An Assessment Framework for LNG Hubs

Report for GIIGNL Hub Study – GIIGNL CSG

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1. Methodology

In this section, we start with a definition of 'hub' in various cases. The key part of this section presents the list of key factors that have been found to make a significant contribution to successful hubs.

1.1 Definition of hubs

In this study, a 'hub' is the place (market) where buyers and sellers exchange the ownership of commodity in paper and in physical delivery. A basic role of a 'hub' is the transfer of commodity from sellers to buyers in order to deliver the contracts at their time of maturity. The ownership is exchanged either for risk management and/or speculative trades (i.e. financial trades), or delivered physically (physical trades) for consumption or balancing transactions.

While we collectively name such trading places in all commodities as 'hubs', the term is not unanimously applied in all commodities. 'Hub' itself is commonly used in natural gas and LNG commodities only. In case of other commodities, 'hub' is not frequently used. Instead, the equivalent words of 'hub' could be 'market', 'price', or 'benchmark', such as Brent market (price) and Newcastle price (for coal). Therefore, in addition to the collectively used term of 'hub', in specific commodities, it will be spelt out as (benchmark) gas hub, (benchmark) LNG hub, Brent Market, Newcastle price, etc. In any case, a difference should be made between the hub itself and the possible information derived from or published based on the transactions executed on this hub.

Hubs trade in products that are standardized for delivery. A hub can trade in a number of products (which are interchangeable as contracts), which are often different due to differencing terms of maturity, such as day-, week- and month-ahead delivery, all of which are often classified as spot products. In contrast, those that have maturity terms of more than one month are futures products. Futures and forwards are covering the same maturities but differ from

each other as the first are obtained through cleared transactions while the latter are obtained through over-the-counter transactions.

There are two categories of hubs frequently referred in the study, 'physical (spot/trading) hubs' and 'benchmark (financial/futures) hubs' according to their function. 'Physical (spot) Hubs' are used by shippers to balance their portfolios that are near to maturity and at delivery. While a trading hub can generate a price index, it is only a 'benchmark hub' that offers benchmark prices for other hubs and often is unique in regional markets. For example, while there are many regional physical trading hubs reflecting local and regional supply/demand balances, natural gas in US hubs is frequently traded at prices as differentials to Henry Hub, which is a benchmark hub [2]. Similarly, while there are many balancing hubs in Europe and many European hubs have futures products, only NBP and TTF are deemed to have relative liquidity in trading volumes of futures [8]. Thus, NBP and TTF are not the only hubs but they are the most preferred and most referenced as benchmark hubs in the European market. A 'benchmark hub' must have good liquidity from spot trading up to several years ahead, as well as being fully transparent in trade and price transactions, and accessible to a wide range of participants [8].

1.2 Methodology of the study

Formation of a hub and its progress towards development of a financial hub and finally a benchmark hub is contingent on a number of enabling factors or key indicators. In order to select the key indicators and test their relative weights, we conducted case studies for 18 commodity hubs from four different commodities. The choice of the key commodities and hubs under study are agreed by the study team based on a number of considerations, such as their importance in the world economy, the different stages of development in hubs and similarity to future LNG hubs. The details of the commodities, products and hubs under study are given in Appendix 1 and summarized in Table 1. Some of the earlier versions of these case studies have been published in peer reviewed literature [9-11].

For each of the hubs, we try to find the key factors to their success or failure, from the literature and from our assessment of various commodity hubs. The key elements of a hub were selected from various reports such as the 'European Gas Hub Study' [12-14], which scores individual European hubs annually, as well as information from the literature.

Table 1 Commodity Hubs under study

Commodity (# of hub)	Hub (products)
Oil (9)	**Brent:** There are 119 options and futures contracts based on Brent trading at the ICE and CME exchanges. These include American and European style options, crude oil difference options to other key benchmark crudes (Dubai, WTI, LLS, ASCI and Urals) and CFDs. The major products are Dated Brent, Brent CIF Rotterdam, Forward Brent (up to 3 months), and Brent Futures (up to 108 months). **WTI**: CME WTI Futures (for maturities up to 108 months), WTI P-Plus, NYMEX CMA **Dubai**: Platts Dubai Assessment, DME Oman Crude futures (up to 72 months), DME Dubai crude oil (Platts) Futures (24 months), (Brent/Dubai Exchange of Futures for Swaps (EFS) and the Dubai inter-month swaps markets at DME **ASCI, LLS**: ASCI and LLS spot prices. ASCI (up to 72 months) and LLS (up to 60 months) futures (traded at ICE & CME), LLS vs WTI and ASCI vs WTI diff spread options (CME), LLS vs Brent (CME) **Urals**: Platts Northwest European Urals, Urals crude futures at SPIMEX **Nigerian crude blends**: Platts assessment of Qua Iboe, Bonny Light, Brass River and Forcados blends as a differential to Brent **Tapis and Minas:** only spot products
Gas (6)	**Henry Hub: CME** (Physical Futures, Last day financial futures, and Penultimate Financial Futures); ICE (Henry LD1 Fixed Price Future, Henry LD4 Fixed Price Future/Option, Henry Penultimate Fixed Price Future/Options (both 100k and 25k), Henry Calendar Year One Time Fixed Price Future/Option) **NBP,TTF, NCG, ZTP Physical (ZEE), ZTP:** In PEGAS, all European hubs have same spot products (Within Day, Day-Ahead, Week-End, Saturday, Sunday, Bank Holiday, and Individual Day) and futures instruments ranging from the next month (ZTP) to up to the next 4 calendar years (TTF). In ICE/ICE Endex, the products for those hubs are different: ZTP (ZTP Spot, ZTPS Spot, ZTP future); TTF (Gas Futures, Gas Base load TAS, Gas Daily Futures, Gas Options, gas spot); NCG (futures and options); NBP (UK OCM Spot; UK NG (EUR/MWH) Future, UK natural gas daily (w/wo financial) future, UK NG futures (w/wo TAS)). **China hub:** Day ahead pipeline gas and LNG *w/wo means two cases: with or without a world
Iron ore (1)	**Asia Iron ore Hub :** The benchmark price of Iron ore is assessed in Asia (Singapore) standardised for delivery to China ports. Various assessments have attained benchmark status and underpin futures contracts. Namely, **The Steel Index prices (TSI)** - Iron ore fines 62% Fe - Tianjin Port (China), Iron ore fines Fe 58%, 62%, 63.5/63% and Fe 65% (low alumina) all CFR Qingdao. **Metal Bulletin (MB)** - The MBIOI-62 is the main benchmark price. The MBIOI-58 is a price representing the lower grade iron ore fines market. **Platts Iron Ore Index (IODEX)** – Fe 62%, CFR Qingdao, North China. The list of Iron ore derivatives traded in the exchange include SGX Iron Ore CFR China Swap/Futures/Option for different specifications of iron ore (62% Fe Fines,

	58% FE Fines) and price index. The major contracts traded in terms of traded volume in the exchange are the Iron ore 58% and 62% swaps and futures, based (underlying) respectively on the Metal Bulletin assessment and Steel Index assessment of Iron ore prices.
Coal (2)	**Newcastle (Australia):** Platts FOB Newcastle 5,500 NAR, Australia (fob Newcastle) API 5 index (weekly), Australia (fob Newcastle) API 6 index (weekly) **Richardsbay (South Africa)** : South Africa (fob Richards Bay, 5,500) API 3 index (weekly), South Africa (fob Richards Bay) API 4 index (daily) API 2 and API 4 Rotterdam Coal futures (up to 84 months maturity) at ICE, Globalcoal Newcastle Futures (up to 84 months maturity), API 2, API 4 and Newcastle Coal options with 122 day, 214 and 305 day expiry traded at ICE.

Note: details about the hubs and products are presented in Appendix 1.

Based on the results of the case studies, we proposed a list of 13 key indicators or factors or criteria classified into four categories. The four categories are **Participants, Physical factors (supply, demand and logistics), Traded Products and Market Rules (Institutional Factors)**. These indicators, although not all are applicable to every single hub studied, are applicable to the majority of hubs and important.

The importance of these factors in hub development is indicated by a weight. The weight is in the scale 1 to 3 where a weight of 1 relates to a minor, but important indicator to the weight of 3 signifying a highly important indicator. In the case that an indicator is not applicable to a specific hub, the weight can be changed to 0. After adjusting for variations in development of different hubs, the final framework, categories, indicators and their weight (importance) are summarized in Table 2.

Table 2 Category, key indicators and weight for the assessment of a hub

	Key Indicators	Weight (importance – 1 to 3)	Score (1 to 5)	Weighted score (weight*score)
Category	**Participants**			
1	*Number of market participants* The risk of market manipulation and illiquidity is low due to a high number of active participants and no dominant player	3		
2	*Diversity of market participants* The nature of the market participants is diverse in terms of buyers / sellers and consumers /	2		

	producers / banks / traders / hedge funds			
Category	**Physical factors (supply, demand and logistics)**			
3	*Storage, producing, transportation infrastructures* Infrastructure exist along the supply chain to connect the hub to external sources of supply or demand so that the hub position can be balanced more globally: storage, production, transportation infrastructures like loading and receiving terminals, shipping, pipeline, railway, truck bays	3		
4	*Physically Traded Volume* The quantity of the commodity supplied or demanded within the hub is significant with regards to the overall global or regional supply / demand	1		
5	*Local supply or demand* The delivery point includes either material sources of supply and/or material sources of demand	2		
Category	**Traded products**			
6	*Price transparency* The trading hub has a price index that is established according to a clear and transparent methodology: actual trades or price submissions or just assessments from some market participants), transparent and independent (reputable Price Reporting Agencies (PRAs)	3		
7	*Product standardization* The market participants agree to trade products that are fairly standardized (quality, delivery point, quantity, timing of delivery)	2		
8	*Variety of products* The trading hub offers a wide range of possible tradable products: physical spot, physical forwards, futures, swaps, options	2		
9	*Risk Management*	1		

	The available products are useful to answer some unmet needs of the market participants: manage performance risk, credit risk and systemic risk and/or implement hedging and speculation strategies			
Category	**Market rules**			
10	*Liberalization of market* The market is liberalised and free to fully reflect the supply / demand balance in the price of the index	3		
11	*Legal Framework* The legal framework applying to the trading hub is stable and a strong rule of law prevails	3		
12	*Regulatory competence* A regulatory authority supervises and controls the functioning of the market to guarantee fair, efficient and sustainable trading without adding unnecessary compliance burden on the market participants	2		
13	*Tax and duties (Fiscal environment)* The applicable tax and duties are business-friendly: competitive, simple, stable	1		
TOTAL				

Note: For the assessment of a specific hub, the weight could be set at zero if the indicator is not applicable.

1.3 Application of the framework to hub assessment

In the assessment of a hub, the assessor will give a score for each indicator for a given hub under study. The score is in a scale of 1 to 5 with 1 being the least developed to 5 being the most developed.

A total weighted score for each hub can then be calculated based on the assigned score and the weight of individual indicators. The organizer of the assessment can ask more than one assessor to conduct the assessment and average the scores. This total score (or a percentage score of the maximum possible score) can be used to compare the hubs, including those potential LNG hubs, in a standardized format. Such assessment and comparison can reveal the maturity of a hub and provide a reference for future development of pricing hubs in new markets.

Our weighing and ranking of the factors and the score for each of the indicators for the hubs are subjectively determined, as no objective study exists at present to do the same. The organizer could conduct interviews or hold target-group meetings to refine the weights. Regardless of the ways used, key stakeholders should be engaged to make sure that their views and concerns are considered.

2. Explanation of the indicators

In this section, we explain in detail the rationale for the inclusion of each of the factors based on our analysis of 19 hubs from five commodities.

2.1 Participants

1) Number of market participants

A large **number of participants** active in the market leads to increased liquidity of trading and opportunities of price discovery. This factor is important as it helps to avoid price manipulation and other concerns related to a small market. Physical parties (shippers), namely producers, wholesalers, retailers and consumers, who use the spot market as a balancing tool [2] form the basic group of participants.

All the successful pricing benchmarks such as Brent, WTI, Northern European gas hubs, HH, Iron ore and coal benchmark markets have 10 or more participants in spot markets. The Brent physical markets see participation of 10 to 15 players in the 25-day Brent-Forties-Oseberg Ekofisk Troll (BFOE) forward market. This is a large set with participants hailing from oil majors, commodity-trading houses, and major Wall Street banks. Diverse ownership of production (with more than 15 producers active for Brent blends at any given month) make the influence of any one producer negligible [15]. The Brent futures market, which is the largest derivatives market globally, show participation from a large number of market players. The largest category of participants in ICE Brent are the commercial hedgers (producers, users, processors, merchants), demonstrating Brent's significance as a hedging tool for physical market participants [16, 17].

Products for the WTI (West Texas Intermediate) blend, come from a large set of producers and fields in the state of Texas, Kansas, and Oklahoma, as well as imported crude from Canada and other sources. Trades in the US pipeline crude markets are for small volumes of 30,000 bbl. per trade. As a result, more companies can access credit and storage facilities to participate in

the physical US crude oil market. On account of the smaller trade limit, and as an exchange traded contract, a large number of players are attracted to the futures market including commercial enterprises such as producers, marketers, traders as well as speculators and variety of financial investors such as institutional and index investors [15].

According to EIA 2017 report [5], there were 40 active market participants and monthly trade of day-ahead product is about 7400 transactions in the Henry Hub market. In European gas markets, it is suggested that a minimum of 10 active companies (those who trade at least once per week) is necessary to form a functioning competitive market [8]. For the NBP (National Balancing Point) market in the UK, there were 40 active market participants and monthly trade of day-ahead product is around 7400 transactions. There were 30 active market participants and monthly trade of day-ahead product is about 7700 in the Dutch TTF (Title Transfer Facility trading point) market. The other hub contender in Europe, ZEE (Zeebrugge trading point, in Belgium) was not as active with only 15 active market participants. The Chinese gas market has more participants in LNG trade than in pipeline trades. In the pipeline gas trading, the active sellers are CNPC and CNOOC. In the case of LNG trade, the market players are more diverse[1] [18].

On the contrary, a limited number of market participants are found in some unsuccessful hubs. Two of major oil producing regions with a small number of active market participants in spot markets are the Russian oil market and the South East Asian oil market. The Russian crude blend, Urals', has limited available volume on the spot market because Russia's largest oil producer Rosneft has pre-sold Urals to trading houses, three of which, Vitol, Glencore and Trafigura take more than half of Urals' seaborne export volumes [19]. This significant dominance by the major producers and traders leads to risk of market monopoly and lower liquidity in trades. The number of Tapis and Minas stream cargoes available for trading in the spot market has reduced as production has shrunk, and as producers hold more volume for their

[1] As of November 2017, there is no defined gas hub in China. However, there are two gas exchanges: the Shanghai Petroleum and Gas Exchange (SHPGX) and the Chongqing Petroleum and Gas Exchanges (CQPGX), which are dedicated to trade gas. CQPGX has yet to start trading gas. The SHPGX started fully operation in November 2016. In September 2017, SHPGX organized pipeline gas trading by five regions (East, North, South, Southwest and West) that are designated by CNCP Sales Branch. There are five benchmark-pricing points in China (Beijing for North, Shanghai for East, Guangzhou for South, Lanzhou for West and Chengdu for Southwest). However, this benchmark pricing are neither physical hub nor virtual trading point (there is no explicit definition yet). Up and middle streams are integrated and dominated by four companies. The market is not liberalized and low in diversity with limited set of market participants.

own refinery systems [15]. Nigerian hub also display low scores in this measure owing to mostly nationalized production and sales tied to long-term contracts.

2) Diversity of market participants

The trading market for commodities ideally should have a **diverse mix of players** that is inclusive of but not restricted to upstream, mid-stream (traders), and downstream players, and financial players (trading houses and financial institutions), or more commonly known as either buyers, sellers, hedgers and traders. We find that all the successful hubs have diversified participants, with purely physical hubs generally ranked below the diversity rank of financial or virtual hubs. Presence of non-physical players will add liquidity and depth to the market. Our study has also found that the dominance of top players in the market can distort prices away from truly market-based prices and thus sufficient diversity in terms of the number of market participants is needed. The WTI market is well diversified in both physicals and financial market. The ability to trade in small volumes has increased the diversity and number of players who find it easier to obtain the necessary credit and storage facilities to participate in the US market.

The measure of diversification is applied across both physical market and futures markets. Despite small number of market participants, both the two Brent physical markets see meaningful price discovery due to the presence of a diverse set of market players in the futures markets. The forward Brent market is also a small market, with roughly 10 participants contributing to price assessment in the window, spanning oil majors, and trading houses. However, the Brent futures market adds to the diversity. The futures market has attracted a wide range of financial players including swap dealers, pension funds, hedge funds, index investors, and technical traders. In 2012, ICE Brent became the world's largest futures contract in terms of volume.

The physical market in Dubai crude is also successful despite only up to 10 daily active participants in the spot market. The Dubai market participants for derivatives is quite diverse with Japanese refiners, major banks (Merrill Lynch BoA, JP Morgan, Morgan Stanley, Societe Generale), refiners (BP, Shell), trading firms (Mercuria, Vitol) and Japanese firms (Mitsui, Sumitomo) actively participating in the trades (Fattouh, 2011).

Iron ore and coal markets see set of players from the very large mining conglomerates, industrial houses and government owned enterprises to relatively small, unorganized producers

and steel mills. Although the producers are more organized in iron ore and coal market, they have limited ability to collude in setting high prices due to the presence of other large suppliers.

Availability of exchange traded contracts in iron ore and coal market attracts large number of participants at any time, ensure that market manipulation and squeeze are limited.

In contrast, the nature of market participants - government or state supported monopolies (for buyers and sellers), and concentration of liquidity with a few privileged players, has restricted the diversity in the market in Russia, South East Asia and Nigerian oil markets. For the Urals market, the Russian state government controls more than 50% of the production of the crude oil, with more than 75% of the production coming from five major Russian oil companies [19]. As for the futures market, only non-Russian legal entities (with long positions) are eligible to take physical delivery. The activity of two major trading houses and the dominance of Russian state in production side makes Urals a market with low diversity in both physical trade and financials.

2.2 Physical Factors (Supply, Demand and Logistics)

3) Storage, producing, transportation infrastructures

Existence of flexible supply chains and delivery infrastructure with sufficient capacity to allow for the efficient transport of the commodity is important to avoid extreme price movements and facilitate hub balance. In the gas hub case, infrastructures must exist along the supply chain to connect the hub to external sources of supply or demand or storage so that the hub position can be balanced between storage terminals, production and receiving terminals. It is ideal for both physical and virtual hubs to be located in a gas transmission system where product transfer is logistically possible [20]. The transportation between the benchmark hub and the main sources of supply or demand is cost effective where there is geographical proximity between supply and demand centres, low transportation unit cost, and low losses along the supply chain.

All the key hub prices that underlie global price benchmarks exhibit the importance of efficient supply chains and infrastructure capacity to allow for trade of physicals in line with market demand and supply. The Brent market developed in a specific location around the North Sea, as offshore pipeline infrastructure allowed for the collection of crude oil produced in the Brent fields to be delivered to loading terminals in UK and Norway. All the five terminals for choice of delivery of the Brent crude blend is well connected with offshore production facilities and on shore storage. Located in the transatlantic route close to major refining centers of both

Europe and USA, the Brent market is formed close to supply and demand centers. Cushing, Oklahoma, where WTI based, is a gathering hub with large storage facilities and is also known as the "pipeline cross roads of USA" due to the extent of pipeline interconnection with various producing and consuming regions. Dubai also has an important locational advantage of being a traditional trading centre in the region, and as a gateway to Middle East with oil trade flows at 19.7 mbd. The port of Jebel Ali has the ability to handle a large part of the UAE's trade in refined petroleum products, and can accommodate large capacity oil tankers. Existing pipelines connect producing fields from Oman, so Oman crude is also part of the benchmark assessment in Dubai. Also, as a major trade port, Dubai is well connected with refining centers in Asia and Europe for the transport of crude oil.

The Henry Hub is also an interconnection point of various important gas pipelines connecting production and supply centers (EIA 2017). The NBP virtual trading point is supported by well-connected underline infrastructure. Netherlands is a major gas consumer and geographical location between Russia and other European demand centers. The Dutch 'Gas Roundabout' implemented in the mid-2000s has promoted the development of TTF [21]. Belgium's ZTP Physical (ZEE) and ZTP notional geographical location in the centre of the European pipeline and LNG transit is advantageous for its development. In contrast, China lack backbone national natural gas transmission networks and thus connections between hubs is limited.

The existence of a flexible and efficient supply chain and of underlying infrastructures supported the development of the iron ore and coal trade in a variety of countries including Australia, South Africa and Singapore. As one of the largest producers of export coal and a benchmark hub, Australia has developed a vast network of railways lines and ports such as New Castle, Hay Point, Gladstone, Port Kembla and Abbot Point as the major coal export ports. The extensive rail network in NSW and Queensland states (largest coal producing region) largely support coal exports. Development of the massive Bowen Basin and Hunter Valley coking coal deposits in Australia was accompanied by large investments in relation to rail and port infrastructure between 1980 and 2000. The South African government, the host to the second global coal benchmark price, invested heavily in having rail and large ports for transport of coal. This has resulted in efficient movement of large quantities of coal cost effectively to global markets. Singapore is the point of price discovery for Iron ore, and is

located at the crossroads of this important trade route. Though not an active physical hub, Singapore assumes the role of a financial and trading hub for the commodity.

4) Physically Traded Volume

It is quite important for the quantity of trade for the physical asset or underlying asset in the hub to be significant to the overall global or regional supply or demand for the commodity. WTI has an open interest of almost 2 million contracts and daily trade volume of 1.2 million contracts. Other crude oil benchmarks ASCI and LLS also see robust physical volume of trade[2]. However, our study has found that there is no accepted minimum level of a physically traded volume for viability of price discovered in the market.

Physical trades in gas hubs are active and substantial. Daily trade in HH market was 192 Thousand MMBtu, and 29 deals per day in spot market in 2015. Daily trade at NBP in 2015 was 77 bcf (EIA 2017). Daily trade at TTF in 2015 was 115 bcf, the largest in Europe. Monthly trade in the Germany hubs is not less than 110,000 GWh. Daily trade of ZTP Physical (ZEE) was 7.2 bcf, the third largest in Europe (EIA 2017).

Both Iron ore market and coal market pricing are underpinned by a large base of spot traded volume and pattern of world supply and demand fundamentals[3]. The worldwide acceptance of both Metal Bulletin (MB) and The Steel Index (TSI) prices (assessed in Singapore) for delivery of iron ore to Chinese ports clearly indicate that the prices benchmarks reflect the market fundamentals.

The main disadvantages of a decline in the physical base of a trade is that physical markets can become too thinly traded and illiquid if sufficient quantity of supply necessary for meaningful trade is not available. Market prices can become a less accurate barometer of current supply and demand as trades are less frequent. In addition, lower traded volumes enable individual market participants to influence the price more easily, and this raises the possibility of market manipulation, raising serious questions with regard to the reliability and relevance of the

[2] The ASCI assessment is on the output of US Gulf of Mexico crude with a total production of 1.9 mbd. Total traded volume of the underlying at 550,000 b/d and is significant. Total production of the three representative crudes underlying ASCI totalled 700,000 bpd on average. Total number of spot trades is 250 per month. As a pipeline based crude, with 30,000 barrel the threshold amount to be in market, the ASCI price market sees more trades than the Brent and Dubai markets. The total traded volume on a monthly basis is on an average 10 million barrels or 300,000 barrels per trading day.

[3] The mining production is highly concentrated with the top three (Vale, BHP Billiton, Rio Tinto) holding 60 per cent share of the traded iron ore, with Australia, Brazil, and China are the main producers of iron ore. On the side of demand, it is more fragmented. However, China is the leading driver of the global demand for iron ore, accounting for 65 per cent of the world's seaborne iron ore in 2013. Other large importers of iron ore include; Japan (11 per cent), Europe (10 per cent), and Korea (6 per cent), which is a clear indication that the Asian countries are the base for physical trade in the iron ore trade.

discovered prices. The lack of a physical base of trade has led to the decline in importance of affected benchmark prices, and to debates on the continued relevance of benchmark prices that show signs of a declining production base. For example, the absence of cargoes available for spot trade, on most of the twenty or more days of any given calendar month, makes objective price determination of Tapis, Minas or Duri very challenging for market participants. Market convergence rarely happens without physical settlement and the lower traded contracts are usually rolled over. The decline in production causes the loss of Asian oil price benchmarks. Tapis production was reduced from a peak of 360,000 Bbls/d to around 280,000 Bbls/d currently; Similarly, Minas production was reduced from a peak of around 420,000 Bbls/d to around 200,000 Bbls/d and Duri from a peak of 325,000 barrels per day to around 200,000 Bbls/d [24]. The total quantity of supply, as well supply available for spot trading averages 4-5 cargo every month or one every week. Since it is difficult to observe the spot price of these grades even for their own assessment of value, they are not suitable to be chosen as representative prices (benchmarks) for other sweet crudes.

However, this declining physical trade is mitigated by the presence of other similar commodities that can be delivered against the original benchmark commodity. The Brent market is a good example. The gradual decline in Brent production saw the addition of crude oil produced from nearby fields (Forties, Osberg, Ekofisk, and Troll field in Norway); with the total volume from the Brent system (excluding Troll) was at 1.17 mbd (2016). Average North Sea crude oil output is currently around two million barrels per day and the BFOE basket making it the largest underlying physical market of any comparable traded and transparent benchmark [22].

As another example, the liquidity squeeze due to decrease in Dubai production has been mitigated by the addition of Oman and Qatari streams into the Dubai blend. Along with robust trading activity in the exchange, the Dubai crude price is now a truly independent spot price, set based on exchange and physical transactions reflecting regional supply and demand. Furthermore, ICE has proposed limiting the size of positions investors can hold to 6000 lots to enhance the reliability of the contract, as trade volumes and open interest for the Asian crude oil benchmark increased [22].

Physical trade volume is necessary but not sufficient for a successful price hub. Russia, as one of the world's largest crude oil exporters, has the physical capacity to set up an international

oil benchmark, but has not succeeded to establish a price benchmark so far. Russia's attempts to establish a futures market for its flagship Urals oil grade is not successful due to a lack of support from international trading houses and the scarcity of oil on offer to be settled against the spot price at expiry (Reuters, 2016). Lack of liquidity in spot market (with most volumes sold on long-term basis) is also cited as a reason for East Siberia – Pacific Ocean pipeline (ESPO) not developing into a benchmark for crude export into North East Asian markets [23].

5) Local supply or demand

L**ocal supply or demand**, or geographical proximity to large physical volumes of trade is a strong advantage for the development of a price hub. The markets where marker prices are assessed usually have a physical base of production, or a strong demand centre, or both, that permits a sufficiently large number of trades. The geographic concentration of liquidity in physical trade serves to support several positive market developments, increased liquidity of trades, enhanced avenues for price discovery, more narrow bid-ask spreads, and in general a more efficient marketplace.

The Brent, US and Dubai crude oil hubs are all close to a major producing region as well as in close trading proximity to major demand centers. The geographical location close to the refining centers of USA and Europe (demand centers) gave Brent an advantage over the other regions due to the possibility of Atlantic arbitrage. The WTI NYMEX contract is settled for delivery at Cushing OK. This location is connected by pipelines to major producing regions and is one of the largest crude oil storage hubs on Earth. Dubai is naturally considered to be a place to host a price benchmark in the Middle East due to the local production volume. Another reason is its geographical proximity to the Middle East region, which has oil trade flows of 19.7 million barrels per day. Dubai also has an important locational advantage of being a traditional trading center in the region and a gateway to markets of the Middle East. Total production of the five fields constituting Dubai benchmark is around 3.6 million Bbls/d, and typically there will be almost 2.4 million Bbls/d of Dubai, Oman, Upper Zakum, Al Shaheen and Murban available to be freely traded. Dubai benchmark is the Asian crude oil price also due to the activity of Asian traders and proximity to major Asian markets.

Natural gas hubs are also influenced by geographical factors related to supply and demand location. The US is the world largest gas producer and consumer of natural gas. The UK also has substantial domestic production - although declining - and it also has various LNG receiving terminals to import gas. The Netherlands has been until recently a major gas

producer, and a large gas consumer and net exporter in Europe. It is also an important gas transit country. Although Germany does not have significant indigenous gas production, its network is well connected to consumers and various suppliers. Belgium is also very well connected to adjacent networks and supply sources and counts no less than 18 border interconnector points. Trading activity in ZTP Physical (ZEE) remained stable while at the same time activities on the ZTP notional hub increased significantly, reaching 50% of ZTP Physical (ZEE) volumes in 2017.

Local demand or supply is also demonstrated to be important for iron ore and coal benchmarks. The physical products underlying the iron ore prices are standardized for delivery into selected Chinese ports, Tianjin, Qingdao and Dalian, all large centers of Iron ore storage, demand and trade. Shipments to all major ports for which freight cost differentials to Tianjin and Qingdao ports can be determined are included in the compilation of the Iron Ore Index. In the case of South Africa and Australia, two of the largest coal exporters to the Atlantic and Pacific markets, significant trade activities enabled by this production base and the close trading relationship with consumption centers should be allowingthe development of Atlantic price and Pacific market price for coal.

2.3 Traded Products

6) Price transparency and discovery

All the successful trading hubs have a price index that is established according to a clear and transparent methodology, based on actual trades or price submissions or assessments from market participants, reported in a transparent and independent manner by reputable Price Reporting Agencies (PRAs).

The spot index that includes prices discovered in financial trading improves price transparency and discover the market fundamentals. The price formation in benchmark hubs therefore starts from the spot market, and further develops in forwards and futures markets. Formation of a liquid forward and futures curve based on concluded trades is the final feature of truly global and successful benchmark prices. As the market for financial products expands with low entry barriers, the prices formed in the financial layer (anchored to the spot prices due to principle of arbitrage) are regarded as more robust and reflective of market prices. The physical layer and financial layer of benchmark hubs reinforce each other in better price discovery, so much so that many of the large producers and consumers price physically traded commodities based on exchange quoted spot and futures prices.

The price indexes are often assessed by PRAs. The arms-length nature of trades in spot transactions in commodity markets (physical trade) mean that information on spot prices and the trade levels are not publicly available but are shared through specialised channels. PRAs are publishers and information providers who report prices transacted in physical and some derivatives markets, and give an informed assessment of price levels at distinct points in time. PRAs ensure that reported deals are analysed and confirmed with counterparties with an escalating review process of marginal deals that can be eliminated from the price review.

Price assessment and trade data of Brent, WTI, Dubai (crude oil), Iron ore (MB, TSI), Coal (API2, API4) benchmark prices are all assessed and disseminated by PRAs such as Argus and Platts. They have different methodologies and approaches for price discovery. For example in the Brent market, these agencies derive the forward Brent price from deals reported to them by brokers and traders in the forward market (Argus) or based on deals conducted in the window (in the case of Platts).

The activities of PRAs lend credibility and continued relevance to the price formation process, often in light of thinly traded physical markets and with gradual decrease in the physical base of trade[4]. When market liquidity is low, the PRA uses well-defined methodologies such as survey of market to assess the spot prices.

WTI and Henry Hub, which are extremely liquid, have migrated to a purely exchange traded contract. Hence, price determination is achieved in exchange based trading. Using the amount of trading on the two large trading markets, CME's NYMEX (Henry Hub futures and other products, 1,100 to 1,500 quadrillion Btu,) and ICE (various products at Henry Hub and other locations, 419 to 768 quadrillion Btu), against the U.S. natural gas consumption in 2015 (26 quadrillion Btu), a national churn ratio is 61–90 (EIA, 2017).

In China, there is no spot price index yet which indicates that a gas hub has not been established. The current published prices are only those that traded in the Shanghai Petroleum and Gas Exchange, which is bounded by a floor and ceiling from the regulated city gate prices.

[4] With the evolution of Brent market, the PRA methodology has also evolved in complexity offering lesser room for price manipulation thus leading to reliable price discovery. Platts introduced a mechanism known as the partials mechanism, to counteract the problem of Dubai's low liquidity in physical spot trade. The partials mechanism has the effect of slicing a Dubai cargo (as well as Oman) into small parcels that can be traded, thereby increasing liquidity and improving price discovery process.

7) *Product standardization*

Product standardization is important to quantify, price and enable trade, allowing for precise estimation of the value of the commodity in the value chain. Any significant variation in the physical nature of the commodity either in physical spot trade or as an underlying factor in the financial trade weakens the status of commodity as a price benchmark. This is seen in the case of the Brent market where the addition of Buzzard field made the trades halt over many days due to absence of standardized procedure to price the commodity based on an accepted scale of quality.

All the commodities that form benchmark prices need to be uniform in their composition varying only within tolerable limits. Alternatively, they must have devised market-accepted methodologies to price based on quality variations to be able to basis of any benchmark-pricing hub. Standardised trading contracts and regulation of the market as part of the broader financial market ensure that reported trades and prices are transparent, trustworthy, and in accordance to global standards.

Standardization of contract terms and operating rules further enhances trading by reducing uncertainty and lowering transaction time and costs. The TSO standardized traded natural gas effectively and erased the difference between high and low calorific gases traded in TTF hub (Heather 2013). For the case of Germany NCG, the country had a system of 19 entry-exit zones, the number of which decreased gradually to 12 and finally to two with the corresponding Gaspool hub for low-calorie gas and NCG for high-calorie gas [25]. Two virtual trading points ZTP for high calorie gas and ZTP-L for low calorie gas were launched in September 2012, after TTF become established [26].

The Brent futures contract was initially launched on the International Petroleum Exchange (IPE), now known as the InterContinental Exchange (ICE), as in the case of other futures contracts, the ICE Brent Futures contracts terms and conditions are highly standardised, which facilitate trading in these contracts. The futures contract specifies 1,000 barrels of Brent crude oil for delivery in a specified time in the future.

In light of the variety of crudes produced, it is observed to be easy to maintain the range of values for the WTI blend, with occasional departures. NYMEX (CME Group) Light Sweet Crude Oil Futures states a WTI Crude and Quality Specifications as containing Sulphur - ≤0.42% by weight and API Gravity between 37 and 42. There are also published specs for Viscosity, Reid Vapour Pressure (RVP), BS&W, and Pour Point but these do not constrain the stream.

When products naturally vary in quality, the pricing methodology specifies standardized methods to account for regional variations in quality. The quality of product in the Brent complex is not uniform with API gravity ranging from 32.6 for Buzzard to 44.1 for Brent and Sulphur content from 0.16% for Forties to 1.44% for Buzzard. This non-uniform nature of quality of blends has resulted in application of 'de-escalator' for every 0.1% of Sulphur content above the threshold level. As the Brent contract can be delivered by any of the 5 crude blends, and Forties is usually the cheapest one, the Brent price usually follows the Forties price [15]. The benchmark exports (Australian coal, South African coal, Iron ore from Australia and Brazil) on which the assessed prices are based are always standardized to a specification level with quality differentials are calculated based on regression based analysis of the past differentials. Usually, quality differences are not cited as causing any price determination problem.

On the contrary, a lack of standardization makes price indexation impossible or challenged. The addition of Oman to the Dubai benchmark has created problems in the Dubai-Oman benchmark. Because Oman crude has a lower sulphur content and a higher gravity than the Dubai crude, in some periods depending on the relative demand and supply for the various crudes, the price gap between the two types of crude tends to widen [27]. One reason that China could not establish a price index is because natural gas is still largely traded by volume rather by heat content in Chinese exchanges [28].

8) Variety of products

A variety of products is essential for a trading hub. Spot trading in the physical markets is a basis for a hub. Spot contracts [5] (defined as all periods as within the month, including month ahead) are mostly used for final portfolio optimisation ahead of physical delivery and/or for balancing at maturity. Gas products such as intra-day, day-ahead (gas for delivery next day), and month-ahead (gas for delivery next month) products are the most frequently traded products in the European Exchanges [8].

While these physical hubs need trade products of different terms of maturity, further development of financial markets along with the large spot market played a key role in establishing benchmark price hubs. In the financial markets, swap and futures are needed to

[5] Heather (2010) classified the traded curve into the spot (today or tomorrow), the prompt (all other periods within the month), the near (front month to the first two seasons), mid (about two years forward) and far curves (up to about five years forward, and even possible to 10 years in NBP and TTF).

provide hedging instrument and trading opportunities. In a hub, a spot index that improves price transparency and discover the market fundamentals need to eventually include prices from trade of financial products based on the physical underlying.

This is well demonstrated by the oil markets. There is a diversity of WTI contracts in American-style, European-style, monthly, weekly, daily, calendar spread, inter-commodity spread, average price, and futures strip option[6]. The Brent market is served by a set of well-functioning futures and forwards (up to year 2024) markets and more than 30 instruments that trade in ICE and CME (NYMEX) platforms, that enable hedging and speculation (therefore increase in liquidity) in the market. Both CME Nymex and ICE have listed futures and swaps contracts based on the LLS price. There are 18 financial contracts based on LLS price trading in ICE and NYMEX. The exchange traded crude oil derivative products at the Dubai Mercantile Exchange are the highly liquid DME Oman Crude oil futures, Dubai Crude oil futures (Platts), Oman crude futures, derivative products based on the Dubai/Oman price as well as the EFS for Swaps contracts for the Brent/Dubai spreads.

Despite the fact that the physical base of trade of Brent price discovery is only a fraction of the production volume from Middle East, Russia and West Africa, the system of Brent price discovery together with the development of financial contracts based on the physical market (spot and forwards) have made Brent the global benchmark for oil pricing[7]. The analysis of Brent pricing and the deep interdependence of Brent spot price with Brent Futures (exchange traded), Brent forwards (OTC), CFDs and other instruments show that price formation is transparent (in various products) and price discovery happens together in an interlinked (via transactions in products) contracts.

In the case of iron ore, the TSI index is the basis for the most popular and widely traded Iron ore derivatives at the SGX. Metal Bulletin 58% Fe Premium Index is used by the Singapore Exchange (SGX) as the settlement price for 58% Fe iron ore derivatives. Furthermore, to meet the overall price risk management needs in the steel industry, the SGX also offers a suite of products across the steel value chain such as Coking Coal, Hot-Rolled Coil Steel and FFA.

[6] Information of contracts in the CME website, accessed on 21st Nov 2017

[7] An interesting feature of the Brent futures contract is that at expiry it cash settles against the ICE Brent Futures Index, also known as the Brent Index which is calculated on the basis of transactions in the forward Brent market. In other words, unlike other futures contracts whose price converges to spot price at expiry, the Brent futures contract converges to the price of forward Brent. The Brent Futures contract is tied closely to the Brent forwards market.

Similar to the oil markets, in Henry Hub, NCG,TTF and ZTP Physical (ZEE), due to the active trading in the futures contracts, the formulation of spot prices and futures are transparent and price discovery between spot and futures happen together in an interlinked (via transactions in products) contracts. For the HH and NBP market, the forward curve is up to 20 years.

The launch of swaps and futures help provide hedging instrument and trading opportunities. For example, Newcastle Coal Futures are traded on the ICE platform. Contracts are financially settled based on the price of coal loaded at the Newcastle Coal Terminal in Australia and are cash-settled against the globalCOAL Monthly NEWC Index. Exchange traded derivatives based on API 4 price enables hedging and risk management. The contracts are heavily traded in European exchanges.

A lack of products with significant trade exists in failed markets. For instance, there is no underlying development of futures and forwards products with Nigerian crude prices. A total of only 3,200 future deals were concluded in Urals crude futures trading at the SIMEX for the first six months of 2017, with no deal for physical delivery of oil under Urals futures trading has been concluded yet.

9) Risk Management

Benchmark hubs possess avenues and instruments for market participants to manage risks such as performance risk, and credit risks and systemic risk. Industry players typically utilise spot contracts and financial derivatives to transact or hedge their physical positions and reduce price risks, whereas non-commercial (financial institutions etc.) usually engage in behaviour that is more speculative.

All successful crude oil price benchmarks have well-functioning risk management roles. As an exchange traded product with high liquidity and depth of market, there is little performance, credit and systematic risk in the Brent market. Moreover, the presence of wide variety of Brent derivative products allow for effective cross hedging of risk. The presence of futures and option contracts and OTC derivatives based on WTI benchmark allows a party to hedge positions and to speculate. As an exchange traded contract with the underlying physically settled, the ASCI product offers reasonable credit protection. With the increased liquidity of crude oil from Dubai, the benchmark has improved in price discovery process. This market allows traders to convert their Dubai price exposure into a Brent price exposure, which is easier to manage given the high liquidity of the Brent futures market.

Given that the entire ecosystem of forwards trade is quite well developed and the parties involved are large companies, banks or established trading houses, credit risk in the European gas market is quite negligible even in the light of market uncertainties. The Churn Rate for NBP in 2015 was about 20, which demonstrates that there were active financial trades that are often used for hedging or speculation activities. TTF showed a higher churn rate of 30 in 2015, making TTF the largest traded gas hub in Europe. The Churn Rate in 2015 was about 5 for both NCG and ZTP Physical (ZEE) hubs in Europe, not quite high as NBP or TTF but sufficiently liquid to be able to form reliable market prices and instruments for hedging purposes [8]. Using the amount of trading on the two large trading markets, CME's NYMEX (Henry Hub futures and other products, 1,100 to 1,500 quadrillion Btu,) and ICE (various products at Henry Hub and other locations, 419 to 768 quadrillion Btu), against the U.S. natural gas consumption in 2015 (26 quadrillion Btu), a national churn ratio is 61–90 (EIA, 2017).

The presence of clearing party eliminates counter party risk and credit risk. ICE Clear Europe acts as central counterparty to all trades thereby guaranteeing the financial performance of ICE Endex contracts registered in the name of its Members up to and including delivery, exercise and/or settlement.

In contrast, there are no Nigerian crude based or Tapis and Minas crude based derivative instruments to hedge market risks or for speculation. The lack of associated derivative markets pose the issue of insufficient hedge against market movements. Credit risk and counterparty risk is not centrally managed for the Over the Counter (OTC) traded products under the Tapis, Minas and Nigerian crude complexes,

2.4 Market Rules (Institutional Factors)

10) Liberalization of market

The benchmark hubs only develop in markets that are liberalised and therefore reflect the supply / demand fundamentals in the formation of prices. Case studies of gas hubs show that if any country wants to create a liquid gas hub within its boundary, it will have to go through tough and challenging market liberalization process in the electricity and gas sector. Such liberalization includes measures such as separation of transport and commercial activities and wholesale price deregulation [2]. The establishment of NBP followed national gas market liberalization with the privatization of the British Gas Corporation (1986) and implementation of the Gas Act (1995), which effectively introduced competition. Similarly, the US market for

both crude oil and natural gas is fully liberalized with full price and quantity deregulation and very low barriers to trade.

In the Brent crude market, since the domestic as well as the export market for the traded crude in the North Sea region is liberalized, the price determination in the Brent market is largely a function of the supply and demand fundamentals, which is further determined by the supply demand balance in global oil markets. The experience from coal hubs in both Australia and South Africa demonstrate that privatization of the sector and significant infrastructure investments together with deregulation has helped market participants trust that benchmark prices reflect price signals formed in markets free from distortion [9].

In contrast, the natural gas industry in China is not unbundled and prices are regulated. Unless market liberalization takes place, it is difficult for Chinese prices to develop into truly market driven prices [18]. In Italy, the dominance of a few companies, prevented a functioning hub emerging earlier [8, 10].

An active government role may be needed during the establishment of a pricing hub with government taking more hands off approach once the hubs reach benchmark pricing level [9]. As shown in the European gas hub cases, the creation of hub indexation poses significant challenges to incumbents, who might be against the liberalization. Therefore, political will and strong leadership are needed to contest with the power of incumbents and restructure the gas market [10]. Governments also need to create the liquidity through mandating the sale of gas to the hub. In Italy, the government, through the Decree Law 7 (2007), mandates importers and domestic producers to sell certain amount of gas at the PSV [29].

11) Legal framework

The **legal framework** applying to the hub needs to be stable and generally a strong rule of law should prevail. The government's role is to put together the **legal framework** for the ease of trading, regulatory environment, infrastructure and transparency. A market oriented business environment and strong stance against market manipulations, along with an impartial legal system that can present dispute redressal mechanisms and penalties for market misconduct, presents a safe business environment for companies. Market regulation works to protect market integrity, to enforce rules that protect all market participants, and to act proactively to mitigate risks in order to prevent damage to the marketplace.

Regulation of financial market players is important for the sustainable development of gas markets. In the case of crude oil prices, even major OPEC members are complaining because they have difficulty in understanding oil pricing formation [10].

The legal framework applicable in the UK market for both Brent and NBP is the English commercial law, which is well established and widely adapted. The trust in the legal systems governing the price benchmarks allowed Brent and NBP to develop into a global benchmark price. The US legal system is reliable and free from interventions, and is one of the role models of free capital markets. This contributes to making the WTI a benchmark and the underlying crude oil production remained a reliable yardstick of the USA supply demand, and stayed relevant with the stable governance structure by the US government. The importance of Dubai as a crude oil trade centre gradually grew in importance due to a consistent government policy of favouring transit and trade. The legal system in the UAE is based on both civil code and principles in English law. South African contract law is adapted from the Roman-Dutch law of contracts, which is westernized and trusted and thus contribute to the establishment of the Richard Bay prices to be a coal price benchmark.

Under the general EU principles and European practice, the legal system administering continental European gas hubs is stable and the rule of law is trusted. For example, under Article 4(1) of Regulation (EU) No 1227/2011 (REMIT), NetConnect Germany is required to disclose inside information in its role as market area manager. Singapore has market oriented business environment, strong stance against corruption, and a sound legal system which together present a safe business environment for private companies.

In contrast, despite holding many advantages as large physical base and diversity in market, the legal system is not trusted by investors in China, Russia and Indonesia thus hampering development of benchmark prices hubs with them. The trust in the Russian legal system as enabler of fair, impartial and fast resolution of trade disputes is quite low. In China, the legal system is not stable and not trusted by investors, in particular, foreign investors. In the case of Iron ore spot pricing, the benchmark prices developed based out of Singapore, while the physical basis of the prices are for delivery to Chinese ports [9]. The Indonesia legal system has strong preference for domestic companies, with national interests at the forefront and does not result in fair and impartial dispatch of justice.

The effective regulation of the PRAs is crucial to get their acceptance by the market players. This is because the accuracy of price assessments depends on the quality of information

obtained, and the internal procedures and methodologies applied to process the information. It is important for the benchmark prices to be assessed by PRAs that operate under the guidelines set by International Organization of Securities Commission (IOSCO) to lend credibility to the reported prices. The well-established PRA guidelines ensure strict rules on the reporting and usage of price data, verification of data, transparency in reported trade and price information and rules on ethics and compliance. The internal compliance program also ensures checks and balances of price reporting.

12) Regulatory competence

It is quite essential that a regulatory authority supervises and controls the functioning of the market (regulatory competence) to guarantee fair, efficient and sustainable trading without adding unnecessary compliance burden on the market participants. Regulations and regulatory agencies set the rules and regulations for market operation that contribute to the efficiency and credibility of the commodity markets.

All the successful hubs are regulated by well-established regulatory agencies operating with direct jurisdiction by the government, with an interest to establish fair and efficient markets. As a benchmark having systemic importance to the global financial sector, the Brent benchmark is also regulated directly by the UK government as part of seven other global benchmarks (such as LIBOR). The Brent market is regulated as part of the acts of government by the Financial Conduct Authority (FCA), earlier known as Financial Services Authority (FSA) as a recognised investment exchange (RIE) under Part XVIII of the Financial Services and Markets Act 2000. Continental European gas market actors are regulated by the Agency for the Cooperation of Energy Regulators (ACER).

The Commodity Exchange Act (CEA) regulates the trading of commodity futures in the United States. The CEA establishes the statutory framework under which the Commodity Futures Trading Commission (CFTC) operates. CFTC regulates in provisions for price indexes and penalties for false reporting. CFTC has powers to prosecute knowingly distribution of misleading information and intentional omissions[8]. As an exchange traded financial contract, WTI, HH and ASCI contracts are also governed by exchanges market regulation department for trade, position, account, and market surveillance to identify and prevent potential rule

[8] http://www.cftc.gov/About/MissionResponsibilities/index.htm

violations and ensure the contract fulfil their self-regulatory responsibilities. The Sarbanes/Oxley act ensures rules are followed and there is no selective reporting of trades.

Dubai Financial Service Authority (DFSA), which is an independent regulatory body instituted by the government to oversee and regulate financial markets, regulate the Dubai Mercantile Exchange (DME). Singapore Exchange (SGX), where Iron ore futures are traded and is regarded as a key price discovery hub for Iron ore is governed under the guidelines of Monetary Authority of Singapore (MAS) with rules to guarantee an efficient market.

In contrast, there are cases of commodity markets where the market prices failed to develop into benchmark prices due to excessive regulation and market control by government. A major feature of the Nigerian oil sector is the dominance of the government in pricing, supply and investment. Regulatory uncertainty has also contributed to lack of investment in the sector [30]. The greatest challenge facing the process of deregulation in Nigeria is the credibility of government. There is perceived lack of transparency and inefficiency of government. Inability of government to remove supply bottlenecks result in distortion in self-determined prices away from the supply demand fundamentals in the short run [32]. The delay in working with respect to settlement of futures contracts in the Russian exchanges has resulted in delay for the market acceptability of the contract among large trading houses. Although the pricing of crude blends in Tapis and Minas is assessed by the PRAs, the Malaysian government exercises control over the prices (if the prices are perceived to be volatile), and thus they do not fully reflect the market supply and demand fundamentals [24].

13) Tax and duties (Fiscal environment)

The applicable tax and duties governing the trade in the hubs need to be competitive, simple and stable. A favourable business climate could create a reinforcing loop as an ecosystem of relevant market players increases attractiveness to other players along the value chain, to participate in the existing hub ecosystem.

Many of the successful hubs are hosted in countries with business friendly, creditable and transparent tax systems. According to the World Bank Doing Business ranking, the UK and US are ranked 10th and 36th globally respectively in terms of paying taxes. Dubai, home to the Dubai crude price benchmark, has a simple tax system with zero income taxes, zero corporate taxes and double taxation treaties signed with all major trade partners. Trading firms Dubai Mercantile Exchange (DME) have no taxes on income and profits. For continental European natural gas hubs, Netherlands (home of TTF) is ranked no 20, Germany (NCG) is

ranked no 48 and Belgium (ZTP Physical (ZEE)) is ranked 24 in terms of paying taxes, according to the World Bank Doing Business ranking. In trading friendly Singapore, the business taxes are specifically aimed to encourage trading activities.

The Brent spot market developed due to a favourable taxation policy by the British government. The British government introduced market driven prices in tax calculations for crude produced within its jurisdiction. As companies could trade in the spot market to realise tax incentives and could be influential in the setting of market prices for their advantage, the spot market for Brent developed taking advantage of the taxation schemes. Tax optimisation also provided the North Sea producers with an incentive to develop the Forward Brent market [31].

In contrast, some other commodity hubs are in jurisdictions with difficult and volatile tax regimes and thus failed to become benchmark hubs. In the case of Nigeria, the Petroleum Industry Bill (PIB) is not business friendly as IOCs are concerned that changes to fiscal terms may make capital-intensive projects commercially unviable [9]. Russia has two main hydrocarbon taxes: the minerals extraction tax (MET) and the export tax. In Russia, tax breaks have been proposed for foreigners dealing with financial derivatives to encourage them to use the commodity exchange products for crude oil, but has not been effective in increasing trade volume, as the taxation and clearing process have not been fully thought through[10].

3. Implications for emerging LNG hubs

While trading hubs have developed for pipeline gas in Europe and North America, LNG price benchmarks are still nascent.

The following price benchmarks for LNG are the most well-known. They are produced by various exchanges and price reporting agencies:

LNG price benchmarks and LNG trading platforms

- JKM : by S&P Global Platts
- ANEA : by Argus
- SLInG : by SGX LNG Index Group
- EAX : by ICIS Heren
- RIM : by RIM Intelligence Company.
- METI : by the Ministry of Economics, Trade and Industry of Japan

[9] https://www.eia.gov/beta/international/analysis.cfm?iso=NGA
[10] https://www.eia.gov/beta/international/analysis.cfm?iso=RUS

JKM (Japan/Korea Marker) by S&P Global Platts
Platts Japan Korea Marker (JKM™) is the LNG benchmark price assessment for spot physical cargoes delivered ex-ship into Japan, South Korea, China and Taiwan.
S&P Global Platts also provides the following indices of LNG other than JKM:

- **GCM**, Gulf Coast Marker is a price assessment reflecting the daily export value of LNG traded free on board (FOB) from the US Gulf Coast.
- **MEM**, Middle East Marker is a price assessment reflecting the daily import value of LNG delivered into the Middle East.

ANEA (North East Asia) by Argus
Argus provides regional indices including North East Asia, South East Asia, China and India. ANEA physical spot price assessments represent cargoes delivered ex-ship (des) to ports in Japan, South Korea and Taiwan, trading 6-12 weeks before the date of delivery.

SLInG by SGX LNG Index Group
SLInG was Jointly developed by Singapore Exchange (SGX) and Energy Market Company (EMC) for a trusted Asian LNG spot index at selected locations. The Sling comprises the following indices:

- Singapore Sling
- North Asia Sling
- Dubai/Kuwait/India (**DKI**) Sling

EAX (East Asia Index) by ICIS Heren
ICIS Heren provides five regional indices available for spot-delivered LNG. The EAX is a calculated average of ICIS Heren assessments for delivery into Japan, South Korea, Taiwan and China.

RIM by RIM Intelligence
Rim Intelligence Company in Japan provides price assessments of various energy markets including crude, petroleum products, LNG, LPG and petrochemicals.

In addition, **METI**, the Ministry of Economy, Trade, and Industry of Japan produces monthly price assessments on the price of LNG delivered to Japan.

Existing platforms for LNG trading are listed below:

JOE, the Japan OTC Exchange was founded to provide an OTC trading platform for commodities and a brokering function centered on energy products such as petroleum and LNG. The company became a wholly owned subsidiary of Tokyo Commodity Exchange, Inc. (TOCOM) in April 2017.

SHPGX, the Shanghai Petroleum and Natural Gas Exchange, was launched to provide a market-based trading platform for oil and gas. The SHPGX reports daily trades in pipeline natural gas and LNG. For the first six months of 2016, there were 458 LNG trades, averaging 20,000 MMBtu per trade from the Ningbo LNG import terminal near Shanghai.

The Chongqing Oil and Gas Exchange, China's second physical gas exchange platform after SHPGX was launched to provide a trading platform for domestic output, pipeline imports from Central Asia and Myanmar, and imports of LNG.

GLX launched in Singapore is an independent company that has designed and operates an online platform allowing to anonymously buy or sell FOB or DES cargoes in real time. Participants can choose between their own existing terms and conditions of the GLX standard terms.

KPLER has developed a ship-tracking software which also provides a direct option for its users to post a bid or offer for LNG cargoes on the online platform.

For Asia in particular, the EIA has summarized the main price benchmarks in the table below:

Table 7-1. Characteristics of Asia Pacific LNG price indexes

Index	Japan/METI	JKMTM	RIM Japan	ANAE	EAX	SLInG
Publisher	METI	Platts	RIM Intelligence	Argus Media	ICIS	SGX & EMC
Start of Stats	Mar. 2014	Feb. 2009	Feb. 2016	2012	Jan. 2014	Sept. 2014
Ship (Cargo) Size	Any	2.9–3.7 Bcf	2.9 Bcf tankers & partial cargoes	2.9–3.3 Bcf & partial cargoes normalized	0.6–5.6 Bcf & partial volumes	2.9–3.7 Bcf
Index Coverage Area	LNG delivered to Japan	Spot physical cargoes delivered into Japan and South Korea	Japan, South Korea, Taiwan and China	Japan, South Korea, Taiwan, China	Physical cargoes to Japan, South Korea, Taiwan & China	Vessels on the water with potential to deliver to Singapore
Assessment Type	Census sent from METI to market players	Daily phone or electronic survey of market players	Trading info from OTC market; Price assessment from JOE LNG market deals & bids/offers	Daily phone or electronic survey of market participants	Daily phone or electronic survey of bids, offers (first-hand or observed)	Survey of select market participants
Assessment Frequency	Monthly price assessments	Daily, with market close prices	Assessed & published daily	Assessed & published daily	Assessed & published daily	Half-monthly assessments, published twice weekly

Sale or delivery	DES contracted and arrival	DES	DES	DES	DES	FOB
Assessment Forward Range	Any forward period for LNG delivery (contract-based); within-month (arrival-based)	Prompt delivery; 3rd & 4th or 4th & 5th half-month forward	Half-monthly assessments for the 3rd–5th half-months forward	Prompt delivery; 2nd–5th half-months forward	3rd–6th half-months out	3rd–6th half-months out
Index Calculated	Contract-based (for deals made in-month) and arrival- based (for cargoes arriving that month)	Prompt or deferred spot prices averaged for assessed half-months	Monthly average price for half-months calculated daily	Physical and forward swap are assessed daily for forward half-months	Daily front and second month ahead prices for all countries averaged	Half-monthly prices are averaged for the first full month
Types of Trades Included	Spot LNG to be delivered	Spot LNG to be delivered	Deals done and bids/offers on LNG cargoes	Spot LNG to be delivered in 6–12 weeks	Global prompt & mid-term charter LNG	Spot LNG able to be shipped to Singapore
Number of Contributors	~ 15	Not specified in Methodology	Not specified in Methodology	Not specified in Methodology	Varies daily; no minimum data threshold	50
Contributor Requirements	Companies/ consumers of spot LNG	Any market participant; buy/ sell prices must pass the "repeatability" test	None; market prices assessed from OTC market trading information	All credible market sources, market participants and brokers/trading platforms	Active or past LNG industry participants, not only the physical market	Active in the physical LNG market
Data Cleaning	N/A	Data aligned with standard assessment specifications	Higher bids & lower offers are prioritized as closer to market values	Market condition adjustments if assessment hierarchy would skew results	Data verified with trading counterparty; technical-purpose cargoes excluded	Top 15% and bottom 15% removed as outliers

As of today, none of the markets related to the above LNG indexes yet seems to meet the requirements for the development of a reliable wholesale price benchmark and, as a result, of an LNG trading hub.

Nevertheless, given the influence of the key indicators described in Chapter 2 of this study, LNG hubs could learn significant lessons from the history of other commodities.

4. Conclusion

In this report intended to study the key criteria for the emergence of an LNG hub , we have reviewed the history of four commodities (oil, coal, iron ore, natural gas) and identified thirteen key factors underlying the emergence of hubs for these commodities.

We have then classified the key indicators into four categories: Participants, Physical factors (supply, demand and logistics), Traded Products and Market Rules (Institutional Factors) and we have developed a standardized grid (*Table 2 Category, key indicators and weight for the assessment of a hub)* which allows users to subjectively assess the maturity of a hub by indicating the respective importance of these factors and the score of a price benchmark with regard to each factor.

This grid and the related methodology could be applied to assess and compare the maturity of various LNG pricing points and their level of development towards an LNG hub.

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Appendix 1– Descriptions of Hubs and main product under study

1) **Brent Market –** The Brent market is the market for trading oil produced in the North Sea for delivery on spot (actual 25 days forward) or acts as the underlying for the exchange traded futures contract in ICE and CME exchanges. Three distinct markets developed for trade of the oil designated as part of the Brent complex, namely the spot market, Brent forwards and Brent Futures, each with its own characteristics and strong interlinks in price discovery. The Brent market complex consists of trade in spot Brent (dated Brent), Forward Brent, Brent futures contracts, OTC derivatives, and Contract for Differences (CFDs). The CFDs trade a floating or fixed price differential between dated Brent and forward Brent price, and EFPs link the Brent futures and forward Brent price [33].

Dated Brent/BFOE, or Dated North Sea Light (by Platts) or North Sea Dated (by Argus) market refers to the sale of a cargo Brent light North Sea sweet oil, with a specific loading slot. It is referred to as the spot market of Brent. Technically, dated Brent refers to the value of the cheapest cargoes of BFOE blends of 600 kbl, available for loading within the next 10 to 25 days. Dated Brent is used to determine the value of sweet crude in the North Sea, West Africa, the Mediterranean, South America, Latin America, Canada, North America, Russia and Central Asia. More than 60% of the world's internationally traded crude oil is priced against Dated Brent (Montepeque, 2011).

Platts Dated Brent is a benchmark assessment of the price of physical, light North Sea crude oil[11]. For reference we will see how the Platts Dated Brent assessment of spot price for Brent crude is determined. Dated Brent price assessment reflects the tradable, repeatable spot market value of the most competitive grade at 16:30.00 London time. The trade size is 600kbl. Platts assesses prices using a Markets on Close (MOC) process[12]. The assessed prices are based on a combination of market observed outright prices, differentials to benchmark and price of derivatives to arrive at assessed spot price. The outright price is the price at which the commodity is offered or bought in the Platts window of trading. Differentials are applied to transaction carried out in relation to a benchmark, where premiums and discounts to the benchmark are assessed[13]. Finally derivatives markets and prices of various products are also used in the absence of meaningful physical trades [35]. Platts has also introduced a CIF Rotterdam benchmark price for Brent in light of the increased cargoes sold as CIF Rotterdam basis to buyers in Norther West Europe. Dated Brent CIF Rotterdam is assessed as both an outright and a differential price, based on the most competitive grade of Brent, Forties, Oseberg and Ekofisk delivered to Rotterdam for each day of the assessment[14] [36]. The assessment range for Dated Brent has been extended to month-ahead instead of 10-25 days, in order to reflect the lengthening lead times for sales of crude oil from the North Sea to end-users [37].

[11] Dated Brent price - https://www.platts.com/price-assessments/oil/dated-brent

[12] Methodology and specifications guide oil timing and increment guidelines – Platts, Sep 2017 for more information on the definitions of MOC and timing guidelines

[13] A Quality Premium is applied as a cost paid by a buyer of a crude cargo to the seller, on return for receiving a better quality cargo of crude than guaranteed at time of trade. They are to be paid by buyer to seller for the nomination and delivery of Oseberg or Ekofisk into a physical BFOE transaction concluded during the Platts Market on Close assessment process. De-escalator, is a cost paid to a buyer as compensation by a seller who delivers an inferior quality cargo of crude than guaranteed at time of trade. Adding these two prices broadens scope of Brent pricing as relation to the price of basket of crudes produced in North sea in relation to the base of Brent blend (34.Platts, *Quality Premiums and Platts Brent crude assessments - Frequently Asked Questions.* 2013, April.)

[14] Platts now publishes assessments on both an outright and differential basis for all component crude grades of Brent for the Rotterdam Brent CIF price. In the absence of any bids, offers or trades, Platts asses CIF basis Rotterdam on the basis of freight and other market indicators

The Forward Brent is one of important the products in the Brent complex[15]. The forward Brent (25 Day BFOE) is also simply referred as paper Brent, is an over-the-counter (OTC) market whereby buyers and sellers trade cargos of crude blends of North Sea with forward trades on partial cargo basis of 100kbl. Forward contracts specifies the delivery month but not the particular date at which the cargo will be loaded. Forward Brent price is quoted for three months ahead. For instance, on 17th December, the Forward Brent is reported for the months of January, February and March. These price quotations represent the value of a cargo of physical delivery in the month specified by the contract (Fattouh, 2011). The 25-day BFOE can be either cash-settled by traders offsetting their position or can be physically settled upon expiry.

The Brent futures contract was initially launched on the International Petroleum Exchange (IPE), now known as the InterContinental Exchange (ICE), in London in June 1988. The ICE Brent Crude futures contract is cash settled with an option of delivery based on Exchange for Physicals (EFP) mechanism[16]. Futures contracts with maturities of consecutive 96 months from the current month are listed in the exchange. The ICE Brent Crude futures contract is a deliverable contract based on EFP delivery with an option to cash settle against the ICE Brent Index price for the last trading day of the futures contract. The Exchange publish a cash settlement price (the ICE Brent Index price) on the next trading day following the last trading day for the contract month. Contract size is 1000 barrels with the expiration date at the end of the designated settlement period on the last Business Day of the second month preceding the relevant contract month[17]. There are 119 options and futures contracts based on Brent trading at the ICE. These include, American and European style options, crude oil difference options to other key benchmark crudes (Dubai, WTI, LLS, ASCI and Urals) and CFD. One important and active market discussed above is CFDs. Another active swaps market is the Brent Dated-to-Frontline (DFL) market which trades the difference between Platts Dated Brent assessments and the ICE first month futures contract. Another related but less liquid market has emerged which trades the difference between Dated Brent and the daily trade-weighted Brent average reported by the ICE [15]. The CFDs are assessed for 8 weeks ahead, which allows for a forward dated Brent curve to be estimated. The CFDs

The Brent futures traded in the CME group are also for a contract unit of 1000 barrels, with monthly contracts for the current year and the next consecutive 7 years are listed for trading. The contracts are financially settled. Spread Options of (1, 2, 3, 6 and 12 month spread options), with the underlying futures spread is defined as the settlement price of the first nearby underlying Brent Crude Oil Last Day futures contract less the settlement price of the second nearby Brent Crude Oil Last Day futures contract. A Brent Crude Oil Last Day Financial Calendar Spread Put Option traded on the Exchange represents the cash difference between the strike price and the underlying futures spread multiplied by 1,000 barrels, or zero, whichever is greater. A Brent Crude Oil Last Day Financial Calendar Spread Call Option traded on the Exchange represents the cash difference between the underlying spread and the strike price multiplied by 1,000 barrels, or zero, whichever is greater. European Call and put options are traded on CME. On expiration of a call option, the value will be the difference between the settlement price of the underlying Brent Crude Oil Last Day Financial Futures and the strike price multiplied by 1,000 barrels, or zero, whichever is greater. On expiration of a put option, the value will be the difference between the strike price and the settlement price of the underlying Brent Crude Oil Last Day Financial Futures multiplied by 1,000 barrels, or zero, whichever is greater. A Brent Crude Oil Put (Call) Option traded on the Exchange represents an option to assume a short (long) position in the underlying Brent Crude Oil Financial Futures traded on the Exchange.

[15] The contract that links the futures Brent and the forward Brent is the EFPs, which are priced as a differential to Brent Futures prices.

[16] Brent Crude Futures - https://www.theice.com/products/219/Brent-Crude-Futures

[17] https://www.theice.com/products/219/Brent-Crude-Futures

2) **WTI Market and Prices** - The **WTI** blend is crude oil produced in the fields of Texas, New Mexico, Oklahoma, and Kansas. Although a wide variety of crude oils is produced in the US, WTI assumes special importance in the global oil and financial markets since WTI underlies the Light Sweet Crude Oil futures contract, one of the largest traded commodity futures contract. WTI is a pipeline crude as against Brent and Dubai, which are waterborne crude. Unlike the Brent futures contract (where delivery is elective via the EFP mechanism), the Light Sweet Crude Oil Futures contract is fully physically delivered for every contract left open at expiry by default. It specifies 1,000 barrels of WTI to be delivered at Cushing, Oklahoma. The contract also allows the delivery of domestic types of crude (Low Sweet Mix, New Mexican Sweet, North Texas Sweet, Oklahoma Sweet, and South Texas Sweet) and foreign types of crude (Brent Blend, Nigerian Bonny Light and Qua Iboe Norwegian Oseberg Blend and Colombian Cusiana) against the futures contract.

The CME WTI futures trade with a contract size of 1000 barrels with Crude oil futures are listed nine years forward using the following listing schedule: consecutive months are listed for the current year and the next five years; in addition, the June and December contract months are listed beyond the sixth year. Additional months will be added on an annual basis after the December contract expires, so that an additional June and December contract would be added nine years forward, and the consecutive months in the sixth calendar year will be filled in. Additionally, trading can be executed at an average differential to the previous day's settlement prices for periods of two to 30 consecutive months in a single transaction. These calendar strips are executed during open outcry trading hours. Delivery shall be made free-on-board ("F.O.B.") at any pipeline or storage facility in Cushing, Oklahoma with pipeline access to Enterprise, Cushing storage or Enbridge, Cushing storage. Futures for the current delivery month expires on the third business day prior to the twenty-fifth calendar day of the month preceding the delivery month. The CME WTI futures are traded on CME Globex and CME Clearport platforms.

WTI Options traded with Light Sweet Crude Futures as the underlying, include American and European options with a contract size of 1000 barrels, with the former is deliverable upon settlement and latter is financially settled upon expiry. Monthly contracts are listed for the current year and the next 5 calendar years and June and December contracts for three additional years. Monthly contracts for the balance of a new calendar year being added following the termination of trading in the December contract of the current year. Calendar spread and financial month spread options of 1,2,3,6, 12 months are traded in the exchange. Some other options traded are the Daily Options, Weekly Options and 1-5 year mid curve options[18].

WTI Crude futures also trade on the ICE platform with a contract size of 1000 barrels and maturities upto 108 consecutive calendar months from the current month. The contract is cash settled against the spot price of the WTI crude published by NYMEX[19]. Apart from the WTI crude futures, 61 other futures and option contracts based on WTI are traded at the ICE. These include crude difference options of various maturities Argus LLS, Argus Midland WTI, Argus Mars, Argus Houston, calendar spreads, spread option with Brent and difference options with key crude oil products.

The WTI pricing is done as follows[20]. NYMEX WTI is the most liquid commodity future in the world. The dominance of WTI crude price in benchmark price of USA is on account of it acting as the underlying to CME (NYMEX) futures contract with the easiest crude that can be delivered to Cushing being the WTI blend. The WTI blend, produced in West Texas Permian basis is delivered into Cushing on two major pipeline systems. Differences between futures and physical trading arrangements make pricing physical WTI barrels complex. Two formula mechanisms are commonly used in physical transactions that link directly to the NYMEX settlement prices – the NYMEX Calendar Month Average

[18] Crude Oil Futures Quotes - http://www.cmegroup.com/trading/energy/crude-oil/light-sweet-crude.html

[19] ICE WTI Crude Futures Specifications - https://www.theice.com/products/213/WTI-Crude-Futures/specs

[20] Adapted from – Sandy Felden, "The cost of crude at Cushing – WTI and NYMEX CMA", and "The cost of crude at Cushing – The CMA Roll Adjust and WTI P-Plus", Oil and Gas Finance Journal, Nov 9, 2012

(CMA average)[21] and WTI P-Plus, which is the sum of well head posted prices plus delivery costs to Cushing. The basic price used for spot calculations of spot delivery for the current months is the average of CMA prices for the current month and 1 month ahead futures of CME WTI futures traded price on the day. The adjustment for spot prices takes into account the roll adjust cost of futures contracts. NYMEX CMA and CMA Roll may then be further adjusted to reflect crude location, crude grade differences and the good old trader's fudge factor. As a result CMA averages show up in crude contracts for nearly all US domestic crudes. The P-Plus mechanism is also rooted in the NYMEX CMA price but uses the market driven differential tat accounts for the supply demand adjusted transport cost of the crude for delivery into Cushing.

3) **Dubai** is considered to be a place as a pricing benchmark in the Middle East, due to availability of spot crude cargoes for trade, geographical proximity to Middle East region with an important locational advantage of being a traditional trading centre in the region and as a gateway to markets of Middle East. Platts Dubai assessments reflect the repeatable, transactable price of Platts Dubai for the month of loading which are traded in a lot size of 25,000 barrels, with physical convergence at 500,000 barrels, or 20 partials at 16:30:00 Singapore time. The Platts Dubai contract reflects the spot value of Middle East sour crude oil, where the buyer of Dubai has the obligation to accept delivery of Dubai or an alternative delivery of Upper Zakum or Oman, at the seller's option. Futures contracts of maturities upto 72 month are traded on the DME for Oman, Dubai crude oil. The other most important two financial contracts surrounding the Dubai market are the Brent/Dubai Exchange of Futures for Swaps (EFS) and the Dubai inter-month swaps markets (Fattouh, 2011).

4) Nigeria's main four crude grades are -- **Qua Iboe, Bonny Light, Brass River and Forcados**. Nigerian crude oil is traded on an FOB basis for loading at a wide range of terminals across the country. Price reporting agency (PRA) assessments reflect the repeatable, transactable price of West African crude cargoes at 16:30 London time, for loading 25-55 days forwards, Monday through Friday and assessed on MOC process basis. The prices of all the major crude blends are assessed as differential to Brent price.

5) **Urals** –Urals Crude Oil export oil mix (a mix of heavy and high-grade oil of Urals with light oil of Western Siberia), extracted in Khanty-Mansiysk autonomous region, Bashkortostan and Tatarstan. Urals brand oil is supplied through the Baku-Novorossiysk pipeline and the Druzhba pipeline system. Urals is currently priced in the physical market, usually at a discount to Brent, by pricing agencies, which survey traders and refiners. The Platts Northwest European Urals assessment reflects cargoes loading 10-25 days forward, with cargoes typically pricing on an average of Platts Dated Brent assessments over five publication days after loading. In order to assess the outright value of a cargo of Urals loading in the future, Platts uses an average of the forward Dated Brent curve 13-28 days forward. The outright price assessment for Urals in Northwest Europe is therefore that day's assessed differential to Dated Brent plus the value of the forward Dated Brent curve 13-28 days after the date of publication [38].

Urals Crude futures are now traded on the Saint Petersburg International Mercantile Exchange (SPIMEX) under ticker symbol U in U.S. dollars (SPIMEX). With contract size of 1000 barrels and initially traded in USD, the Urals futures trade on a free on board (FOB) basis of the Baltic Sea port of Primorsk its exporting schedule for Primorsk no later than by the fifth day of each month preceding the month of the shipments. The SPIMEX Urals Crude Futures contract is settled by physical delivery upon expiration. Such a futures contract thus has a direct link with the crude oil spot market. Physical delivery

[21] The CMA is the average of NYMEX close prices during the month when the physical crude is delivered.

of crude oil under the contract is executed against positions opened as of the relevant contract expiration date.

7) **Tapis and Minas** - Historically, the pricing of sweet crude oil delivered to refineries in Asia used to be dominated by local benchmarks. Malaysia's Tapis crude oil, from the South China Sea offshore Malaysia's Terengganu state, has been a widely used benchmark for light sweet crudes and condensates produced in the Asia Pacific region. Meanwhile, Indonesian Minas (light) and Duri (heavy) exported from Dumai terminal have served respectively as benchmarks for medium and heavy sweet crudes produced in the Asia-Pacific region [24]. The Tapis and Minas prices are assessed by PRAs based on the spot trading activity or from the price announcements by national oil companies. The price differentials assessed by PRAs often used to differ as much as $5 on account of infrequent trading in the benchmark crudes [39]. Platts publish Tapis and Minas price benchmarks as quoted Official Selling Price (OSPs) of crude published by national petroleum companies Petronas and Pertamina. Producers typically price their crude using price markers generated from spot market activity. In this case, OSPs are normally announced on the basis of a differential (either premium or discount) to a monthly average for the relevant price markers. The differential typically captures the difference in quality, and therefore value, between the crude oil being priced and the spot market reference being used. It might also reflect market dynamics like the balance between supply and demand, the difference between the loading period and the period of time reflected in spot market assessments, or differences in regional market conditions [40]. Owing to reduced spot liquidity and lack of measurable trades to determine prices and has offered the use of Asian dated Brent (adjusted for Asian trading times) and price differentials as an alternative. For the Argus, the Asia-Pacific crude price assessment consists of price assessments made at 4:30pm Singapore time for Minas, Tapis and North West Shelf crudes. The Indonesian Minas crude price is published as a fixed price assessment and as a differential to the Indonesian Crude Price (ICP). Malaysian Tapis crude is published as a fixed price assessment and as a differential to the North Sea Dated and substitute Dated on UK holidays [41].

8) ASCI[22] and LLS[23] prices - The **ASCI** price is a volume-weighted average of all deals done for three grades of crude combined – Mars, Poseidon and Southern Green Canyon (SGC), all gulf coast and midcontinent crude streams. The ASCI index provides a daily price for medium sour crude at the US Gulf of Mexico trading hub. Saudi Arabia, Kuwait and Iraq use the ASCI index to price exports to the US. Grades of crude priced against the ASCI index include Arab Extra Light, Arab Light, Arab Medium, Arab Heavy, Kuwait Export Blend, Basra Light and Kirkuk[24]. The **LLS** price index represents the volume-weighted average of all spot LLS deals done throughout the trading day on a differential basis to WTI at Cushing. The PRA determined **LLS** price represents a blend of sweet crude meeting Capline LLS specifications and traded at the Capline terminal at St James, Louisiana. LLS prices down the forward curve aligned to the Nymex settlement is also assessed. LLS is reflective of market economics at the Gulf coast for light sweet grades, whether foreign or domestic, and correlates more closely to global crude prices[25].

[22] ASCI Price - http://www.argusmedia.com/methodology-and-reference/key-prices/asci/

[23] LLS Price - http://www.argusmedia.com/methodology-and-reference/key-prices/argus-lls/

[24] Heavy sour crudes are predominantly produced in Gulf regions and light sweet crudes are often the marginal production. The economics of supply and demand indicates that light crude (marginal supply volumes) serve as benchmark crudes and heavy crudes are priced as a differential to benchmark (Fattouh, 2011)

Financial contract for ASCI (upto 72 months) and LLS (upto 60 months) futures are traded at ICE & CME. Similarly LLS vs WTI and ASCI vs WTI diff spread options (CME), and LLS vs Brent (CME) are also actively traded.

9) **Henry Hub** is a natural gas pipeline located in Erath, Louisiana that serves as the official delivery location for futures contracts on the New York Mercantile Exchange (NYMEX). The Henry Hub pipeline is the pricing point for natural gas futures on the NYMEX and the OTC swaps traded on Intercontinental Exchange (ICE). The settlement prices at the Henry Hub are used as benchmarks for the entire North American natural gas market.

Physical (spot) gas trading continues at the hub via OTC bilateral trading and to some extent on the exchange as well. Spot trading in Henry Hub is defined as: a one-time open market transaction for immediate delivery (within the calendar month) of a specific quantity of product at a specific location where the commodity is purchased "on the spot" at current market rates.[26]

While many exchanges are trading products based on HH, CME's NYMEX and ICE are the two large trading markets. The CME Group offers various financial derivatives based on gas market indexes (futures contracts, swaps, and options) at approximately 40 hubs. [27] CME Futures for Henry Hub include Physical Futures, Last day financial futures, and Penultimate Financial Futures. CME also lists over 280 derivative financial natural gas contracts in addition to the Henry Hub futures contracts. [28] The standard futures contract is for 10,000 million British thermal units (MMBtu). Financial futures also have another size option: 2,500 mmBtu. Options includes Basis and Monthly, Weekly and Daily Options. Options types include American, calendar spread, European and daily.

ICE Endex offers 11 futures and options for Henry Hub: Henry LD1 Fixed Price Future, Henry LD4 Fixed Price Future/Option, Henry Penultimate Fixed Price Future/Options, Henry Calendar Year One Time Fixed Price Future/Option. All products are in standard 100, 000 mmBtus, but Henry Penultimate Fixed Price Future and Option are also available at 25, 000 mmBtus. [29]

In Henry Hub, futures contracts trading dominates and now averages approximately 400,000 futures contracts per day, and more than that when options and other derivative products are included.[30] The amount of trading on the two large trading markets, CME's NYMEX (Henry Hub futures and other products) and ICE (various products at Henry Hub and other locations), in recent years has ranged from 1,100 to 1,500 and 419 to 768 quadrillion Btu, respectively [5].

The physical delivery of NYMEX products such as Natural Gas (Henry Hub) Physical Futures and Last Day Physically-Delivered Futures Contract (the unit of 2,500 MMBtu) reveals the spot prices. The Physical Futures has the contract unit of 10,000 mmBtu and is settled by delivery. It lists the current year plus the next twelve calendar years.[31] The last-day financial futures lists monthly contracts for the current year and the next 12 years. It is available at 10,000 mmBtu and 2,5000 mmBtu.[32] All the ICE financial products are cash settled based upon the monthly price published by NYMEX.[33]

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[26] https://www.eia.gov/dnav/ng/TblDefs/ng_pri_fut_tbldef2.asp

[27] CME Group, "CME Group All Products Code and Slate," (accessed October 18, 2016), http://www.cmegroup.com/trading/products/.

[28] CME Group, "CME Group All Products Code and Slate," (accessed October 18, 2016), http://www.cmegroup.com/trading/products/.

[29] https://www.theice.com/products

[30] CME Group, "Daily Energy Volume and Open Interest," (accessed June 2, 2016), http://www.cmegroup.com/market-data/volume-open-interest/energy-volume.html.

[31] http://www.cmegroup.com/trading/energy/natural-gas/natural-gas_contract_specifications.html

[32] http://www.cmegroup.com/trading/energy/natural-gas/natural-gas-last-day_contract_specifications.html

[33]

General information for the European hubs (10-14). *European hubs face common situations. In European gas hubs, spot contracts [34] (defined as all periods as within the month, including month ahead) are mostly used for final portfolio optimisation ahead of physical delivery and/or for balancing at maturity. The spot trading is managed by natural gas exchanges like the European Energy Exchange (EEX) or Powernext [5]. The pan-European gas platform PEGAS was launched in 2013 as a cooperation between EEX and Powernext. Since January 2015, all business activities of EEX and Powernext on the European gas markets are operated by Powernext under the PEGAS brand. The product range of PEGAS covers spot and derivatives contracts for the major European gas hubs as well as trading in location and time spread products. The PEGAS also manages other European hubs covered in this study and thus we will not repeat the information. ICE offers direct market access and a regulated futures and options platform, as well as gas balancing markets and gas storage service for European hubs.*

An earlier study shows that in the European gas hubs, the volume of the trade of futures contracts occurs almost entirely at the ICE/Endex that trades NBP and TTF, while volumes of spot trade were more evenly distributed among the ICE Endex, EEX and Powernext (which merged with EEX later) (Heather, 2015).

10) The **National Balancing Point**, commonly referred to as the **NBP**, is a virtual trading location for the sale, purchase and exchange of UK natural gas, operated by National Grid, the transmissions system operator in the UK. It is the pricing and delivery point for the ICE Futures Europe natural gas futures contract. It is the 2nd most liquid gas trading point in Europe (after TTF) and has a major influence on the price that domestic consumers pay for their gas at home. Gas at the NBP trades in pence per therm. The UK NBP gas market is Europe's longest-established spot-traded natural gas market, in operation since the late 1990s. The price of UK NBP is widely used as an indicator for Europe's wholesale gas market, alongside the more recent, but rapidly growing, continental European trading hubs such as the Dutch TTF.

The Uniform Network Code (UNC or Code) prescribes two forms of gas trading: 1) spot OTC for day-ahead transactions; and 2) on-day commodity market (OCM) for deals to balance the market [5]. Tradable NBP contracts at PEGAS include spot (Within Day, Day-Ahead, Week-End, Saturday, Sunday, Bank Holiday, and Individual Day) and futures instruments, ranging from intraday trading to the next 3 calendar years (the next 4 Months, the next 4 Quarters, the next 4 Seasons, the next 3 Calendar years). [35] The trading unit is pence/therm and the contract volume unit is kth/day.[36]

The NBP contracts are traded on ICE, ICE-Endex, and EEX [8]. In ICE, there are quite a lot futures for NBP: UK OCM Spot (up to seven days, through ICE Endex),[37] UK NG (EUR/MWH) Future, UK natural gas daily financial future, UK natural gas daily future, UK NG futures, UK NG futures TAS . In the case of UK NG futures, the trading period ranges from 78-83 consecutive month, 11-13 consecutive quarters, 13-14 consecutive seasons (6 months), or 6 consecutive years. Delivery is made equally each day throughout the delivery period. [38] UK Natural Gas Daily Futures products include varies of product up to 92 consecutive daily contracts. The daily contracts are for physical

[34] Heather (2010) classified the traded curve into the spot (today or tomorrow), the prompt (all other periods within the month), the near (front month to the first two seasons), mid (about two years forward) and far curves (up to about five years forward, and even possible to 10 years in NBP and TTF).
[35] https://www.powernext.com/sites/default/files/download_center_files/NBP.pdf
[36] https://www.powernext.com/pegas-trading
[37] https://www.theice.com/products
[38] https://www.theice.com/products/910/UK-Natural-Gas-Futures

delivery. The daily settlement will be determined by ICE using price data from a number of sources including spot, forward and derivative markets for both physical and financial products. The UK NG futures, and UK NG Daily Futures[39] requires physical delivery and thus generate reference (spot) prices for other settlement. [40]

11) The **Title Transfer Facility**, more commonly known as **TTF**, is a virtual trading point for natural gas in the Netherlands. Set up by Gasunie in 2003, it is almost identical to the National Balancing Point (NBP) in the United Kingdom and allows gas to be traded within the Dutch Gas network and network in other countries that link to the Dutch network. Wholesale gas trading at the TTF is predominantly conducted over-the-counter via interdealer brokers. TTF has been grown well recently and is now the most liquid gas hub in Europe and wide adopted in gas contracts in Europe.

Physical short-term gas and gas futures contracts are traded and handled by the ICE-Endex Exchange and via the PEGAS exchange. The trading unit is Euro/MWh and the contract volume unit is MW.

Tradable TTF contracts on PEGAS include spot (Within Day, Day-Ahead, Week-End, Saturday, Sunday, Bank Holiday, Individual Day and Hourly) and futures instruments, ranging from intraday trading to the next 4 calendar years (the next 4 Months, the next 4 Quarters, the next 4 Seasons, the next 4 Calendar years). [41] All PEGAS products lead to physical delivery and thus generate spot prices for settlement.

Some ICE futures products also requires physical delivery and thus generate spot prices. In ICE Endex has the most products for TTF than other European gas hubs: Gas Futures, Gas Base load TAS, Gas Daily Futures, Gas Options and gas spot.[42] Dutch TTF Gas Base Load Futures list Months ($\leq$ 71), quarters ($\leq$ 11), seasons ($\leq$ 11) and years ($\leq$ 5) in parallel and requires delivery.[43] Dutch TTF Daily Gas Futures products lists up to 92 consecutive daily contracts and are listed in parallel.[44] The Dutch TTF gas futures, daily futures and gas spot all requires delivery and thus can reveal spot prices for settlement.

12) **NetConnect Germany (NCG)** is one of Germany's two delivery zones. It is a virtual delivery point operated by NetConnect Germany since 2008. The high-pressure pipeline system in Germany's largest market area (as Sep 2017) has a total length of approximately 20,000 km and connects more than 500 downstream networks. Around two thirds of all gas volumes supplied to end users in Germany are transported through the NCG market area. In its role as market area manager, NetConnect Germany GmbH & Co. KG (NetConnect Germany) handles the operational management of the market area cooperation.

Physical short-term gas and gas futures contracts are traded and handled by the ICE-Endex Exchange and via the PEGAS exchange. The trading unit is Euro/MWh and the volume unit is MW.[45] Tradable NCG contracts on PEGAS include spot (Within Day, Day-Ahead, Week-End, Saturday, Sunday, Bank Holiday, Individual Day and Hourly) and futures instruments, ranging from intraday trading to the next 4 calendar years (the next 4 Months, the next 5 Quarters, the next 4 Seasons, the next 4 Calendar

[39] https://www.theice.com/products/20774967/UK-Natural-Gas-Daily-Future
[40] https://www.theice.com/products/20774967/UK-Natural-Gas-Daily-Future
[41] https://www.powernext.com/sites/default/files/download_center_files/TTF.pdf
[42] https://www.theice.com/products
[43] https://www.theice.com/products/27996665
[44] https://www.theice.com/products/45436633
[45] https://www.powernext.com/pegas-trading

years). All contracts lead to physical deliveries.[46] In ICE Endex, NCG only have two products futures and options[47], which is line with the fact that NCG is not a liquid finance hub [10].

13) The ZTP Physical hub (formely known as Zeebrugge (ZEE) Hub (Zeebrugge Beach)) is the natural gas physical trading point in Zeebrugge, Belgium. Created and operated by Fluxys since 1999, it is connected to the National Balancing Point (UK) via the Interconnector. ZTP Physical is the first European continental gas trading hub.
Physical short-term gas and gas futures contracts are traded and handled either through OTC market (via brokers or bilaterally) or through the PEGAS exchange (There are no products on ICE Endex). Tradable ZTP Physical (ZEE) contracts on PEGAS include spot (Within Day, Day-Ahead, Week-End, Saturday, Sunday, Bank Holiday, Individual Day and Hourly) and futures instruments (the next Month, the next 3 Month, the next 3 Quarters, the next 3 Seasons, the next Calendar years), ranging from intraday to the next calendar year. All spot and futures contracts lead to physical deliveries on the specified physical point of the gas transport network. The most common trading unit is pence/therm and the contract volume unit is kth/day as well as €/KWh and /€MWh.

14) From October 1, 2012 with the introduction of the entry/exit model for transmission activities, the Belgian trading landscape underwent a transformation with the creation of a a virtual hub (**ZTP notional**) alongside the existing ZTP Physical. Introduction of a virtual hub doubled trading options in Belgium, offering virtual trading alongside the physical hub as well as a choice between €/MWh and p/th. Both ZTP Physical and ZTP Notional are managed by Belgium's transmission system operator (TSO) Fluxys Belgium. The trading unit is Euro/MWh and the contract volume unit is MW.

Physical short-term gas and gas futures contracts are traded and handled by the ICE-Endex exchange and via the PEGAS exchange. Tradable ZTP Notional contracts on PEGAS include spot (Within Day, Day-Ahead, Week-End, Saturday, Sunday, Bank Holiday, Individual Day and Hourly) and futures instruments (the next Month up to M+6). In ICE Endex, ZTP Notional has three products ZTP Spot, ZTPS Spot, ZTP future. Balancing activity is performed by the balancing operator on the ZTP Notional hub trough the PEGAS exchange platform.[48]

15) As in September 2017 there is no defined gas hub in **China**. However, there are two gas exchanges: the Shanghai Petroleum and Gas Exchange (SHPGX) and the Chongqing Petroleum and Gas Exchanges (CQPGX), which are dedicated to trade gas. The SHPGX started fully operation in November 2016 while CQPGX has yet to start trading gas. SHPGX initially traded pipeline gas and LNG for next day delivery without standard deliver points. In September 2017, SHPGX organized pipeline gas trading by five regions (East, North, South, Southwest and West) that are designated by CNCP Sales Branches. In each region, a province capital is designated as a pricing point. Therefore, there are five benchmark pricing points in China (Beijing for North, Shanghai for East, Guangzhou for South, Lanzhou for West and Chengdu for Southwest).

16) The **Dōjima Rice Exchange (DRE)**, located in Osaka, was the center of Japan's system of rice brokers, which developed independently and privately in the Edo period and would be seen as the forerunners to a modern banking system. It was first established in 1697, officially sanctioned, sponsored and organized by the Shogunate in 1773, reorganized in 1868, and dissolved entirely in 1939, being absorbed into the Government Rice Agency. Since members of the samurai class, including

[46] https://www.powernext.com/sites/default/files/download_center_files/NCG-GASPOOL.pdf
[47] https://www.theice.com/products
[48] https://www.theice.com/products

daimyo (feudal lords) were paid in rice, not cash, the rice brokers and moneychangers played a crucial, and incredibly profitable, role in the emerging early modern economy of Japan.

17) **Asian Iron Ore hub prices** - Iron ore was one the last major commodities to be traded as an option in the stock exchanges. Most of the metals are priced off exchange traded price in LME. Iron ore being the most dominant example of the traditional dominance of spot pricing is an exception.

The Steel Index, a division of PRA Platts, publishes 5 benchmark prices for Iron ore, Iron ore fines 62% Fe - CFR Tianjin Port (China), Iron ore fines 58% Fe (low alumina) - CFR Qingdao Port (China), Iron ore fines 62% Fe (low alumina) - CFR Qingdao Port (China), Iron ore fines 63.5/63% Fe - CFR Qingdao Port (China), and Iron ore fines 65% Fe - CFR Qingdao Port (China)[49].

Iron ore fines 62% Fe - CFR Tianjin Port (China) is assessed for sinter Fines of granular size below 10mm for at least 90% of the cargo, with maximum of 40% below 150 micron), with an Iron content typically of : 62.00% Fe, Moisture: 8.00%, Alumina: 3.50%, Silica: 4.00%, Phosphorus: 0.070%, Sulphur: 0.05% (all can vary within accepted level of tolerances). The minimum lot size is 20,000 metric tonnes and the pricing Point is normalized as CFRFO Tianjin port, China. Time of loading is within 4 weeks and delivery within 8 weeks of transaction. Prices submitted for transactions with specifications in the following ranges are normalised to the 62% Fe reference product.

Iron ore fines 58% Fe (low alumina) - CFR Qingdao Port (China)) is assessed for sinter Fines of granular size below 10mm for at least 90% of the cargo, with maximum of 40% below 150 micron), with an Iron content typically of : 58.00% Fe, Moisture: 9.00%, Alumina: 1.50%, Silica: 5.50%, Phosphorus: 0.040%, Sulphur: 0.02% (all can vary within accepted level of tolerances). The minimum lot size is 20,000 metric tonnes and the pricing Point is normalized as CFRFO Tianjin port, China. Time of loading is within 4 weeks and delivery within 8 weeks of transaction. Prices submitted for transactions with specifications in the following ranges are normalised to the 58% Fe, 1.5% alumina reference product. The Iron ore fines 62% Fe (low alumina) - CFR Qingdao Port (China) price is assessed for Iron ore of similar qualities as 62% Fe benchmark with the crucial difference that typical Alumina content is lower at 2%. Iron ore 63.5% Fe and 65% Fe are also assessed – CFR Qingdao port.

The Metal Bulletin, publishes benchmark index prices for 62%, 58% and 58% Premium, Fe Fines CFR Qingdao, China. The MBIOI-62 is the benchmark price representing the iron ore fines market. The MBIOI-58 is a price representing the lower grade iron ore fines market. Minimum trade size is 30,000 tonnes. All transaction data within the specification ranges, are normalised to the base specification based on the value-in-use implied by the market. The index is rounded to two decimal places. The index is published at 6.30pm Singapore time. The Metal Bulletin Iron Ore Indices are tonnage-weighted calculations, where actual transactions carry full weight as reflected by the reported volume, while offers, bids and market participants' own assessment of the market are weighted at the specified minimum tonnage for the respective index. Metal Bulletin publishes a daily differential premium for 58% Fe high specification; low alumina and phosphorous material (MBIOI-58P). The MBIOI-62 and MBIOI-58 are rounded to two decimal places. The premium is rounded to the nearest $0.50. The figure representing the combined MBIOI-58 and High Specification Premium is the 58% Fe Premium Index [42].

The third important benchmark price for Iron ore is the Platts Iron Ore Index, or IODEX, is a benchmark assessment of the spot price of physical iron ore. The assessment is based on a standard specification

[49] https://www.thesteelindex.com/en/iron-ore/

of iron ore fines with 62% iron, 2% alumina and 4.5% silica, among other gangue elements. Since the breakdown of annually negotiated prices in 2010, the IODEX has been the primary physical market pricing reference for seaborne iron ore fines delivered into China, the biggest importer of the steelmaking ingredient. The assessment is published on a CFR Qingdao, North China basis, but also used by steelmakers, traders and mining companies globally to price long-term and spot contracts. Ores delivered on quality, location and timing dimensions differing from those underlying the IODEX are normalized using differentials, which are updated periodically to remain reflective of current market practice[50].

In exchange trades, Singapore based **SGX** dominates Iron ore trading, due to its trading centre status and also proximity to the large Chinese market. The list of Iron ore derivatives traded in the exchange include SGX Iron Ore CFR China () Swap/Futures/Option for different specifications of iron ore (62% Fe Fines, 58% FE Fines) and price index. The major contracts traded in terms of traded volume in the exchange are the Iron ore 58% and 62% swaps and futures, based (underlying) respectively on the Metal Bulletin assessment and Steel Index assessment of Iron ore prices. Contract size for futures is 100 Mt and for swaps is 500 Mt. All positions are cash settled[51]. Even though price determination of the contract at settlement is based on the average of the TSI or MB prices, the prices reflected in the exchange trading feeds back into the physical assessments in a complex relationship. As a host to PRAs assessing Iron ore prices and derivatives trading in SGX, Singapore has developed as a host of price controlling market participants without having large volumes of physical transactions, , thus making it a price reporting, financial trading, and risk management hub of iron ore trade.

Coal market is broadly divided into Atlantic region and Pacific region markets. For at least 20 years until the 2000s, Australia and South Africa were the top two exporters of steam coal, with similar export volumes until the early 1990s and Europe the largest import market for coal. At some point in time, both countries supplied coal to the Atlantic Region and the Pacific Region markets, which have helped establish FOB Newcastle 5500 NAR (assessed by Platts) and FOB Richards Bay (API 4) as international benchmarks.

18) Specifically, the Platts **FOB Newcastle 5,500 NAR** assessment is a daily 7-45 day forward price assessment for higher-ash thermal coal exported out of the port of Newcastle on Australia's eastern coast and typically shipped to China[52]. FOB Newcastle 5,500 NAR is an important assessment, reflecting a shift in spot market liquidity from the industry standard FOB Newcastle 6,300 kcal/kg GAR quality coal bought mainly by Japanese utilities to lower calorific value, higher ash coal preferred by Chinese, Korean and Taiwanese end-users. Argus assesses Australia (fob Newcastle) API 5 index (weekly) and Australia (fob Newcastle) API 6 index (weekly). The API 5 and API 6 indexes are the price for exports of 5,500 kcal/kg NAR and 6000 kcal/kg NAR coal (net as received), high-ash coal from Australia. The indexes are calculated respectively as an average of the Argus fob Newcastle 5,500 kcal/kg or 6000 kcal/kg assessment and the equivalent from IHS McCloskey.

The important exchange traded futures product is the Globalcoal Newcastle Coal futures. Contracts are financially settled based upon the price of coal loaded at the Newcastle Coal Terminal in Australia. The contract is cash settled against the globalCOAL Monthly NEWC Index[53]. The contract trades upto 84 consecutive months maturities, with a contract size of 1000 tonnes of coal with date of contract expiry at the last business day of the month of contract.

[50] https://www.platts.com/price-assessments/metals/iodex-iron-ore
[51] http://www.sgx.com/wps/portal/sgxweb/home/products/derivatives/commodities
[52] FOB Newcastle 5500 NAR Coal - https://www.platts.com/price-assessments/coal/newcastle-5500
[53] https://www.theice.com/products/1137

19) **FOB Richardsbay** - Key price indexes assessed FOB Richardsbay South Africa are — South Africa (fob Richards Bay, 5,500) API 3 index (weekly), South Africa (fob Richards Bay) API 4 index (daily)

The API 4 index is an average of the Argus fob Richards Bay assessment and the IHS McCloskey FOB Richards Bay marker, assessed for concluded deals of exports of South African coal of defined quality. Richards bay 6000 and 5500 are the two prices quoted in the industry. Assessments are based 50pc on a volume-weighted average of deals done and 50pc on a survey of active market participants. In the absence of transactions, the assessment will be based on the market survey and the highest bids and lowest offers received (Argus). All prices are assessed FOB Richards bay port for delivery anywhere in the world. The physical benchmark price forms the basis for coal derivatives traded in Northern Europe and is termed as a globally quoted benchmark price (supplier side) of steam coal[54]. API 3 index, is the average of the weekly Argus' fob Richards Bay 5,500kcal/kg NAR assessment and the weekly IHS McCloskey South African 5,500kcal/kg NAR FOB marker. The API 3 prorated-API 4 differential is also assessed, which is the difference between the weekly API 3 index and API 4 index adjusted for the difference in calorific value between the two grades of coal[55].

The API 2 Rotterdam Coal futures contract traded at ICE is cash settled against the API 2 Index published in the Argus/McCloskey Coal Price Index Report. The contract trades up to 84 consecutive months maturities, with a contract size of 1000 tonnes of coal with date of contract expiry at the last business day of the month of contract[56]. The API 4 Rotterdam Coal futures contract traded at ICE is cash settled based on the price of coal loaded at the Richards Bay Coal Terminal in South Africa. The contract is cash settled against the API 4 Index published in the Argus/McCloskey Coal Price Index Report. The contract trades upto 84 consecutive months maturities, with a contract size of 1000 tonnes of coal with date of contract expiry at the last business day of the month of contract[57]. ICE also trades in API2, AP4 and Newcastle Coal options with 122 day, 214 and 305 day expiry. Altogether, 49 coal based contracts are traded in the ICE. Each of the options have a contract size of 1000 metric tonnes and extend with maturities upto consecutive months for 4 years. All the contracts are cash settled.

[54] API 4 (Coal) - http://www.argusmedia.com/methodology-and-reference/key-prices/api-4/
[55] Coal Price Indexes - http://www.argusmedia.com/coal/argus-mccloskeys-coal-price-index-report/
[56] https://www.theice.com/products/243/API2-Rotterdam-Coal-Futures/specs
[57] https://www.theice.com/products/241