DIW BERLIN

1154

Discussion Papers

Deutsches Institut für Wirtschaftsforschung 2011

Facilitating Low-Carbon Investments – Lessons from Natural Gas

Anne Neumann and Karsten Neuhoff

Opinions expressed in this paper are those of the author(s) and do not necessarily reflect views of the institute.

IMPRESSUM

DIW Berlin
German Institute for Economic Research
Mohrenstr. 58
10117 Berlin

Tel. +49 (30) 897 89-0
Fax +49 (30) 897 89-200
http://www.diw.de

ISSN print edition 1433-0210
ISSN electronic edition 1619-4535

Papers can be downloaded free of charge from the DIW Berlin website:
http://www.diw.de/discussionpapers

Discussion Papers of DIW Berlin are indexed in RePEc and SSRN:
http://ideas.repec.org/s/diw/diwwpp.html
http://www.ssrn.com/link/DIW-Berlin-German-Inst-Econ-Res.html

Facilitating Low-carbon Investments – Lessons from Natural Gas

Anne Neumann[1] and Karsten Neuhoff[2]

Abstract

Decarbonisation of energy and transport infrastructure requires significant private sector investments. The natural gas industry has demonstrated such large scale private sector infrastructure investment over the last decades, typically using long-term contractual arrangements. Are therefore institutional frameworks necessary that facilitate long-term contracting or provide regulation reassuring about future resource streams associated with low-carbon infrastructure – or do factors idiosyncratic to natural gas explain the prevalence of long-term contracts in natural gas infrastructure investment?

We identify four reasons for the use of long-term contracting arrangements. The transformation of the natural gas industry and regulatory structure has gradually reduced the rational for three of these reasons, suggesting that remaining rational, securing of revenue streams to finance investments has become the main motivation for the use of long-term contracts. This rational is not idiosyncratic to the natural gas industry, and thus suggests that long-term contracting can also play a significant role in facilitating low-carbon infrastructure investment.

We furthermore discuss the role of institutional frameworks necessary for long-term contracting, and identify the significant role governments have been playing in sharing the counterparty risk inherent in long-term contracts.

Keywords: Investment, low-carbon economy, natural gas

JEL: L78, O13, Q58

---

[1] Corresponding author. Anne Neumann, University of Potsdam, Chair for Economic Policy, August-Bebel-Str. 89, D-14482 Potsdam, Germany, anne.neumann@uni-potsdam.de, +49-331-977-3839, and DIW Berlin.

[2] Karsten Neuhoff, DIW Berlin.

We are grateful for discussions with participants of the Workshop on Energy and Carbon Markets and Regulations held at the Florence School of Regulation, May 12-13, 2011.

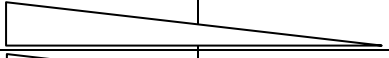
1 Introduction

Decarbonisation of energy and transport infrastructure requires significant private sector investments. The natural gas industry has demonstrated such large scale private sector infrastructure investment over the last decades and offers some analogies for investments in low-carbon assets in response to climate policy frameworks. In both sectors assets are capital intensive, often with long pay-back periods, and governments retain a strong interest in the development of the sector – for energy security reasons as much as for climate policy objectives. This analogy motivates our exploration of what potential lessons from the natural gas experience can be drawn for the development of a new carbon market that supports low-carbon investments.

The natural gas industry has developed in a regulated environment with government supporting and strictly regulating national (often still monopolistic) firms to produce, transmit, and distribute natural gas. The bedrock of the industry are long-term contracts concluded by producers and buyers. During the last two decades a more market based approach has emerged, with commercial trading and investments by private companies. In this new, market-driven approach, significant additional volumes of infrastructure investments have come forward. Long-term contractual arrangements remain however a consistent feature across these investments. Are therefore institutional frameworks necessary that also facilitate long-term contracting for investments in low-carbon infrastructure – or do factors idiosyncratic to natural gas explain the prevalence of long-term contracts in natural gas infrastructure investment?

We identify four reasons for the use of long-term contracting arrangements in natural gas: Asset specificity of investments to one trading partner, search costs for identifying and negotiating a buyer/seller, foreclosure of markets, and securing revenue to finance investments. Ten to thirty years (EU vs. US) after restructuring, the natural gas market offers an opportunity to assess the development of contracting arrangements within a liberalised market. The transformation of the natural gas industry and regulatory structure has gradually reduced the rational for three of these reasons, suggesting that securing of revenue streams to finance investments has become the main motivation for the use of long-term contracts. This rational is not idiosyncratic to the natural gas industry, and thus suggests that long-term contracting can also play a significant role in facilitating low-carbon infrastructure investment.

Table: Arguments in favor for long-term contracts in a changing environment

	Pre-1990	1990	2010
Asset Specificity	+		
Search Cost	+		
Foreclosure	+	-	-
Securing Revenue	+	+	+

This raises the second question: What regulatory and market frameworks are conducive to long-term contracts? Again we explore the experience in the natural gas industry and find that in many instances governments have been playing a significant role in facilitating contractual arrangements, e.g. by sharing some of the counter-party risk inherent in long-term contracts in addition to contributing to stable regulatory frameworks to facilitate investments.

The paper is structured the following way. We first describe the development of the natural gas industry followed by a characterisation of the evolution and structure of long-term contracts. This allows for discussion of the reasons for the use of long-term contracting so as to understand their role in facilitating investments. Finally, recent experience in restructured natural gas markets and the relation to the regulatory framework providing incentives for private actors to invest are highlighted.

2 Development and financing of international natural gas infrastructure

In North America, naturally occurring gas was discovered as early as 1626 by French explorers around Lake Erie. Manufactured natural gas, as opposed to naturally occurring gas, was first imported to the United States in 1816 and used for street lightning. The mid-1800s saw the development of a nascent domestic industry; the first US well was drilled in 1859 and a two-inch diameter pipeline was built that ran 5½ miles from the well to a village in Pennsylvania. In the 1900s, natural gas could be shipped between municipalities and the first intrastate long-distance pipelines were built. The invention of the Bunsen burner in 1885 opened new opportunities, e.g., safe use of natural gas for cooking and heating. In 1891, the first lengthy pipeline of 120 miles was constructed between supply in Indiana and Chicago.

Historically, most discovered natural gas was vented into the atmosphere, flared when found alongside coal or oil or simply left in the ground. Following World War II, welding techniques, pipe rolling, etc., allowed for construction of reliable natural gas transmission. The improvements in transportation and discoveries of new uses led to rapid expansion of the sector. The federal Natural Gas Act of 1938 established the first framework for regulating prices. Almost fifty years later, FERC Order 436, which introduced open access to pipelines and limited the use of long-term contracts, enabled the development of a competitive wholesale market.

The situation in Europe evolved differently. Small discoveries of natural gas were made near Hamburg in 1910 but natural gas did not gain importance until the discovery of the Dutch Groningen field in 1959. Deliveries of liquefied natural gas (LNG) from the US arrived in the UK before deliveries from Algeria to the UK began in 1964. The vast reserves in the North Sea, which would provide substantial natural gas to Europe for decades to come, were discovered in 1965. By the end of the decade, West Germany, Italy, France and Belgium were receiving Dutch and North Sea gas. Figure 1 illustrates the European pipelines in 1970. Given the stability of crude oil and oil product prices and the well-established role of coal, natural gas remained a specialty fuel that was mostly limited to areas closest to domestic production or import points.

Figure 1: European Natural Gas Pipeline System in 1970

Source: GTE, 2001 (4th Madrid Forum)

The OPEC-oil price shock in 1973 brought dramatic changes, i.e. inter-fuel competition and policy encouragement to replace imports of oil (and reduce the need for future oil imports). Demand for natural gas in the European Economic Community[3] (EEC) accelerated, from 56 billion cubic metres (bcm)[4] in 1970 to nearly 200 bcm by 1979 (Adelman et al., 1986, Chapter 2). Over time, demand expanded in the industrial, electric utility, residential and commercial sectors. The development of a long-distance transportation pipeline system in Europe was spurred by the discovery of substantial reserves in the Former Soviet Union and Algeria as well as the exploitation of indigenous sources.

Today a mature, interconnected transport network exists, despite political interference in the development of infrastructure from the former Soviet Union to Western Europe. For example, a US embargo on equipment (mainly compressor station technology developed by General Electric) delayed the construction of the West-Siberian pipeline (Hardt and Donna, 1982; Victor et al., 2006). Eventually, contracts to supply natural gas to Western Germany were signed and thus the project was ensured via long-term purchase agreements, usually coupled with a guarantee from the Soviet and Western governments to secure financing (Victor, 2008).

In general, infrastructure (both pipeline and LNG) and markets for natural gas developed against the background of bilateral state agreements with state-backed financing.[5] Construction costs of the Transmed pipeline from Algeria to Italy (completed in 1983) were Y2000USD8,700 billion, of which

[3] The EEC existed between 1957 and 1993 as a forerunner to the European Union. Member countries were Belgium, France, Germany, Italy, Luxembourg and the Netherlands.

[4] Cubic meter is a SI unit used to measure quantity of natural gas at atmospheric pressure.

[5] See Victor et al. (2006) for international studies.

nearly 75% was debt-financed. Y2000USD1,200 billion came from Italian banks and Y2000USD1,800 billion from the European Investment Bank alone.

With the beginning of implementing an internal market for natural gas in Europe policy makers have identified important strategic investment projects fostering the creation of this market. Already a council Regulation of 1995 (2236/95) lays down general rules for granting Community financial aid for trans-European networks. These guidelines were renewed in 2006 and renamed TEN-E (trans-European Energy Networks) in order to provide clear guidance as to what is of European interest. In reality, it accumulates six axes of priority interest next to 118 single natural gas network projects (of which 40 are pipelines). A new attempt to prioritize projects was made by the European Commission in November 2010 when adopting the Communication "Energy infrastructure priorities for 2020 and beyond - A Blueprint for an integrated European energy network" (COM(2010) 677 final). In addition the creation of a European Agency for the Cooperation of Energy Regulators (ACER), a European Network of TSOs and Ten-Year-Development plans laid the basis for future European network planning and investment. This points out that the market will provide most of the investment, but there remains a need for coordination.

3 The structure and development of long-term contractual arrangements

We summarise the main features of long-term contracts. In Europe the natural gas contracts are primarily structured as take or pay contracts. The buyer agrees to pay for a specified volume whether or not it is taken. Usually, there is an option to take more, which introduces some flexibility. The Annual Contracted Quantity (ACQ) is also determined, but allows taking a predefined percentage more or less over the course of a year. The contract will spell out the terms for monthly or daily maximum or minimum quantities; make-up gas (the right to take natural gas later which has been previously paid for); and the right to reduce future delivery if the amount of natural gas taken exceeds contracted volumes in some years (carry forward gas). For smaller fields and in cases where the producer encounters difficulties in forecasting extracted volumes, there may be no such contractual provisions and the quantities will be nominated by the seller.

Long-term contracts also detail what happens when a buyer does not take the entire amount of natural gas required during the course of a year, e.g., the buyer may defer delivery by one or more years. This ToP clause[6], also termed the minimum bill, is usually around 85-95%. It is notable that the flexibility observed in European import contracts has been sufficient, such that ToP provisions have rarely been used (EC, 2007).[7]

Three types of pricing of natural gas contracts exist: 1) parity with crude oil prices; 2) market value; or 3) cost-plus pricing. In the early days of natural gas in Europe, mechanisms were needed to ensure that prices over the lifetime of an (infrastructure) project remained broadly in line with market values.

[6] It is really a take-or-take-not-but-still-pay clause.

[7] Hubbard and Weiner (1986) provide a balanced discussion of the effect of regulation on ToP-provisions in the US.

Given the substitutability of oil and natural gas in both the short and long term, pricing natural gas at parity with crude oil became the preferred strategy. After the first price shock in 1973, the principle of netback pricing evolved, by which natural gas was priced at a level equal to the delivered price of the cheapest alternative fuel, adjusted for differences in efficiency or the cost of meeting environmental standards, less the cost of transportation, storage and taxes (IEA, 1998, p. 32).

Natural gas produced in different regions will vary in heating values, making it easier to quote the payment for calorific values. The exact pricing for contracted volumes is typically kept confidential, but it is common knowledge that contracted prices are linked to a constant and to energy substitutes. The main intention is to maintain competitive price levels for the buyer. Typical linkages are to inflation, crude oil, coal and petroleum products (heavy and light fuel oil). Less information is public about additional agreements, such as off-take reductions, seasonal prices or options to take proportions at spot or fixed prices.

An analysis of 500 existing long-term contracts for natural gas in Europe, carried out under the Sector Inquiry by DG Comp (EC, 2007), finds that the majority of the contract prices are linked to oil and oil derivatives, so that natural gas prices reflect the development of oil markets although with a time lag, typically of six months. The finding illustrates an almost identical indexation pattern for contracts bringing natural gas to Europe from the Netherlands, Norway and Russia: more than 80% of the contracts are coupled to the price of heavy and light fuel oil. This represents more than 60% (275bcm) of European consumption. Algerian export contracts show that the prices are coupled almost 75% to crude oil and 25% to heavy and light fuel oil. Overall, this indicates that European natural gas prices are directly driven by the price of oil and oil products. In the UK, natural gas prices are determined roughly by 37% hub gas prices, or slightly less than 30% inflation and only 20% oil products (Sector Inquiry). Nonetheless, all prices in these European long-term contracts do not react directly to changes in supply and/or demand, and most indices are incorporated using trailing averages. In the North American market, there is no formal linkage of natural gas to oil prices in the contracts.

As mentioned, a seller aims to smooth income from a capital-intensive investment. The lifetime of a large-diameter steel pipeline is 40-60 years, but contract duration in written agreements is generally between 20 and 30 years. We note that some outliers indicate that longer durations are possible. There is also no evidence that the distance from producing to consuming regions has a direct impact on the length of negotiated deliveries.

Uncertainty increases with contract duration and therefore provisions for adaptations are indispensable. Parties adjust to current market conditions, for instance, if fundamentals in oil markets change and the resulting prices either skyrocket or plunge by providing short-term advantages for one party to deal with the specific circumstances in exchange for benefits the other party obtains in the longer-term. Likewise, if demand in a country may not reach the level anticipated by the buyer at the time the contract is written. For these and other reasons, routine renegotiation of prices is often

included.[8] Renegotiations rarely go to arbitration but are finalized with agreements that offer benefits for both parties.

Contract duration associated with greenfield projects is on average three years longer than for contracts tied to existing infrastructure (Hirschhausen and Neumann, 2008). The US experience also shows that private actors (as opposed to state-owned companies) are willing to invest in large pipeline and LNG projects given a stable and reliable regulatory framework that secures revenue.

The developmental phases of the European natural gas industry (Table 1) can be summarized following Adelman *et al.* (1986). The use of long-term contracts is characterized by the steady development of national markets based on discoveries in France, Italy, Germany and Austria after World War II, and local monopolies provided natural gas as a speciality fuel to a limited number of buyers.

Table 1: The changing nature of natural gas contracts

Period	Buyers	Producers	Price	Quantity	Risk allocation
pre-70s	small, but growing; gas as specialty fuel	few; emergence of the NL	Fixed	relatively low minimum takes	sellers take development cost risk
1970s	growing; industrial and electrical customers	growing; NOR, UK, SU, AL	indexed to oil	high minimum takes	buyers
1980s	level; decrease in industrial and electric sector but growth in residential and commercial sector	increasing	more complex indexing	range of takes required	buyers typically; sellers rarely
post-‘ 90	growing; residential and commercial sector, transport	increasing (LNG, shale)	more flexible, reflecting market realities	continuing variability	sellers and buyers

Source: Based on Adelman et al., 1986

The number of buyers and sellers grew after the discovery of natural gas in the Netherlands and the UK in the 1970s. Oil price indexation in contracts began and sellers negotiated high off-take

[8] Bolle (1989) argues that renegotiations take place roughly every third year.

quantities. Until the 1980s, the industry was marked by modest expansion in production and consumption. Even though international trade became a factor, overall markets remained tight and oil prices high. Thus, the efficiency of long-term contracts in terms of providing stable revenues to producers and steady natural gas supply to buyers was not prone to much scrutiny by regulators and policy-makers.

With the availability of additional natural gas from Algeria, Norway and the former Soviet Union in the 1980s, it became clear that consumption would grow rapidly, with oil market shares bound to decline. Optimism about future demand coupled with scepticism about future domestic supply gave rise to contracts that incorporated rigid ToP clauses and high, built-in prices.

During the 1990s, market restructuring in the US and the reform agenda in Europe changed the industry, i.e. an increase in natural gas producers, exploitation of new sites and different types of natural gas. The run-up in global consumption can be attributed to competition in consuming regions and public acceptance of natural gas as cleaner than other fossil fuels and improving relationships with major producing countries like Russia. At the same time, real marketplaces emerged, making natural gas a widely tradable commodity. LNG technology linked regional markets in which market participants benefit from short-term price signals to global supply; this exposed traditional long-term contracts in North America and Europe to immense pressure. The result is that most LNG contracts have added more flexible arrangements in terms of pricing and quantities.

4 The motivation for long-term contracting

The literature identifies a variety of reasons that motivate the use of long-term contracts to back investment in exploration and transportation of natural gas.

The main argument is based on transaction cost theory (Williamson, 1985) and relates to the protecting asset specific investments. Empirical evidence gathered from more than 300 international long-term contracts for natural gas by Hirschhausen and Neumann (2008) shows significant reductions in contract duration as the global industry moves to market-oriented co-ordination mechanisms. Maturity of the transportation network lessens the need to back up large-scale, upfront investments using hierarchial contracting forms. Moreover, as shown by Ruester and Neumann (2009) asset specificity in particular in the LNG industry has decreased recently.

Second rational for long-term contracting is the reduction of search costs to identify and negotiate with trading partners for each individual sale of gas (Brito and Hartley, 2007). With liquid spot markets and non-discriminatory access to the transportation network this has become has become however less cumbersome. Experience from the US and the UK during early deregulation reveals rapid expansion of contracts based on spot or over-the-counter (OTC) markets: by the 1990s, natural gas delivered under long-term contracts in the US reached 50% (IEA, 1998), and empirical evidence for European import contracts suggests a similar development (see Neumann and Hirschhausen, 2004). At the same time, average US natural gas contracted volumes declined from 1.27 bcm/a to 0.24 bcm/a (IEA,

1998).[9] New trading places in Europe and the depth of liquidity in the US market for natural gas (5-6 years) are influential as well. Linking the price of natural gas in the "old" contracts directly to trailing averages of oil or petroleum products cannot reveal market realities. In both the US and the UK, spot price indexation to natural gas, electricity or coal prices has partially or fully replaced oil price indexation. In Continental Europe, there are increasing linkages to electricity or spot natural gas prices, although the "old" oil linkage will remain for some time, given the extensive contracts in place.

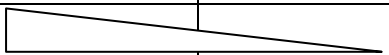
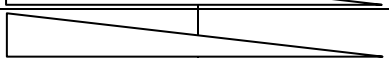
The availability of natural gas on short notice, as well as natural gas that is not under long-term contracts, promotes competition and the more efficient use of infrastructure. Merchant players, independent utilities and traders can optimize supply portfolios and arbitrage between locations. After opening the market to competition in the US and Europe, several trading places emerged, in which numerous buyers and suppliers contract for short-term delivery. At the same time, LNG export/import provides opportunities to seize price differentials from either side of the Atlantic and to create a global market for natural gas. According to Neumann and Hirschhausen (2004), Stern (2009) and EC(2007), approximately 300 bcm of European natural gas supplies are directly linked to oil or petroleum product prices via long-term contracts. Natural gas consumption in Europe in 2009 totalled 520 bcm, leaving nearly 40% (or 200 bcm) traded short-term. Recent figures suggest that traded volume at major European natural gas hubs was 120 bcm (IEA 2009).[10]

Third, dominant players across many industries are suspected of using long-term contracts to foreclose the market for new entrants. The separation of production, transport and marketing of natural gas has however removed (or at least decreased) the opportunities to foreclose the market using long-term contracts. Furthermore, the dominance of incumbent market participants is weakened albeit existing long-term contracts in place reduces flexibility to some extent.

Finally, long-term contracts can help to secure the revenue streams for new investments and thus facilitate financing. With continued investments being pursued, this argument remains a motivation for the use of long-term contracts where regulatory environments do not provide alternative options to secure revenue for infrastructure investment (e.g. based on a regulatory asset base).

Table 2 summarizes the findings. It maps the developments of the natural gas market against the rational that has been quoted for the use of long-term contracts.

Table 2: Arguments in favor for long-term contracts in a changing environment

	Pre-1990	1990	2010
Asset Specificity	+		
Search Cost	+		
Foreclosure	+	-	-
Securing Revenue	+	+	+

[9] It is worth noting that pipeline companies in the US merely offer the transport of natural gas, not the sale. In European terminology, this would translate into full ownership unbundling.

[10] These figures do not differentiate between independent natural gas importers or traders and vertically integrated companies.

Although we observe a decline in three of the motivating factors for long-term contracts, the discussion of section 3 has demonstrated the continued prevalence of such contracvts. For large new infrastructures (i.e. NordStream in Europe) non-commercial long-term contracts remain the favourite instrument to materialize investments. This points to the main motivation of long-term contracts in the gas industry as means to secure revenue to finance investment.

We furthermore observe that increasing liquidity of markets for forward contracts extending up to 10 years in the US adds to the ability of financing small projects without relying on long-term contracts. However, we also notice that the stable regulatory framework ensuring revenues for individual projects in the US provides for an alternative to long-term contracting and can facilitates sufficient investments by private companies in large pipelines[11].

5 Government support for infrastructure finance

The previous section points to the role of long-term contracts for the investment in natural gas extraction and transmission in the absence of regulatory guarantees. This raises the question whether government is necessary to provide regulatory and market frameworks that are conducive to long-term contracts or to provide additional support? Again we explore the experience in the natural gas industry, so as to assess where adjustments of regulatory frameworks and complementing policy measures might be necessary to facilitate low-carbon investments.

The regulatory environment under which companies operate differs across nations and continents. The experience from the US shows that private investment in significant infrastructure projects is forthcoming. First and foremost, a pipeline in the US refers to a company operating such a facility which is separated from the sales function (FERC Order 636, 1992). As of today, the Natural Gas Act requires that rates charged for interstate pipeline services (transport) be "just and reasonable" set by cost-of-service ratemaking. Under cost-of-service ratemaking, rates are designed based on a pipeline's cost of providing service including an opportunity for the pipeline to earn a reasonable return on its investment. Companies investing in new pipelines make a filing with the regulator proposing future rates which is then open to all relevant parties. The Commission finally sets rates for interstate pipeline services taking into account all hearings and filed information. This suggests that regulatory frameworks can facilitate capital-intensive investments.

In contrast, financing of infrastructure in Europe works differently. Significant additional infrastructure (green-field projects) can apply for Community funding from i.e. the EIB. On a European level, priority investments of common interest have been identified (Trans-European Energy Networks, TEN-E). The new Communication of Energy infrastructure priorities takes the debate on apparently missing infrastructure in natural gas and electricity further. On a more direct level we observe two main things. First, all new infrastructure (for both LNG and pipelines) is tied to the

[11] One has to note, however, that transport capacities on these pipelines are often contracted for at a long-term basis.

signature of long-term supply and/or capacity usage contracts. European legislation additionally allows to exempt new infrastructure from third-party access (Article 36, 2009/73/EC) and to derogate from third-party access on the basis of existing long-term contracts with their respective minimum off-take quantities. Bearing in mind these regulatory implications new projects regularly ask for governmental support before construction. One of the most prominent recent examples is the NordStream pipeline from Russia to the Baltic Sea circumventing transit countries and allowing direct deliveries to Germany. Apart from the involvement of the former German chancellor who is now on the board of the project team it is worth noting the required financial support from Germany. For the construction of the pipeline the consortium (Gazprom 51%, BASF/Wintershall and E.ON Ruhrgas each 15,5 %, Gasunie and GDF SUEZ each 9 %) asked the German government at the end of 2009 for debt guarantees for 2.6 Mrd. €, of which 1.6 Mrd € were sought in order to secure purchase orders from a German pipeline producer. Thus in total, about 70% of the project costs are backed by export credit guarantees from governments in Germany and Italy. Transport capacities are marketed by the consortium and the Gazprom has already booked the capacities.

Long-term contracts retain an important role even after market restructuring, but a stable regulatory frameworks that allow for long-term contracts to finance infrastructure investment (e.g. EU exemption from third party access, US regulatory guaranteed transport rates) also supports investments. Regularly this is supported by backing contracts or other ways to address counter-party risk factors. The experience from the natural gas sector suggests that also for low-carbon investments, governments need to carefully consider how they can facilitate long-term contracting arrangements to support low-carbon investments, and potentially support the ability and credibility of actors to sign such long-term contracts or use alternative regulatory mechanisms to reduce investment risks.

6 Conclusion

This paper has provided an overview of the evolution of the natural gas sector in Europe. Historically, the development of capital-intensive infrastructure was backed by long-term ToP contracts and government guarantees. The major features of contracts struck in the “old”, because immature and monopolized, world of natural gas were extensive in duration and price linkage to oil and/or petroleum products, and the pricing failed to reflect market conditions or changes in supply and/or demand. Later, long-term importing contracts became economically viable instruments to hedge counterparty risk against the background of transaction cost economics, and enabled the establishment of natural gas consumption and transportation networks without jeopardizing profits from oil imports. Market restructuring ushered in substantial changes. Natural gas became a commodity traded short-term in numerous locales across the globe. Today, throughout North America and Europe, the existing mature pipeline infrastructure has been paid for, and demand for natural gas is soaring. While there is little risk that development of new infrastructure will not be refinanced, the scenario only holds under a stable regulatory environment which provides reasonable planning horizons for public and private investors.

Some of the structural elements and objectives of market restructuring are shared between natural gas and infrastructure required for decarbonisation of our economies. Both sectors have a capital intensive asset base that is subject to technical network constraints and re-regulation coincides with the urgent need to make investments whilst reducing price risk.

Despite the liquidity in the natural gas market the policy discussion typically focuses not on whether complementing government actions are necessary, but how they can be structured to avoid distorting impacts on other investment choices. This suggests that governments have to be prepared to assess where complementing actions are necessary and whether private actors have sufficient incentives and capabilities to pursue investments, or whether additional policy frameworks are required.

References

Adelman, M.A., C. Blitzer, L. Cox, M. Lynch, J. Parsons, D. White, and A. Wright (1986): Western Europe Natural Gas Trade. MIT, Center for Energy Policy Research (International Natural Gas Trade Project Report).

Brito, Dagobert L. and Peter R. Hartley (2007): Expectations and the Evolving World Gas Market. *The Energy Journal*, Vol. 28, No. 1, pp. 1-24.

Bolle, Friedel (1989): Take or Pay-Verträge und vertikale Integration im Erdgashandel. *Zeitschrift für Energiewirtschaft*, Vol. 13, No. 4, 249-255.

European Commission (2007): DG Competition Report in Energy Sector Inquiry, SEC(2006)1724, 10 January 2007, Brussels.

GTE (2001): Capacity Congestion. Presentation at 4th Madrid Forum (European Gas Regulatory Forum), Madrid, Spain.

Hardt, John and Donna L. Gold (1982): *Soviet Gas Pipelines: U.S. Options.* Issue Brief Number IB82020, The Library of Congress Congressional Research Service, Major Issues System.

Hirschhausen, Christian von and Anne Neumann (2008): Long-Term Contracts and Asset Specificity Revisited: An Empirical Analysis of Producer-Importer Relations in the Natural Gas Industry. *Review of Industrial Organization*, Vol. 32, No. 2, pp.131-143.

Hubbard, R. Glenn and Robert J. Weiner (1986): Regulation and Long-Term Contracting in US Natural Gas Markets. *The Journal of Industrial Economics*, Vol. 35, No. 1, pp. 71-79.

International Energy Agency. (1998): *Natural Gas Pricing in Competitive Markets.* Paris, OECD.

— (2009): *Natural Gas Market Review.* Paris, OECD.

Klein, Benjamin, Robert G. Crawford, and Armen A. Alchian (1978): Vertical Integration, Appropriable Rents, and the Competitive Contracting Process. *The Journal of Law and Economics*, Vol. 21, No. 2, pp. 297-326.

Neumann, Anne and Christian von Hirschhausen (2004): Less Long Term Gas to Europe? A Quantitative Analysis of European Long Term Gas-supply Contracts. *Zeitschrift für Energiewirtschaft*, Vol. 28, pp. 175-182.

Ruester, Sophia and Anne Neumann (2009): Linking Alternative Theories of the Firm – A First Empirical Application to the Liquefied Natural Gas Industry. *Journal of Institutional Economics*, Vol. 5, No. 1, pp. 47-64.

Stern, Jonathan (2009): Continental European Long-Term Gas Contracts: is a transition away from oil product-linked pricing inevitable and imminent? Working Paper NG34, Oxford Institute for Energy Studies.

Victor, Nadejda M. (2008): *Gazprom: Gas Giant under Strain*. PESD Working Paper 71, Stanford University, CA.

Victor, David G., Amy M. Jaffe and Mark H. Hayes (2006): *Natural Gas and Geopolitics: From 1979 to 2040*. Cambridge University Press, UK.

Williamson, Oliver E. (1975): *Markets and Hierarchies.* New York, Free Press.

— (1985): *The Economic Institutions of Capitalism – Firms, Market, Relational Contracting.* New York: Free Press.