Benefits of Natural Gas for Poland

- Needs for the Development of a Gas Hub

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1. INTRODUCTION

1.1 Air Pollution – A Burning Problem

Is it going to be another cold winter this year? Millions in Poland may have a battle ahead... Fighting the cold may give rise to a black guise over the otherwise white snow-covered winter landscape. After almost three decades decline of heavy industry, air pollution remains a severe problem in Poland today. Poor air quality in Poland is largely a result of coal and wood burning for residential heating, while emissions from power and road transport are also significant. According to the European Environment Agency (EEA), there were almost 46,020 premature deaths caused by PM2.5 (a major air pollutant) in Poland in 2014. The non-fatal impact of air pollution in Poland is also alarming. For example, a local public movement group Krakowski Alarm Smogowy claims that breathing Krakow's air is equivalent to smoking 2,500 cigarettes a year[1].

Picture: Krakow in smog. Source: Pawel Krzan, www.krakow4u.pl

The poor are likely to suffer the most since they are more likely to burn cheaper fuels i.e. wood and low-quality coal at home. The Polish public has been more and more vocal about the air pollution situation. In 2015, President Andrzej Duda signed the first ever Polish anti-smog bill, allowing local governments to adopt their own local air quality regulations andin January 2016, Krakow became the first city to introduce city-wide coal ban with a goal to completely phase out coal stoves from home heating by 2019. While Krakow's move is an encouraging start for Poland, further government policy supports are required to combat the air pollution problem in Poland.

There are many ways to tackle air pollution such as heat pumps, district heating, renewable energy within electricity generation, and natural gas as examples. A precondition for deployment of existing or new approaches/technologies in a cost-efficient manner is well-functioning markets.

1.2 Gas sector reforms and liberalisation of the market

With the inclusion of Poland into the EU, the efforts to step up the liberalisation of the Polish energy market have increased. The introduction of the 3rd Energy Package introduced amongst other things, provisions for third party access to infrastructure, unbundling of incumbent firms, and greater regulatory oversight. The main elements are presented in Box 1 below.

[1] https://krakowskialarmsmogowy.pl/en

Box 1: Main features of 3rd Energy Package

- ❖ Effective unbundling of energy production and supply interests from the network. This should eliminate any conflict of interests between these activities. Unbundling should prevent network operators from favouring their own energy production and supply companies

- ❖ Increased transparency of retail markets and strengthening of consumer protection rules

- ❖ More effective regulatory oversight by independent market watchdogs, the national regulatory authorities

- ❖ Establishment of the Agency for the Cooperation of Energy Regulators (ACER) to ensure effective cooperation between national regulatory authorities and to take decisions on cross-border issues

- ❖ Better cross-border collaboration and investment: a new European Network for Transmission System Operators will bring together EU electricity and gas grid operators to cooperate and develop common commercial and technical codes and security standards.

Source: EU Commission, DG Energy

For Poland the adoption and implementation of the 3rd Energy Package implied unbundling of the existing incumbent companies and establishment of independent TSOs and increased regulatory independence. In Poland this led to the establishment of Gaz-System (the TSO for gas), gas distribution companies, trading companies, and suppliers.

Later in 2015, the Energy Union, EU's strategy to tackle the energy transition, was introduced. The Energy Union strategy emphasises three objectives of EU energy policy; namely 1) security of supply; 2) competitiveness and 3) sustainability. The Energy Union focusses on five mutually supportive pillars:
1. Energy security, solidarity and trust;
2. A fully integrated European energy market;
3. Energy efficiency contributing to moderation of demand;
4. De-carbonising the economy;
5. Research, Innovation and Competitiveness.

1.3 Infrastructure on the rise

The EU Energy Union pillars harmonise well with the Polish Energy Policy developed in 2009. In particular, the integration with the neighbouring countries and establishment of alternative supply sources to Poland has received a lot of interest and attention from both the Public, the EU Commission, and the political establishment in Poland. The focus on interconnections led the EU Commission to launch the project of common interest initiative ensuring finance for studying feasibility of cross border projects and key infrastructure. With an increased emphasis on security of supply, Poland is actively creating alternative supply sources to the existing pipeline through Belarus from Russia and has thus been at the receiving end of this program with many new infrastructure developments being matured and studied:

- Reverse flow in the Yamal pipeline (allowing gas to flow from Germany) in 2014 and the opening of the LNG terminal in Świnoujście in 2015;
- Extension of the existing LNG terminal, and the building a new FSRU LNG terminal in Gdansk;
- Creation of Baltic Pipe that will bring gas from Norway to Poland; and
- The Gas Interconnector Poland-Lithuania (GIPL).

These new supply sources do not only improve security of supply,they also introduce the opportunity to create a gas hub in Poland, where suppliers, shippers, and consumers all can benefit from availability of many sources of gas. The Świnoujście LNG terminal allows access to the world market of LNG, and the connection towards Germany gives direct access to the German market and indirect access to the central and north western European market and associated hubs. These markets already have a diversified supply from which the Polish gas market and potentially a strong regional gas hub in Poland can benefit.

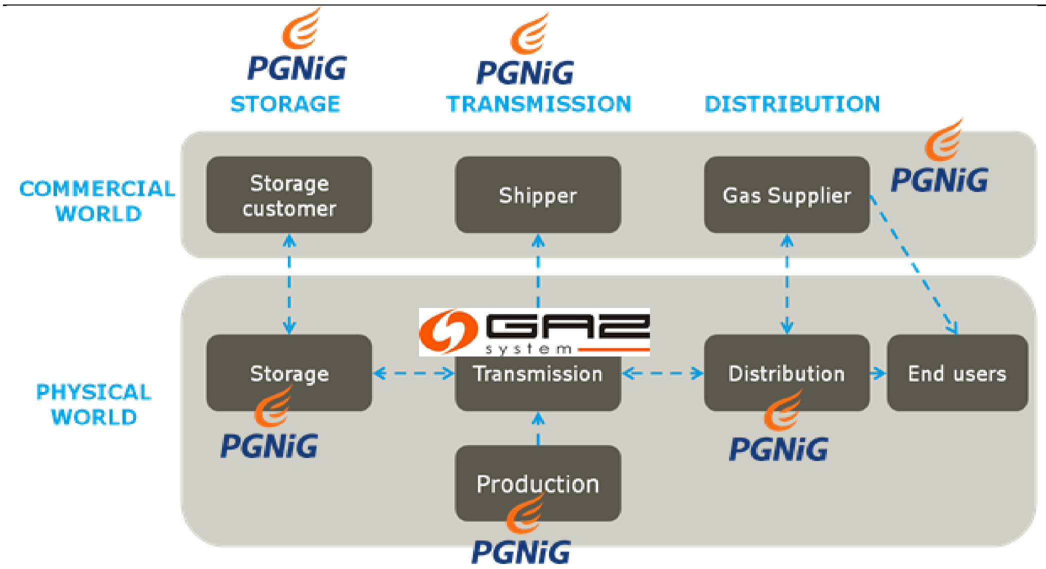
1.4 Structure of the market and current situation

The supply side is characterised by supply of gas from Russia, taking into account that some of the gas supplied from Germany originates from Russia, it can be argued that Poland is facing a monopoly supplier of gas. On the buyer side, despite all the efforts to liberalise the market, PGNiG is still the dominant buyer on both the wholesale and retail market. PGNiG is a traded listed company with the Polish state treasury owning >71.88 pct. of the shares[2].

With supply and demand concentrated on a few players, the preconditions for a wholesale price above a competitive level are present. A price above the competitive level will have several negative effects, including gas consumers paying too much and inefficient use of energy. A competitive price where the market price reflects the true costs of energy will overcome these inefficiencies. In a situation with one dominant, incumbent market player, it is possible that one (or more) entrants to the market can shift the pricing from monopolistic towards competitive. However, it is crucial that the entrants (collectively) become a sizeable competitor to the incumbent. If not, the monopoly will still set the price and the entrants merely mimic that high price – with no gains on efficiency or price for the consumers and the population.

Despite significant advancement within the regulatory framework and the gas import infrastructure, the situation today is characterised by what the market perceives and experiences as access barriers to the market. On the physical side, PGNiG owns and operates all storages, a major share of natural gas production is owned by PGNiG and finally almost 100% of the distribution networks are managed by PGNiG. This indicates, compared to other EU countries, a relatively high concentration of infrastructure on one hand, albeit the business is organised in several subsidiaries. Hence, PGNiG is a major actor in the market and is present in all steps of the value chain. All in all, although unbundling has taken place, the market could benefit from more actors. This is further underlined by the fact that more than 20 suppliers since August 2017 decided to hand in their import license following stricter regulation on storage obligations.

Figure 1: Main structure and main actors on the polish gas market



Source: Illustration Ramboll

[2] http://en.pgnig.pl/investor-relations/stock-informations/shareholder-structure

1.5 Project Description and Purpose

With the developments within air pollution and the Polish energy and gas markets in mind, this report sheds light on the competitive situation in the gas market. Further, the report highlights what could be done to ensure an easy and smooth move from highly polluting fuels to cleaner alternatives.

A central hypothesis is that competition on the wholesale in Poland is lower than it could be, and that this is affecting the decisions to change the fuel composition. Many issues are relevant, and several policy tools could be applied. However, for the sake of clarity and simplicity, we narrow in on the following policy channels of influence which we believe could be the most significant:

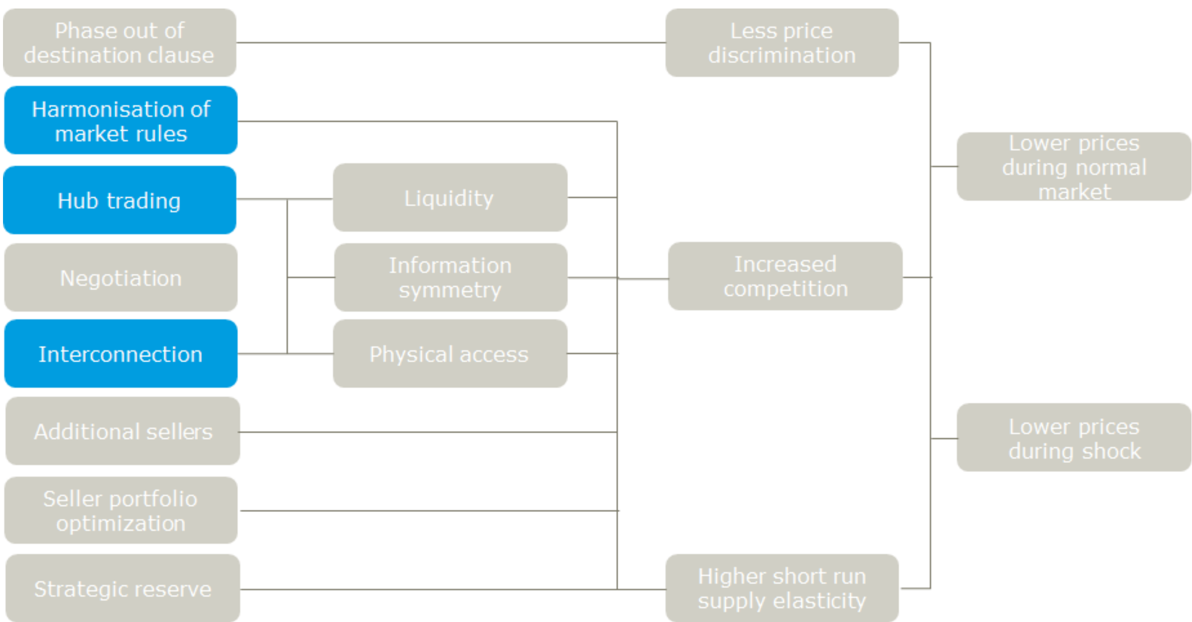
A) Harmonisation of market rules, i.e. are there any barriers to competition in the regulatory environment;

B) Can hub trading be expanded and are there any barriers to this;

C)The roles of interconnections and new infrastructure – physical access increases the possibility for gas to gas competition.

The three policy channels above do in one way or the other increase competition and lead to lower prices of natural gas – everything else being equal.

Figure 2: Policy variables and influencers treated in this study



Source: Ramboll, Ecorys, Vivid

2. AIR QUALITY AND THE ROLE OF NATURAL GAS

2.1 What exactly is air pollution?

Air pollution is contamination of the air environment (indoor or outdoor) by any chemical, physical or biological matters; pollutants may occur naturally (e.g. from dust and wildfires) as well as from human activities. Air pollutants have many impacts on health, ecosystems, the built environment and the climate; as well as affecting local areas, air pollutants may travel long distances and affect large areas.

The European Environment Agency (EEA) has singled out air pollution as the single largest environmental health risk in Europe, causing heart disease, stroke, lung diseases and lung cancer, common reasons for premature death. Emerging literature shows that air pollution has also been associated with health impacts on fertility, pregnancy, and new-borns and children. According to the World Health Organisation (WHO), pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulphur dioxide.

- **Particulate Matter (PM)** is a collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface. Particulate matter includes dust, smoke, soot, pollen and soil particles. The most health-damaging particles are those with a diameter of 10 microns or less (PM10), especially fine particles of 2.5 microns or less (PM2.5). Within these particulate matters Benzo[a]Pyrene (BaP), a potent carcinogen, is present. BaP is not the only carcinogen present in PM, but is emitted by wood and coal combustion. Combustion of coal, fuel oil, and diesel is a significant source of PM2.5. Long-term exposure to PM2.5 is associated with increased mortality due to lung diseases and cardiac events.

- **Carbon monoxide (CO)** is a colourless, odourless gas that can be emitted from the incomplete combustion of fuels: coal, gas, oil, wood, etc. CO can increase the severity of lung ailments, cause dizziness, fatigue, nausea, and even death.

- **Ground-level Ozone (O3)** is created by chemical reactions between Nitrogen Oxides (NOx) and Volatile Organic Compounds (VOC). This happens when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources chemically react in the presence of sunlight. According to the United States Environmental Protection Agency (EPA), breathing ozone can cause many health problems including chest pain, coughing, throat irritation, and airway inflammation. It can also reduce lung function and harm lung tissue. Ozone can worsen bronchitis, emphysema, and asthma, leading to increased medical care.

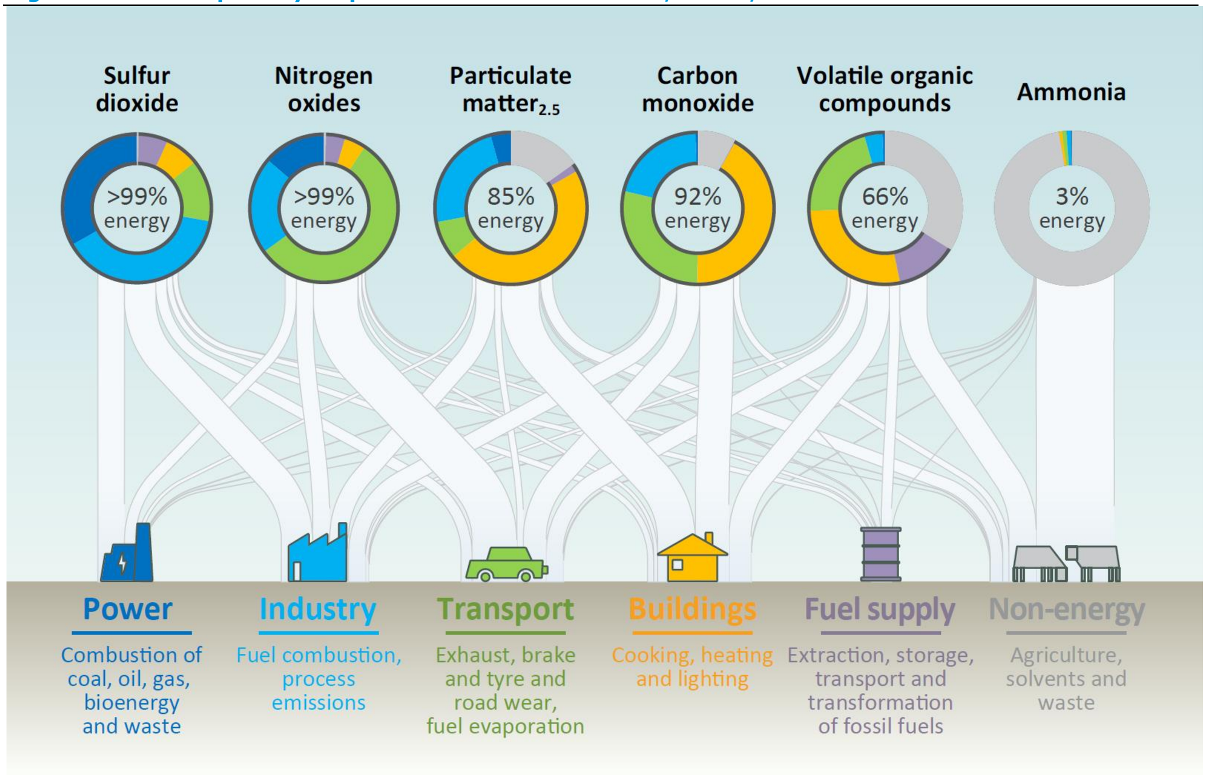
- **Nitrogen Dioxide (NO2)** is one of several nitrogen oxides (NOx) produced from high-temperature combustion, mainly in transport and power generation. According to the EPA, breathing air with a high concentration of NO2 is harmful for human health. Short-period exposures can lead to respiratory problems such as coughing, wheezing or difficulty breathing; Longer exposures to high concentrations of NO2 may contribute to the development of asthma and potentially increase susceptibility to respiratory infections. People with asthma, as well as children and the elderly are generally at greater risk for the health effects of NO2.

- **Sulfur Dioxide (SO2)** is produced from burning fossil fuels (coal and oil) that contain sulfur. SO2 is harmful to health and is a key to the formation of acid rain. SO2 can impact the respiratory system, impair lung function, and cause eye irritation. Studies have found that hospital admissions for cardiac events and mortality increase on days of high SO2 concentration.

2.2 Who are the polluters?

According to the International Energy Agency (IEA), the energy sector is by far the largest source of air pollution from human activities. They come predominately from the combustion of fossil fuels and bioenergy, but also from coal extraction and other forms of mining (oil sands, uranium) and industrial activities, the processing/washing of coal, transportation of coal and natural gas, oil refining and charcoal production, as well as non-exhaust emissions from the transport sector.
Figure 3 illustrates, at the global level, the source of each main air pollutants. In 2015 for example, nearly a half of PM2.5 (Particulate Matter) emission comes from Buildings (cooking, heating and lighting), while almost a quarter of the emission comes Industry (fuel combustion, process emissions).

Figure 3: Selected primary air pollutants and their sources, Global, 2015



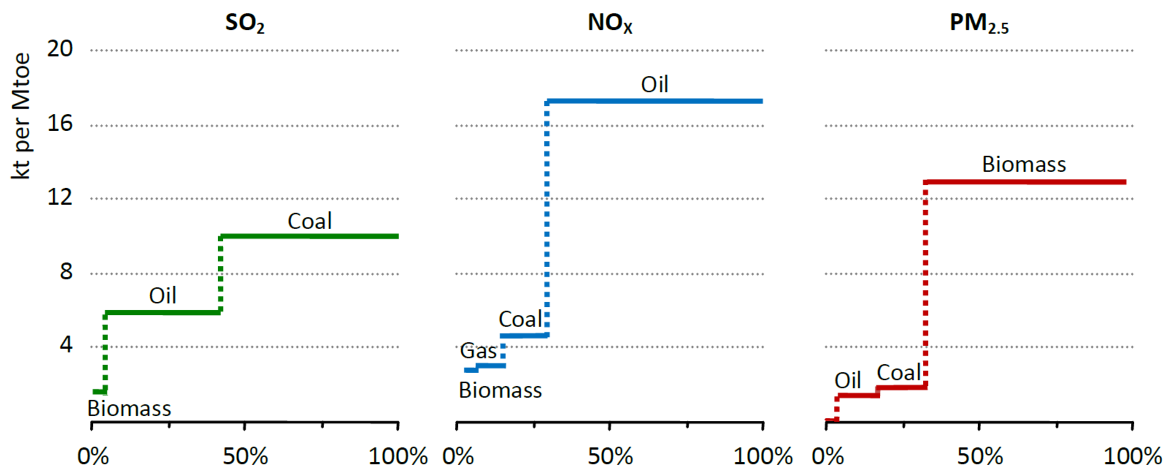
Source: International Energy Agency (IEA)

Note: Ammonia (NH3) is common nitrogen waste, it is a colourless gas and predominately comes from agricultural and waste management activities. Ammonia produces an unpleasant odour; however, it is unlikely to have adverse effects on health at environment concentration level.

On the global level, the overall major pollutant emissions by different type of fuels can be illustrated in Figure 4. In 2015, Coal had the highest emission rate in SO2 (over 10 kt per Mtoe), accounting for more than half of total SO2 emission in the world. Oil was by far the biggest emitter of NOx, followed by Coal. For PM2.5 emission, biomass (e.g. wood) accounted for around two-thirds of the total, while coal and oil combinedly accounted for around one-third.

Unlike biomass and other fossil fuels, natural gas produces less major air pollutants.

Figure 4: Global average emissions factors and share of major pollutant emissions by fuel, 2015



Source: International Energy Agency (IEA)
Notes: The most relevant fuels in terms of emission factors are represented; fuels not shown are considered negligible. Global average emission factors are calculated across all types of sectoral activity and all types of technology. Emissions depends on the adapted technology, in particular if NO_X reducing equipment is installed.

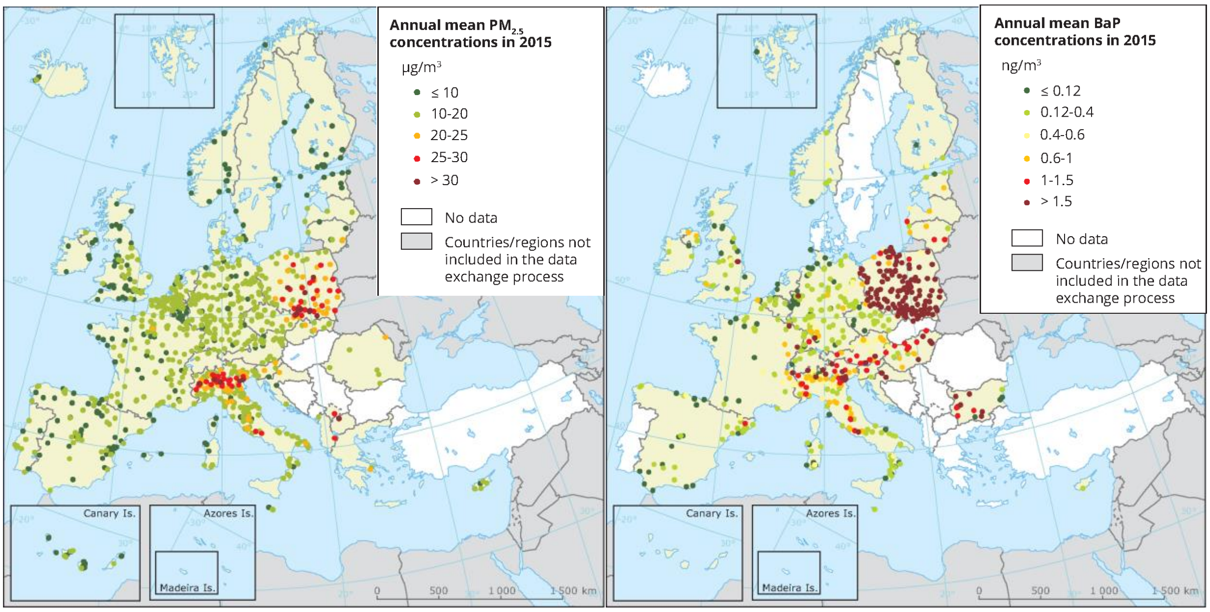
2.3 What's the situation in Poland?

According to the National Centre for Emission Management (KOBiZE), the main cause of the increased air pollution in Poland are non-industrial combustion processes, i.e. burning coal, wood and other low-quality fuels in home stoves, boilers and fireplaces. Coal is the cheapest heating fuel available in Poland, and some parts of the population also burn wood and waste in coal boilers to reduce the cost of heating. The main air pollutants from the residential heating are Particulate Matters. Meanwhile, historical data (2007) from the Ministry of Environment indicate that Power and Transport sectors also produce a significant amount of pollutants, although the main contents are SO2 and NOx, respectively.

The WHO Air Quality Guideline (AQG) for PM2.5 annual mean is 10 µg/m3; however, as illustrated in Figure 5, all regions in Poland exceeded this AQG level and many regions reached more than three times of this AQG level.

The WHO has not recommended a guideline value for BaP; however, a reference level of 0.12 ng/m3 was estimated assuming WHO unit risk for lung cancer and an acceptable risk of additional lifetime cancer risk of approximately 1 in 100,000. Further, EU has since the beginning of 2013 operated with a maximum target value of BaP of 1 ng/m3 on yearly average. It is clearly illustrated in Figure 5 that the BaP level in most parts of Poland far exceeded the reference level 0.12 ng/m3 and the EU target level of 1 ng/m3.

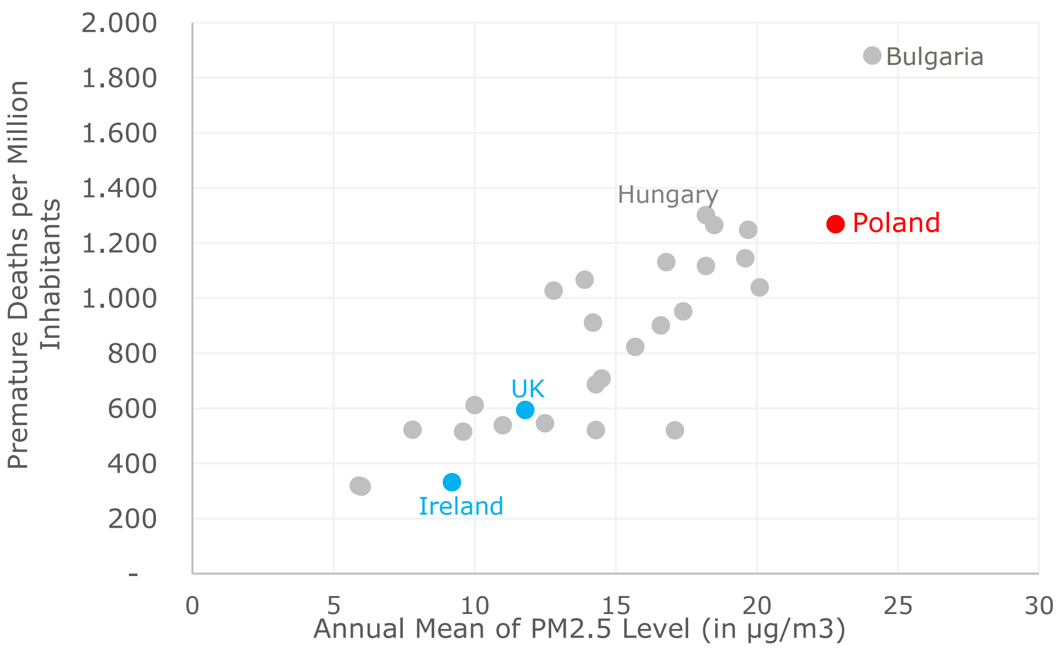
Figure 5: Concentrations of PM2.5 and BaP in 2015



Source: European Environmental Agency (EEA)

According to the EEA, in 2013, the number of premature deaths attributable to PM2.5 in the European Union member countries was as large as 436,000, where Poland accounted for 48,270, i.e. 1/9 of the total.

Figure 6: Premature Deaths Attributable to PM2.5 (EU 28 member Countries, Year 2013)



Source: European Environmental Agency

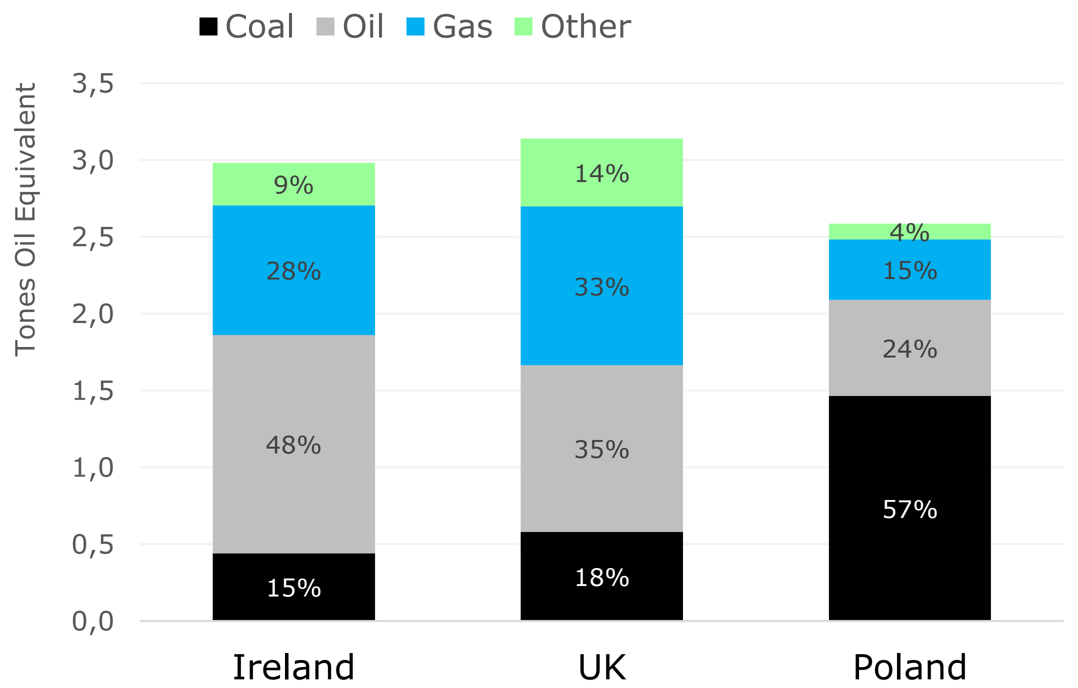
As shown in Figure 6, in 2013, Poland had 1,268 premature deaths per million inhabitants attributable to PM2.5, the third highest among the 28 EU member countries, only behind Bulgaria and Hungary.

It is worth emphasising that these statistics only reflect the population severely harmed by air pollution, i.e. those who suffered premature deaths. There are much larger proportions of the population having been harmed by air pollution to various extent, and these impacts are not quantified.

The level of coal consumption in Poland has traditionally been very high. In 2013, the coal consumption per capita in Poland was 1.5 tonnes oil equivalent, accounting for 57% of its total primary energy mix. This was much higher than all other EU member countries (except for Czech Republic) both in absolute volume (per capita) and concentration in the primary energy mix.

In comparison, countries with less penetration in coal (as well as biomass) tend to have lower level of PM2.5, which in turn leads to lower associated premature death rates. For example, Belgium, UK, and Ireland all had lower coal consumption per capita than Poland as seen in Figure 7, and the premature deaths per million inhabitants in these countries were 900, 594, 331, respectively – significantly lower than that of Poland (1,268).

Figure 7: Primary Energy Consumption Per Capita (excl. biomass), Year 2013



Source: Ramboll calculation based on BP Statistical Review 2014.

If Poland can achieve the same level of PM2.5 attributable premature death rates as that of the UK, it could mean that almost 26,000 people can be saved each year.

2.4 Now what?

It is clear that Poland needs cleaner energy sources. According to a World Energy Council report in 2014, Poland has no considerable hydro energy resources and the resources of the other types of renewable energy are not rich. Despite the ongoing development of the wind generation and biomass fired generation, these sources may cover no more than a dozen percent of the electricity requirements. According to the World Nuclear Association, there is currently no nuclear power in Poland – the first planned nuclear power plant (3GWe) is expected to start commercial operation in 2029, while the second one (3GWe) will be as late as 2035.

Therefore, we believe that natural gas can be an important and pragmatic solution for air pollution in Poland. Natural gas is widely regarded as a solution for a cleaner energy future. Many places have started sturdily replacing coal (and other heavy polluting fuels) with gas in pursuit of better air quality.

Krakow's recent ban on solid fuels (coal, wood and waste) in residential heating is an impressive first step for air pollution reduction in Poland. Switching from coal and wood to cleaner fuels can be costly for most households and therefore creates resistance for policy implementation. Recognising such challenges, Krakow authorities offer grants to residents to help them replace the 'dirty fuel' systems, as well as targeted subsidies to the poorest residents on heating bills following their switch, particularly to natural gas. The campaign has been promoted across Krakow, on billboards, city light stands, TV screens in city trams, as well as on the Internet.

According to International Gas Union (IGU), Krakow draws on both regional and EU structural funds to support its air quality and energy poverty improvement programmes. In addition to banning residential coal burning and mandating the replacement of coal-fired stoves, Krakow's air pollution reduction program also aims to expand the city's gas distribution network, modernise its district heating system and promote renewable energy sources for domestic heating.

While Krakow has started its rigorous pursuit in reducing air pollution, it is still the only city in Poland that has implemented a ban on "dirty fuels". A nationwide rollout of similar regulations will likely require strong Central Government supports from both policy and market standpoints. For example, sufficient grants, subsidies and even favourable loans can be made available to residents for their switch from coal and wood to gas, coupled with the development of relevant transmission and distribution infrastructures. Similarly, financial incentives can be given to encourage the development of gas-fired and renewable power plants. Moreover, Compressed Natural Gas (CNG) vehicles can be promoted to reduce emissions from the transport sector.

The International Gas Union (IGU) has conducted a number of case studies on the impact of gas on air quality. We believe the experience of different countries can provide good references for the Polish public and policymakers. A few examples are summarised in the following section.

2.5 Case Study 1: Dublin

In the late 1980s, Dublin's air quality was among the worst in Europe due to the burning of cheap coal. The air pollution in the city was directly associated with increased premature deaths, especially in cold winter months.

In 1990, the city government implemented a coal ban in response to several spells of severe coal-related winter smog. Since then remarkable improvements in the public health have been achieved; by 2009, Dublin's air quality had improved dramatically and included in the European Green City index as one of the leading European cities. The ban drove a rapid expansion in the natural gas consumption for residential use (especially for home heating), as well as commercial and transportation use. About two-thirds of households in Dublin now use natural gas, and gas now accounts for over 75% of the residential sector energy demand in Dublin, compared with 7% for oil and 0.4% for coal. These measures succeeded in significantly reducing benzene, carbon monoxide, SOx, and smog levels, with particulate matter concentrations falling 80-90% from 1990 to 2014.

Dublin's success encouraged 29 other cities and towns to introduce similar legislations between 1990 and 2013. Similar results throughout the country drove the Irish government to issue a nationwide ban on bituminous coal burning in 2015, which is set to take effect in 2018. Importantly, political opposition to the ban has been low and the public has also been largely supportive, allowing for relatively smooth passage and implementation.

Although coal is still permitted for use in electricity generation, its share of the country's electricity portfolio has almost halved from 40% in 1990 to 21% as of October 2016. Meanwhile, gas and renewables currently account for 38% and 35% respectively.

Overall, the total gas consumption in Ireland doubled between 1990 and 2015, twice the rate of total energy consumption increase. Coal consumption on the other hand fell by nearly 40% over the same period.

Ireland's ability to substitute coal with gas was made easier as it has been able to secure gas supply from indigenous production and import from the UK. The absence of a large indigenous coal industry also helped to avoid strong resistance on the coal ban.

2.6 Case Study 2: Berlin

Today, Berlin is one of the cleanest major cities in Europe with regard to air quality. However, this was not always the case – a widespread shift from coal to gas in power, heat generation, and residential heating was perhaps the most important factor for the improvements in the air quality since the reunification of Germany. Between 1989 and 2015, Berlin's SOx emissions dropped by 95%, NOx emissions decreased 76% and PM10 emissions were on track to decline by 83%.

Direct coal burning in the residential and commercial sector has disappeared by the early 2010s. The number of coal-fired furnaces (mainly used for residential heating) diminished sharply from 400,000 in 1990 to around 40,000 by 2010, they were mainly replaced by gas-fired units or district heating. Natural gas also gained ground in Berlin's coal-dominated power and district heat generation sectors. Between 1990 and 2012, the total gas consumption in Berlin more than doubled in absolute terms, and the share of gas in the city's primary energy balance increased from 17% to 41%, meanwhile the share of coal declined from 37% to 17% during the same period.

Currently, road transport is the largest emitter for many air pollutants in Berlin. The city has promoted the use of CNG vehicles since 2000, although the CNG vehicles only currently account for less than 1% of the active vehicle fleet, the air quality impacts can be quite significant on the local level, especially in areas with a high concentration of taxi traffic (e.g. around airports and train stations). Recognising natural gas as a "clean alternative" to diesel vehicles in transportation, the city has plans to support the growth of CNG vehicles, e.g. through public sector vehicle purchases, reducing tolls for CNG trucks, and a public communication campaign highlighting the benefits of natural gas vehicles.

2.7 Case Study 3: New York City

Although New York City's air quality has been improving for several decades, air pollution remains a serious concern.

In 2007, New York City launched a comprehensive air-quality monitoring program. The initial results showed that not only were PM2.5 and Ozone levels above national standards, but also that PM2.5 and SO2 levels were particularly elevated in areas with a high density of buildings burning heavy fuel oil for heat or power.

To address this challenge, New York City initiated and supported a number of state and local regulatory reforms and incentive programs. The city also noted it would try to accelerate the heating oil phase-out by supporting the development of natural gas transmission pipelines, as well as working with utilities and neighbourhoods to try to cluster buildings in underserved areas where additional gas distribution could have the greatest air quality benefits.

Thanks to these policies, about 30% of heavy fuel-burning buildings in New York City converted to cleaner fuels by the Autumn of 2013, out of which approximately 75% converted to natural gas or ultra-low sulfur No.2 oil. The conversion to natural gas was particularly strong due to market factors such as increased gas supply and lower gas prices. By mid-2015, the phase-out of heavy fuel oil had been completed, and all buildings had converted to No. 2 heating oil or natural gas. A report found that the SOx concentration in the winter of 2012-2013 reduced 69% compared to the winter of 2008-2009, while the PM2.5 level from burning fuel oil dropped 35%. The City estimated that the overall improvement in PM2.5 levels contributes to 780 fewer deaths in the city and over 2,000 fewer emergency room visits each year.

2.8 Case Study 4: Beijing

The problem of air pollution is widespread throughout Chinese cities, around 50% of air pollution in urban areas in China is attributable to coal. In Beijing, around 40% of the city's PM2.5 pollution comes from outside, primarily from Tianjin and Hebei areas; on high haze days, the figure shoots up to 90%, highlighting the need for regional coordination.

Recognising the need to improve urban air quality, China has enacted a number of new laws and regulations in recent years. The revised laws and regulations contain several key initiatives:

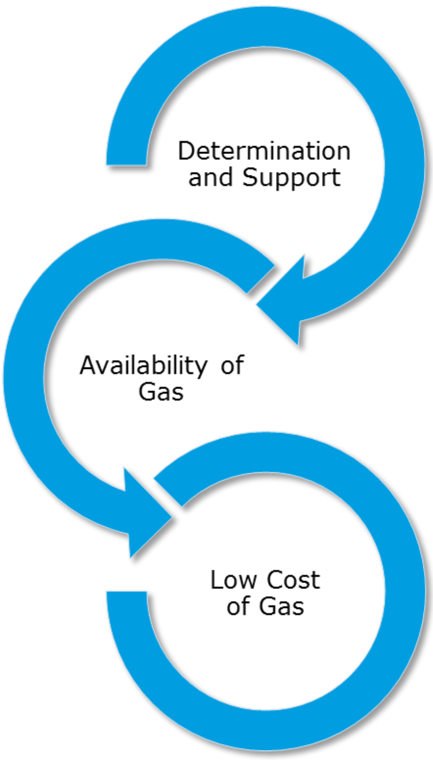
- Toughened its ambient air quality standards and emissions limits.
- Increased the enforcement powers of its environmental agencies.
- Made achieving the new environmental standards a political priority, so that there is more incentive for local authorities to take actions that may adversely impact e.g. reducing excess production capacity.
- Adopted a range of policies and goals to promote increased power generation from renewables, nuclear, as well as increased supply and infrastructure to distribute natural gas.

There is a specific action plan to reduce PM2.5 levels for the Beijing-Tianjin-Hebei region, this includes decommissioning the highest emitting vehicles, prohibiting construction of any new heavy polluting industries, and replacing coal with renewables and natural gas. There is a goal to reduce coal consumption in Beijing by 57% by 2017, and in the Beijing-Tianjin-Hebei region overall by 16%. The plan also provides that local officials will be judged not only by the usual quantitative measures (such as meeting PM2.5 standards), but also on specific initiatives they undertake, such as fostering cleaner production or green buildings.

These policies and goals have only recently been developed and are still in early stages of implementation, making it difficult to judge how effective they will be.

Lessons learned from the case studies

The 3 main lessons learned which can be drawn from the studied cases.



Determination and strong policy supports. Many cities did not act until the consequences of the pollution became visible. Authorities are required to take a strong stand in tackling air pollution, even if it may mean financial support and small losses of economic growth – population's health is more important than GDP numbers.

Availability of gas. To become a credible alternative - gas or any other alternative source of energy need to be available at a significant scale. The introduction of gas in Ireland was initially driven by the need for evacuating gas from the South to the North including Dublin in the 1980s. Later, in the 1990s, the pipeline from the UK was completed and commissioned supporting additional growth and expansion of the market.

Low cost of gas. Related to the above, the more availability and sources, the more competitive prices. The New York example indicates that the high availability of low cost shale gas contributed to the competitiveness of the commodity.

In Poland these conditions are present but only partially fulfilled. As stated previously, several cities with Krakow in the lead have acknowledged the need to act. Driven by visible air pollution a political momentum has been achieved in diversifying the energy mix. Availability of gas has improved – from being predominantly reliant on Russia, Poland has achieved the possibility for physical diversification through LNG, enhanced connections to Germany and Baltic Pipe.

However, it needs to be acknowledged that there are challenges in the expansion of the gas sector in Poland, mainly:

- Security of Supply
    - Currently two-third gas imports come from Russia;
- Market regulations
    - Access to infrastructure and diversity of market players;
    - Hub development

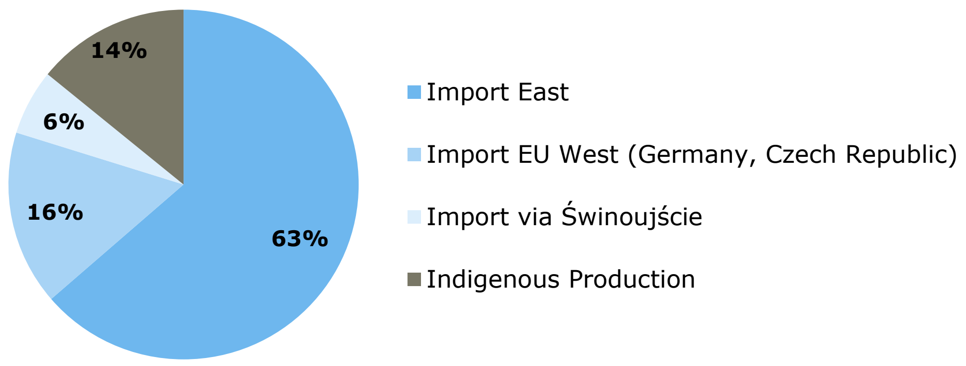
Security of supply is being addressed by the Polish Government and has resulted in several LNG and pipeline projects aimed at bringing new sources of gas to Poland and connecting with the neighbouring countries. Access to new and existing infrastructure is in several cases restricted either directly or indirectly. A potential lack of access to key infrastructure directly affects the diversity of market players both in terms of numbers and sizes. Finally, while Poland possess excellent possibilities for becoming a hub, there are still some way to go in terms of liquidity and use ability. In the following, these two topics are investigated further.

3. MARKET ACCESS & INFRASTRUCTURE DEVELOPMENTS

3.1 Overview of current entry points and imports

Supply of natural gas to Poland totalled at 176.6 TWh in 2016, of which 151.8 TWh (86%) were imported and 24.8 TWh (14%) of indigenous production. The detailed breakdown of 2016's natural gas origin is illustrated in Figure 8 below.

Figure 8: Origin of Poland's Natural Gas Supply 2016



Source: Gaz-System

With 112.1 TWh, the majority of gas is imported from Russia. Second largest import source is other EU members, such as Germany and the Czech Republic, with around 28.5 TWh. 11.2 TWh are imported via the LNG Terminal Świnoujście. The remaining 24.8 TWh originate from domestic gas production.

The Energy Policy until 2030 recognises the important role of natural gas in Poland's national energy strategy. Therefore, investments in the national and cross-border gas system, diversification and security of supply have been prioritised.

As of 2016, Poland's gas transmission system encompassed:

- 10 989 km high-pressure gas pipelines
- 67 entry points
- 983 exit points
- 896 gas stations
- 15 compressor stations
- 44 system notes
- 2 cooperating transmission network systems, covering high- and low-calorific gas

This network mainly runs on the east-west axis of the European grid, with 6 major physical entry points to the transmission network and their interconnection points (IPs) to neighbouring countries:

- Drozdowicze (Ukraine)
- Hermanowice (from where export to Ukraine is possible).
- Wysokoje (Belarus)
- Lwówek and Włocławek (on Yamal-Europe pipeline)
- Lasów (Germany)
- Cieszyn (Czech Republic)

Particularly Gaz-System's investments so far have helped to create energy security and the technical basis for the diversification of gas:

- 2011: Establishing the Cieszyn connection to Czech Republic
- 2012: Upgrading the Lasów connection to Germany

- Expanding metering station in Mallnow (German border) to allow for virtual and physical reverse flow on Poland's Yamal-Europe pipeline section
- 2015: Constructing the LNG terminal Świnoujście and more than 1 200 km new gas pipelines (to connect the terminal to north-western Poland)

Since June 2016, Poland's LNG terminal in Świnoujście is in service. It is operated by Gaz-System's daughter company Polskie LNG SA and offers short- and long-term regasification and reloading services. Currently, the expansion of regasification and additional services, such as transhipment, bunkering, rail and truck loading, is being evaluated.

In the long-term, the gas imports from Qatar will be increasingly important to Poland. In March 2017, PGNiG extended their contract with Qatargas, increasing Poland's annual LNG imports from Qatar to 2 million tons per year (MTPA) from 2018 until 2034. This equals to about 2.7 billion m3 of gas after regasification.

Poland's storage facilities have also been expanded in recent years. The working gas volume has been lifted to around 32.5 TWh and injection and withdrawal capacities have been increased. Further investments are being planned by Gaz-System and Gas Storage Poland.

3.2 New projects Baltic Pipe, GIPL, LNG expansion

GIPL

The Gas Interconnection Poland-Lithuania (GIPL) pipeline between Poland and Lithuania has been financed, but the routing is not decided yet. It will provide a bidirectional interconnection between the two countries, aiming at linking the Baltic States' gas markets to the European system. Although delayed, the GIPL pipeline is still expected to be constructed within the coming years. The project is conducted by Gaz-System and Amber Grid.

Northern Gate

Poland has launched the Northern Gate initiative to counter its heavy dependency of gas from Russia. Northern Gate is a common name for of the following infrastructure investments in the north.

1) First, it is the enhancement of the yearly capacity and regasification of the existing LNG terminal in Świnoujście from 5 to 7.5 bcm/y.
2) Second, a new LNG terminal in Gdańsk. This terminal is thought to be a Floating Storage and Regasification Unit (FSRU), similar to the LNG terminal in Klaipeda, Lithuania.
3) Finally – and most importantly –the Norwegian Link, brining Norwegian gas via Denmark through the offshore pipeline Baltic Pipe to Poland. Baltic Pipe's (NO-DK-PL) implementation is planned for 2022, essentially connecting Norwegian supplies to the Baltic and CEE region.

3.3 Access to infrastructure

3.3.1 Allocation of new capacity - volume versus capacity diversification

The current situation and the future investments will give Poland a significant boost with respect to the capacity diversification of gas towards the country. However, it is important to bear in mind that although the physical capacity into the country is well diversified, this is not necessarily the case for the volumes. Capacity bookings in Baltic Pipe for example are expected to be heavily dominated by PGNiG with up to 90% of 10 bcm/y over 15 years booked by PGNiG. Other companies could have participated; however, the storage obligation requirement forced many traders to give up their import license. Without an import licence participating to an open season for new import capacity is hardly interesting and defendable from a business point of view.

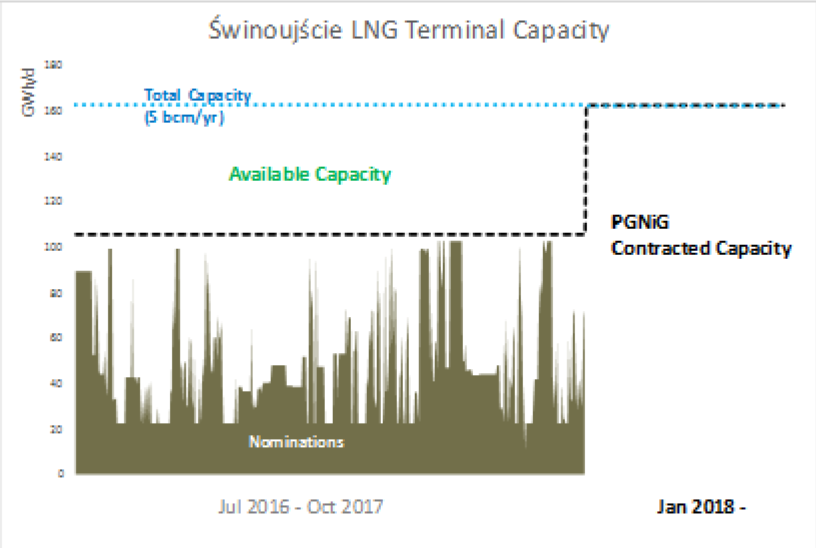
3.3.2 Access to LNG

The Świnoujście LNG terminal has a regasification capacity of 5 bcm per annum. PGNiG currently holds 65% of the capacity, and has contracted the remaining 35% for a period of 18 years starting from January 2018 – meaning there will be no capacity for any third party until further expansions of the LNG terminal.

It is worth to note that during the period from July 2016 to October 2017, the average load factor of PGNiG's contracted capacity was only 47%. Although such level is not unusual for countries with LNG regasification capacities, unlike pipelines where unused capacity can be handed over quickly, the process of surrendering unused capacity at the LNG terminal can take several weeks. This makes it difficult for a third party to engage and to react on potential price signals in the market.

Therefore, despite PGNiG's intention to increase its LNG import volumes, it appears unlikely that the company will utilise the majority of its booked capacity. In practise other gas importers/traders are likely to be denied the opportunity to use the Świnoujście LNG terminal and compete in the market via this channel, at least in the short to medium term.

Figure 10: Swinoujscie LNG Terminal Capacity

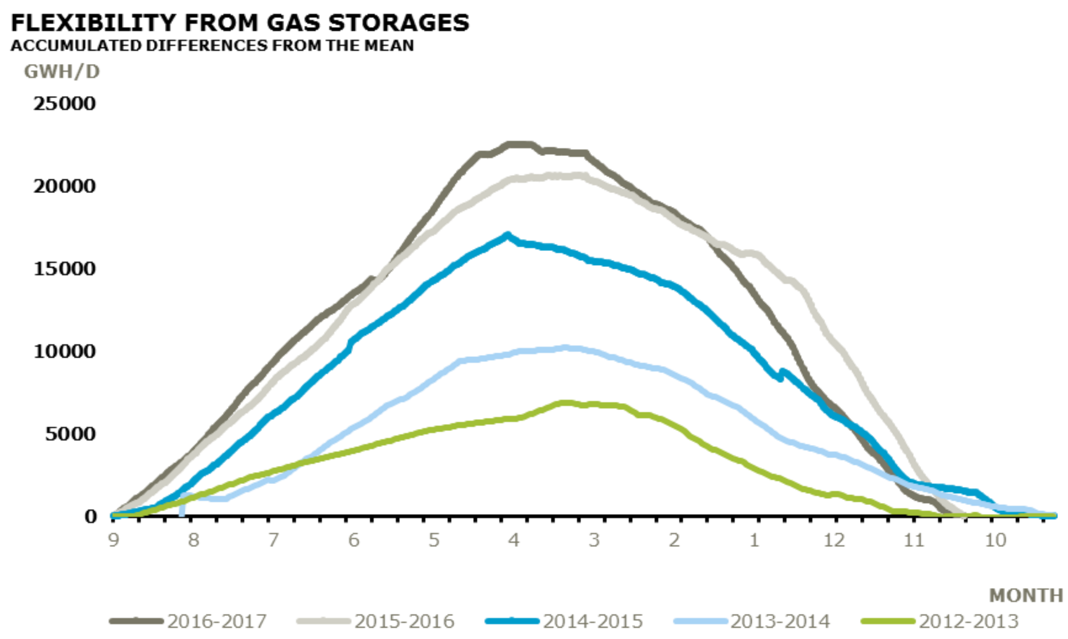


Source: Polskie LNG

3.3.3 Access to storage and storage obligations

Storage is becoming increasingly important for provision of flexibility in Poland. The figure below shows the accumulated differences from the mean utilisation of the gas storage for the last five gas years. This measure illustrates the flexibility provided by gas storage. It can readily be seen how storage year by year has been increasing in importance in terms of provision of flexibility to the market by plotting the accumulated deviations from the mean over the year. This is either at the expense of the flexibility in the import contracts (Take or Pay of 85%) or of the domestic production. In any case storages are being used in a more flexible manner than previously.

Figure 9: Storage Flexibility – accumulated deviations from mean



Source: Data GIE Ramboll illustration

This section provides more details on the storage regulations and particularly their development. It also showcases Poland's structural barriers to market diversity. Currently, the storage facilities and their capacity are controlled by PGNiG and, to a smaller extent, by Gaz-System.

3.3.4 Storage obligation

Poland has for many years operated with a requirement that importing shippers should maintain a certain share of their imports as a strategic reserve. Over the years the requirement has been updated several times below a short summary of the key developments is presented.

On July 22 2016 the amendment to the Act on Mandatory Stocks introduced major changes to the existing system of mandatory stocks of natural gas. Now the mandatory stocks had to be maintained by all business entities that conducted cross-border trading in natural gas as well as any other entities that delivered natural gas to Poland, irrespective of whether they delivered the gas for trading or for their own consumption. According to the amendment, now there is no exemption from this obligation. Before the amendment came into force, gas traders delivering natural gas to Poland to resell it to customers could be exempted by the Minister of Energy's decision from the obligation to maintain reserves if their aggregate annual import of natural gas to Poland did not exceed 100 million m3 and the number of their customers did not exceed 100,000. The exemption decisions that have already been issued expired on 30 September 2017.

Gas storage on the territory of Poland practically means using services of PGNiG Capital Group because Gas Storage Poland Sp. z o.o. – the operator of the storage system – is a part of the Group. According to the wording of art. 24-24a of the Act on Mandatory Stocks coming into force on 1 October 2017, the stocks should be physically maintained on the territory of Poland in storage installations connected to the transmission or distribution system, except for the following:

- The stocks can be physically maintained outside of the territory of Poland – on the territory of another EU or EFTA & EEA member state, in storage installations connected to a gas network, provided that: 1) technical parameters of storage installations and gas networks to which the installations are connected would ensure the possibility to deliver the entire amount of mandatory gas stocks stored outside the territory of Poland to the Polish transmission or distribution network within 40 days;
- 2) contracts concluded by the cross-border gas trading energy company for storage services and for transmission services would ensure the possibility to deliver, on constant basis and in any conditions, the entire amount of mandatory gas stocks stored outside the territory of Poland to the Polish transmission or distribution network within 40 days.

The amendment to the Act on Mandatory Stocks also introduced (by new article 24b) a new way of fulfilling the obligation to maintain obligatory reserves of natural gas. Holding mandatory stocks may be entrusted to another entity on the basis of a so-called stock ticket contract. The draft of such a contract will be subject to the approval of the President of the Energy Regulatory Authority. Therefore, gas trading companies will not be obliged to own the stored gas.

In July 2017, the senate voted on the storage law, but the following grey areas remained:

- A compensation price must be paid to the supplier when stocks need to be disposed in emergency situations
- The obligation to keep the capacity at IP idle until an emergency arises is not consistent with the Use-It-Or-Lose-It (UIOLI) rules of the EU (Commission Decision of 24 August 2012 on amending Annex I to Regulation (EC) No 715/2009)

Moreover, network users need to confirm the firm availability for deliveries to Poland in case of emergency. An according clause needs to be part of transport agreements with neighbouring TSOs. As contracts in neighbouring systems are standardised, this is close to impossible to comply with. Further, the required firmness of capacity at IPs neglects possible technical interruptions, even in force majeure situations. To keep transport idle, the costs rise higher. Additionally, the incumbent operator remains in control over the Polish gas market via distribution of tickets. Due to this, it is also not expected that foreign storage may be used in the future. In fact, 20 market participants with import licenses have returned those already.

The storage obligations serve as a barrier for entry for shippers as it ties import of gas to Poland to either purchase of tickets from the competing company or to excessive purchase of transmission capacity at the border. Thus, higher prices are in several ways explicitly and implicitly supported by the regulatory setup.

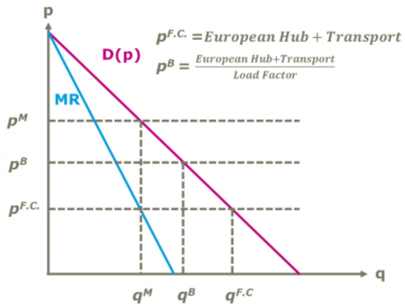
3.3.5 Incentives and impacts of the storage obligation

For smaller shippers there is no incentive to lower the price significantly below the monopoly price in the market as the upside is restricted due to the limited supply possibility. On the other hand, the leading market player, PGNiG, does not have any incentive to start a price war as the revenue loss from the diverging behaviour of the entrant is insignificant. Thus, the monopolistic pricing is tacitly supported in the market. We would expect that as the entrant grows, market converges towards Cournot outcome. To reach perfect competition price signals will have to be based on the hub (+ transportation cost).

Market rules and regulations restrict convergence towards the perfect competition in other ways as it limits the entrant's possibility to provide flexibility inside Poland. The Polish storages are owned and operated by the leading market player and often sold out. Thus, an entrant must secure storage in Germany to fulfil the Polish storage requirement. However, the entrant also needs to book extra capacity to the Polish border to meet the market demand for flexibility and comply with the amendment to the storage obligation. These restrictions on trade work as a de facto increase of the marginal cost (as the 'transportation and flexibility cost' is increased). Thus, even with many entrants active in the market, the storage requirement in combination with sold out storages in Poland, will increase the price, as depicted in the figure below. In the figure below, the marginal cost of the entrants is increased. The resulting Bertrand pricing, p^B, is at a level above the competitive price level (but arguably below the monopolistic prices).

Figure 10: direct and indirect effects of storage obligation

Direct Effects



Indirect Effects

"Tacit collusion on gas pricing is incentivised as each entrant will have no incentive to lower prices as the potential extra sale and demand derived from this cannot be serviced by the entrant"

Source: Ramboll

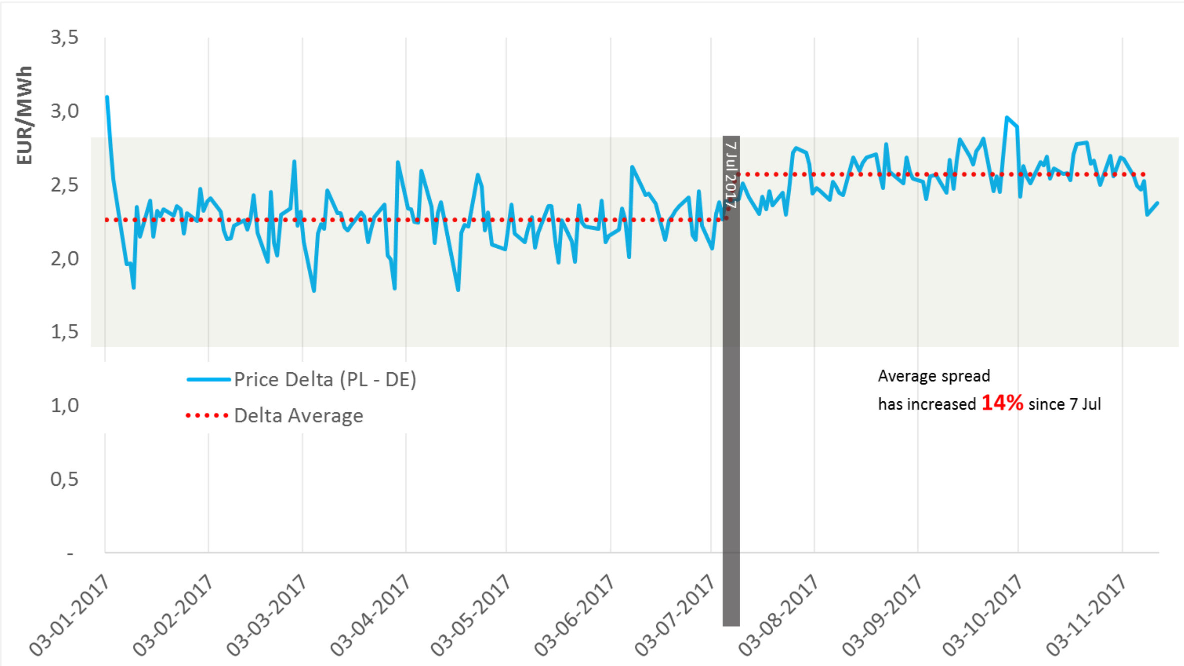
Based on the description laid out above, we calculate the difference in transportation costs in different competition landscapes. The calculation rests upon a set of assumptions:

- Fixed consumption in Poland (however, not assumed independent of price but the relationship is not modelled)
- Import capacity fixed (short term)
- The price of natural gas is competitively set in Germany
- The German gas hubs set the price for both pipeline and LNG (as LNG is the alternative source)
- No oil indexed long contracts are modelled
- TGE price is regarded irrelevant, as it is set on the marginal volumes

In a situation under full competition, the entrant's marginal price will be determined by the German hub price + transportation cost towards Poland. The incumbent, who sources gas from Russia, can either sell gas in Poland or export it to the NCG hub. Thus, the alternative to sell gas in Poland is the German hub price - transportation cost towards Germany. That means that prices in Poland can even go below German hub price + transport, the entrant's marginal price. As the full competition scenario assumes access to flexibility within Poland, the transportation cost is merely the exit- and entry tariffs. A load factor of .85 is assumed. Normalising transport tariffs from Germany to 1, the transmission cost will thus be 1/.85=1.18.

Under limited competition, it is assumed that Polish storage capacity is not available or simply too expensive to consider and that extra cross-border capacity to fulfil the storage obligation must be purchased. Thus, flexibility for the market and security of supply must be provided at the border leading to increased capacity bookings in the German grid. Assuming a load factor of .5 at the border point and applying the same normalisation as above, the cost of transport under this regime is 2. Hence, the lack of access to storage in Poland implies a 70 %. increase in the transportation cost.
The increased transportation costs have made gas trading in Poland commercially unviable for some traders and so far 20 traders have withdrawn their licenses. Accordingly, the gas (calendar year ahead) price spread between Polish TGE and German GASPOOL has increased 14% from Jan-Jul average to Jul-Nov average.

Figure 11: 2017 Gas Calendar Year Ahead Price Spread: Poland - Germany



Source: Ramboll calculation based on Poland TGE and Heren data.

It is perhaps still too early to assess the full impact of this updated storage obligation; however, one can reasonably expect larger gas price spreads between the Polish and German markets, if more traders withdraw or reduce their trading activities. This will probably mean the end-users and/or the government need to bear the relatively higher gas price in Poland, adversely affect the development of gas sector in the country.

4. POLAND AS A GAS HUB

In the following chapters, we analyse the possibilities for Poland to become a hub for natural gas.

4.1 What is a Hub?

Originating from network science, a hub is a heavily linked node, and in this context, it is a market place for gas. While natural gas exchanges presented the first form of separating gas pricing from oil indexed pricing, hubs break the borders between gas exchanges.

In a hub, trading is based on standardised contracts where terms and conditions are equal. This standardisation enables liquidity which in turn results in volume and thus traders – together forming a functioning hub. Naturally, the delivery period, quantity and price are subject to alterations. The contracts can be traded via exchanges or bilaterally.

The development of new gas trading hubs is a complex process, which spans over many years. There are many steps to the process, each one needing participation and trust of its participants in the effective functioning markets. All European gas exchanges of today have arisen from a highly regulated, domestic gas markets usually dominated by a state monopolist, selling gas using long-term contracts with gas price linked to oil price according to a fixed formula. The road from this towards a fully functioning market with volumes, active participants, liquidity and transparent information takes time and effort, including ensuring that the markets are reliable and do not get disrupted. Normally, developing a hub takes 10-15 years and requires commitment of governments, suppliers and TSO.

A successful hub must provide full transparency to participants, with prices and volume data being readily available to all. Initially gas sales happen as physical transactions, but as the hub develops, more and more transactions become non-physical, with trades made against a liquid underlying physical gas market, but most of the time no physical transfer of gas takes place.

Hubs have many independent buyers and sellers, open access to transport facilities, trading liquidity, and clear and transparent price and volume reporting. A healthy market must have liberalised commercial, industrial and residential sector participants, who through choice can chase competitive price and supply conditions. Over time, hubs play an important part as they allow various participants on supply and demand side to manage their physical and commercial risks of supply.

Thus, the basis for a hub environment is a liberalised wholesale market. A hub lives from the diversity and number of its participants. Therefore, a market with a single trader cannot be a hub: It fails to attract traders and thus fails to create the otherwise expected positive spill over effects of a hub. A liberalised market sets a competitive environment between suppliers as the end-consumers demand competitive prices. This risk needs to be balanced, both on a system and portfolio level, and incentives suppliers to participate in the hub. This balancing as well as supply and demand ultimately determined a hub's market price of gas.

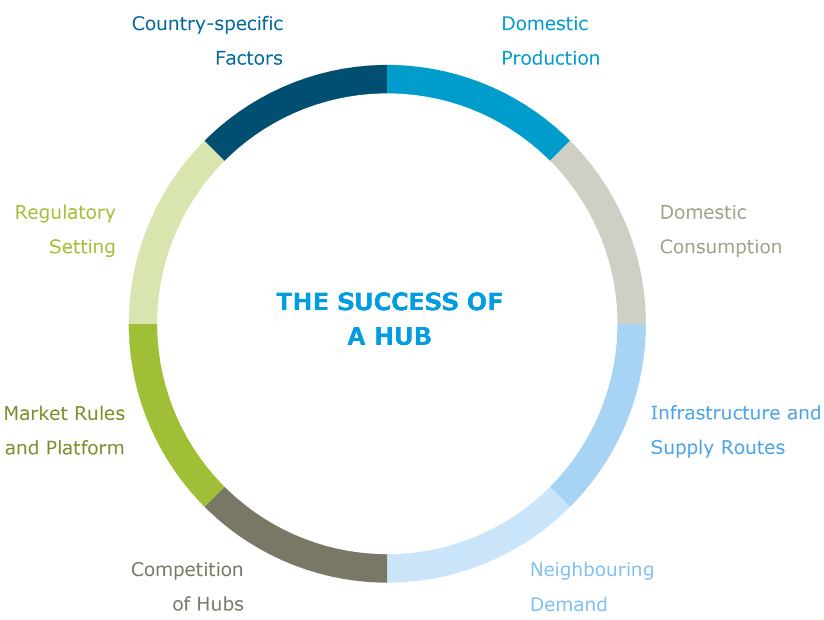
4.2 Benefits of a hub

Like any market place, the dynamics of a hub bring many benefits:

- Competitive prices, leading to a diversity of the energy mix
- Higher demand, due to access to more buyers
- Liquidity in the market place – translating into the availability of gas, based on strong pricing signals
- Diverse supply and demand, leading to a security of supply and sale
- Increased country relevance in the region and industry
- Increased international reputation, due to liberal trade and regulation

Much like any other market place, the performance of a hub is determined by several factors which should therefore be regarded pre-requisite points of consideration:

Figure 12: The Dynamics of a Hub



In the following each of the above preconditions for a hub are investigated, first by examining some of the key characteristics of the Polish market with respect to production, consumption, infrastructure, and neighbouring countries.

4.3 Dynamics and Preconditions for a hub

4.3.1 Key characteristics of the Polish Gas Market

Domestic Production of gas

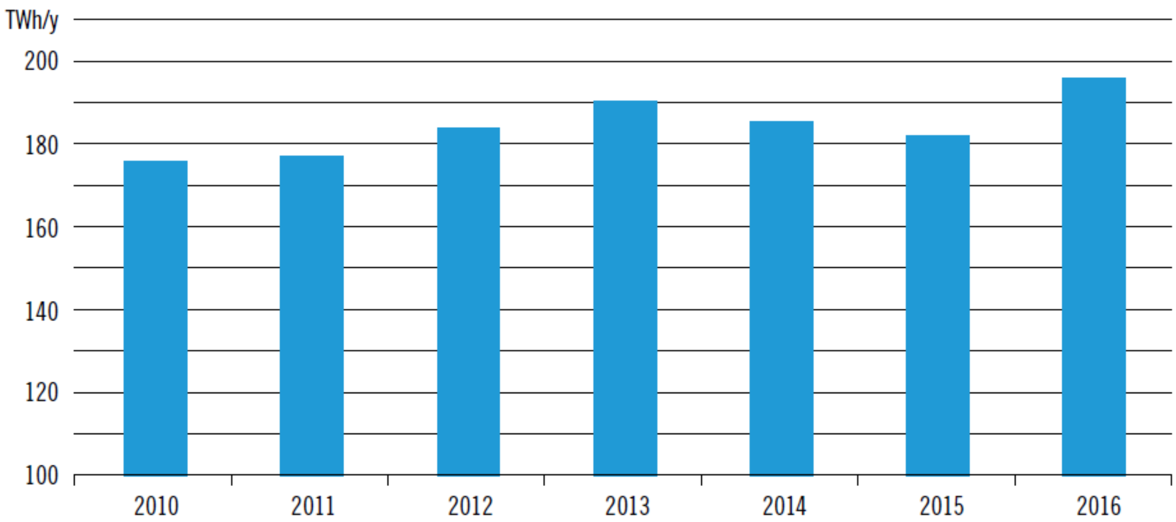
A strong domestic production lays a good basis for a well-functioning market place, such as a hub. By being able to meet demands through own resources and production, a participant is positioned to gain a large market share.

The Polish energy market is significantly determined and shaped by the country's own resources which are coal, lignite and natural gas. While the coal industry dominates the energy sector, Poland has significant natural gas resources and a Polish hub will provide a strong reference price for the domestic production, upon which contracts can be built.

Domestic Consumption and Demand

Since 2010, Poland's gas market grew from 175 TWh to 195 TWh in 2016, mainly due to increases in industrial and residential consumption:

Figure 13: National Annual Gas Consumption in TWh/y 2010-2016



Source: BEMIP

From 2015 to 2016, the gas consumption grew by around 7.5%. Among the member countries of the Baltic Energy Market Interconnection Plan (BEMIP), Poland has the highest absolute gas demand with its yearly consumption of around 195 TWh/y. It is also the only country with an expected increase in demand, to around 240 TWh/y by 2025. Three developments enable and foster this increase:

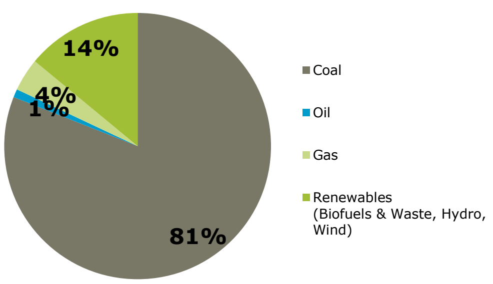
- Gasification of new regions
- Substitution of coal-fired stoves with gas
- Increase in the use of gas-fired power plants for electricity generation

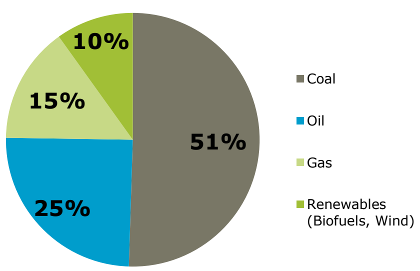
This growing gas demand is an important indicator for hub demand.

Energy mix and electricity production

In 2015, when the Ministry for Energy published the latest data, Poland's total primary energy supply (TPES) of 94.9 Mtoe was composed as illustrated in Figure 14. Among the OECD member countries, Poland has the highest coal level in electricity production. In 2015, the country's total generated electricity was 164.3 TWh and produced as shown in Figure 14:

Figure 14: Poland's Electricity Generation 2015 & Poland's TPES 2015





Source: IEA

Fossil fuels, particularly coal, also make up most of Poland's energy supply. The share of coal is even higher in electricity generation. Apart from this sector coal is also being used for local heating.

How these numbers relate to other countries[3], can be seen when comparing the number to the IEA indices:

Table 1: Poland in Comparison with IEA Members

Fuel	Electricity Poland	IEA Average	IEA Ranking	TPES Poland	IEA Average	IEA Ranking
Coal	81%	30%	2	51%	18%	2
Oil	1%	2%	12	25%	36%	24
Gas	4%	25%	23	15%	26%	22
Hydro	1%	13%	23	0	2%	23
Nuclear	0	19%	17	0	10%	17
Biofuels	6%	3%	14	9%	6%	12
Wind	7%	5%	14	1%	1%	12
Geothermal	0	0	9	0	1%	16
Solar	0	2%	25	0	0	25

4.3.2 Neighbouring Demand

It is hard to imagine a hub developing in a country that does not have a sizeable domestic consumption. Further, a successful hub should reach beyond solely serving the domestic market.

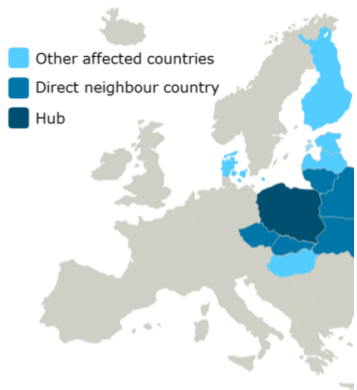
Denmark, Sweden and Poland are closely connected to the European gas market, whereas the Baltic States are linked among each other, but not to the European market. Finland is entirely isolated (until Baltic Connector is built in 2022). Apart from its BEMIP peers, Poland has several border countries that are not part of that regional cluster but could partake in a hub and benefit:

Direct neighbour countries

- Czech Republic
- Slovakia
- Lithuania
- Belarus
- Ukraine

Other affected countries:

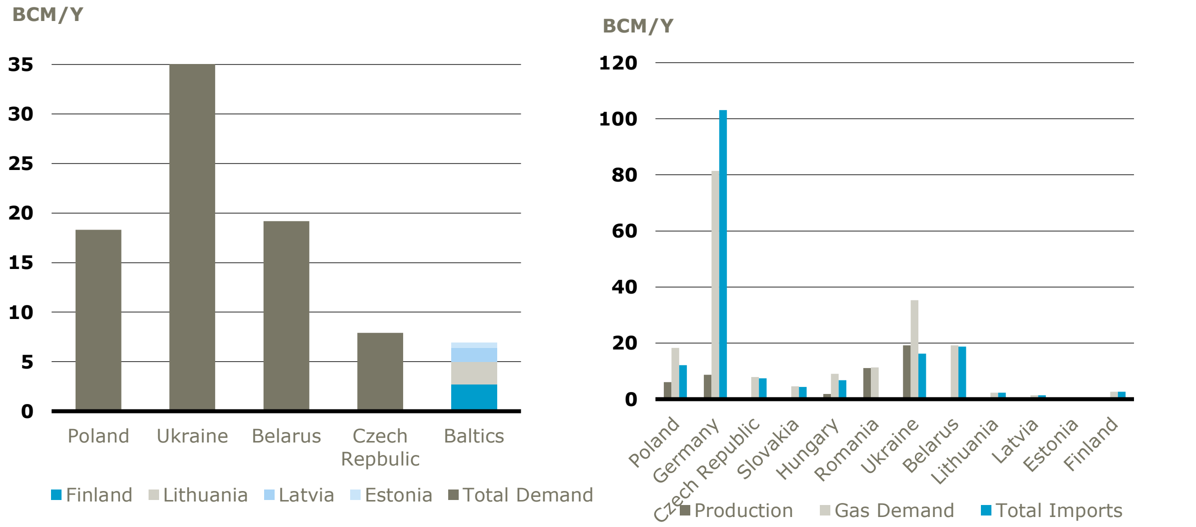
- Hungary
- Latvia
- Lithuania
- Russia
- Romania
- Finland (after Baltic Connector)
- Denmark (after Baltic Pipe)



Source: Illustration

Figure 15 shows the gas consumption in the markets to be connected via GIPL and Baltic Connector (Lithuania, Latvia, Estonia and Finland) compared to the Polish market. Moreover, it depicts the situation in other major regional markets, Belarus, Czech Republic and Ukraine. It is seen that in comparison the Polish market is large by itself, but also that the neighbouring countries further expand the hub opportunity. Additionally, it is seen that only few countries have domestic production. Instead, many countries need to import gas, creating a necessity for successful and competitive trading.

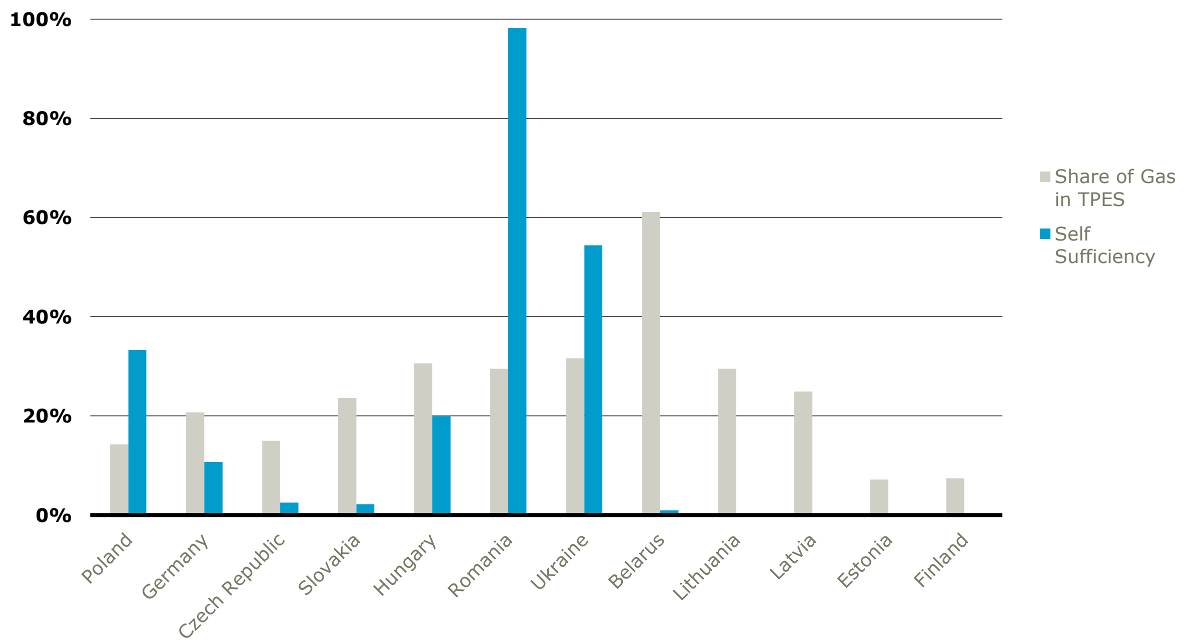
Figure 15: Gas Demand in the Region & National Gas Production, Demand and Imports in 2015



Source: IEA

The only neighbouring countries that achieve a sort of self-sufficiency are Romania and Ukraine. Yet, many countries have a high share of gas in their TPES. This indicates a need for imports. In any case, where there is a need to gas trading, a hub is beneficial.

Figure 16: TPES Gas Share and Self Sufficiency in 2015 in %



Source: IEA

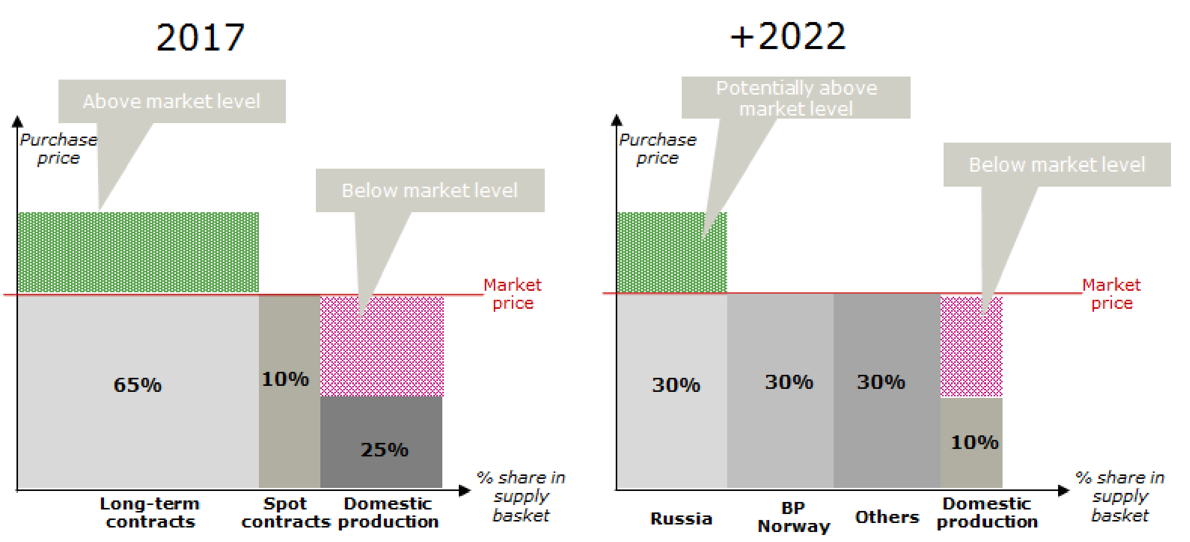
Previously, countries imported on long term (oil-indexed) contracts. This pattern is dissolving, and today the imports exhibit a shift towards shorter and less long-term contracts in the selected countries. This further strengthens the need for a hub, where excess gas can be sold, and additional volumes secured by the market participants.

4.4 Pricing of gas

Several benchmarks are relevant for Poland, amongst others hub pricing, pricing of Russian gas in long term contracts, the benchmark price of Russian gas at the German border, prices in Germany and domestically produced gas in Poland. Each of these has different qualities and deficiencies, the hub price while being a measure of the day to day fluctuations only covers a minor part of the market. The Russian price is a good approximation of the average market price but still the exact commercial terms remain out of the public reach. Prices in Germany, reflecting the market in Germany, could under some circumstances (such as availability of free capacity between Poland and Germany) work as a benchmark.

Historically, average prices in Poland have been higher than in the neighbouring countries primarily driven by long-term contracts with Russia and to a lesser extent Qatar LNG. In some periods however, the situation is different - oil indexed contracts are in several circumstances priced below the hub indexes of north western Europe under periods of low oil prices. Additionally, domestic production is cheap and reduces the impact of potentially higher priced gas imports. Only a minor part is sourced through spot contracts and imports from the EU. The Polish 30/30/30 strategy emphasises the diversification to achieve a balanced supply portfolio as illustrated below.

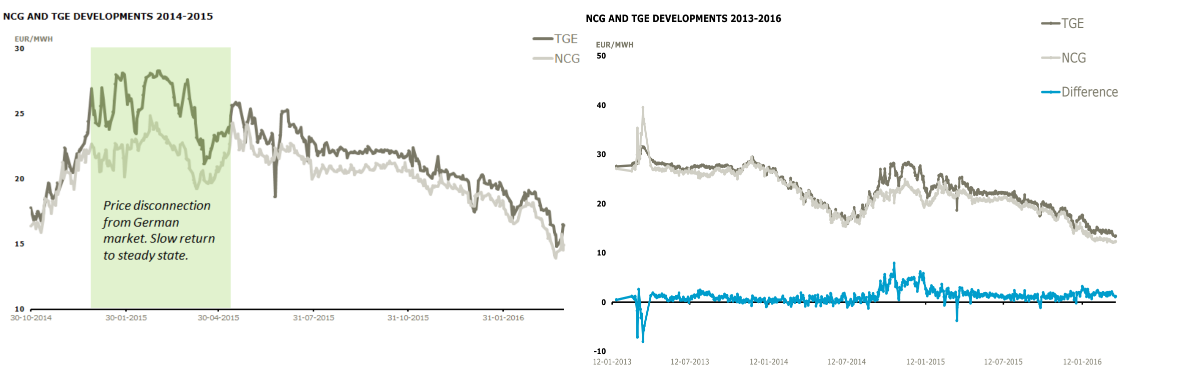
Figure 17: Illustration of average price components



*BP=Baltic Pipe

The strategy requires infrastructure such as Baltic Pipe but also LNG imports. This infrastructure enables the necessary connections to regional and international gas markets. As prices to an increasing extent will be based on the market, the challenges lie in Poland securing that adequate capacity between supply sources and consumption is available and that the capacity is available and fully utilised. Examples of the consequences of such a disconnection are illustrated below, where the effects of a reduction in supplies on the Polish hub price, causing a prolonged difference in prices, are illustrated.

Figure 18: German and Polish hub prices – historically



Under perfect competition it could be expected that the price in Poland should be below the price in Germany. However, from a hub perspective it is above – albeit in most periods only marginally.

4.5 Hub developments

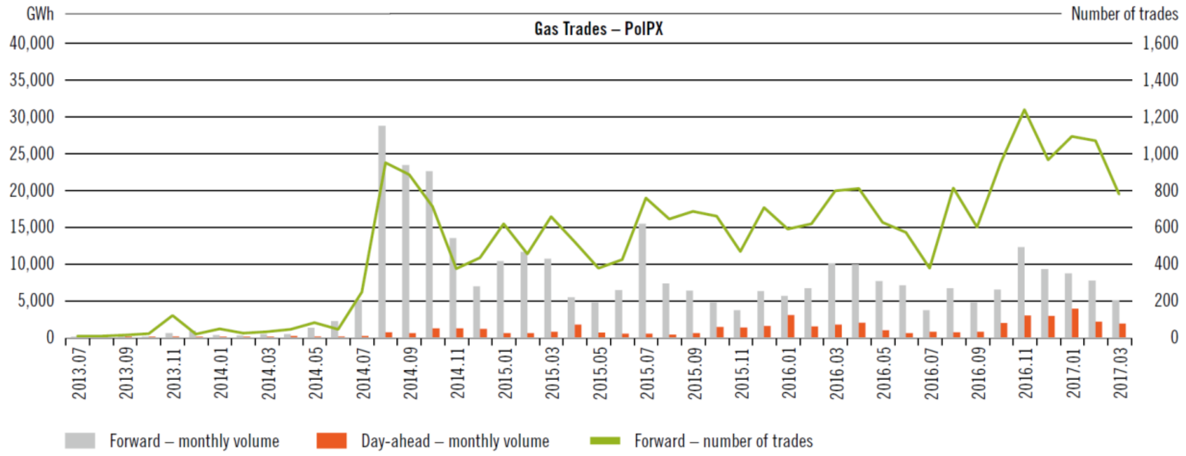
4.5.1 The Polish Power Exchange

The Polish Power Exchange (PolPX) provides a platform for trading electricity, natural gas, production limits, emission allowances and property rights.

The participants of the stock market are mainly gaseous fuels trading companies and big end-users who can either act independently after concluding a relevant agreement with TGE and becoming members of the commodity exchange, or act through brokers. There are 172 issued gas trading licences of which 63 are active players who make up 20% of the gas market share in 2015. Trading on the exchange is conducted through the conclusion of sales contracts (transactions) between the exchange members. In 2016, TGE provided the following instruments: Intraday Market, Day-Ahead Market and Forward Instruments Market with Physical Delivery. Sales of natural gas were also conducted in the auction system.

Since its launch, the dynamics of PolPX increased significantly, showing the growing interest in natural gas and flexibility of trading.

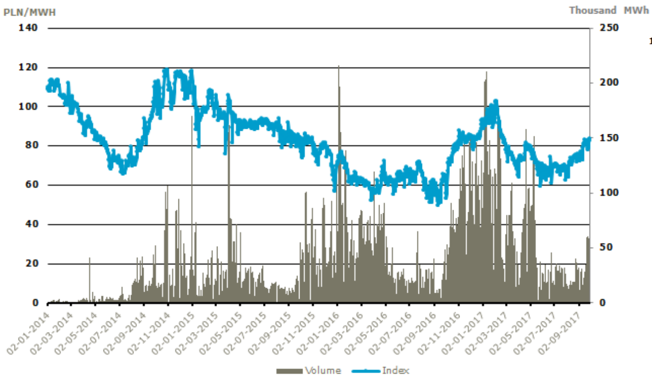
Figure 19: PolPX Trading Dynamics 2013-2017

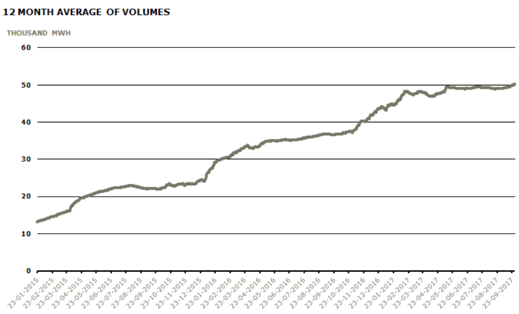


A clear jump in traded volume can be seen in 2014, levelling off in 2015 at around 5 000-10 000 GWh. Gaz-System states that this sudden increase was the result of a gas release programme that obliged market participants to sell large gas volumes on the exchange market. However, in July 2014, the registration documents for PolPX as well as its interface were translated and provided in English, which explains the precise increase in volume from August 2014. Therefore, the translation significantly contributed to the increase.

In 2016, the volume of transactions concluded on the stock exchange natural gas markets achieved 114 468 886 MWh which was the best annual result ever in the history of the PolPX (more than in 2015 by 7.1%). The spot market volume of 24 595 118 MWh (more than in 2015 by 76.6%) played a key role. Meanwhile, the forward instruments market volume decreased by 3.3% to 89 873 768 MWh. In 2016, the weighted average price on the spot market (DAM&IDMg) was 71.16 PLN/MWh, i.e. was lower than in 2015 by 16.30 PLN/MWh, this could however also be a result of declining oil prices. The development of the market was caused i.e.. by the obligation imposed on energy companies – by the Act of 26 July 2013 on changing the Energy law act and other acts – to sell on stock exchange a share of volume of natural gas which is put to the transmission system. From 11 September to 31 December 2013, the share was 30%, in the year 2014 – 40%, and from 1 January 2015 it was 55%.

Figure 20: Natural Gas Trading Volumes and Indices on Spot (DAMg) & 12-month average of volumes





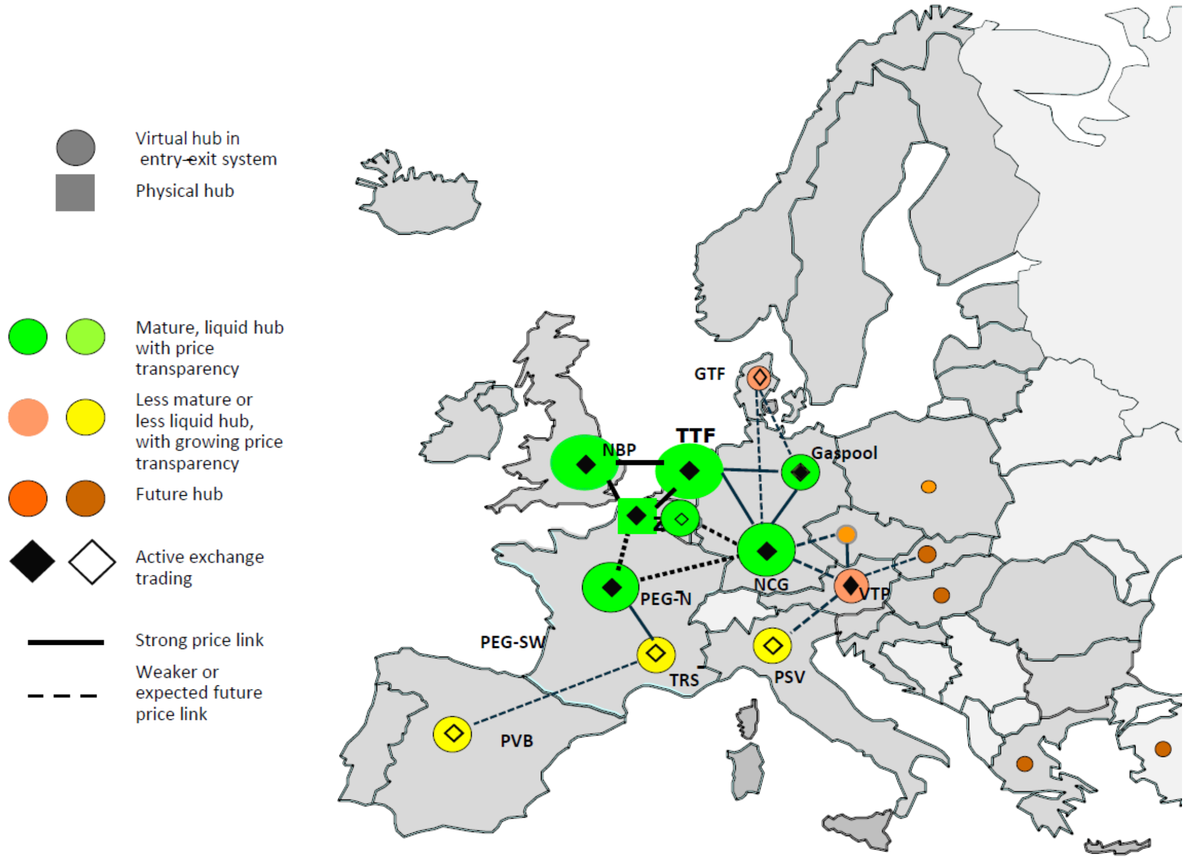
Source: TGE

The volumes traded on the day ahead contract have steadily increased, apart from that, no other trends can be observed in the data on volumes although the last 3-4 months could indicate a levelling off. In general, the liquidity and competition on the market is further increased by several European policy, guideline and network code changes that aim at liberalising the EU gas market. The fundamentals of PolPX are good and there is a strong and increasing demand for the exchange system, indicating the interest of market participants in a hub and the willingness to trade natural gas flexibly and competitively. However, the Polish compliance requirements are stricter than elsewhere, creating regulatory barriers.

4.5.2 Europe's Hub Environment

Both the Central Eastern European (CEE) countries and the Baltic States do not have a natural gas trading hub. With ideal hubs in Western Europe – most notably in National Balancing Point (NBP) in United Kingdom and Title Transfer Facility (TTF) in the Netherlands, but also NetConnect Germany (NCG), below the various hubs are illustrated.

Figure 21: Europe's Hub Environment, 2016, EFET



Source: EFET

As can be seen in Figure 21, Poland is in a good geographical position for developing a hub. While there are many well-functioning virtual trading points (VTPs) in the west, the east entirely underdeveloped and underserved. Yet, the area is also presented with future potential for hubs, particularly as the closest hub, the VTP CEGH in Austria, is not fully mature yet.

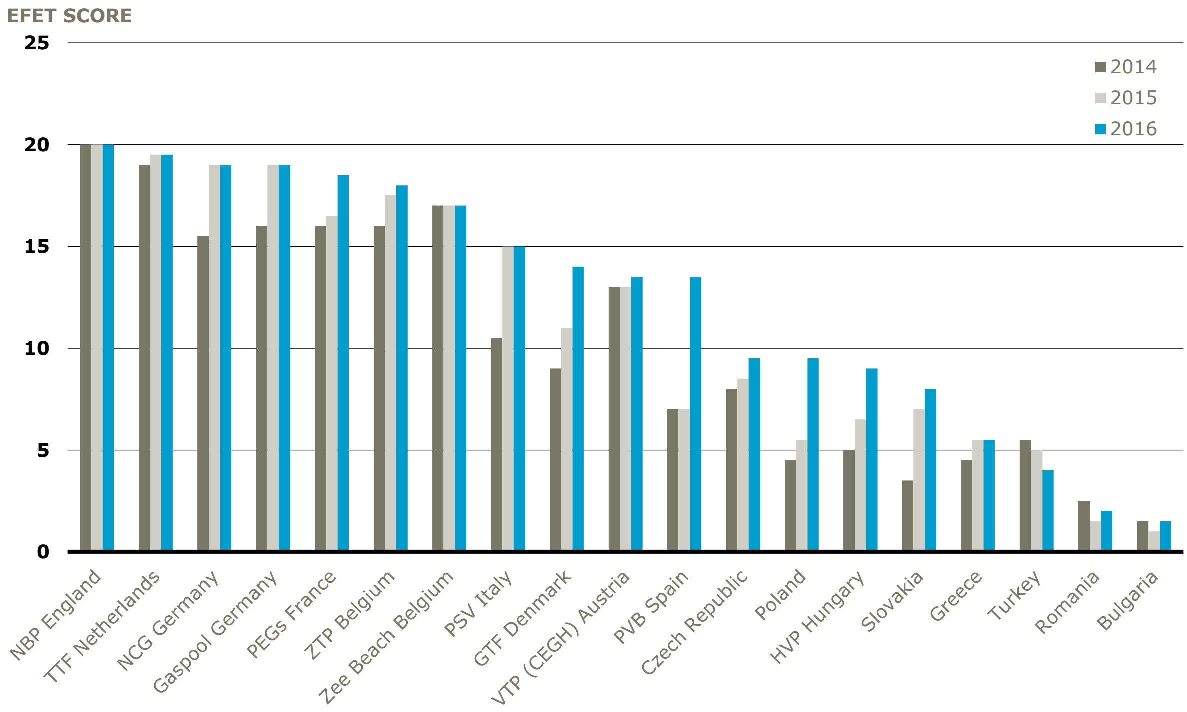
In 2016, EFET conducted a study to assess the maturity of the European hub environment. The framework they used was also developed to serve as a best practice model for creating successful virtual trading points or hubs. They benchmarked Europe's existing hubs and derived recommendations. Their defined criteria are:

Responsible Party	**What Should Be Done**
NRA	Establish a consultation mechanism
TSO	Entry-exit system established
TSO	Title Transfer (gas can be traded without physical delivery, usually by transfer between balancing groups)
TSO	Cashout rules (long short positions set to zero at the end of the balancing period against payment of penalty in €/MWh)
TSO	Accessible to non-physical traders (to trade gas you do not require to flow gas physically from entry to exit)
TSO	Firmness of hub (cash out rules instead of pro rata curtailment of flows in case not enough gas is traded at the hub)
TSO	Credit arrangements non-punitive
NRA	Resolve market structural issues (defined role for historical player: gas release programs, transport capacity release programs, market maker obligations, etc.)
NRA	defined Role of Hub operator (what are its responsibilities in comparison with the TSO)
NRA	Agree regulatory jurisdiction if cross border
Market	Establish a reference price at the hub for contract settlement
Market	Standardised contract (e.g. EFET Master Contract)
Market	Price Reporting Agencies active at the hub
Market	Market makers
Market	Brokers
NRA	Establishment of exchange
Market	Index becomes reliable and used as benchmark

Table 2: Criteria of Hub Maturity, EFET

It has to be noted that even the highly acclaimed NBP and TTF hubs only score 20 out of 25 possible points in this scheme. Therefore, benefits can already be leveraged at every step of the way to maturity.

Figure 22: Hub Scores as Assessed by EFET in 2016



Source: EFET

Poland's EFET score has doubled from 2014 to 2016, indicating improvements but also a potential for further development.

The development of new gas trading hubs is a complex process, which spans over a number of years. This chapter describes the example of development of two most successful gas trading exchanges in Europe – the UK's NBP and Netherlands' TTF.

4.5.3 NBP: Europe's First Trading Hub

Modern European transnational gas industry has begun with discovery of Groningen field in 1959, which provided first gas to enable cross border gas pipelines in Europe. Construction of such infrastructure was and still is very expensive and this was financed by buyers and sellers entering into long-term fixed volume contracts with the price being linked to the underlying oil price. In this situation, the buyer took volume risk and the seller took the price risk, enabling the seller to invest into oil and gas infrastructure.

Such arrangement was highly successful in developing European gas industry, which subsequently expanded to include LNG imports from North Africa and Middle East in the 1960s, piped gas from North Sea in the 1970s and Russian gas in the 1980s. By 1990s, the European gas industry was highly developed, but consisted of discreet and relatively isolated national gas systems, which developed independently in each country.

The process of liberalising gas markets in the UK began in the 1980s. At the time, the UK gas industry was insulated from the EU industry as there were no interconnectors or legal and regulatory harmonisation with EU states. The UK's gas industry was dominated by British Gas, which was a state company that acted as a monopolist in downstream, midstream and upstream sectors.

Thatcher's government at the time spearheaded a large, concerted movement taking UK into the modern world and privatisation and British Gas was the obvious candidate for privatisation. Legislation was done to enable the unbundling of British Gas' activities and in 1997, trading at the National Balancing Point has begun. The NBP soon attracted a lot of participants, producers, wholesalers, large consumers and financial players and an interconnection between Bacton and Zeebruge has connected UK's gas network with Continental Europe.

Soon after, British Gas was split into upstream (BG Group), downstream (Centrica) and network operator (National Grid Gas), with strict limitations to its trading powers, enabling a number of traders and market players to enter the NBP trade. In 2001, there was a blip caused by the collapse of Enron, which was a leading gas trader in the UK, but overall the industry maintained its momentum, making NBP the largest trading hub by volume until 2016.

Today, NBP enables the trade of natural gas across the whole of UK, including from upstream companies, LNG importers, international interconnectors and more. The market is dominated by non-shipper gas traders, with variety of types of contracts, enabling participants to actively hedge their financial risks.

4.5.4 TTF: Europe's Second Gas Trading Hub

EU Gas Markets (1998-2007)

Continental European countries were much slower at liberalising their gas trade. This is often explained by very powerful incumbent industries resisting any change, relative scepticism in the free market and also perceived lack of EU's mandate to regulate the gas industries.

The first steps in that process took place in 1998 when EC issued the First Gas Directive, which provided initial push towards unbundling and third-party access. It achieved very little and Second Directive of 2003 was issued to push this process further alongside regulation 1775, which clearly defined rules for 3rd party access, capacity allocation and transparency.

In those years, a number of trading hubs were opened in the region, but these were relatively unsuccessful at the time as incumbents have protected their positions and after some investigations, the EC passed a 2009 Third Energy Directive and Regulation 715, named Third Package, which called for:

- Unbundling of integrated utilities;
- Created Agency for Cooperation of Energy Regulators (ACER) to implement single EU energy market;
- Developed network codes with regard to capacity allocation, balancing, interoperability, etc.

It was soon followed by a European Gas Target Model, which set the aim to reduce the number of trading and entry/exit points within the EU and simplifying trade, by concentrating it at hubs within the zones, which can act as price discovery and trade formation mechanisms.

The Rise and Rise of TTF

The third Energy Package has given a major boost to liberalisation of gas industry in Europe and TTF was a notable example of the success of the EU's liberalisation, but also the Dutch government's desire to promote its gas industry, with the so-called "Gas Roundabout" of Europe strategy.

TTF was opened in 2003 and initially its growth has been relatively slow. It was benefited from excellent connections with major pipelines in Europe, good access to LNG and very importantly substantial domestic production, which provided good liquidity to the hub.

Recession of 2008-09 led to downturn in gas demand, with increased LNG projects around the world, dominated by Qatar as well as many others such as Sakhalin and Australian LNG. Several large import terminals were built in EU, while the shale revolution of the US has taken down a major importer of LNG. These processes led to a glut of natural gas around the world and in the EC.

At the time, the EC's gas trade was still largely dominated by long term oil price linked contracts, which led to prices much higher than what was available on LNG spot markets. Domestic consumers were demanding the spot prices from the suppliers, but this was resisted by the suppliers as existing midstream traders forced to buy indexed gas under long term contracts, while customers asked for gas costed at much lower hub prices. Over time, Statoil (NO) and Gasterra (NL) relented, but Algier's Sonatrach and Russian Gazprom continued to defend oil-linked gas prices.

Following legal and political pressure, several contracts were cancelled by European courts and the amount of hub traded contracts began to rise dramatically. This was particularly the case in North West Europe, where natural gas dominates.

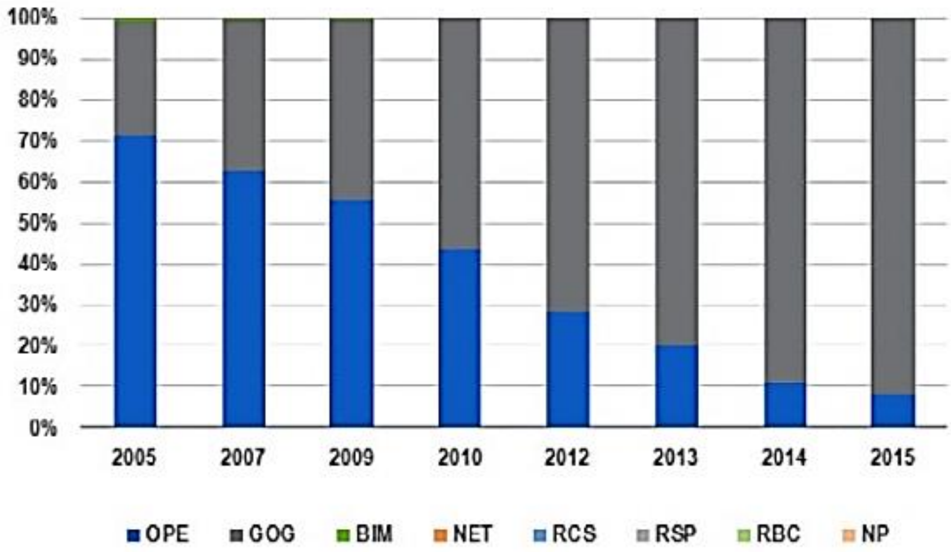


Figure 23: Northwest Europe Price Formation 2005-2015 (Source: IGU)

Figure 23 illustrates the scale of the shift in North-West Europe, where over a decade the traded volumes of GOG (Gas on Gas = spot trades) has gone from 30% of the market to well over 90%, pushing out oil linked (OPE) contracts.

The Netherlands' TTF was the overall winner in this trend, as much of this trade was done at TTF, which became a reliable indicator of gas prices in European gas markets. It was helped by its location in Europe as well as the fact that its prices were set in Euros. Around the time the Dutch regulator simplified access rules to the market, while Dutch gas producers began to sell their production in the market, providing it with a lot of guaranteed liquidity. All these factors meant that in 2016, it has overtaken NPB by volume and has proceeded to extend its lead (Figure 24).

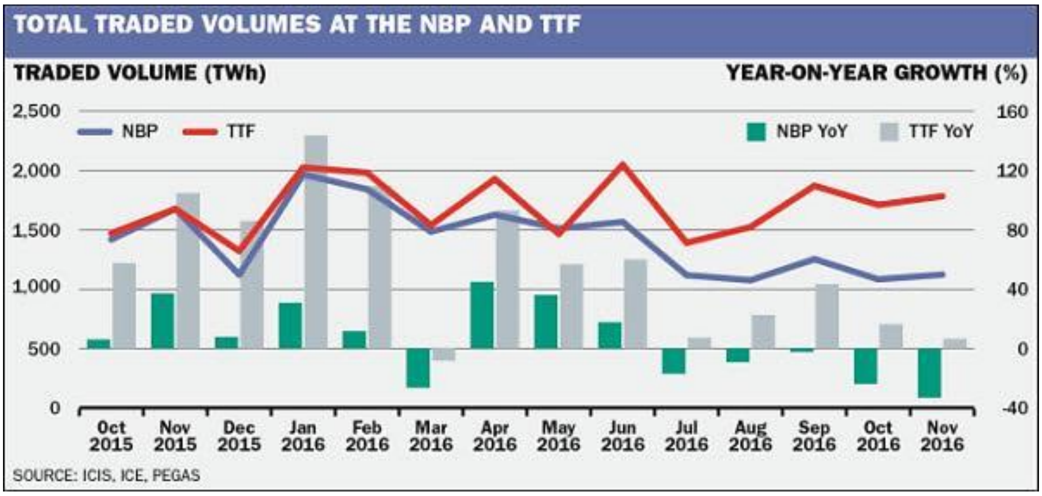


Figure 24: Total Traded Volumes at the NBP and TTF (Source: ICIS)

4.5.5 German Hub Environment

Germany of course has huge potential for developing a gas hub, as it is both a large gas consumer and has good gas infrastructure including Nord Stream (and Nord Stream II planned). With two major balancing zones (Gas Pool and Net Connect Germany (NCG)), each offering a trading place for natural gas. Thus, the trading today is divided into two trading areas. The proximity to the very successful hub in the Netherlands (TTF) (where most traders active in Germany are also present) reduces the imminent need for a hub in Germany, as excess/required gas volumes easily can be secured across the border. Thus, it is not evident that Germany can act as the hub for CEE and Baltic countries.