

2.1 Concept

The guiding principle for structuring this book is the natural gas value chain—exactly in this order, i.e., ‘natural gas’ and then (its) ‘value chain’.

Explanation of commercially relevant elements of what is commonly referred to as the ‘natural gas business’ is believed to be achieved best by choosing a ‘mid-stream bias’, i.e., by focusing on the stages of transportation, storage, and sales.¹ Implicitly or explicitly, such discussion will involve all ‘levels’ of the natural gas industry, i.e., all distinguishable groups of enterprises active in bringing natural gas from the source to the sink, i.e., to the end user’s burner tip.²

The detailed discussion of sales, transportation, and storage is preceded by brief discussions of fundamentals, specific for the natural gas industry. First, an overview of worldwide natural gas market is provided by depicting selected figures, and then non-economic and non-commercial fundamentals are discussed. This comprises the description of the chemical and physical properties of natural gas (in more-or-less technical terms) and environmental effects, as well as—to facilitate the general

understanding but not being a focus of this book—sources and sinks, i.e., the initial and final stages of the value chain, namely, ‘exploration and production’ and ‘final usage’. However, the description of these stages will have to remain superficial. In the next preliminary treatment, i.e., the economic and commercial fundamentals, the ‘product’ and the market structures are described. This delineates the framework for the subsequent description of the selected stages of sales, transportation, and storage. As all entrepreneurial activities are reflected in contracts, contractual elements often are used to structure and explain the subject. Basic elements of portfolio management, i.e., the main ideas and objectives, are used to demonstrate the interdependence of the stages, strategic and tactic options for market participants, and the importance of risk identification.

To facilitate reading, units and a glossary of terms are included, as well as a list of literature recommended for further reading that covers primarily basics, which could not and should not be mentioned or discussed in this book, *inter alia*, the economic and technical background knowledge required in the natural gas business. Throughout the book, case studies and examples will be included wherever appropriate.

In short³: Natural gas, a hydrocarbon, formed over millions of years, is trapped in subsurface reservoirs worldwide. Various, however, predominantly seismic, methods of exploration are applied in order to ‘find’, i.e., discover, the

¹See Fig. 2.1. The separation of these three stages of the value chain is, by default, consistent with the requirements of unbundling, see Sect. 5.3.

²These levels are represented by producers, importers, regional utilities, regional distributors, local distributors, and end user for the commodity sales. For transportation and for storage the equivalent transport system operators and storage system operators exist. See also the market structure in Sect. 5.4.

³Partly depicted in Fig. 2.1.

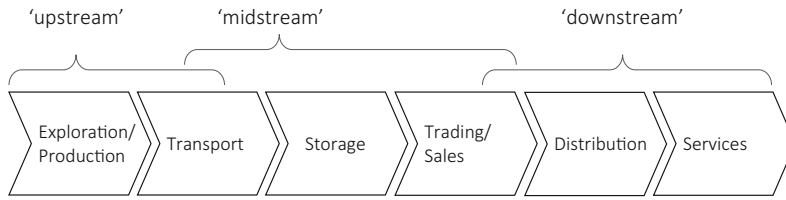


Fig. 2.1 Simplified natural gas value chain

reservoirs and, subsequently, to start production. The natural gas produced, i.e., ‘brought to the surface’, is processed, eventually cooled to be transported as LNG, and transported, in liquid or gaseous state, from the production site to the region or country, where it is consumed, i.e., (primarily) combusted to accomplish the energetic requirements of households or industrial end users, to produce electricity, or used as a feedstock. As demand for quantities at each point in time typically does not comply with production, natural gas is stored on its way from source to sink—often in vicinity of consumption sites. Additional services may be offered to the end user—primarily to increase demand and reduce problems of utilization.

Market participants acting at each level⁴ could cover several, but not necessarily all, stages of the value chain. So, even if, e.g., a regional utility (or regional distributor) is neither active in exploration and production nor in sales to end users, it might offer sales, transportation, storage, and other services, i.e., act along a selected stage or stages of the value chain. However, products, prices, and costs incurred can best be distinguished for the stages of the value chain. Moreover, the stages of the value chain are, contrary to some ‘levels’ of the industry, universally present. Hence, the description of commercial perspectives for the industry will be structured ‘along the stages of the value chain’, not for different levels of the industry. For sales, transportation, and storage, the products and pricing principles are explained in detail. In addition, some details of technical basics of transportation and storage as well as costs will be given.

Any commercial transaction is based on contracts. Yet, despite being essentially a legal topic, commercially relevant contractual issues, be it for sales, transportation or storage, are an integral part of any explication of the natural gas business. The business and even its technical opportunities and restrictions are reflected in contracts and, therefore, such contracts are both instructive and relevant. Consequently, the main commercially relevant contractual elements, in addition to products and prices, will be included in each of the sections covering one element of the value chain. By default, this will also be consistent with the regulatory requirements concerning, in particular, unbundling.

2.2 Historic Outline

While the history of oil can be traced through a broadly internationally perspective, the natural gas industry was developed differently in different regions. Nothing like a ‘worldwide history of the natural gas industry’ exists. Therefore, the history of the industry will be outlined by describing briefly the development of the natural gas industry in selected regions.⁵

2.2.1 North America

The first natural gas company of the world was Fredonia Gas Light Company founded in 1858.

⁴For an explanation and illustration of the ‘levels of the industry’, see Sect. 5.5 and Fig. 5.4.

⁵The interested reader is referred to various national publications. An overview, broader and deeper than the one presented here, is given by Colombo et al. (2016).

The first natural gas well was drilled more than 30 years earlier in 1821. Yet, until the middle of the Nineteenth century, ‘town’ gas dominated the market. This was nearly exclusively used for lighting. Heating, electricity production, and industrial usages were developed during the second half of the Nineteenth century only. In the 1890s, natural gas ‘pipelines’ began to emerge from Texas and Oklahoma. In the 1950s, 93% of world’s natural gas was produced in the US. Continuous growth caused natural gas to account for 44% of primary energy consumption in 1965. Autarky in the US ended at the beginning of the 1970s, when natural gas imports from Canada began. In later years, increasing natural gas consumption in the US was also supplied by LNG imports. LNG-receiving terminals were constructed primarily in the Northeast and the South of the US. The shale-gas boom, starting by the middle of the first decade of the new millennium, made most of the receiving terminals otiose. As several companies in the US are preparing for exports, liquefaction plants have been constructed or are under construction. First exports of LNG were executed in early 2016.

2.2.2 Europe

Europe relied for decades on coal gas that was abundantly available. Ruhrgas, later for decades the most important player in the German natural gas industry, was founded in 1926 as ‘Aktiengesellschaft für Kohleverwertung’ (stock company for coal utilization). The era of natural gas started in Europe not before the Groningen field in the Netherlands was discovered and production started in 1965. In the 1970s, imports from the Soviet Union (giving rise to intense political discussions at the time) and Algeria, as well as Norway started, while town gas production gradually declined, effectively ceasing in the 1980s. Starting at the end of the Twentieth century indigenous production in the European Union decreased and imports increased. Diversification of supplies, either by LNG or via pipelines, is, therefore, one of the political priorities of the European Union.⁶

2.2.3 Russia

The natural gas industry in the Soviet Union started effectively in the 1960s only. The Ministry of the Gas Industry was created in 1965 and promoted the increase of natural gas consumption. In the 1960s, exports began, first to Eastern Europe and by the end of the decade with the first exports to Western Europe. By the end of the 1980s, Gazprom was designated the state-owned monopoly for natural gas.

How Brotherhood Changed the Political Landscape

It is common knowledge that, today, Russia earns a considerable share of its export income with the export of natural gas. This success story started on 3 December 1964 when an intergovernmental agreement between the Soviet Union and Czechoslovakia was signed in Moscow. Both countries were, since 1949, members of the Council for Mutual Economic Assistance, or COMECON, an organization that focused mainly on building trustful commercial relationships between the participating countries. One of these commercial relationships was the delivery of crude oil and natural gas from the Soviet Union into the COMECON countries, as did the December 1964 agreement. The agreement foresaw the building of the Brotherhood pipeline (братство or bratstvo) from Daschawa in today’s Ukraine to Bratislava (former Czechoslovakia), today’s capital of Slovakia, and subsequent deliveries of natural gas. The pipeline went into operation in June 1967, and the natural gas was delivered to a power plant and chemical production facilities.

Geographically, Bratislava is not far from Vienna, and so Austria became a few years later the first Western state that imported natural gas from the Soviet Union.

⁶For the history of regulation in Europe, see Sect. 5.3.

The basis for these deliveries, which started in 1971, was a contract between the Soviet Union and the Austrian company ÖMV (today OMV) signed in June 1968. The contract included a so-called barter component, i.e., Western companies (in this case, Austria's VÖEST and Germany's Mannesmann and Thyssen) delivered pipes, and, in return, the Soviet Union delivered natural gas. This barter idea became the blueprint for other natural gas sales of the Soviet Union to, e.g., Germany and Italy, and is the nucleus of Russia's strong position today as an exporter of natural gas to Central and Western Europe.

2.2.4 Japan

The Japanese archipelago is not connected by natural gas pipelines to the Asian mainland, and natural gas was not used until the 1960s. Then, in the early 1960s, the interest of Japanese companies to import LNG was triggered as a consequence of the enactment of environmental regulations. The first LNG import to Japan started in 1969. Further contracts were signed in the 1970s, *inter alia*, for imports from Brunei and Indonesia, principally to cope with an increased demand for natural gas in the agglomerations of Tokyo and Osaka. Increased utilization of natural gas for electricity generation necessitated further imports from Malaysia and Australia. Japanese companies were also pivotal for the development of the Ras reservoir offshore Qatar. Starting at the beginning of the new millennium, Japanese companies also participated in or initiated upstream developments in Russia, Australia, Mozambique, and Papua New Guinea and endeavored to import natural gas from the US.

The successful development of the natural gas industry in Japan has helped other industries to develop and attain leading global positions, amongst them shipbuilders, machinery manufacturing, and thermal-power system construction.

2.2.5 South-East Africa⁷

In Mozambique and Tanzania, natural gas was found already in the 1960s. However, natural gas production started only decades later. Only beginning in 2009 did major oil companies, like Anadarko, Eni, Statoil, (former) BG Group, and Ophir Energy, make several huge natural gas discoveries. As the total reserves are still not finally appraised, estimation for Mozambique's recoverable natural gas resources range from 2.8 to 5.1 tcm, and Tanzania's at about 1.1 tcm. Companies are planning to build LNG trains, both in Mozambique and in Tanzania. It is envisaged to construct up to four LNG trains in Mozambique within the next years. Even further extensions are discussed for the mid-term future.

Tanzania proposed to the operators the construction of an offshore LNG facility with two liquefaction trains. Yet, exploration in the area is still ongoing.

Already today, natural gas is used to generate electricity in Tanzania, and is exported by pipeline from Mozambique to South Africa. Originally considered as a by-product of oil, natural gas is gaining importance in the region. However, marketability requires investments in further exploration and infrastructure—for processing and transportation, eventually also for storage, but general infrastructure, like roads, harbors and airports, too.⁸

2.2.6 Global LNG

The first (US) patent for LNG handling/shipping was awarded in 1917, but it was not before the early 1940s that an LNG peak-shaving plant was constructed in Cleveland, Ohio. The first experimental LNG cargo reached Canvey Island in the UK in 1959, and only five years later, i.e., 1964,

⁷See Copinschi and Smedley (2016), p. 198 et seq.

⁸This has been recognized: For example, airports and roads in Mozambique have been constructed with the help of Chinese investors, in preparation for future exports of oil and natural gas to China.

the state-owned natural gas-producing companies of Algeria and later Libya supplied France, the UK, Italy, and Spain with LNG. Japanese imports started at the end of the decade.⁹ The first imports to South Korea took place in 1974, to Taiwan in 1990. Australia started exporting LNG in 1991 and Trinidad and Tobago in 1999.

However, only in the mid-2000s did LNG become what the industry observers dub as ‘one of the hottest topics of the natural gas industry’.

One of the main ‘game changers’ was the perceived change in the US supply and demand balance. Deliveries dedicated for the US were detoured, as the ‘shale-gas revolution’ started and solved perceived US-supply constraints. US import projects were cancelled. The world’s LNG market globalized. However, the main geographic regions, i.e., the Atlantic Basin, involving trade in Europe, northern and western Africa, and the US Eastern and Gulf coasts and the Pacific Basin, involving trade in South Asia, India, Russia, and Alaska, both complemented by Middle-Eastern LNG-exporting countries between these regions, remained and still characterize the global LNG market. Yet, implication for price alignment between these markets started to be evident only by 2015.

2.3 Preliminary Overview— Development from Scratch

As in most of the network industries, both natural gas networks and consequently the markets, are characterized by economies of scale, sometimes economies of scope and also direct, as well as indirect, network effects.¹⁰ Furthermore, other economic, commercial, legal, and technical restrictions apply. Therefore, when starting from scratch or intending to extend a natural gas business in a region or country, several requirements have to be fulfilled in order to ensure the

economic viability, technical operability, and legal compatibility. The essential requirements are briefly described.

First and foremost, natural gas has to be available, i.e., sufficient reserves of natural gas should be present and ready for development and production. The closer these reserves are located to the market, the easier and cheaper the development of a natural gas market will be. The availability of a potential downstream market thereby fosters upstream developments. Contracts for the sale of natural gas can be used by producers to finance their investments in production facilities.

Sweden

The Swedish natural gas market is less developed than are others in Europe. With a population of nearly 10 million people, Sweden’s natural gas consumption did not exceed 20 TWh/a during recent years. Overall, only 3.5% of the total Swedish primary energy requirements are covered by natural gas. Yet, in the southwest of Sweden, where a natural gas infrastructure has been established, this figure increases to approximately 20% of the primary energy consumption.¹¹

There are several reasons for this (practically) insignificant market penetration. Except for some small quantities of biogas (and biomethane), Sweden has to import all its natural gas. The only pipeline connection to Sweden exists via Denmark.¹² Physical diversification of supplies is not a feasible option. At Skallen, one lined rock-cavern storage facility with a (very limited) capacity of 10 million Nm³ was constructed. In addition, Sweden’s population density of 24 inhabitants/km² is considerably lower than the average for the

⁹See Sect. 2.2.4.

¹⁰Network effects are often equated to economies of scale. This view is not shared. While economies of scale (as well as economies of scope) refer to the supply side, (other) network effects result from demand side effects, e.g., interoperability.

¹¹See Energimarknadsinspektionen (2012), p. 1.

¹²South of Stockholm, at Nynäshamn, an LNG facility is in operation since 2011. The supplies received are used in the area of Stockholm only. A connection to the natural gas transportation system in the southwest of Sweden does not exist.

European Union, with approximately 120 inhabitants/km² or, to choose an extreme example, the Netherlands with more than 500 inhabitants/km².¹³ This implies that (potential) investors cannot profit from noticeable economies of scale (or sometimes also referred to as ‘economies of density’). The end users are sparsely distributed, and the marginal costs of connecting the next end user to the grid are high, as it (at least on average) requires considerable pipeline extension.

In summary, the market participants and investors claim that the following factors are hindering a sustainable and economically viable extension of the Swedish natural gas market: Supplies are not diversified and only hardly diversifiable; local geology thwarts plans to construct significant storages; the specific transportation costs, i.e., costs per quantity, are high, as long distances have to be bridged; and, finally, end users in most parts of Sweden have not had the chance to get acquainted with natural gas.

If a natural gas infrastructure, consisting primarily of transportation, LNG, and storage facilities does not exist, and sales of natural gas are intended, such infrastructure has to be constructed. In order to be economically viable, primarily the following prerequisites should be ideally fulfilled:

- Potential demand/end users has/have to exist or can reasonably be expected to develop. Ideally, demand/end users will:
 - be ‘large’, ensuring ‘sufficient’ revenues and reduction of specific costs;
 - be diversified with regard to price (structure), quantity and flexibility requirements, and segments, in order to reduce risks,¹⁴ in particular:

- credit risk,¹⁵
- price risk,¹⁶
- volume risk,¹⁷
- flexibility requirement (by equilibration of deliveries to end users with different requirements¹⁸);

- be located in clusters, i.e., in case a new region has to be developed, economies of scale will be more pronounced in clusters, as the marginal costs for connecting additional end users will decrease.

- Infrastructure can be developed at (relatively) low costs.

This implies that a transportation and distribution system can be constructed efficiently, i.e., that a sufficiently large number of end users can be connected to the system. Therefore, locally clustered demand/end users will decrease marginal costs for connecting additional end users.

In addition, infrastructure to safeguard security of supply, as well as short-, mid- and long-term flexibility will have to be constructed. As the ‘tools’ used to provide such services are predominantly either underground storages located in the vicinity of demand or (flexible) production, the (geologic) conditions to develop storage facilities

¹³See World Bank (2016).

¹⁴Excursus: In this book, the following distinction will be used: While ‘uncertainty’ describes a state or situation (in the future) for which neither the values of (a) variable(s) nor its/their probability distribution(s) is/are known, ‘risk’ refers to a situation (in the future) where the probability distribution(s) of (a) variable(s) is/are known but not the value(s). (Often risk is solely referring to the probability of loss).

¹⁵Credit risk refers to the risk that a debtor defaults, i.e., will not pay back a loan.

¹⁶Price risk is caused by the probability of any ‘adverse movement’ in the (market) price of an asset, commodity, or any other good.

¹⁷Volume risk, having been defined in the traditional natural gas market as the risk of incompatible sales and supplies, i.e., over- or undersupply, (by definition) does not exist in liquid markets. Here any quantity can be purchased or sold, yet at different prices, i.e., in modern markets, volume risks are converted to price risks.

¹⁸Also referred to as ‘foisonnement’ (using metaphorical French).

have to be favorable or the production has to be in or near the region of consumption.

- The investors have to have sufficient capital at their disposal to bear all costs for infrastructure construction, operation, and maintenance.
- A legal (or regulatory) framework, including technical standards, has to be established providing investment security and fostering further market development.
- Supplies are available at competitive prices, either from indigenous production or from international sources. Ideally such supplies will:
 - on an annual basis, match demand,
 - be diversified in order to:
 - ensure optimal utilization of the network,
 - increase security of supply by reducing the impact in case one source is interrupted,
 - enable the customer to optimize its portfolio, and
 - fulfill potential regulatory requirements.

If, on the other hand, infrastructure exists already and non-discriminatory third-party access to infrastructure is granted (or its own infrastructure is available) and it is intended to enter a market competitively, then competitive sales products, as well as competitive supplies, low costs of infrastructure utilization, and a legal framework encouraging such market entry, are essential.

WINGAS

While today entry into most mature natural gas markets is facilitated by non-discriminatory rules of third party access to transportation and storage capacities, this was not the case in Germany in the early

1990s. To supply its mother company BASF, in 1990, Wintershall made efforts to purchase natural gas directly from North Sea producers and in parallel asked incumbent Ruhrgas for access to its transportation capacities. Such access was not granted. Natural gas from producers in the Norwegian North Sea was also not available. Instead, Wintershall, supported by BASF, and Gazprom agreed to co-operate. To this end, joint ventures, one of them WINGAS, were founded, and pipelines across Germany and Germany's largest storage at Rehden were constructed. Due to non-existing third party access to pipelines, some of the pipelines were laid parallel to existing pipelines. At the same time, the sales organization was established, and major long-term delivery contracts with Gazprom's export affiliate, Gazexport, were concluded. Investment-based market entry was achieved in a mature market, with already existing, but at that time not accessible, infrastructure.

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