 165	CEGH 170	1010	-9	920	-25	685
ZTP		n/a	n/a	235	⇔	235	+138	560
PVB		n/a	n/a	145	+17	170	+61	260
VOB		n/a	n/a	95	⇔	95	-5	90
ZEE		500	870	235	-66	80	-56	35

*rounded to nearest 5TWh; not the same data sources in all years.

Sources: 2008: converted from bcm in IEA 2009 Natural Gas Review, p.30;
2011-2022: LEBA, ICIS, ICE, ICE-Endex, EEX, Powernext, PEGAS, CME, CEGH, GME; MIBGAS; P. Heather

Figure 3: Traded volume development: Q1-2016 to Q4-2022



Sources: LEBA; ICIS; ICE ; ICE-Endex ; EEX ; Powernext ; PEGAS; CEGH ; GME; CME; MIBGAS; TGE; P. Heather

[37] The methodology used in this table is: (Volumes) Green: =/>5000; Amber: <5000; Red: <1000; Brown: <100TWh.

The figure clearly shows the wide variations between the European hubs with TTF firmly set at the top; the long gradual decline of NBP (although still the second largest hub in Europe); the more or less steady performance of the German NCG through to 2021, with the GPL volumes adding to the increase in the merged THE volumes after October 2021; the slow but sure rise in the Italian PSV, despite a slight setback since 2021; the slow but sure rise at the Austrian VTP, albeit from a much lower level, and also topping out since 2021; and the rather erratic performance of the French PEG Nord/TRF, before the increase seen in 2022.

Finally in this section on traded volumes, Table 4 shows the total traded volumes at the 'emerging' hubs although, as can be seen in the second column, some of these have actually been operational for quite some years. The Author has previously commented[38] on the particular circumstances regarding the Polish VPGS and the Danish GTF/ETF hubs. At the VPGS in particular, although the total volumes there were a little under 140TWh in 2022, these are predominantly volumes traded between the incumbent supplier PGNiG and its distribution and retail subsidiaries. Danish OTC (GTF) trades are primarily conducted by Shippers adjusting or balancing their portfolios; at the exchange ETF there is almost no curve trading at all and again, the spot trading is primarily balancing operations; there does not appear to be any trading from financial participants.

Table 4:[39] Traded volumes - emerging hubs: 2022

2022		EMERGING HUBS TRADED VOLUMES (TWh)						
HUB	Started	OTC			EXCHANGE			TOTAL
		PRMT	CURVE	TOTAL	SPOT	CURVE	TOTAL	
VPGS	2014	No activity reported			21.94	116.58	138.53	**138.53**
GTF/ETF	2004/08	n/a	n/a	17.99	17.58	0.04	17.62	**35.61**
PVT^	2020	No activity reported			15.06	15.73	30.79	**30.79**
MGP	2010	n/a	n/a	1.27	26.01	Nil	26.01	**27.28**
VTT	2020	No activity reported			4.03	9.98	14.01	**14.01**
Baltic-FI*	2012-20	No activity reported			6.78	0.17	6.95	**6.95**
SVOB	2016	n/a	n/a	4.05	no exchange trading			**4.05**
HTP**	2018	No activity reported			2.87	n/a	2.87	**2.87**
UDN***	2011	No activity reported			2.23	n/a	2.23	**2.23**
PVN	2021	No activity reported			Only WD,DA,ID			**0.06**

^total physical trades transacted on the Romanian Commodity Exchange (BRM) but not necessarily conducted at the PVT.
***the Baltic-Finland market area, as defined by the GET Baltic exchange, being the sum of the LT/LV-EE/FI Market Areas.**
****HEnEx's Gas Trading Platform finally went live 21st March 2022; prior to this, all trades were 'balancing trades' on the Desfa platform.**
*****the Turkish exchange EPİAŞ went live on 1st October 2018.**

Sources: ICIS, EEX, TGE, CEEGEX, HUDEX, EPİAŞ, BGH, GET Baltic, BRM, MIBGAS, HEnEx; P. Heather

The Author has now included the newly operational Portuguese PVN hub, as it has finally started to trade some spot volumes on the MIBGAS exchange; also, the Greek HTP finally shows 'actual' traded volumes, as the HEnEx gas platform[40] finally went live in March 2022 and recorded 2.87TWh of spot trades; there is still no OTC trading recorded in Greece.

[38] In particular, see: Heather (2015), Chapter 5.5.2.3 "Poland", pp. 44-46; also Heather (2019), paras. 5-6, p.16; and Chapter on "Emerging Hubs", pp. 18-19.
[39] The methodology used in this table is: (Volumes) Green: =/>5000; Amber: <5000; Red: <1000; Brown: <100TWh.
[40] Unfortunately, accessing the data is very time consuming as each days' trades have to be downloaded separately!

All of the hubs in the table, with the exception of the Bulgarian VTT[41] and the Turkish UDN,[42] recorded lower volumes in 2022. Despite the sustained rise in traded volumes at the VTT since the introduction of the Gas Release Programme (GRP) in 2019, the liquidity of the gas market increased significantly. Many new companies supplied gas to end consumers in the country, including some large international companies. However, the GRP was suspended[43] on 1st January 2023 on the pretext of reduced Russian supplies,[44] which does not augur well for hub liquidity and for traded volumes in the future.

The Romanian PVT volumes were halved from the 2021 level following the introduction in September 2022 of a new 98% tax[45] that would retrospectively apply to wholesale electricity and gas transactions in Romania. Unfortunately the Romanian government has had a track record on interfering with the liberalised gas and electricity markets but somehow the traded volumes had risen year on year and reached 53TWh in 2020 and 54TWh in 2021, of which 51TWh were curve contracts; the total in 2022 was down to 32TWh, of which just 16TWh were curve trades.[46]

The remaining two hubs shown in Map 1 are the NIBP and the IBP, the balancing hubs in Northern Ireland and the Republic of Ireland. Both countries are intrinsically linked to Great Britain for their gas supplies coming from the Moffat Interconnection Point in Scotland and delivered through three undersea pipelines; the Republic also has indigenous supply from the Corrib Gas Field, off the north-west coast. The Author could not easily find any trading data for either virtual hub. The Gas Networks Ireland (GNI) website[47] states that it operates and maintains the gas network in Ireland;[48] furthermore, its wholly owned subsidiary GNI (UK) Ltd is the Gas Market Operator for Northern Ireland.

On the GNI website, under the heading "Activity at IBP",[49] it displayed a total of 55.08TWh for the year 2022, and under the heading of "Balancing Actions (energy in kWh) via Trading Platform",[50] it displayed a total of 0.24TWh for the year 2022. There is no explanation as to what is meant by 'activity' at the IBP and the data is given for each Gas Day, without stating the type of contract. There appears to be no separate data for just Northern Ireland.

Even though this is likely to just be balancing/spot trades, the total volumes would place IBP/NIBP above the Danish hubs in the emerging hubs table.

A major change in the traded gas markets over the past few years, and especially since 2021, has been the move away from OTC trading towards more exchange trading. Figure 4 shows the relative shares of both OTC and exchange volumes at all of the main hubs listed in Table 3, and all but UDN and PVN shown in Table 4.

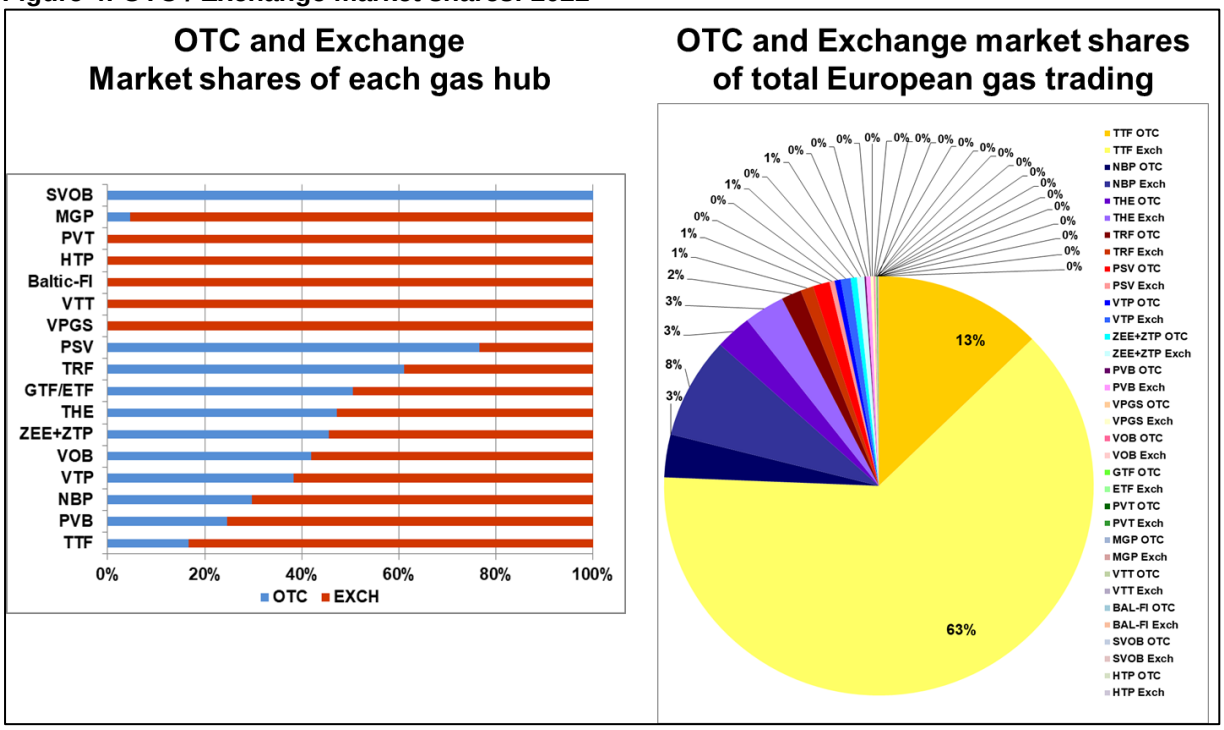
The share of exchange trading went from 52% in 2020, to 65% in 2021, and to 77% in 2022. Some of the emerging hubs do not have any OTC trading at all,[51] nor has Poland for a few years now. When looking at individual hubs, the share of exchange trading is highest at TTF, PVB, and NBP,[52] but still

[41] VTT traded volumes in 2020 were 3.38TWh and in 2021 12.48TWh.
[42] UDN total traded volumes in 2020 were 2.22TWh and in 2021 1.31TWh.
[43] See ATEB, 12th December 2022: "Termination of Bulgarian natural gas release programme": https://ateb.bg/en/2022/12/12/
[44] Surprisingly, the introduction to the article states that this was done "in order to provide liquidity to the state gas exchange and participate in the liberalization of the market".
[45] See: "New Romanian tax rules catastrophic for domestic, EU energy markets – industry associations", ICIS, 14th September 2022: https://www.icis.com/explore/resources/news/2022/09/14/10805498/new-romanian-tax-rules-catastrophic-for-domestic-eu-energy-markets-industry-associations/
[46] For more information on how trading is effected at the PVT, see: Heather (July 2021), paras. 1-2, p. 11.
[47] https://www.gasnetworks.ie/home/
[48] It also part owns and operates the two Interconnectors from GB to the Republic.
[49] https://www.gasnetworks.ie/corporate/gas-regulation/transparency-and-publicat/dashboard-reporting/activity-ibp/
[50] https://www.gasnetworks.ie/corporate/gas-regulation/transparency-and-publicat/dashboard-reporting/balancing-actions-and-prices/balancing-actions-energy-in-kwh/
[51] VTT, Baltic-Fi, HTP, and PVT; (nor does the new PVN).
[52] 83%, 75%, and 70% respectively.

quite low at ETF, TRF and PSV.[53] The remaining four hubs[54] are between 53% and 62%. The Slovak SVOB is the only hub without any exchange trading.

When looking at the pie chart on the right of Figure 4, it is very clear visually to see the dominance of TTF; as well as TTF accounting for 76% of all European gas trading, it accounts for 56% of OTC trading, and 81% of exchange trading. The total traded volumes from the top four hubs and the breakdown into the OTC and Exchange volumes, along with the respective percentage shares are shown in Table 5.

Figure 4: OTC / Exchange market shares: 2022



Sources: LEBA, ICIS, ICE, ICE-Endex, EEX, CME, GME, MIBGAS, TGE; HUDEX, CEEGEX, BGH; P. Heather

Table 5:[55] Top 4 Hubs Total Traded, OTC, and Exchange volumes and shares: 2022

2022	TOP 4 HUBS TRADED VOLUMES AND OTC/EXCH SHARES					
HUB	Total Volume TWh	Share %	OTC Volume TWh	Share %	EXCH Volume TWh	Share %
TTF	43,134	75.65	7,218	55.92	35,916	81.42
NBP	6,334	11.11	1,884	14.60	4,450	10.09
THE	3,307	5.80	1,563	12.11	1,744	3.95
TRF	1,417	2.48	865	6.70	552	1.25

Sources: compiled by the Author from data behind other Tables and Figures; P. Heather

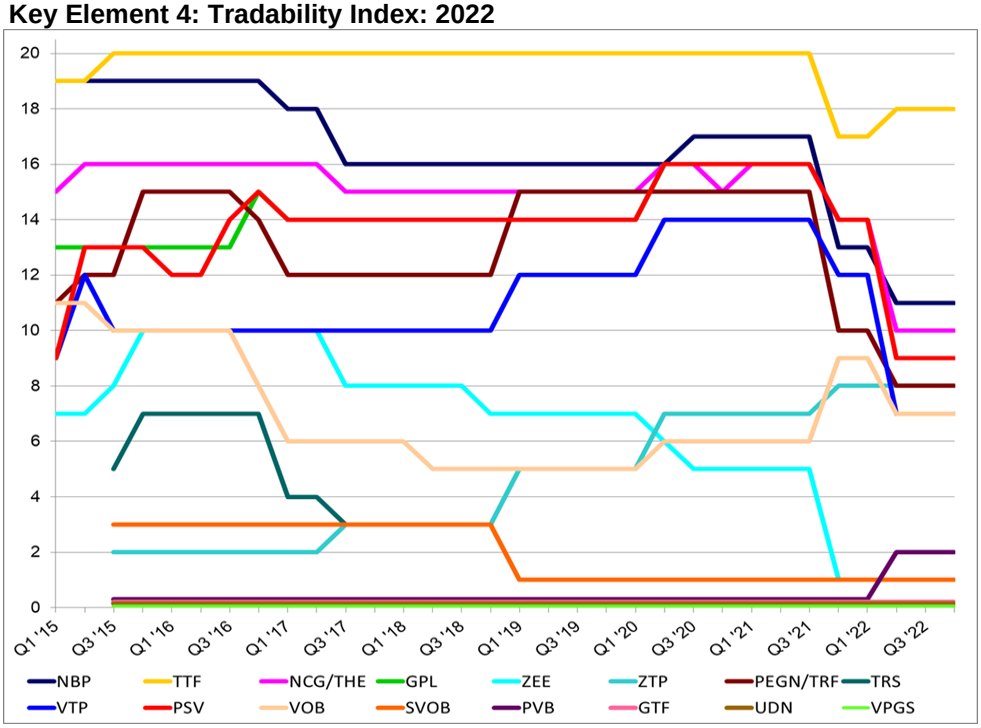
[53] 49%, 39%, 23% respectively.
[54] VTP 62%, VOB 58%, ZEE+ZTP 54%, THE 53%.
[55] The methodology used in this table is: (Volumes) Green: =/>5000; Amber: <5000; Red: <1000; Brown: <100TWh; (Shares) Green: =/>25; Amber: <25; Red: <15; Brown: <5.

When adding the share of the top four hubs, TTF, NBP, THE and TRF, they together account for 95% of total European gas trading, made up of a total 89% of OTC trading, and 97% of exchange trading. These data clearly show how much bigger the TTF is compared to even its nearest rivals.

Moving on to Key Element 4, the Author does not place much emphasis on the Tradability Index[56] but has always included it in the analysis of the hubs because it is sometimes quoted in various reports; it is not very meaningful as it does not record the depth of a market, only the bid/offer spread and must therefore be read alongside the other metrics.

There were some large changes to the scores in 2021 and 2022: all but VOB and ZTP fell in Q4-2021, especially the French TRF, British NBP, and Belgian ZEE;[57] in 2022, just two hubs improved, TTF and PVB,[58] whilst ZTP and ZEE stayed the same;[59] and the five other main hubs fell further.[60] Although this metric doesn't show the depth of a market, there is no doubt from the results that the Dutch TTF is far ahead of all the other hubs, indicating that there are tight bid-offer spreads in all but two contracts.[61]

Figure 5: Key Element 4: Tradability Index: 2022



Sources: ICIS European Gas Hub Reports 2015-2022; P. Heather

Another important metric is Key Element 5, the traded gas hubs churn rate.[62] In this one metric all others are, necessarily, reflected: if there are many participants, trading many different products in large quantities, then the churn rate is likely to be high. The churn rate is used by traders as a 'snapshot' of a market's liquidity; some traders will not participate in markets with a churn of less than 10 and many

[56] This is calculated by ICIS for 13 European hubs plus the Turkish UDN. The methodology consists of assessing the "bid-offer spread typically available every day to all interested counterparties", on 10 different contracts and for two bid-offer points of <€ 0.5/MWh and <€ 0.3/MWh, and then attributing 1 point if available, giving a score out of a maximum 20 points.
[57] TRF fell from 15/20 to 10/20; NBP from 17/20 to 13/20; and ZEE from 5/20 to 1/20.
[58] TTF improved from 17/20 to 18/20; PVB from0/20 to 2/20.
[59] ZTP stayed at 8/20; ZEE at 1/20.
[60] THE fell from 14/20 to 10/20; NBP from 13/20 to 11/20; VTP from 12/20 to 7/20; TRF from 10/20 to 8/20; and VOB from 9/20 to 7/20.
[61] According to the ICIS European Gas Hub Report, Q4-2022, p.8, the only contract to not have a bid-offer spread of less than €0.3/MWh or €0.5/MWh was the Balance of Month.
[62] For an explanation, see: Heather (July 2019), p 11.

financial players will only participate when the churn is above 12. In his analysis the Author has determined that a hub is 'mature' when the churn rate is 10 times or more.

Since 2020 the author has calculated and shown both the hubs' net[63] market churn rates for the last three years as well as the gross[64] churn. Using a net churn methodology can be appropriate in the early stages of the development of a hub, as it is initially more focused on the Market Area (in most cases, national) balancing requirements. However, to judge the growing liquidity and maturity of a hub, as it trades further down the curve and attracts risk management volumes, the gross churn methodology is more accurate as it shows a given hub's ability to be a pricing benchmark beyond its own market area. This is because there are many various reasons for the amount of trading effected at a given hub: trading of actual physical gas or trading to hedge and risk manage gas, both destined for consumption in that hub area; but also, trading in relation to quantities of gas destined for export to neighbouring market areas.

Table 6 shows the net and gross churn rates for the 10 main hubs[65] studied in this Paper. The results for 2022 show that there is only one European benchmark hub, the Dutch TTF standing far ahead of all the others and the only hub considered as 'mature', and one regional Sterling marker price, the British NBP. These two are the only hubs considered as 'active' in terms of the gross churn. No other hub is even near the Author's threshold of 5 times for 'active' hubs, with the Austrian, German, and French hubs all registering a gross churn of just 2.4 times, and the Italian hub a mediocre 1.2 times; the remaining hubs are all under 1 times churn making them 'illiquid'.

Table 6:[66] Key Element 5: Churn rates 2022

2022	TRADED GAS HUBS CHURN RATES					
	Net Churn* basis			Gross Churn** basis		
HUB	**2020**	**2021**	**2022**	**2020**	**2021**	**2022**
TTF	114.5	136.7	142.1	60.0	67.5	63.0
NBP	12.6	8.0	8.2	11.2	7.3	6.1
VTP	10.8	9.3	8.0	2.0	1.9	2.4
NCG	4.0	3.2	3.9	2.1	1.8	2.4
THE						
GPL	3.0			1.6		
TRF	2.0	1.9	3.4	1.6	1.6	2.4
PSV	1.9	1.4	1.3	1.9	1.4	1.2
ZEE+ZTP^	2.5	1.6	3.6	1.1	0.7	0.9
PVB	0.4	0.5	0.7	0.4	0.4	0.6
VOB	1.0	0.9	1.1	0.2	0.2	0.3

*** Total traded volume / Consumption in hub area.**
**** Total traded volume / Demand in hub area (= Total Physical Throughput = Consumption + Exports).**
^ Physical volumes are for Belgium as a whole.

Sources: 2020-2022: LEBA, ICIS, ICE, ICE-Endex, PEGAS, EEX, CME, CEGH, GME; MIBGAS; P. Heather

[63] The net churn is the total traded volumes at a given hub, divided by its consumption, as defined and used by the EU.
[64] The gross churn is the total traded volumes at a given hub, divided by its physical demand or throughput.
[65] With the two Belgian hubs together, using total physical data for Belgium as a whole, as it is very difficult to get accurate physical data for the ZEE area alone.
[66] The methodology used in this table is: Green: =/>10; Amber: <10; Red: <5; Brown: <1

The Author has heard it said that it is not realistic to place such emphasis on the TTF churn, as the Netherlands has relatively low gas consumption. This is indeed true and, if using the EU definition of churn, using the physical consumption as the denominator, the churn is a staggering 142 times; the author agrees that this figure is meaningless. He further agrees that even using the physical demand as the denominator could be seen as unrealistic but, if you compare that demand figure to that of Germany, it is almost exactly half;[67] that would imply that, if both country's traded gas markets were similarly 'mature', then the TTF gross churn would be about twice that of the German gross churn. In fact, the Dutch TTF gross churn is over 26 times greater than that of the German THE hub.

To try to achieve a more realistic indication of the TTF's gross churn, and the real maturity, importance, and relevance of this hub as a benchmark, or reference price for physical contracts beyond its national borders, the Author has since 2019 calculated the churn rates for the global benchmarks.[68] In those calculations, the TTF's churn rate using the physical consumption data from the surrounding countries[69] comes out at an impressive, mature and indeed liquid, 22.6 times. There is no doubt in the Author's mind that TTF is a reliable benchmark that can and does in practice, offer accurate price signals of the gas flowing in the (north-west) European gas grids, that is used by shippers from many European countries to price physical contracts, and to hedge their portfolio exposures.

4. The LNG effect on trading activity in 2022

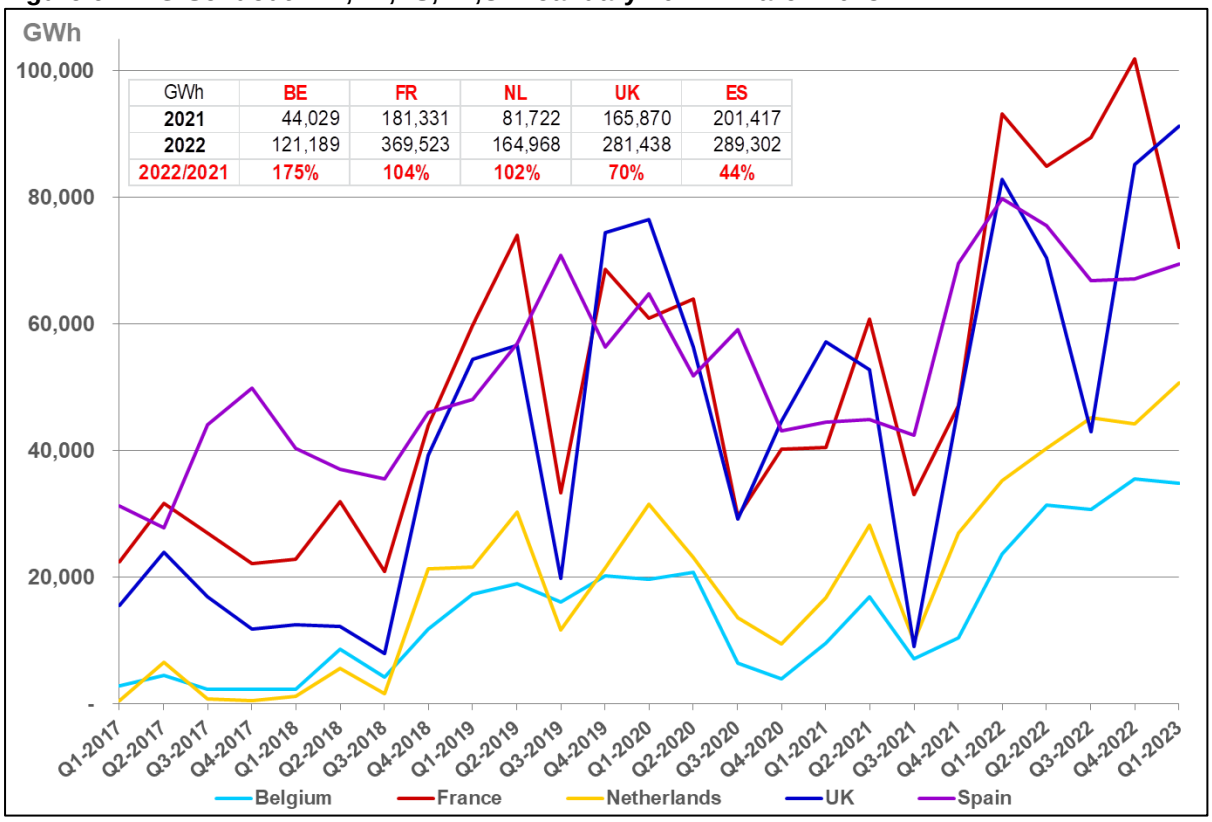
From all the above analysis it is clear that three countries in particular saw a marked increase in all but one of the 5 Key Elements:[70] Belgium (ZTP), France (TRF), and Spain (PVB); not just increases but significant ones too, especially in the number of participants and the traded volumes. These latter results in particular are out of line with the other hubs in both 2021 and 2022. This begs the question as to why they seem to have outperformed other European hubs, especially in 2022.

Figure 6 shows the LNG sendout volumes in the five European countries showing the greatest increases from 2021 to 2022: Belgium, France, the Netherlands, the United Kingdom, and Spain. As Russian pipeline volumes to western Europe fell dramatically in 2022,[71] a new 'dash for gas'[72] emerged and those countries with established LNG import terminals were the first to receive additional cargoes, many signed under new supply contracts, as well as a number of spot cargoes diverted from other destinations in order to profit from the high European gas prices.

These extra LNG volumes helped sustain or even increase trading volumes in those countries, through the need of both LNG suppliers and gas buyers to actually sell most[73] of the liquefied LNG into the hub and buy the gas from the hub. This would be the case regardless of contractual pricing terms: the LNG contract could still have, say, TTF as a reference marker price, which would entail extra risk management trading at the TTF hub.

[67] Physical demand in the Netherlands in 2022 was 684.38TWh; for Germany it was 1373.52TWh. Source: JODI Gas World.
[68] See Chapter 8 for more detail.
[69] The countries used in the analysis are France, BeNeLux, Germany, Austria, and the Czech Republic.
[70] In the Tradability index ZTP stayed the same, TRF fell by 2 points, and PVB rose by 2 points.
[71] As described in the Chapter 1, total Russian pipeline supplies to Europe were 142bcm in 2021 and 63bcm in 2022.
[72] This is a reference to the so-called Dash for Gas in Britain in the 1990s, with many North Sea fields coming on stream and the building of a new fleet of CCGT gas powered generation plants.
[73] However, if the importer is a portfolio player/aggregator, it would simply bring the liquefied gas into its portfolio, without the need for an explicit sell/buy trade at the national hub.

Figure 6: LNG Sendout: BE,FR,ES,NL,UK: January 2017 – March 2023



Sources : Kpler; J. Sharples, P.Heather

As can be seen in Figure 6, the sendout volumes in Belgium increased by a substantial 175% yr/yr from 2021 to 2022, although this country had the lowest absolute volume of the group shown. French sendout had the second largest increase, 104% yr/yr, and also by far the largest absolute volume; the Netherlands had a 102% increase, the UK a 70% increase, and Spain a 44% increase. These additional sendout volumes must have had a positive impact on the total traded volumes at the respective national hubs. They would also therefore account for the significant increase in traded volumes at the 'smaller' of the five countries' hubs, ZTP, TRF and PVB; they had less of an impact at the NBP although they no doubt helped to sustain the traded volumes in a market that has seen gradual decline over the past 6 years; finally, they would not, and did not, have the same impact at the TTF, which is overall a much larger marketplace and at which these additional LNG imports would constitute a very small share of the total trading.

Figure 6 additionally shows that in Q1-23, the LNG sendout volumes in the Netherlands, Britain, and Spain continued to increase, whereas in Belgium there was a slight dip and in France there was a sharp decline from the 2022 levels. This was primarily due to the ongoing strikes in France against pension reforms which brought the terminals, among other parts of the economy, to a standstill.[74] Many cargoes were diverted to other terminals, in the UK, Belgium, or further afield.

Since the massive rise in hub prices and the need to continue the move away from Russian gas, there have been many projects to bring more gas into Europe, including a number of new LNG terminals and FSRUs,[75] in particular in the Netherlands and in Germany.

[74] For more detail, see: Platts, 2th March 2023, "European LNG cargo glut looms amid French strike action": https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/lng/032823-european-lng-cargo-glut-looms-amid-french-strike-action

[75] Floating Storage and Regasification Units.

In the Netherlands, the Gate terminal received a permit in September 2022 to add a fourth tank, with a regasification capacity of 4bcma;[76] this will be in addition to the existing 12bcma capacity.[77] The Dutch government is looking to further expand the capacity with one or more terminals. Additionally, the EemsEnergyTerminal at Eemshaven has two FSRUs, operational since September 2022, with a regasification capacity of 8bcma.[78]

In Germany, the government has encouraged and supported a concerted effort to increase the country's LNG import facilities in an effort to reduce its reliance on Russian gas[79] and currently has some eight new projects, including three that have already started to feed gas into the grid.

The first import facility to be completed was the Wilhelmshaven FSRU with a regasification capacity of 4bcma; this became operational in November 2022. The Lubmin 2 FSRU with a regasification capacity of 5.2bcma became operational in January 2023.[80] The Brunsbüttel FSRU, with a capacity of 3.5bcma (to be upgraded to 7.5bcma in Q4-2023) received its first LNG cargo in February 2023.[81]

Three further LNG import terminals are planned:[82] an onshore terminal at Wilhelmshaven is now under construction with an expected operational date of 2026. Also a further four FSRUs are expected to start operations by the end of 2023: Wilhelmshaven 2, Stade, Lubmin and Lubmin 3, which together will have a total planned capacity of 15-20bcma.

This will almost certainly lead to an increase in trading at the Dutch TTF and the German THE hubs in 2023, for the same reasons as the increased trading at the Belgian, French and Spanish hubs in 2022.

5. A summary of the traded gas hubs in 2022

Table 7 summarises the 5 Key Elements in 2022 for the 10 main traded gas hubs in Europe. The combination of each of the Key Elements and their respective scores is what determines the overall rankings of the hubs, as can be easily observed by the colour coding, used in the table and in Map 1.

Table 7:[83] Summary of the 5 Key Elements 2022

[76] See: **https://www.vopak.com/newsroom/news/news-lng-gate-terminal-expand-its-capabilities?language_content_entity=en**
[77] See: **https://www.gateterminal.com/en/gate-terminal/profiel/facts-figures/**
[78] See: **https://www.eemsenergyterminal.nl/en/more-about-eemsenergyterminal**
[79] For more detail see: Natural Gas World, 24th November 2022: "Germany's LNG import project plans": **https://www.naturalgasworld.com/german-lng-import-plans-102271**
[80] For more detail see: Platts 10th January: "First regasified LNG sent into German gas grid from Lubmin FSRU: operator": **https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/lng/011023-first-regasified-lng-sent-into-german-gas-grid-from-lubmin-fsru-operator**
[81] For more detail see: Kpler 17th February 2023: "Germany's Brunsbuttel LNG terminal receives its first commercial cargo": **https://www.kpler.com/blog/germanys-brunsbuttel-lng-terminal-receives-its-first-commercial-cargo**
[82] Further information can be obtained from: Clean Energy Wire, 11th May 2023: "Ukraine war pushes Germany to build LNG terminals": **https://www.cleanenergywire.org/factsheets/liquefied-gas-does-lng-have-place-germanys-energy-future**
[83] The methodologies used in this table are: (Tradability Index): Green: =/>18; Amber: =/>16; Red: <16; Brown <5; (Hub rankings): Green/Mature:12-15 Orange/Active:8-11 Amber/Poor:4-7 Red/Inactive:1-3.

2022	5 KEY ELEMENTS					
HUB	Active Market Participants*	Traded Products**	Traded Volumes	Tradability Index (Q4)	Churn Rate***	Score /15****
TTF	275	49	43135	18	63.0	15
NBP	127	36	6335	11	6.1	11
THE	187	32	3305	10	2.4	9
TRF	116	23	1415	8	2.4	9
VTP	125	22	685	7	2.4	8
PSV	96	22	940	9	1.2	7
ZTP	76	15	560	8	1.0	6
PVB	52	15	260	2	0.6	4
VOB	50	12	90	7	0.3	4
ZEE	13	7	35	1	0.1	1

* Hub Score in the OTC Active Traders table.
** Score /56 derived from the OTC and Exchange product categories in the Traded Products Table.
*** Gross churn basis.
**** Score based on each of the Key Elements scoring zero for Brown; 1 point for Red; 2 points for Amber; 3 points for Green.

Source: Calculated from previous tables

TTF is now the only Mature 'tier one' hub, scoring a maximum 15/15, returning to the top spot after a brief drop to 14/15 in 2021. All the 5 Key Elements are shown as green and all of those results are the best/highest of all the hubs.

NBP went from Mature to an Active 'tier two' hub in 2021 and has remained there in 2022. This is due to a fall in its Tradability Index score and, especially, a lower churn rate from 11.2 in 2020, to 7.3 in 2021, and to 6.1 in 2022.

There is then a progressive drop in scores for the next three 'active' hubs of THE (unchanged at 9/15 from 2020), TRF (up from 7/15 in 2020), and VTP (down from 9/15 in 2020); all three markets, but particularly the German THE could improve in 2023.

Of the four Poor 'tier three' hubs the Italian PSV has slipped lower in each year, from 10/15 in 2020, to 8/15 in 2021, and now at 7/20 in 2022. This is disappointing as up to 2020 it had made continued, solid progress and was firmly at the top of the Active group of hubs, even ahead of the German NCG. The ZTP improved to 7/15 from 4/15 in 2021 and 5/15 in 2020. The PVB at 4/15 has dropped 2 points from its 2020 and 2021 scores of 6/15; and finally in this category, the VOB at 4/15 has eased just one point from its 2020 and 2021 scores of 5/15.

The very poor relation in 2022 of the European hubs was the Belgian ZEE hub, which is now in the new Inactive 'tier four' category with a score of just 1/15.[84]

In addition to the now Inactive ZEE, the remaining 12 hubs shown as operational but Inactive on Map 1 are still struggling to develop; all but the PVT, Baltic and VTT were described in detail in Heather (2019).[85] Several of these hubs have been established for a number of years but have struggled to gain traction, in particular the Greek HTP, which finally started trading in March 2022.

[84] In 2020 it was at 6/15, and in 2021 at 5/15.
[85] See: Heather (July 2019), pp.18-22.

Of these emerging hubs, all traded lower volumes, except the Bulgarian VTT and Turkish UDN; the Polish VPGS was 'best' but trading is dominated by PGNiG group companies; the Greek HTP finally had a trading platform and did record just under 3TWh of spot trades.

Having examined each of the 5 Key Elements in detail, as well as several complimentary analyses, it is clear that the Dutch TTF is far and away the leading European traded gas hub, used by many more market participants than any other hub, has a very high traded products score, with far greater total traded volumes than all the other put together: TTF also accounts for 76% of all European gas trading, for 56% of all OTC trading, and 81% of all exchange trading. TTF also has the highest Tradability Index score, only falling down on the 'balance of month' contracts, and finally, by far the greatest churn rate.

6. The 3 Main Indicators

There are 3 Main Indicators[86] that reveal the level of liberalisation and market development of traded gas hubs: the political will to create the necessary framework to get the process off the ground; the cultural attitudes to trading and change to want to succeed in a trading environment; and these in turn then dictate the level of commercial acceptance in order to see all the changes through that will allow the market to grow organically.

These 3 Main Indicators are the basis of creating successful traded gas markets. They are somewhat subjective but are essential to allowing a traded gas market to develop. They do not however in themselves guarantee that a market will succeed and become mature, as can be observed by comparing the results in Table 8 against those of the 5 Key Elements in Table 7.

The EFET Gas Hub Development Study is a good proxy for evaluating the three Main Indicators across all countries, as it assesses 5 regulatory conditions, 5 TSO conditions and 6 market conditions. The results of the 2020 Study are given in Table 8, enhanced by a four colour coding.[87] The Table shows data for 2020 as EFET did not publish their analysis for 2021 due to the volatility in the market; however, they have confirmed that the results were unchanged or very similar for the 'top' hubs.

EFET are unlikely to publish a report for 2022 due to the current difficult and uncertain trading conditions across all of Europe, but have unofficially indicated that some east-European countries would be marked down due to regulatory and fiscal changes. Following discussions with the Author, he has estimated the values for selected hubs given in the 2022 column in bold type.

This independent analysis, using very different criteria to the 5 Key Elements, arrived at much the same conclusions as to the European hubs' stages of development. The ranking of the top 10 hubs is very similar: TTF and NBP are top of the list, followed by THE, PSV, TRF (PEGs), and VTP; ZTP is placed higher which shows that the regulatory conditions are reasonably good but in the Author's analysis the hub's trading volumes place it a little lower; EFET stopped ranking ZEE 5 years ago.

As for the 'emerging' hubs, the EFET analysis shows that there has indeed been steady improvement at most of the hubs although, as mentioned in the notes to the Table, six of those hubs have been estimated to have fallen back in 2022: Turkey, Poland, Lithuania, Ukraine, Bulgaria, and Romania.

Table 8: EFET Hub scores categorised as mature, active, poor and inactive; 2014–2022

[86] See Heather (2015) for a full description of the 3 Main Indicators. This Insight gives the situation in 2022.
[87] The methodology for the rankings is: Mature/Green: =>18; Active/Orange: <18; Poor/Amber: <15; Inactive/Red: <9.

HUB	Score 2014	Score 2015	Score 2016	Score 2017	Score 2018	Score 2019	Score 2020*	Est. Score 2022**
NBP	20	20	20	20	20	20	20	20
TTF	19	19½	19½	19	19	19	19	19
NCG/THE	15½	19	19	17½	17½	17½	17½	17½
GPL	16	19	19	17	17	17½	17½	n/a
ZTP	16	17½	18	19	17	17½	17½	17½
PSV	10½	15	15	16	16½	17½	17½	17½
PEGs	16	16½	18½	17½	17	17	17	17
ZEE	17	17	17	16½	n/a	n/a	n/a	n/a
VTP	13	13	13½	16	16½	17	17	17
AOC/PVB	7	7	13½	16	15½	16	16	16
VOB	8	8½	9½	13	14	14½	**16**	16
GTF	9	11	14	15½	14½	15½	15½	15½
MGP	5	6½	9	12½	11½	12½	**13½**	13½
SVOB	3½	7	8	8½	9½	10	**10½**	10½
HTP	4½	5½	5½	6½	8½	10	**10½**	10½
IBP	n/a	n/a	n/a	n/a	n/a	n/a	**9½**	9½
UDN	5½	5	4	5½	6	9½	**10½**	**9**
Finland	n/a	n/a	n/a	n/a	n/a	n/a	**9**	**9**
Estonia	n/a	n/a	n/a	n/a	n/a	n/a	**8½**	8½
VPGS	4½	5½	9½	10	9½	9½	**10**	**8**
Lithuania	n/a	n/a	n/a	n/a	n/a	n/a	**8½**	**8**
Croatia	n/a	n/a	n/a	n/a	n/a	7½	**8**	**8**
Latvia	n/a	n/a	n/a	n/a	n/a	n/a	**8**	**8**
Slovenia	n/a	n/a	n/a	n/a	n/a	6	**6½**	6½
Portugal	n/a	n/a	n/a	n/a	4½	5½	**5½**	5½
Ukraine	n/a	n/a	n/a	3½	3½	7	**9**	**5**
Bulgaria	1½	1	1½	1	4½	5	**7½**	**5**
Romania	2½	1½	2	3	3	4½	**6½**	**5**

***: EFET only evaluated hubs <15 in 2019; these are shown in bold type;**
****: 2022 scores copied over from 2020, except those in bold type, estimated from discussions**

Source: 2020 EFET Review of Gas Hubs Assessments; 2022 scores derived from discussions; P. Heather

The reasons behind the re-evaluation were for incumbent domination in Turkey preventing competition; incumbent domination and storage laws in Poland stopping market participation; the reluctance of Lithuania to join the Baltic Market Area; the war in Ukraine impeding market development and slow reform of certain regulatory laws; the cancellation of the Gas Release Programme in Bulgaria; and the anti-competitive energy taxation law in Romania.

7. Are the traded gas hubs still relevant today?

The process of gas (and electricity) market liberalisation in Europe has taken a long time to achieve the current status where there is free market competition in nearly all countries. This has provided all consumers, from power generators, to industrial and commercial, and to residential, with competitively priced gas[88] at any given time. As the newly liberalised market opens up, new entrants start to participate and provide ever more liquidity which in turn will bring extra competition to deliver the keenest prices.

[88] This does not necessarily mean 'cheap' gas but the best priced gas, given supply/demand conditions.

First and foremost, all the hubs as they have been set up in Europe have the fundamental function of providing a means of physically balancing the volumes of gas in the grid on a daily basis, as prescribed by European law. This is effective in all European countries, even if the way it is implemented in practice does vary a little from hub to hub. Balancing the actual volumes flowing in any given gas grid is of course a safety requirement and is tightly governed by regulation and monitored by the gas Transmission System Operator (TSO).

So the question now, and one which is very pertinent currently given the political interventions mentioned in the Introduction to this Paper, is whether one, some, or all of the hubs can and are used for risk management purposes?

In the development of any given hub, if there are a greater variety of participants, including financial players, this will increase the liquidity of that hub further and this will then also allow the physical suppliers, wholesalers, and buyers, the opportunity to efficiently risk manage their portfolios. In time, as any particular hub and contract develops tight bid-offer spreads and a good depth of market, this will turn into a virtuous spiral that will encourage yet more participants to trade in that hub/contract; this is essentially what happened to the British NBP, overtaken later on by the Dutch TTF.

TTF has become a hub that is highly liquid and which has, since the late 2010's, in a similar way to Henry Hub, the North American benchmark hub, been used to price physical contracts not only in its own Market Area but much wider, across the neighbouring west-European countries, and some other European countries as the reference price used in physical supply contracts, and even globally as the reference price used in a number of LNG contracts.

Although the details of many physical gas contracts are confidential, there are several examples quoted in the public domain that indicate how gas hubs, and TTF in particular, are being used to price physical gas supply contracts:

It was reported[89] that in Q4-2022 the Romanian incumbent Romgaz signed a contract with Azerbaijan's state oil and gas company SOCAR for the delivery of spot gas volumes in Q1-2023; the price is to be indexed to the ICIS TTF Day Ahead and Weekend contracts price assessments. Indeed, a number of wholesale contracts in several east-European countries[90] are reputedly linked to TTF.

Azeri gas sales into Italy, through the TANAP/TAP pipelines are said to be[91] in part priced against the Dutch TTF; furthermore, some Spanish and Italian wholesale and retail contracts have in the past been linked to TTF. More generally, a recent report[92] stated that "The Dutch Title Transfer Facility (TTF) gas contract prices are widely used in the EU gas markets as an index for long-term contracts"

When looking at LNG import contracts into Europe, a similar picture emerges; TTF is often the reference price used. The IGU has said[93] that 67% of LNG imports to Europe are price-linked to gas hubs, and a Reuters article[94] said that "LNG to Europe has historically been pegged to TTF".

[89] ICIS European Gas Hub Report, Q4-2022, p.35, "Q4 Developments", 2nd bullet point.
[90] The Author has been told of such contracts in, inter-alia, Slovakia, Hungary, and Bulgaria.
[91] Said in discussion with the Author by a person close to Petronas Azerbaijan.
[92] Euractiv "Non-paper on emergency wholesale price cap instruments for natural gas": para. 6, p.1: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiw4_yUqdr_AhXSxwIHHccvCpYQFnoECCIQAQ&url=https%3A%2F%2Fwww.euractiv.com%2Fwp-content%2Fuploads%2Fsites%2F2%2F2022%2F09%2F25082025_Non-paper_emergency_price_cap_instruments_for_gas__clean_.pdf&usg=AOvVaw1_rY_RjEYVx4X6xC99phHC&opi=89978449
[93] IGU Wholesale Gas Price Survey 2022 Edition, p.19, last paragraph: "In Europe, 67% of LNG imports are now GOG": https://www.igu.org/resources/2022-wholesale-price-report/
[94] Reuters, 19th January 2023: "Explainer: Slow start? European Union's LNG price plans explained": https://www.reuters.com/business/energy/eu-launches-lng-benchmark-attempt-tame-price-spikes-2023-04-03/

Finally, it should also be noted that liquid traded gas hubs, such as NBP previously, and TTF today, will allow the financing of large upstream projects. The ICE TTF contract[95] can be traded up to 156 consecutive calendar months (or 13 years) forward, which is comparable to the crude oil market, and therefore can reliably indicate a price curve into the future. These gas forward curves are used to price and evaluate large projects with regard to potential price exposure and returns, in the same way that oil forward curves did when there was oil indexation in gas contracts; crucially, the big difference is that they should necessarily reflect the supply/demand structure of the gas market, and not that of oil transposed to gas.

The large increase in exchange trading has led to new contracts being set up: the ICE introduced during 2021 two new contracts priced in $/mmbtu, one at the NBP and the other at the TTF. After a slow start, the NBP contract traded 4.5TWh in 2021 but that increased three fold in 2022 to 13TWh; the TTF contract was far more successful from the start, trading 1078TWh in 2021 and 1514TWh in 2022. This TTF volume in 2022 accounted for 3.5% of the total TTF traded volume, and incredibly this was even more than the total French TRF traded volumes. Additionally, the CME (Nymex) exchange opened new $/mmbtu denominated cash-settled TTF futures and options contracts[96] in August 2022. The Author was told in conversation that this was a result of demand from mainly US-based LNG exporters but in reality there were no volumes traded at all during the rest of the year.

In late 2022, the ICE exchange announced that it would open parallel Dutch TTF futures and options contracts on its ICE Europe platform based in London; this is to "offer market participants an 'insurance option' in the event that the EU's new gas market correction mechanism is at risk of being triggered."[97] As the UK has left the EU, any trading on the London-based exchange would no longer be subject to EU rules but ICE has to first seek authority from the British regulator, and this was granted early in 2023.

These contracts were finally launched on 20th February 2023[98] and will serve as a back-up for all market participants currently using the ICE Endex platform based in the Netherlands; the idea is that the two contracts can be traded in parallel; in fact they are the same contracts with the same margining and are totally fungible. In the event of gas prices rising to, and beyond, the EU's price cap, market participants will be able to continue trading seamlessly on the London platform and therefore continue to be able to risk manage their portfolios. This will no doubt give great reassurance to all gas market participants as to the reliability of the TTF contract and will firmly see it continue as *the* reliable benchmark on which to price LTCs, including LNG contracts.

This appears to already be happening: in the first five months of 2023, the ICE exchange has reported[99] having record market participation in both the TTF futures and options contracts, with the traded futures volumes rising 17% yr/yr, traded options volumes rising 179% yr/yr, and open interest rising 68% yr/yr.

[95] For full contract specification, see: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwja16HcrNr_AhXkhP0HHf2KAh4QFnoECAwQAQ&url=https%3A%2F%2Fwww.theice.com%2Fapi%2Fproductguide%2Fspec%2F27996665%2Fpdf&usg=AOvVaw27n-EEuicYEeOgJdaU2y45&opi=89978449

[96] For further details, see: https://www.cmegroup.com/market-regulation/rule-filings/2022/7/22-105_1.pdf

[97] See Footnote 98.

[98] For further details, see: Platts, 20th February 2023, "ICE launches new TTF gas futures, options market in London as planned": https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/022023-ice-launches-new-ttf-gas-futures-options-market-in-london-as-planned#

[99] For further detail, see: https://mondovisione.com/media-and-resources/news/ice-announces-record-traded-volumes-in-ttf-natural-gas/

8. TTF remains a global pricing benchmark for gas

The Author has been following the development of gas trading activity in the Asia-Pacific region for a number of years and, since 2019, has developed a methodology to try to compare the churn rates[100] of the main representative gas markets around the world.

The Dutch TTF is truly *the* leading pricing benchmark for North-West Europe and indeed many other European countries also, as well as being used to price some LNG cargoes destined for Europe. It has become an investment asset class[101] in its own right and there are signs that it is becoming a global benchmark too. Not only have the TTF total traded volumes grown to such an extent that they represent 76% of total European traded gas volumes, but its churn rate calculated against the much greater physical consumption figure of the countries including and surrounding the Netherlands,[102] and whose shippers are known to be using TTF for their risk management, has now grown to nearly 23 times.

This section looks at TTF in the global context, alongside the other European benchmark, NBP, and against the US Henry Hub (HH). In past years these were also compared to the nascent LNG pricing benchmark, JKM.[103] However, the Author was not able to collect all the relevant data to get an accurate picture of JKM's true churn in 2022.

Henry Hub is *the* pricing benchmark in North America,[104] with most of the other Market Centers (or hubs) being priced by differential against it. HH is used to price physical gas contracts in North America, and is also used to price some LNG cargoes destined for South America, Asia and Europe. It is extensively used for risk management of physical gas portfolios and is an investment asset class in its own right.

The British NBP was the North West European benchmark hub for over a decade but has since lost that mantle to TTF; it remains *the* pricing benchmark for the British Isles and is also used to price most LNG cargoes destined for the British Iles.

Finally, and although not strictly a 'hub', the JKM has become the pricing benchmark for LNG cargoes delivered into Asia, although it has also been used to price LNG cargoes to other parts of the world.

For the purposes of calculating the churn rates, the relevant denominators used are the gas consumption in the United States, Canada and Mexico for HH; the gas consumption in France, Germany, Austria, Czech Republic, and Benelux for TTF; the gas consumption in the United Kingdom and the Republic of Ireland for NBP; and the LNG imports into Japan, Korea, Taiwan, and China for JKM.

Table 8 shows the results of this global comparison and uses a similar colour coding[105] to the Author's European hubs analyses. It shows which benchmarks are illiquid, mature, liquid and very liquid. The results clearly show that HH remains the premier global gas benchmark with an impressive churn of 49.7 (down from 50.1 times last year) when compared to US consumption alone. This is the second year in a row that the HH churn has fallen,[106] by 12.8% since 2020. However, there is no doubt that this remains a very mature and very liquid gas pricing benchmark and remains so even after Mexican

[100] Note that these are calculated using consumption as the denominator and so for TTF and NBP the results are different to the gross churn rates in Table 3. For JKM, the denominator is LNG imports.
[101] Part of the Futures asset class of investments.
[102] See Footnote 69.
[103] Japan Korea Marker, a price marker published daily by S&P Global Platts.
[104] It is the most used benchmark in the US and Mexico, although less so in Canada where three liquid local hubs are also used; see: https://www.cer-rec.gc.ca/en/data-analysis/energy-commodities/commodity-prices-trade-updates/
[105] Dark Green/Very Liquid:=/>40; Mid Green/Liquid:15<40; Light Green/Mature:10<15; Amber/Poor: 5<10; Red/Illiquid:<5. The calorific value conversion factors are those stated by the IEA for each country.
[106] The HH churn in 2020 was 57.0, and in 2021 was 50.1.

consumption [107] is added (the churn falls slightly to 47.2 times) and after including Canadian consumption[108] (the churn is a little lower still at 40.9 times).

TTF, when compared to the consumption in the five countries of its main sphere of influence, has a very respectable churn of 22.6 (a little lower from 23.8 times last year). There is no doubt that this is a mature and liquid gas pricing benchmark.

Table 8: Global Gas Benchmarks Churn Ratios - 2022

Global Benchmark churn rates 2022 (HH, TTF, NBP: trading/consumption; JKM: trading/LNG imports)			
	Country/Region	**Hub**	**Churn**
VERY LIQUID	United States	HH	49.7
	US + Mexico	HH	47.2
	US + Mexico + Canada	HH	40.9
LIQUID	FR-DE-AT-CZ-Benelux	TTF	22.6
POOR	Britain	NBP	8.3
	UK-IE	NBP	7.6
ILLIQUID	Asia	No hubs yet but increasing spot trading	
	CN-JP-KR-TW	JKM	Est. at <0.8

Sources: JODI, S+P Global Platts, CME, LEBA, ICIS, ICE, ICE-Endex, PEGAS; P. Heather

NBP, when compared to the consumption across the United Kingdom and the Republic of Ireland, has a churn of 7.6 times (down from 7.8 last year); this is due to both a slight fall in total traded volumes and a slight fall in physical consumption in the UK and Ireland.[109] It can still, however, be considered a regional Sterling gas pricing benchmark.

S&P Global Platts refined their JKM price assessment to use a MOC[110] methodology in early 2018[111] and it is effectively still in its infancy as a reference price marker. Nevertheless, it is being used increasingly to price LNG spot cargoes and some medium term cargoes, for delivery in the Asia-Pacific region; it has also been used to price cargoes for delivery further afield.

[107] All of Mexico's gas is priced against HH.
[108] Although realistically, HH is only used to price a proportion of Canadian contracts, the remainder being against Canadian hubs, especially Alberta.
[109] Total NBP traded volumes fell by 4.7% year/year; physical consumption in the stated countries fell by 3.7%.
[110] Market On Close.
[111] Since Q2-2018, the JKM price assessment has been according to MOC assessment methodology. For more information, see 'How does Platts assess JKM™?': https://www.spglobal.com/platts/en/our-methodology/price-assessments/lng/jkm-japan-korea-marker-gas-price-assessments

There are two exchanges offering JKM futures and options derivative contracts,[112] the ICE and CME. Trading at these exchanges grew exponentially from about 2019 to 2021 but actually eased back in 2022.

There is no doubt that this marker price is gaining support from the LNG industry, with producers, aggregators and buyers using it more each year. However, the turbulent global energy markets of 2021 and 2022 did not favour the JKM.

Asia has started to liberalise its gas markets but still has a long way to go; the increase in short term and spot LNG trades over the past few years eased back by 4.4% in 2022[113] but the use of the JKM as a price formation process is helping the transition to take place. The JKM, when compared to its main sphere of influence, has an estimated churn of less than 0.8 times in 2022 (down from 0.89 in 2021). This is an illiquid market but is clearly showing signs of growth.

9. Summary and Conclusion

The purpose of this Paper has been to analyse the results of the trading data in 2022 for the European traded gas hubs, in order to be able to assess whether these hubs continue to be relevant, or not, in the pricing of long term physical gas contracts? Particular focus has been placed on analysing the Dutch TTF hub as this has been the subject of political comment as to whether it is still fit for purpose, because of high prices rather than of actual construct.

It is argued that as more, generally lower priced, LNG is coming into Europe to replace the severe loss of Russian pipeline volumes, this should have been reflected in the TTF hub price. What the politicians seem to have ignored is the fact that once the LNG has been offloaded into tankage, and then regasified and entered into the national gas grid, there are additional costs to be added, as well as the infrastructure congestion in getting the regasified LNG further downstream, creating a sharp price imbalance; however, the main flaw in the politicians' argument is that once the LNG is regasified and co-mingled with pipeline gas in the grid, it is simply 'grid gas' and it is this grid gas that is traded. Had Europe not attracted extra LNG supplies, the TTF price would undoubtedly have been higher still. In the case of the Dutch grid, the trading is that of TTF contracts, whether traded OTC or on an exchange.

For several years now, the TTF contract has been the most liquid by far in Europe, and has been widely used as the reference price for physical wholesale gas contracts. This paper has analysed the data for 2022 and has hopefully been able to answer the question whether it is still fit for purpose.

The European gas markets have experienced a very turbulent ride over the past three years: firstly, the demand for gas was greatly reduced by the global Covid-19 pandemic of 2020 then, as global demand started to rise again in mid-2021, prices started to rise to unprecedented levels followed, in early 2022, by the Russian invasion of Ukraine. These factors directly or indirectly led to a series of events that resulted in a 56% drop in Russian pipeline gas supplies to Europe. Furthermore, all this has been happening against the backdrop of the ongoing debate about the Green Transition and the potential phasing out over time of carbon sources of energy, including natural gas.

These events resulted in a severe readjustment of the European traded gas markets, at all levels from international trade, to European wholesale and retail sectors too.

Map 1 showed all the European gas hubs that were operational at the end of 2022. There is now just one Mature hub, the Dutch TTF; the British NBP lost its 'mature' status in 2021 and is now classified as Active, alongside three other hubs, the German THE, the French TRF, and the Austrian VTP; and three

[112] JKM derivatives trading was launched in 2012.

[113] GIIGNL 2022 Annual Report, p.5: Spot and short-term trades 2019:119MT (⇔34% total trades); 2020: 142.5MT (⇔40% total trades), an increase in volume of 19.8%; 2021: 136.3MT (⇔36.6% total trades): https://giignl.org/document/giignl-2022-annual-report/

Poor hubs, the Italian PSV, the Spanish PVB, and the Belgian ZTP; all of the remaining hubs including the Belgian ZEE are classed as Inactive.

The Portuguese virtual hub (PVN) became operational during 2021 and has started to trade some balancing and short-term volumes on the exchange. This means that virtually all of Europe does now have a virtual hub, although some still trade very little volumes, in particular Croatia and Slovenia, which are limited to minimal balancing transactions.

In the Baltic States, the vision of creating a single Baltic Market Area has faltered as Lithuania has still not agreed to join the Latvia-Estonia Market Area, which itself has a single Entry/Exit system agreement with Finland. In Greece, the HEnEx gas platform finally went live in March 2022 and recorded a small amount of spot trades.

Despite the extreme trading conditions over the past 2 years, trading across all the European hubs has remained relatively buoyant and very much in line with the underlying physical volumes in each country. All countries had lower total traded volumes compared to 2020, except for five (France, Belgium (ZTP), Spain, Hungary, and Bulgaria), of which all but Hungary had higher physical volumes too. When comparing the 2021/22 year on year difference, all countries had lower total traded volumes, except for five (Germany, France, Belgium (ZTP), Spain, and Bulgaria), of which all but Germany also had higher physical volumes.

9.1 The Review of the 5 Key Elements in 2022 and the Importance of LNG

The first Key Element is the number of market participants, and TTF is way ahead of all the other hubs with a calculated 'score' of 275, and has almost as many 'active' curve traders as there are spot/prompt traders, the only hub with this characteristic. TTF attracts not only physical traders but also financial, institutional and speculative traders.

A good measure of a hub's maturity is the types of products available to trade and their traded volumes, which are a good indication of whether a market is used for balancing or risk management. TTF is yet again top with a score of 49/56, the same as it had in 2020.

Key Element 3 looks at the total traded volumes: high absolute traded volumes are usually indicative of a liquid market with a large number and varied range of participants. The greatest increase in total traded volumes in 2022 was at the Belgian ZTP hub, rising 138% to 560TWh, and the biggest drop in total traded volumes at the Belgian ZEE hub, falling 56% to just 35TWh.

In absolute numbers, the Dutch TTF hub has by far the largest traded volumes, in all products across the whole curve: over three times more than all of the other hubs put together, and nearly 7 times more than the next most traded hub, the British NBP; 13 times more than the German THE hub, in Europe's largest gas consuming country; and over 30 times more than the French TRF, despite this hub seeing a 'surge' in traded volumes in 2022.

Turning to Key Element 4, the Tradability Index, just two hubs improved in 2022, TTF and PVB, whilst ZTP and ZEE stayed the same; the five other main hubs fell further. Although this metric doesn't show the depth of a market, there is no doubt from the results that the Dutch TTF is far ahead of all the other hubs, indicating that there are tight bid-offer spreads in all but the Balance of Month contracts.

Maybe the most important metric is that of the hub churn rates, as recorded in Key Element 5. In this one metric all others are, necessarily, reflected: if there are many participants, trading many different products in large quantities, then the churn rate is likely to be high.

There is only one 'mature' hub with a churn rate above 10 times: the Dutch TTF, which scores a massive 63 times churn. The British NBP is second with a churn of 6.1 placing it in the 'active' category and it is also a regional Sterling marker price. The Austrian, German, and French hubs all registered a gross churn of just 2.4 times, and the Italian hub a mediocre 1.2 times, placing these four hubs in the 'poor' category, whilst the remaining hubs are all under 1 times churn making them 'inactive'.

An important element this year has been the 'LNG effect' that has resulted in a boost to traded volumes at those hubs receiving greater LNG import volumes. From all the above analysis it is clear that three countries seem to have outperformed other European hubs with a marked increase in all but one of the 5 Key Elements: Belgium (ZTP), France (TRF), and Spain PVB.

When analysing the LNG sendout volumes, the five European countries showing the greatest increases from 2021 to 2022 were Belgium, France, the Netherlands, the United Kingdom, and Spain. The sendout volumes in Belgium increased by a substantial 175% yr/yr, France had the second largest increase of 104% yr/yr, the Netherlands had a 102% increase, the UK a 70% increase, and Spain a 44% increase.

These extra LNG volumes helped sustain or even increase trading volumes in those countries, through the need of both LNG suppliers and gas buyers to actually sell most of the liquefied LNG into the hub and buy the regasified gas from the hub. This would be the case regardless of contractual pricing terms. The LNG contract could still have, say, TTF as a reference marker price, which would entail extra risk management trading at the TTF hub.

Since the massive rise in hub prices and the need to continue the move away from Russian gas, there have been many projects to bring more gas into Europe, including a number of new LNG terminals and FSRUs, in particular in the Netherlands and in Germany.

This will almost certainly lead to an increase in trading at the Dutch TTF and the German THE hubs in 2023, for the same reasons as the increased trading at the Belgian, French and Spanish hubs in 2022.

From the summary of the 5 Key Elements, TTF is now the only mature 'tier one' hub. NBP went from mature to an active 'tier two' hub in 2021 and has remained there in 2022.

There is then a progressive drop in scores for the next three active hubs - THE, TRF, and VTP; all three markets, but particularly the German THE could improve in 2023.

Of the four poor 'tier three' hubs the Italian PSV has slipped lower in each year, to just 7/20 in 2022. This is disappointing as up to 2020 it had made continued, solid progress and was firmly at the top of the active group of hubs; the ZTP improved to 7/15 from 4/15 in 2021 and 5/15 in 2020; the PVB has dropped 2 points from its 2020 and 2021 scores; and finally in this category, the VOB has eased just one point from its 2020 and 2021 scores.

The very poor relation of the European hubs in 2022 was the Belgian ZEE hub, which is now in the new inactive 'tier four' category with a score of just 1/15. The remaining European hubs shown in Map1 are all classed as inactive.

Having examined each of the 5 Key Elements in detail, as well as several complimentary analyses, it is clear that the Dutch TTF is by far and away the leading European traded gas hub, used by many more market participants than any other hub. It has a very high traded products score, with far greater total traded volumes than all the other put together. TTF also accounts for 76% of all European gas trading, 56% of all OTC trading, and 81% of all exchange trading. TTF also has the highest Tradability Index score, only falling down on the 'balance of month' contracts, and finally, by far the greatest churn rate.

9.2 The continued relevance of traded gas hubs and of TTF in particular

This leads to the question whether traded gas hubs, and the TTF in particular, are still relevant today and can genuinely provide a reliable representative price of the gas flowing in the grids? Of course, the most important function of the hubs, as they were set up in Britain and then across the European Union, is to provide a safe and effective means of balancing the high pressure network. There is no doubt that they all do perform this role.

The question then is whether any of the European hubs can provide reliable pricing signals and the means by which market participants can risk manage their portfolios?

From the analysis carried out in this paper, there is no doubt that several of the European hubs do provide the right pricing signals in their respective markets, and even provide the ability for market participants to risk manage some of their portfolio exposures. This would be the case say, in France and Belgium and the other countries mentioned that have seen a large increase in their LNG imports. It is also the case for the British NBP which is the regional pricing reference for the UK and Ireland; but it is especially the case for the Dutch TTF.

In the development of any given hub, if there are a greater variety of participants, including financial players, this will increase the liquidity of that hub further and will then also allow the physical suppliers, wholesalers, and buyers, the opportunity to efficiently risk manage their portfolios. In time, as any particular hub and contract develops tight bid-offer spreads and a good depth of market, this will turn into a virtuous spiral that will encourage yet more participants to trade in that hub/contract; this is essentially what happened to the British NBP, overtaken later on by the Dutch TTF.

The Dutch hub has progressively developed from its inception but in particular since the Dutch government instigated the Gas Roundabout policy[114] in the late 2000s, followed by a much stronger growth in the mid-2010s to when it eventually overtook NBP as Europe's premier traded gas hub in 2016. The hub has been used by an ever greater number of market participants across all of Europe, and globally.

TTF has become a contract that is highly liquid and which has, since the 2010s, in a similar way to Henry Hub, the North American benchmark hub, been used to price physical contracts not only in its own Market Area but much wider, across the neighbouring west-European countries, and some other European countries as the reference price used in physical supply contracts; and even globally as the reference price used in a number of LNG contracts. Finally, it should also be noted that a liquid trading gas hub, such as NBP previously, and TTF today, will allow the financing of large upstream projects.

With the marked increase of exchange trading, there are now three exchanges that offer TTF contracts, ICE, EEX, and CME. They now all offer options as well as futures contracts, although it is on the ICE platform that the vast majority[115] is traded.

On the ICE exchange the TTF contract can be traded up to 156 consecutive calendar months (or 13 years) forward, which is comparable to the crude oil market, and therefore can reliably indicate a price curve into the future. These gas forward curves are used to price and evaluate large projects with regard to potential price exposure and returns, in the same way that oil forward curves did when there was oil indexation in gas contracts. Crucially, the big difference is that they should necessarily reflect the supply/demand structure of the gas market, and not that of oil transposed to gas.

Both the ICE and CME exchanges have introduced TTF contracts priced in $/mmbtu,[116] in 2021 and 2022 respectively. These were said to be as a result of demand from mainly US-based LNG exporters. The ICE $/mmbtu TTF futures volumes alone, in 2022, accounted for 3.5% of the total TTF traded volume, and incredibly this was even more than the total French TRF traded volumes.

In response to the EU's gas market correction mechanism which would prevent trading above a certain price, the ICE exchange announced in late 2022 that it would open parallel Dutch TTF futures and options contracts on its ICE Europe platform based in London; these contracts were finally launched on 20th February 2023 and will serve as a back-up for all market participants currently using the ICE Endex platform based in the Netherlands.

This will no doubt give great reassurance to all gas market participants as to the reliability of the TTF contract and will firmly see it continue as the reliable benchmark on which to price LTCs, including LNG contracts.

[114] See Heather (2012), p.10

[115] See Table 2: ICE <91%, EEX 9%, CME <1%.

[116] ICE also introduced an NBP futures contract priced in $/mmbtu.

This appears to already be happening. In the first five months of 2023, the ICE exchange has reported having record market participation in both the TTF futures and options contracts, with the traded futures volumes rising 17% yr/yr, traded options volumes rising 179% yr/yr, and open interest rising 68% yr/yr.

On a global level, the analysis shows that the TTF is truly *the* leading pricing benchmark for North-West Europe and indeed many other European countries also, as well as being used to price some LNG cargoes destined for Europe. It has become an investment asset class in its own right and there are signs that it has become a global benchmark too.

Henry Hub is *the* pricing benchmark in North America, with most of the other Market Centers (or hubs) being priced by differential against it. HH is used to price physical gas contracts in North America, and is also used to price some LNG cargoes destined for South America, Asia and Europe. It is extensively used for risk management of physical gas portfolios and is an investment asset class in its own right.

The British NBP was the North West European benchmark hub for over a decade but has since lost that mantle to TTF; it remains *the* pricing benchmark for the British Isles and is also used to price most LNG cargoes destined for the British Iles.

Finally, and although not strictly a 'hub', the JKM has become the pricing benchmark for LNG cargoes delivered into Asia, although it has also been used to price LNG cargoes to other parts of the world.

HH remains the premier global gas benchmark with an impressive churn of 47.2 when compared to the consumption in the US and Mexico; TTF, when compared to the consumption in the five countries of its main sphere of influence, has a very respectable churn of 22.6; NBP, when compared to the consumption across the United Kingdom and the Republic of Ireland, has a churn of 7.6 times

Asia has started to liberalise its gas markets but still has a long way to go; the increase in short term and spot LNG trades over the past few years eased back by 4.4% in 2022 but the use of the JKM as a price formation process is helping the transition to take place. The JKM, when compared to its main sphere of influence, has an estimated churn of less than 0.8 times in 2022 (down from 0.89 in 2021). This is an illiquid market but is clearly showing signs of growth.

On a global scale, HH is the North American benchmark hub and remains the premier global gas benchmark, TTF and NBP are benchmark hubs for their regions, and JKM is currently the only feasible price marker in Asia, but is very far from being an active and reliable one.

9.3 Final Conclusion

The final conclusion of this paper is that all European traded gas hubs are most definitely still relevant, if only to enable the safe and efficient balancing of the gas grids; but they can also be much more than that. Some are relevant for actual local market pricing, whether wholesale or retail, and possibly for limited (mainly short term) risk management purposes.

The Dutch TTF though is all those things, but also is used by a great many market participants, from all around the world, as a reliable price marker for several surrounding European countries, as well as on a wider scale across Europe, and even globally.

Yes, this hub in particular does continue to be relevant in the pricing of long term physical gas contracts and, yes, it is still representative of the price of gas in the Dutch, and wider European, grid network at any given time and, yes, this Author believes that it will continue to be so.

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Appendices

The European traded gas hubs in 2022

NBP - National Balancing Point; GB; 1996

ZEE and ZTP - Zeebrugge Hub / Zeebrugge Trading Point; BE; 2000/2012

PSV - Punto di Scambio Virtuale; IT; 2003

TTF - Title Transfer Facility; NL; 2003

(AOC) PVB - Almacenamiento Operativo Comercial / Punto Virtual de Balance; ES; 2004/2015

GTF and ETF - Gas Transfer Facility and Exchange Transfer Facility; DK; 2004 and 2008

(PEGs) TRF - Points d'Échange de Gaz (Nord, Ouest, Est, Sud, TIGF) / PEG Nord (merger of PEGs N,O,E); FR ; 2004/2009

- Trading Region South (merger of PEGs S, TIGF); FR; 2015
- Trading Region France (merger of PEG N, TRS); FR; 2018

(CEGH) VTP - (Central European Gas Hub; AT; 2005) Virtual Trading Point; AT; 2013

(GPL/NCG)THE - Gaspool and NetConnect Germany; DE; 2009 to September 2021

- Trading Hub Europe; DE; 2021

MGP - Magyar Gázkiegyenlítési Ponton; HU; 2010

UDN - Ulusal Dengeleme Noktası; TR; 2011

VOB - Virtuální Obchodní Bod; CZ; 2011

VPGS - Virtual Point Gaz-System; PL; 2014

NIBP - Northern Ireland Balancing Point; NI; 2015

SVOB - Slovenskom Virtuálnom Obchodnom Bode; SK; 2016

IBP - Irish Balancing Point; IE; 2017

HTP - Hellenic Trading Point; GR; 2018

PVT - Punctul Virtual de Tranzactionare; RO; 2020

VTT - Virtualna Tŭrgovska Tochka; BG; 2020

PVN - Ponto Virtual de Negociação; PT; 2021

Churn rates: 2020 to 2022 – Top 6 Hubs

Volumes in TWh	Σ OTC (less cleared)	Σ Exch. Fut/Opt	Σ Exch. spot	Σ Traded	Σ NET Physical	Net market churn	Σ GROSS Physical	Gross market churn
TTF 2020	21,561.51	24,530.90	594.91	46,687.33	407.65	114.5	777.79	60.03
TTF 2021	16,512.34	36,172.40	767.12	53,451.85	390.86	136.8	791.65	67.52
TTF 2022	**7,217.58**	**34,463.24**	**1453.15**	**43,133.97**	**303.50**	**142.1**	**684.38**	**63.03**
Δ Holland	**-56%**	**-5%**	**89%**	**-19.3%**			**-13.6%**	-6.7%
NBP 2020	2,733.05	7,240.84	88.27	10,062.16	796.07	12.6	901.67	11.16
NBP 2021	1,957.43	4,595.28	93.25	6,645.96	832.05	8.0	907.09	7.33
NBP 2022	**1,884.26**	**4,322.59**	**127.12**	**6,333.98**	**775.58**	**8.2**	**1,034.14**	**6.12**
Δ Britain	**-4%**	**-6%**	**36%**	**-4.7%**			**14.0%**	-16.4%
VTP 2020	841.79	77.73	90.76	1,010.28	93.55	10.8	503.35	2.01
VTP 2021	686.19	100.99	133.28	920.46	99.14	9.3	488.72	1.88
VTP 2022	**263.72**	**228.11**	**194.56**	**686.39**	**86.15**	**8.0**	**288.93**	**2.38**
Δ Austria	**-62%**	**126%**	**46%**	**-25.4%**			**-40.9%**	26.1%
NCG+GPL'20	2,834.67	65.85	413.41	3,313.94	952.36	3.5	1,765.59	1.88
THE 2021	2,437.27	117.01	598.33	3,152.62	993.76	3.2	1,754.38	1.80
THE 2022	**1,562.72**	**734.28**	**1009.65**	**3,306.65**	**845.38**	**3.9**	**1,373.52**	**2.41**
Δ Germany	**-36%**	**528%**	**69%**	**4.9%**			**-21.7%**	34.0%
TRF 2020	705.44	26.41	156.62	888.47	434.16	2.0	548.32	1.62
TRF 2021	619.18	34.85	199.52	853.55	457.61	1.9	534.70	1.60
TRF 2022	**865.39**	**258.92**	**292.52**	**1,416.84**	**419.52**	**3.4**	**592.91**	**2.39**
Δ France	**40%**	**643%**	**47%**	**66.0%**			**10.9%**	49.7%
PSV 2020	1343.55	26.99	83.23	1,453.78	750.56	1.9	753.89	1.93
PSV 2021	1004.26	54.73	94.57	1,153.56	805.45	1.4	821.80	1.40
PSV 2022	**719.61**	**121.33**	**98.93**	**939.87**	**725.42**	**1.3**	**774.02**	**1.21**
Δ Italy	**-28%**	**122%**	**5%**	**-18.5%**			**-5.8%**	-13.5%

Churn rates: 2020 to 2022 – the remaining hubs, all under 1.0 gross churn

ZEE+ZTP/L'20	366.77	1.80	99.66	468.23	189.80	2.5	446.45	1.05
ZEE+ZTP/L'21	159.55	1.76	150.88	312.18	190.99	1.6	422.71	0.74
ZEE+ZTP/L'22	**269.70**	**52.84**	**269.90**	**592.44**	**164.18**	**3.6**	**635.32**	**0.93**
Δ Belgium	**69%**	**2906%**	**79%**	**89.8%**			**50.3%**	26.3%
GTF/ETF 2020	31.10	0.28	11.29	42.67	27.48	1.6	47.21	0.90
GTF/ETF 2021	32.11	0.01	17.57	49.69	27.65	1.8	47.76	1.04
GTF/ETF 2022	**17.99**	**0.04**	**17.58**	**35.60**	**20.11**	**1.8**	**46.67**	**0.76**
Δ Denmark	**-44%**	**213%**	**0%**	**-28.3%**			**-2.3%**	-26.7%
PVB 2020	93.19	16.59	33.04	142.82	361.04	0.4	374.37	0.38
PVB 2021	74.28	32.99	53.07	160.34	381.49	0.4	415.29	0.39
PVB 2022	**63.42**	**90.56**	**104.43**	**258.41**	**365.78**	**0.7**	**433.42**	**0.60**
Δ Spain	**-15%**	**175%**	**97%**	**61.2%**			**4.4%**	54.4%
VOB 2020	81.71	3.91	8.86	94.48	93.70	1.0	475.30	0.20
VOB 2021	61.43	9.47	23.46	94.36	100.58	0.9	493.29	0.19
VOB 2022	**37.44**	**16.40**	**35.52**	**89.36**	**80.90**	**1.1**	**277.26**	**0.32**
Δ Czech	**-39%**	**73%**	**51%**	**-5.3%**			**-43.8%**	68.5%
VPGS 2020	0.00	124.13	26.94	151.07	216.10	0.7	462.99	0.33
VPGS 2021	0.00	148.90	31.63	180.53	230.23	0.8	437.45	0.41
VPGS 2022	**0.00**	**116.58**	**21.94**	**138.53**	**191.32**	**0.7**	**198.32**	**0.70**
Δ Poland	**n/a**	**-22%**	**-31%**	**-23.3%**			**-54.7%**	69.3%
PVT 2020	0.00	46.24	6.65	52.89	121.32	0.4	122.81	0.43
PVT 2021	0.00	50.86	13.34	64.20	123.72	0.5	131.09	0.49
PVT 2022	**0.00**	**15.73**	**16.59**	**32.32**	**104.46**	**0.3**	**114.00**	**0.28**
Δ Romania	**n/a**	**-69%**	**24%**	**-49.7%**			**-13.0%**	-42.1%
MGP 2020	0.41	0.70	23.27	24.37	111.86	0.2	173.00	0.14
MGP 2021	2.29	0.88	30.42	33.59	118.55	0.3	128.79	0.26
MGP 2022	**1.27**	**0.00**	**26.01**	**27.28**	**100.78**	**0.3**	**117.44**	**0.23**
Δ Hungary	**-44%**	**n/a**	**-15%**	**-18.8%**			**-8.8%**	-10.9%
VTT 2020	0.00	2.43	0.94	3.37	31.38	0.1	59.62	0.06
VTT 2021	0.00	10.09	2.39	12.48	36.47	0.3	137.88	0.09
VTT 2022	**0.00**	**9.98**	**4.03**	**14.01**	**29.22**	**0.5**	**162.38**	**0.09**
Δ Bulgaria	**n/a**	**-1%**	**69%**	**12.3%**			**17.8%**	-4.7%
SVOB 2020	17.68	n/a	n/a	17.68	52.14	0.3	548.65	0.03
SVOB 2021	26.52	n/a	n/a	26.52	58.47	0.5	450.38	0.06
SVOB 2022	**4.05**	**n/a**	**n/a**	**4.05**	**56.61**	**0.1**	**262.87**	**0.02**
Δ Slovakia	**-85%**	**n/a**	**n/a**	**-84.7%**			**-41.6%**	-73.9%
Σ Europe 2021	**23572.85**	**41330.22**	**2208.81**	**67,111.88**	**4,847.02**	**13.8**	**7,962.98**	**8.43**
Σ Europe 2022	**12907.15**	**40430.60**	**3671.94**	**57,009.69**	**4,268.92**	**13.4**	**6,995.59**	**8.15**
Δ Europe	**-45%**	**-2%**	**66%**	**-15%**	**-12%**		**-12%**	