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Infrastructure, regulation, investment and security of supply: A case study of the restructured US natural gas market

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Abstract

In this paper, we discuss the relationship between infrastructure regulation and investment in light of the emerging "security of supply" debate. We approach the subject by surveying the literature of the past two decades, especially examining the interactions among restructuring, regulation, and investment. The empirical section of this paper relies on case studies of the relationship between the regulatory framework for the US natural gas sector and the development of investment in LNG terminals, interstate pipelines, and storage facilities in the US. I find that there is little reason for concern about infrastructure investments, resource adequacy, and supply security.

Keywords: Infrastructure; Regulation; Investment; Natural gas

> "There is no inherent conflict between the liberalization of electricity and gas sectors that meet reasonable supply security goals as long as the appropriate market, industry structure, market design, and regulatory institutions are developed and implemented."
>
> Paul Joskow, Beesley Lecture, London, October 25, 2005, p. 2

1. Introduction

The issue of infrastructure investment is back on the global policy agenda in ways not seen since the 1970s. This concern is due primarily to: (i) the reconsideration of traditional incentive-oriented regulation, now challenged by new theories (e.g. real options) and the empirical assumption of insufficient infrastructure investment; (ii) sectoral considerations such as the upcoming debate about next-generation network regulations in telecommunications of supply-security issues in electricity and natural gas; and (iii) post-9/11 discussions, including a new understanding of the risks (e.g. outages) to large, critical-infrastructures resulting from technical or man-made events.

The discussion about regulation and investment dates to the classical argument by Averch and Johnson (1962) about overinvestment in a rate-of-return regulated natural monopoly as contrasted with theories of underinvestment (Baumol and Klevorick, 1970). von Hirschhausen et al. (2004) provided a survey of the literature, including sector-specific considerations. However, both the theoretical literature and the policy-oriented discussions have expanded, so that a reassessment of several key concerns is in order. Not surprisingly, however, no overarching consensus has been reached about the effects of regulation on infrastructure investments since existing models fail to provide unambiguous results. We assert that case-specific assessments are still needed to derive concrete, applicable policy conclusions.

This paper surveys historical and current discussion about the relationship between infrastructure (or network) investment and regulation/competition, and applies the findings to an in-depth case study of the link between restructuring and infrastructure investment. In particular, we examine the relationship between the regulatory framework in the natural gas sector (vertical separation, open access, etc.) and the

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investment behavior of companies in the US. Our working hypothesis (derived from Joskow, 2005), is that restructured, vertically unbundled markets can provide the proper investment signals if the reform process is accompanied by the appropriate regulatory framework.

The paper is structured as follows: the next section presents the major arguments for and against restructuring, regulation, and infrastructure investments. We distinguish between general theoretical approaches and those referring to a specific sector (e.g. telecom) or specific institutional aspects (e.g. regulatory institutions). Depending on the theories employed, it becomes evident that similar policies can have very different implications for investment and welfare. The subjective assessment of each author reviewed may also imply specific findings. Heinacher and Preissl (2006, p. 27) concluded that "the crucial question is not whether there is a fundamental contradiction between investment and regulation, but whether in certain circumstances and under certain market constellations regulation has a negative impact on investment incentives and innovation".

The second section presents a case study of the relationships among regulation, competition, and investment in the US gas market. Natural gas is under-researched, particularly in North America, where the sector used to be considered as competitive and, contrary to electricity, there was no concern about supplies and infrastructure so far. With the advent of energy supply security concerns, the critical infrastructure debate, and the growing role of natural gas as a low CO2 producer, both the American public policy debate and worldwide academic research are currently on the rise. Federal legislation, e.g. the Energy Policy Act of 2005 (EPAct 2005), and emerging studies of supply security issues (e.g. Jensen, 2004) are proof of both national and international interest.

Despite these developments, there has been no real focus on specific issues in natural gas infrastructure investments. Therefore, we examine the relationship between the regulatory framework for the natural gas sector and the development of investment in LNG terminals, interstate pipelines, and storage facilities. We find that while some improvements in the regulatory framework may enhance investments, there is little reason for concern about infrastructure investments, resource adequacy, or supply security. Going beyond the sectoral specifics, we discuss the parallels and differences with other infrastructure sectors.

2. State of the literature

2.1. The historical regulatory debate

There is an ongoing policy debate about the relationship between industry restructuring (referred to as "liberalization" in Europe) and investment incentives. Industry representatives generally claim that industry restructuring in an unstable institutional environment places infrastructure investments that ensure supply security at risk. Market proponents, on the other hand, argue that a laissez-faire approach stimulates maximum investment. Economic theories do not provide clear indications of the conditions under which "efficient" levels of investments can be achieved and what factors lead to over- and under-investment. Institutional and transaction cost approaches insist on the need for appropriate institutional settings to assure long-term investment, e.g. Joskow (1987) for the US coal industry.

The historical debate has been dominated by Averch and Johnson (1962) on overinvestment in a rate-of-return regulated natural monopoly industry. They argued that because the guaranteed rate of return is higher than the market interest rate, companies have an incentive to utilize more capital input and less labor, which causes an inefficient allocation of resources and overinvestment.

One situation leading to underinvestment may be the regulatory abuse of discretionary power. Thus, Baumol and Klevorick (1970) argued that the risk of being expropriated (fully or partially) would lead to suboptimal investment by the regulated company. Helm and Thompson (1991) suggested that the social costs of underinvestment are higher than the social benefits of overinvestment. Von Hirschhausen et al. (2004) provided an overview of the regulatory literature that analyzed externalities, issues of ownership and corporate governance, and investments in service quality.

The empirical evidence for clear cases of overinvestment or underinvestment is rare and controversial. Given the breadth of the theoretical discussion, this is not surprising. A recent example is the controversy over energy market restructuring in the UK. Helm (2005) suggested that the recipe for privatizing and regulating utilities since the early 1980s in the UK, Australia, and New Zealand favored a short-term perspective and may have insufficiently emphasized longer-term aspects such as investment and quality. However, Pollitt (2002, p. 71) found no evidence that privatization and restructuring hurt investment, an assessment also shared by Joskow (2005, p. 47).

2.2. Asymmetry, investment and uncertainty

The debate broadened in the mid 1990s with arguments about asymmetric treatment of incumbent operators and entrants, and about investment under uncertainty. Several academics cited Dixit and Pindyck (1994) on "Investment under Uncertainty" and the real-option approach; they suggested that under uncertainty, delaying investments may be beneficial even though a project may indeed cover its capital costs.

Along these lines, theoretical and empirical work has suggested that by not accounting for the dynamic nature of (regulated) investment, regulators can underestimate the real cost of capital of an incumbent. Thus, Hausman (1998) and Hausman and Myers (2002) suggested that relying on traditional regulation to establish competitive prices may lead to adverse effects on innovation and new investment. These authors reasoned that this approach may neglect the significant sunk costs by an incumbent, and the value of the "real option" offered to a new merchant competitor that must only pay the regulated "competitive" price. Hausman (1998) analyzes the "total

service long-run incremental cost rule'' (TSLRIC) for incumbent local exchange carriers (ILEC) and concluded that ''failure by regulators to recognize the sunk cost character of much network investment leads to the grant of a free option to the competitors of the incumbent; … the adoption of TSLRIC as a cost basis to set the prices for unbundled elements has negative economic incentives effects for innovation and for new investment in telecommunication'' (p. 17). Similarly, Hausman and Myers (2002) analyzed the regulation of US railroads, concluding that the ''simulated competitive rate benchmark is too low because it fails to account for the sunk and irreversible nature of many investments in railroads….We find that required return calculated from the STB model that ignores these factors is too low by between 30% and 84.4%'' (p. 308).

2.3. Vertical unbundling and infrastructure investment

Much of the ''supply security'' debate is linked to fears of insufficient infrastructure investment in vertically unbundled value-added chains. This is true for the discussion in telecom, electricity, natural gas, railroads, and other sectors. The advantages of increased competition and lower prices in the competitive segments are weighed against potentially lower investments by the incumbent infrastructure supplier (see Gómez-Ibénez, 2003, chapter 10). Although a detailed assessment of these arguments is beyond the scope of this paper, suffice it to say that the case for vertical integration to support infrastructure investment is not so simple.

Vertically bundled network companies that own, for example, the infrastructure plus a trading activity have fewer incentives to invest in infrastructure expansion then an unbundled infrastructure network operator. The reason is that the integrated provider has exactly what it needs to bring its products to market. Other things being equal, network expansion and letting-out to a third party would weaken the integrated provider's position downstream, and thus decrease its overall profit. By contrast, a network-only company has an incentive to expand its capacity once the demand exists, because every molecule, electron, m^3 or bit transported increases its profits. Another argument, generally heard in the telecom sector, is termed the ''investment ladder'': ''favorable access conditions for market entrants at the service level will eventually motivate them to build up their own infrastructures—or to climb up an imagined investment ladder'' (Heinacher and Preissl, 2006, p. 24; see also Hausman and Sidak, 2004, who found that the investment ladder hypothesis is not supported empirically).

The papers by the US and UK representatives at the 2007 OECD Competition Committee argued in favor of vertical unbundling to enhance supply security. The UK contribution concluded that ''a market based approach is the best way of delivering a level of security of supply that reflects what business and domestic customers want and are willing to pay for'' (UK Office of Fair Trading and UK Office of Gas and Electricity Markets, 2007, p. 7). Likewise, the US policy makers pointed out that price signals in competitive markets will lead to efficient long-term investment decisions (US Department of Justice and US Federal Trade Commission, 2007).

2.4. Case study evidence from communication and electricity

Guthrie (2006) provides an extensive survey on the impact of regulation on risk and investment in infrastructure. Motivating his paper by empirical case study evidence from electricity generation and transmission and the telecommunication sector, Guthrie obtains quiet different investment patterns. Thus, in the telecommunication has been observed that incentive regulation of the incumbent (AT&T) had favored investment by local exchange carriers into network modernization (such as fiber-optic cable deployment) in the 1990s. On the other hand, the more recent reintegration between local network operators and long-distance operators has tended to hold back investments, unless favored by regulatory holidays (such as the Verizon fiber-optic-roll-out).

In electricity too, the effects of regulation on investment are not clear-cut (Guthrie, 2006, p. 926 sq.). With respect to generation, (price-capacity) regulation may keep companies from investing, because they can not be certain to recover their fixed costs. The so-called ''missing money'' problem (Hogan, 2005) refers to the fact that capped prices for a partially congested infrastructure do not allow the investor to recover the fixed costs. As a solution, Hogan (2005) has argued for abandoning the price cap on wholesale markets, so that generators can obtain a (scarcity) rent to cover their fixed expenditure (the ''missing money''). Opponents of this mechanism insist on the political infeasibility of skyrocketing prices, and suggest combining a price cap with a forward capacity market (Crampton and Stoft, 2006). It has also been argued that bankers would be unlikely to provide large sums of investment if they are to rely on scarcity rents for returns, due to the high uncertainty attached to these investments.

In electricity transmission, the issue is still more complex. Controversies between the Federal Energy Regulatory Commission (FERC) in the US and state regulators, have led to almost a standstill of transmission investment. As electricity generation and demand grow, this leads to increasing congestion, which is paradoxically beneficial to the network operator. The theoretically optimal solution, introduction of Financial Transmission Rights (FTR) has not yet been applied widely. In this respect, uncertainty rather than to strict performance benchmarks have impeded investments thus far.

Last but not least, there is a recent discussion about the relationship among regulation, unbundling, and the infrastructure investments related to new services or innovations. Although this discussion has emerged primarily from the telecommunications sector, it may be relevant to natural gas as well. The debate opposes a static vision of regulation, aimed at maximizing short-run social welfare, with a dynamic vision that focuses on innovations and Schumpeterian competition through creative destruction. The static vision tends to set access prices close to short-run marginal costs in an effort to favor entry by third parties. The dynamic vision favors

temporary monopolies, e.g. through regulatory holidays for an incumbent that are expected to lead to innovative products and new services.

The debate pits adherents to stricter access regulation (e.g. Vogelsang)[1] against supporters of a "hands-off" approach (e.g. Hausman, 1997). See Heinacher and Preissl (2006) for a survey of the theoretical and empirical results. Public policy (on both sides of the Atlantic) is being shaped by the introduction of extremely high-speed broadband fiber networks (VDSL). Incumbents generally ask for regulatory holidays in exchange for multi-billion-dollar investment programs, while their competitors ask for low-priced access to these networks.

3. Case study: Restructuring, unbundling and infrastructure investment in the US natural gas sector

The global supply security discussion often confines itself to electricity generation and transmission (Joskow, 2006), but the subject of natural gas supply security is beginning to emerge (for the US, see Joskow, 2005, and for the UK and Continental Europe, see Helm, 2005). Here, two different aspects of supply security should be distinguished: (i) the physical supply of energy resources to a country or a region that may be threatened by supply disruption, cartelization of upstream producers, and so on;[2] and (ii) supply security with respect to adequacy of investments in (natural gas) infrastructure, such as LNG terminals, transmission pipelines and storage facilities. We can also distinguish between the short-term operating reliability and longer-term resource adequacy of infrastructure (Joskow, 2005); this paper concerns the latter issue.

Although telecom is more newsworthy these days, and electricity more politically sensitive, the natural gas sector in the US includes several important characteristics mentioned in the previous section. We selected this sector as our case study partly because concerns about supply security and infrastructure investments have arisen quite recently, and because federal policies to unbundle and introduce competition have been relatively transparent and straightforward. We can also analyze a thirty-year track record starting with the Natural Gas Policy Act of 1978.

Three infrastructure components play important roles in assuring supply security, i.e. LNG terminals, pipelines, and storage facilities, and we examine them individually. The US is the second-largest gas producer in the world (526 billion cubic meter (bcm) in 2005), and the largest gas consumer (634 bcm). There are 8000 major natural gas wells representing 86% of total production with the remainder coming from associated oil production; thus, domestic production is competitive. At present, the reserves over production ratio is about 10 years; therefore, imports are increasingly important. Imports from Canada contributed to 13% of consumption (102 bcm in 2005), and imports of LNG tripled between 2002 (6.5 bcm) and 2005 (18.5 bcm, or 3%). By 2020, it is expected that LNG will represent about 20% of total consumption (of a total of 760 bcm).

US regulation of natural gas began in the 1930s with an attempt to curb the abuse of market power in the interstate pipeline business (see IEA, 1998, and Makholm, 2006, for details). Today, the Federal Energy Regulatory Commission (FERC) regulates interstate affairs, and state utility commissions regulate the 1400 local distribution companies (LDCs). Significant restructuring of the industry started with the removal of wellhead ceiling prices in 1978 (Natural Gas Policy Act). In 1984, FERC Order 380 released local distribution companies (LDCs) from long-term take-or-pay contracts. Vertical unbundling was the objective of Order 436 (1985), which also suggested that interstate pipelines offer open access to their transportation infrastructure. The "final restructuring rule" (FERC Order 636, 1992) was a milestone in moving from "simple" non-discriminatory third-party access (TPA) to a fundamental vertical unbundling of transportation and sales activities, creating competition among natural gas sellers. Pipeline companies were obliged to publish "electronic bulletin boards" (EBB) to provide shippers with information about the availability of services. The rule also required pipeline companies to expand access to interstate storage capacity. EPAct 2005 added new provisions to ease investment in infrastructure, e.g. in LNG terminals.

Restructuring has had a substantial impact. Gas production and marketing are completely deregulated. Consumers may buy directly from producers, or use marketers as intermediaries. Many industrial customers and power plants obtain gas directly from interstate and intrastate pipelines, and only use LDCs for transport services. Financial market growth has helped to ensure supply security. The futures market now offers contract periods up to seven years and is liquid for at least a two- to three-year period. Henry Hub is an ideal point for physical delivery, situated at the crossroads of 16 natural gas pipelines and close to producing fields, LNG terminals, and storage facilities. The following three sections look at the impact of restructuring on investments and supply security at the three different levels of infrastructure: LNG terminals, pipelines, and storage. In each section, we first identify the regulatory issue, and then describe the investment decisions.

4. LNG regasification terminals: Is TPA exemption really necessary?

4.1. The regulatory issue: Access

For an import dependent country such as the US, LNG has become an important source of diversifying suppliers, over and above the traditional pipeline supplies. In fact, LNG has gone from being an expensive, exotic fuel traded only at the regional level to being a globally traded energy source (Jensen, 2004). Although in the past LNG was used mainly for peak-shaving

[1] Vogelsang, Ingo (2006): Die regulatorische Behandlung neuer Märkte im Bereich der Breitbandkommunikation. Gutachten für den Bundesverband Breitbandkommunikation, Boston, 14 April.

[2] Refer to Stern (2006) for recent discussions of geopolitical issues in natural gas, and to Adelman et al. (1986) for a similar analysis from two decades ago.

purposes, the growing use of natural gas for electricity generation is transforming it into a year-round commodity. There is a general consensus that LNG imports will increase as domestic production stagnates and imports from other sources (e.g., Canadian pipeline gas) decline.[3]

Like many other countries, the US has reopened or expanded existing terminals, and begun to site and construct new ones. Following the oil crisis in the 1970s, four LNG terminals were built (Everett, MA; Cove Point, MD; Elba Island, GA; and Lake Charles, LA); the latter three were mothballed in the 1980s, and only reopened recently. All four are currently undergoing substantial expansion. The first newly built terminal in the "new world" of global LNG was finished in 2005, with total investments of about $700 million (Excelerate's "Gulf Gateway Energy Bridge").

4.1.1. The regulatory issue: TPA exemption?

Should a terminal be treated as a competitive activity or as an essential facility? In the latter case, regulation would need to secure non-discriminatory access at appropriate prices. LNG terminals have in fact been subject to some form of third-party access (TPA) obligation. In the US, LNG terminals were considered to be part of the transportation chain and thus subject to open-access service under Section 7c of the Natural Gas Act. Thus, three of the four terminals built two and a half decades ago are subject to open access regulation. But FERC has undergone a policy shift, largely motivated by supply security considerations and the increased demand for LNG imports: In its "Hackberry Decision" of 2002, the commission terminated open access requirements for LNG terminals. They are now generally treated as "supply sources" and as such fall under Section 3 of the Natural Gas Act. FERC specifically stated that it wanted this policy shift to encourage the construction of new LNG facilities by removing some of the economic and regulatory barriers to investment (EIA, 2005).

However, it is not clear that waiving open access restrictions is really necessary to induce investment or whether or not investment would have occurred in any event. Waiving open access restrictions may in fact have favored investments by integrated groups with a large share of capacity covered by upstream and downstream contracts. However, as argued below, the Hackberry Decision has not eliminated all merchants from the business.

From a theoretical perspective, assuming that upstream and downstream markets are fully competitive, a terminal owner should charge the same access fees to a cargo from its own trading arm and to a third party. An unbundled infrastructure operator has incentives to use its capacity to the highest extent possible. It is not clear that a pure "tolling" facility would be less profitable than an integrated LNG terminal. By contrast, releasing LNG-facilities from regulation could be economically harmful, if downstream markets are not fully competitive. In that case, an integrated gas company could abuse its dominant position to withhold capacity from the market.

4.1.2. Significant investment is forthcoming

The empirical analysis of investment trends in US LNG reveals that infrastructure investment is forthcoming because the economic conditions are very favorable. As mentioned above, significant expansions already underway in the four older terminals almost double the total sendout capacity. Fig. 1 shows the five existing terminals, forty-four proposed LNG terminals in North America (US, Mexico, and Canada); indicating that the current LNG-boom is likely to continue.[4] FERC has recently granted permits to three facilities on the Gulf Coast.[5] It is difficult to assess the probability of success for individual US projects outside the Gulf of Mexico (Jensen, 2004; Frisch et al., 2005). We estimated that nominal LNG import capacity is likely to increase to about 125 million tonnes per annum (mtpa) in the US (173 bcm/year) by the year 2012, and to 144 mtpa (198 bcm/year) in North America including the East Coast of Mexico and Canada (von Hirschhausen, 2006, p. 12 sq.).

An analysis of corporate investment strategies confirms that vertical integration and TPA exemptions are not the only methods of investment. Private merchants are among the leading investors in US LNG terminals. Their strategy consists of developing terminals as a service provided to industry. The merchant company may develop its own upstream and/or downstream facilities, but is ready to offer LNG-importing capacity for rent to the market ("tolling"). Two prominent examples are Chenière Energy, the largest single investor in LNG infrastructure (its strategy is to become a tolling service provider for the four planned terminals), and the Excelerate Group, which employs a similar business model.

Given the heightened interest in LNG investment, one need not worry about supply security with respect to North

[3] The EIA (2006) Annual Energy Outlook emphasizes the importance of LNG: its "high LNG" scenario sees LNG imports at 280 bcm in 2030 (EIA, 2006, p. 90), whereas the reference scenario predicts net imports of 110 bcm. Even the "low LNG" scenario (about 53 bcm) corresponds to almost a threefold increase with respect to 2004 imports.

[4] One pattern emerges: the advanced new-build projects are either located in the Gulf of Mexico (Louisiana, Texas, or offshore) or are not on US territory, but feed into the US pipeline system (Mexico, Bahamas, and Canada). Texas and Louisiana are two major gas-producing states where local governments are familiar with industrial projects, facilitating the approval process. The region is also attractive due to proximity to Henry Hub. However, the illustration is not up to date. In reference to Number 39 for example, on April 9, 2007, the California State Lands Commission voted 2 to 1 against BHP Billiton LNG International's "application for a General Lease—Right of Way Use, of sovereign lands located in the Pacific Ocean, offshore Ormond Beach, Ventura County, for the construction, use, operation, and maintenance of two 24-inch diameter pipelines for the transportation of natural gas from the Cabrillo Port Liquefied Natural Gas Deepwater Port to an onshore connection with the Southern California Gas Company's existing natural gas transmission system", making it unlikely that the terminal will be built (public concerns about terrorism and earthquakes were also critical factors); http://www.slc.ca.gov. An extended list of potential North American terminals is at http://www.ferc.gov/industries/lng/indus-act/terminals/horizon-lng.pdf.

[5] Sempra Energy's Cameron terminal near Hackberry, LA; the Freeport LNG Development's terminal near Freeport, TX; and Cheniere LNG's Sabine Pass terminal in Cameron Parish, LA.

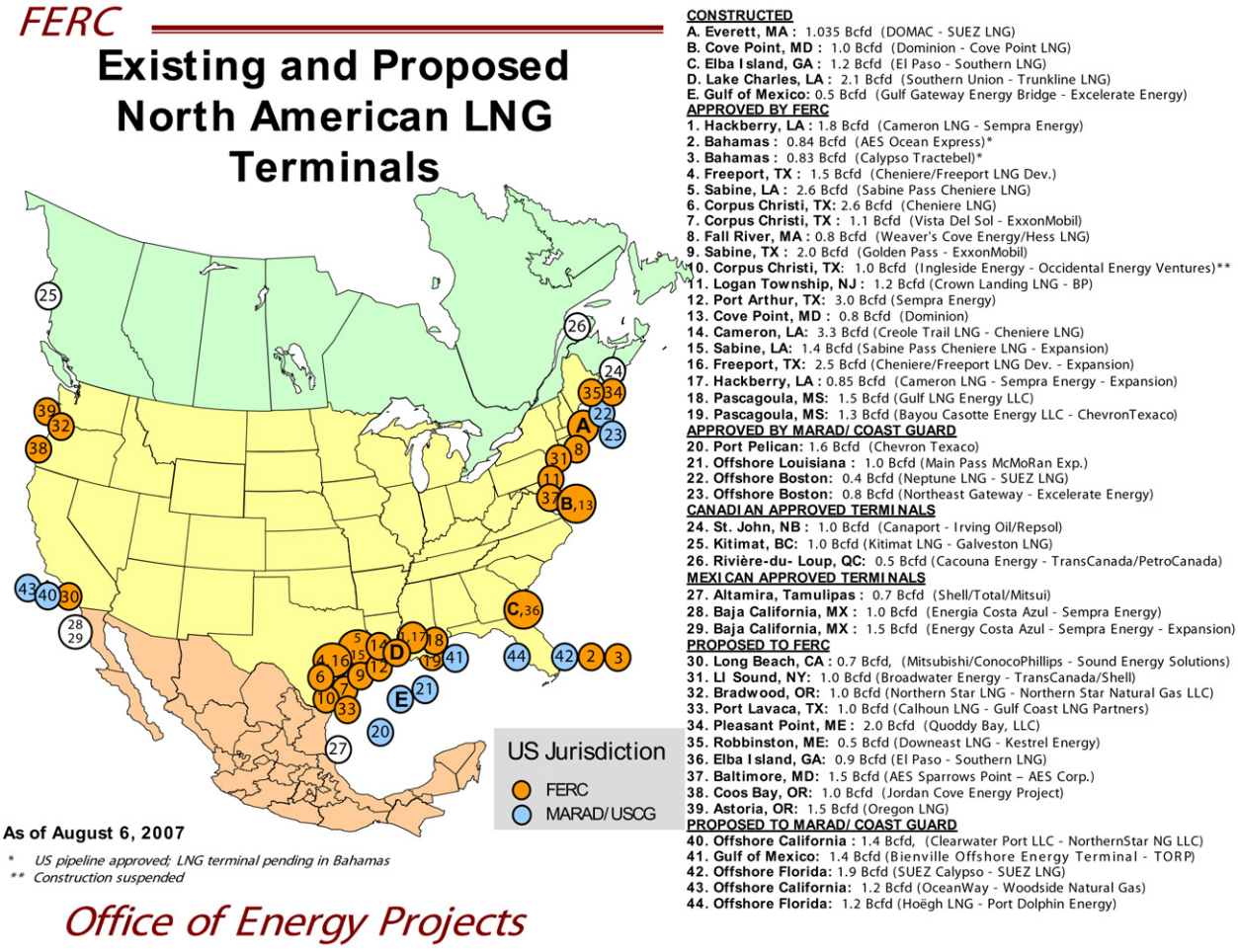

Fig. 1. Existing and proposed North American LNG terminals. Source: FERC; available at http://www.ferc.gov/industries/lng/indus-act/terminals/exist-prop-lng.pdf.

America's LNG infrastructure. In particular, the industrial structure of the investors indicates that exclusive rights for the upstream business of the investing party are not necessarily a condition for investment.

5. Gas transmission pipelines: Defining "adequate" return on investment

5.1. Cost-of-service regulation maintained

High-pressure interstate pipelines play a key role in securing the supply to an importing country or a region. To date, all countries, including the US, still regulate natural gas transmission pipelines. It is generally feared that pipelines could abuse their market position if allowed to charge market-based rates. Likewise, it is generally accepted that vertical unbundling between traders/importers and pipeline companies is a necessary condition to favor competition, and, hence, that it favors supply security.

The US interstate network evolved organically, and today corresponds fairly well to the structure of demand. The system carries gas from the main supply areas in the South and the Gulf of Mexico to the consumption areas in the Northeast, the Midwest and California. Under current regulations, the pipeline business is structurally unbundled from both upstream producers and downstream consumers (open access). Primary transportation services are subject to cost-of-service regulation, but free market-based trading exists for secondary capacity, i.e. resold primary capacity.[6] Marketers play an important role as intermediaries between upstream producers and large, downstream customers; thus they generally provide a diversified mix of services, of which interruptible and released capacity account for about two-thirds of their total capacity needs (IEA, 1998, p. 87).

Day-to-day regulation is a complex process of exogenous regulation by FERC, self-regulation between pipeline and shippers, and market processes, e.g. for secondary capacity. The primary rates charged by a pipeline company from

[6] LDCs rely mostly on primary service in direct bookings with pipeline companies because of state regulations obliging them to guarantee their customers a given supply. Likewise, large industrial users and electricity users generally prefer to hold firm primary capacity, but they also rely on interruptible and released capacity because of the potential for short-term fuel switching (IEA, 1998, p. 87).

shippers that have signed contracts are subject to cost-of-service regulation. Transportation rates are set under the Natural Gas Act, 15 u. S. C. §717, similar to the setting of rates for LDcs and telephone exchange companies. For its initial regulation, FERC calculates ROI to recover costs of prudent operation, depreciation, taxes, and a return on the capital invested, subject to an overall ROR (Loeffler, 2004). Pipelines can file rate cases after a normal first review period (~5 years), but they can also bargain directly with shippers. So-called "special contracting" between pipeline and shippers is allowed using negotiated rates, and is frequently employed (the customer can choose to return to cost-based rates).[7]

5.2. "Overinvestment" due to high rates-of-return?

Although the pipeline system has gone through periodic boom and bust investment cycles, on average the system has grown at a considerable rate (Makholm, 2006). After the 1992 implementation of Order 636, the natural gas pipeline system underwent an investment boom. From 2002 to 2004, the average annual expenditure for pipeline development was $3.5 billion, corresponding to approximately 2000 miles or 100 bcm/year of added capacity per year.[8] Pipeline expansion is likely to continue. Proposed investments for 2006 and 2007 were $2.7 billion and $3.2 billion, respectively. A list of pipeline projects contains more than 10,000 miles of new pipelines, or 500 bcm/year (Court, 2006), and no significant bottlenecks are expected.

The competitive nature of the industry, coupled with high demand, has generated a significant amount of incremental pipeline capacity. However, it has been argued that FERC uses the allowed ROR as an instrument to attract investments in pipeline infrastructure (Joskow, 2005, p. 20). The central question is how to estimate an appropriate, risk-adjusted cost of capital. In determining the appropriate rate base, the traditional "used and useful" approach is applied. The average weighted cost of capital is determined by estimating the appropriate rate of debt, the cost of equity and the capital structure ("gearing ratio"). Based on the representative sample of investment projects quoted by Loeffler (2004) and our own calculations, we estimated the weighted average cost of capital (WACC) for US interstate pipeline projects (newbuilds and extensions) between 1996 and 2003 at 11.6%, which is higher than one would generally expect (Fig. 2). Values range up to 12.64% for the Shell Gas Pipeline Co. (1996, 82% equity financed), with a lower bound of about 8.4% for the Questar Southern Trails Pipeline (1999, 70% debt financed).

Overall, our analysis does not support the hypothesis of insufficient investments in the transmission pipeline infrastructure. Given that the US natural gas market today is open and competitive, infrastructure investments have not been impeded. If ROR regulation has occasionally been criticized for triggering overinvestment and an inefficient use of capital and labor, it has also secured long-term investment. The current institutional and regulatory settings in the US pose no serious structural obstacles to natural gas pipeline developments and no particular cause for worry regarding medium-term resource adequacy.

6. Natural gas storage: Open access favors investment

6.1. Market structure and regulation

The US has about 430 natural gas storage sites (operated by about 120 companies), amounting to a working capacity of 120 Bcf (billion cubic feet). There are three types of storage facilities: (i) depleted reservoirs in oil and/or gas fields; (ii) aquifers; and (iii) salt cavern formations (Simmons & Company International, 2000). While large storage capacities exist in the gas-producing states of Texas and Louisiana, and—to a lesser degree—in the Midwest, the gas-consuming Northeastern states and California have little storage capacity. Salt dome storage is more expensive but offers considerably more flexibility in terms of higher withdrawal and injection rates relative to working gas capacity; base gas requirements are relatively low. The majority of salt cavern storage facilities have been developed in salt dome formations located in the Gulf Coast states.

The owners and/or operators of the facilities are not necessarily the owners of the gas being stored. Indeed, most working gas held in these facilities is under lease by shippers, LDCs, or end users that own the gas. Energy marketers lease storage capacity both to increase the flexibility of products for customers and to enhance profitability (Simmons & Company International, 2000, p. 8). Storage can be used as a real hedge and/or as a financial instrument; over the last few years, NYMEX has developed a liquid futures and options market for US natural gas storage inventories.

The strategic role of storage for seasonal and peak-shaving purposes has been underestimated in many countries. No longer a simple backup inventory or seasonal supply source, storage in the US has become a carefully managed asset. For example, gas utilities may use storage to hedge summer injections and minimize their storage refill costs. The deregulation of underground storage and the growth in gas-fired electricity generation have placed a premium on high-deliverability storage facilities. Many independent storage service providers, who are often smaller and more flexible, have targeted the use of salt formations and other such high deliverability sites. Merchant storage sites are used almost exclusively to serve third-party customers, such as marketers and electricity generators, who can benefit the most from the characteristics of the facilities. The intensification of LNG imports further enhances the strategic role of storage and the magnitude of seasonal arbitrage spreads.

Similar to the pipeline business, opinions are divided on whether storage activities should be regulated by FERC or left exposed to market-based rates. (There are currently 14

[7] FERC has also started to test incentive regulation schemes such as performance-based ratemaking (PBR), in which pipeline companies share efficiency gains with customers via lower prices.

[8] The goal of recent investments was to expand import capacity from Canada. Within the US, priority is given to expanding capacities between the regions of increasing production (Gulf of Mexico, Central Region) and regions of increasing demand (Southwest, Northeast, Midwest, West).

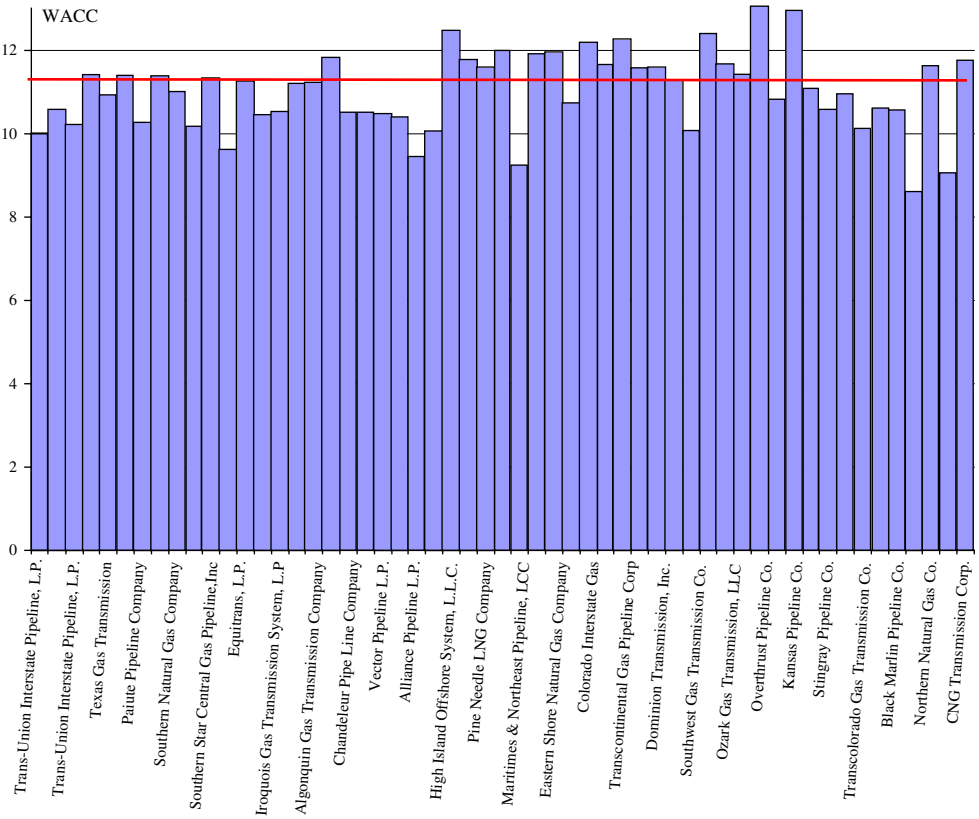

Fig. 2. Regulated rates-of-return for pipeline companies.

larger regulated storage companies, of which 12 are integrated with pipeline operators, and two are independent.)

New recognition of the strategic role of storage has caused FERC to adopt more investment-friendly regulations, largely due to the Western Market Crisis of 2000–2001, higher gas prices since 2004 and growing political awareness of the importance of supply security. One obstacle to storage investment was FERC's narrow interpretation of market power, which prevented storage operators from applying market-based rates. Under EPAct 2005, companies can now set their own rates based on open season and market characteristics which FERC then accepts or modifies accordingly. The Gas Storage Pricing ORDER 678 (of June 19, 2006) (i) expands the definition of the relevant product market to include close substitutes for gas storage services for the authorization of market-based rates; and (ii) implements the new Natural Gas Act Section 4(f), which permits FERC to authorize market-based rates even where an applicant has market power. Current rate policies thus provide more flexibility when designing cost-based rates, negotiated rates, and market-based rates.

6.2. The investment boom in regulated and merchant storage

Investments in the US natural gas sector are booming, now that both interstate storage sites and state storage facilities owned and/or operated by large LDCs, intrastate pipelines, and independents operate on an open-access basis. Storage is used in conjunction with various financial instruments (e.g. futures and options contracts, swaps, etc.) in attempts to benefit from changing market conditions. In the "new" world of commercial storage, players are free to pursue varied investment strategies. Independent storage operators are more interested in high deliverability rates, and therefore invest mainly in salt caverns and high deliverability sites. The largest growth in daily withdrawal capability has been from high deliverability storage sites, which include salt cavern storage reservoirs as well as some depleted oil or gas reservoirs. The largest investment projects in recent years have been concentrated in the Southwest/Gulf Coast area (EIA, 2004).

Since the beginning of 2000, FERC has approved 49 storage projects, and there are 14 storage projects pending. Potential projects total about 107 Bcf of capacity and have a deliverability of 5.3 Bcf per day. The majority of these projects are located in the Gulf Coast region. Further development of storage will also depend on the amount of gas supplies from potential LNG terminals in that region. The changing nature of natural gas storage, which has gone from being a regulated, staid industry to a dynamic, market-oriented industry, in combination with increasing natural gas demand, has led to an upward revision of forecasts for future storage requirements.[9] 210 Bcf are required by 2008, and another 440 Bcf by 2020. Currently, the average size of the approved projects is about

[9] Official FERC projections assume new gas storage requirements in the range of 650 Bcf until 2020 (FERC, 2004, p. 15).

$50 million. This indicates that the barriers to entry are relatively low, and that commercial investment in storage has become a feasible alternative to traditional investment.

The US storage market is well developed and there are no evident shortages that would endanger supply security. Restructuring has changed the perception of storage by the market players, and has fostered independent, merchant-oriented storage operators. Although the ownership of storage capacity remains largely with the interstate pipelines and gas utilities, natural gas marketers now control about one-quarter of the available underground storage capacity through contracts and gas supply asset management agreements. The market has become transparent, favoring further investments by independent companies.

7. Conclusions

Infrastructure regulation and investment have always been controversial issues, and today's debate has lost nothing of its relevance and sharpness. On the contrary, recent discussion about supply security and resource adequacy has revived some of the old arguments, and brought forward new ones. This paper has highlighted the major conceptual disagreements: while the historical regulatory economics approach stressed the danger of overinvestment, current developments in microeconomics and institutional economics place more emphasis on the risks of underinvestment. This is seen most clearly in the theory of investment under uncertainty as applied to infrastructure investment.

We have provided empirical evidence using a case study on infrastructure investments in the US natural gas industry. There is a general consensus that events during the last thirty years transformed the largest natural gas industry in the world into the most competitive as well (IEA, 2002).We observe that restructuring and vertical unbundling went hand-in-hand with significant infrastructure investments. In fact, the greatest (political) obstacle to ensuring resource adequacy and supply security in the US is most likely to be the issue of siting.

The approach and the results cannot be easily transferred to other sectors or countries, but they provide working hypotheses for similar work. Thus, it appears that unbundling can support competitive markets if the infrastructure really becomes a natural monopoly. Opening the upstream and downstream markets to competition favors infrastructure investments. Access regulation does alter the investment behavior of both, the incumbents and the new entrants, through ''more research is needed before the possibilities are fully understood''. (Guthrie, 2006, p. 968). In general, while the investment implications of regulation are better appreciated today than they were a decade ago, clear one-size-fits-all answers are not possible. As Guthrie (2006, p. 969) concludes, more study of regulation and its impact on investment behavior, especially investment timing, is needed.

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