European University Institute

ROBERT SCHUMAN CENTRE FOR ADVANCED STUDIES

EUI WORKING PAPERS

RSCAS 2013/73
Robert Schuman Centre for Advanced Studies
Loyola de Palacio Programme on Energy Policy

Gas Network and Market: à la carte?

Miguel Vazquez, Michelle Hallack and Jean-Michel Glachant

European University Institute
Robert Schuman Centre for Advanced Studies
Loyola de Palacio Programme on Energy Policy

Gas Network and Market: à la carte?

Miguel Vazquez, Michelle Hallack and Jean-Michel Glachant

EUI Working Paper **RSCAS** 2013/73

ISSN 1028-3625

Printed in Italy, September 2013
European University Institute
Badia Fiesolana
I – 50014 San Domenico di Fiesole (FI)
Italy
www.eui.eu/RSCAS/Publications/
www.eui.eu
cadmus.eui.eu

Robert Schuman Centre for Advanced Studies

The Robert Schuman Centre for Advanced Studies (RSCAS), created in 1992 and directed by Brigid Laffan since September 2013, aims to develop inter-disciplinary and comparative research and to promote work on the major issues facing the process of integration and European society.

The Centre is home to a large post-doctoral programme and hosts major research programmes and projects, and a range of working groups and *ad hoc* initiatives. The research agenda is organised around a set of core themes and is continuously evolving, reflecting the changing agenda of European integration and the expanding membership of the European Union.

Details of the research of the Centre can be found on:
http://www.eui.eu/RSCAS/Research/

Research publications take the form of Working Papers, Policy Papers, Distinguished Lectures and books. Most of these are also available on the RSCAS website:
http://www.eui.eu/RSCAS/Publications/

Loyola de Palacio Energy Policy Chair

The Loyola de Palacio Energy Policy Chair was created in October 2008 at the RSCAS in honour of Loyola de Palacio, former Vice President of the European Commission and Commissioner for Energy and Transportation in the Prodi Commission. It promotes research in the area of energy policy. It is funded by contributions from donors. Professor Jean-Michel Glachant is the holder of the Chair.

The Chair focuses on the fields of energy economics, law, regulation, as well as geo-politics. It addresses topics such as the *achievement of the EU internal energy market; sustainable energy systems and the environment; energy security of supply; the EU model of energy regulation; the EU energy competition policy; the EU policy towards carbon free energy systems in 2050.*

The series of working papers aims at disseminating the work of academics on the above-mentioned energy policy issues.

For further information
Loyola de Palacio Energy Policy Chair
Nicole Ahner (scientific coordinator)
Email contact: Nicole.Ahner@eui.eu
Robert Schuman Centre for Advanced Studies
European University Institute
Via delle Fontanelle, 19
I-50016 San Domenico di Fiesole (FI)
Fax: +39055 4685755
http://www.loyola-de-palacio-chair.eu

Abstract

The institutional setting of open gas networks and markets is revealing considerably diverse and diverging roads taken by the US, the EU or Australia. We will show that this is explained by key choices made in the liberalization process. This liberalization is based on a redefinition of the property rights associated with transmission grid usage. That leads to different systems for the transmission services, as well as for the gas commodity trade, which in turn depends on the network services to get any market deal actually implemented. Not only do those choices depend on the physical architecture of the network, but also the perceived difficulties and costs to coordinate the actual transmission services through certain market arrangements.

Keywords

Network regulation, gas market, property rights, carriage systems.

1. Introduction

Natural gas market arrangements are characterized by considerably diverse institutional frames. Initially, one would observe that transmission infrastructures are correspondingly diverse, so that it may be concluded that infrastructures determine the best institutional frame for each variant of market arrangements. It is true that gas diversity is quite related to the network architecture. However, as we will show, it does not depend just on the physical architecture of the transmission system. It also depends on the economic mechanisms chosen to coordinate the transmission services and the gas market trade (Glachant, Hallack and Vazquez 2013).

Natural gas is characterized by a relatively low calorific value per cubic meter, which makes cheaper transporting it under pressure using large infrastructures. Hence, the physical architecture of such transmission grids define how specific the infrastructure is, and this in turn helps define the type of economic organization that might be found in the industry. The specificity of assets in gas industries has been extensively discussed by the literature, (Correljé, Groenleer, and Veldman 2013), (Creti and Villeneuve 2004), (Hubbard and Weiner 1991), and (Masten and Crocker 1985). Of course the degree of development of such infrastructures affects those physical characteristics and the potential choices for market arrangements.

For instance, a transmission system made up of a single pipeline that links two points is quite specific, as all transactions then depend on the precise coordination between a very small number of players (let say: the supplier, the transporter, and the consumer). This is a typical situation for a transmission system in its first steps of development, where users are placed close to a unique supply point (that can be a production field, a LNG regasification facility or a large pipeline). In this case, vertical (or quasi-vertical) integration is used to make the system work.

Later on, with a gas system where the consumers and suppliers are diverse and can be connected to different transmission routes, gas transactions become less specific. This is typical of more developed transmission systems, where the transmission infrastructure is a meshed set of pipelines, compressors, storage facilities, etc. In this case, two different coordination mechanisms may be used. First, the pipelines usage coordination may be done by the shippers (buying and combining by themselves different transmission services in different pipelines). Second the pipelines usage coordination may be done centrally for a given network of pipelines and put under an umbrella called "entire network services" (e.g. shippers may buy a "multiple pipeline" service –hence a "network" service- instead of collecting one by one each individual pipeline service).

In this schematic world one understands very well why a young gas system such as the Brazilian one (a simple Y network) does not work like the gigantic cobweb of the USA. However this rationale scheme does not allow any room for the actual EU or Australia gas systems to exist. If we focus on understanding the differences among the existing kinds of open markets (being in this paper the US, the EU and Australia), the infrastructure key role does not come only from the naked architecture of the gas grid but from the institutional structure of gas trade rooted in network access rights given to market players. Our analysis therefore has to concentrate on how gas markets have been open with a definition of open access rights. This plays a role as important as the physical architecture of the set of transmission assets.

After this introduction, in section 2 we will show that the understanding of existing gas market arrangements requires a dedicated level of analysis being called the "contractual level" where open access rights are defined. Section 3 develops a theoretical framework for this analysis. Section 4 claims that the way in which open access is granted becomes the primary decision into the building of gas markets. It also shows in turn that considering different access features creates different trading places. Section 5 and 6 illustrate the previous analysis in the context of the US, UK, Australia

(Victoria) and Brazil gas markets, from both the short-term and from the long-term point of view. The last section concludes.

2. The key "contractual level": access rights to "single pipelines" or "entire networks"?

Considering the physical architecture of a gas grid, it should be simple to choose the best among the more integrated and the more decentralized institutional frameworks. In general terms, the higher the specificity of transmission assets, the higher the need for vertically integrated solutions –involving some hierarchy (some command and control). For instance, Brazil has a relatively small gas industry (even if quickly growing), with a big Y-shaped pipeline linking the South, Northeast and Central regions. In contrast, another continental state such as the United States, the network presents as a considerably meshed cobweb. Some points in this web may be intersections of more than 10 pipelines (e.g. Henry Hub in Louisiana), so the needs for quasi-vertical integration should be lower there.

While very likely, this reasoning does not explain the diversity of coordination mechanisms used to support gas trade in open markets. For instance, this does not consider the actual UK coordination mechanism, as well as the other European countries or Australia, differing from both Brazil and the US.

To fully address the different institutional frames supporting open gas markets, we need another level of analysis which is the contractual level: the way the transmission services are defined, measured, implemented and settled among players. In other words the key question here is to define how the gas network is to be used vis-à-vis the gas trade in the wholesale market[1].

The European approach (see for instance (Newberry 2002)) considers that all sets of multiple infrastructures used to transport gas in a trade zone work as a single "gas network" delivering to market players comprehensive "network services" covering all their trade zone. In order to trade gas in this zone, players simply have to "enter" that gas system. Parallel to the rule of "entire network" usage, Britons, as Europeans, keep their gas grids organized as franchised monopolies called "Transmission System Operators". At this point a large part of the institutional setting in the industry is already decided: "entire network services" + franchised monopoly. The operation of this typically European network monopoly (which works as an essential facility for the gas market) is of course duly regulated with an explicit and detailed network code. As for Australia, the network (the set of infrastructures) in Victoria is also a monopoly. Key transmission use rules in Australian are determined by a public authority being the gas market operator. In Australia, the existence of a set of network rules characteristic of the EU system is substituted by a right given to the gas market over the network services (Ruff 2012). However, franchised or not, gas transmission is not necessarily a natural monopoly. On the contrary, the modern US view (started by (Kahn 1988)[2] and continued by (Makholm 2012)) considers each pipeline of the gas system as an independent facility, and thus one may easily open competition among alternative pipelines as a market for transmission alternatives which becomes a relevant force for the coordination of the industry.

It is still true that transporting a given amount of gas from a single point A (say a gas field) to a single point B (say a country gate) will be even more economical if a single pipe line is built and operated. But this property of natural monopoly is attached to a "single entry point"/"single exit point" transportation facility. As demand for gas grows significantly various producers may enter the game upstream (opening new entry points) and several gates may pop up in the country (opening new exit points). The bigger the demand, the more likely it is to have a multi-entry/multi-exit network. A single

---

1 Loosely, the intuition behind the concept of "network industry" can be thought of as industries with activities that involve the interaction of many individuals (see for instance (Shy 2001) for a proposal of definition).

2 As (Kahn 1988) highlights, if one chooses a certain point in time, we may be able to define an optimum for the network design as if there were no infrastructure. However, one does need to consider the existent infrastructure.

and bigger infrastructure is certainly always more efficient where scale economies dominate the transportation game. But when a second or a third pipeline is constructed, it may have a different owner and hence may break the former monopoly (as in the famous German case Wintershall / Bayer). The monopoly rationale for gas pipelines may end at any time either because of routes alternatives or new infrastructure development undertaken at different periods inside more mature and better connected grids. Nevertheless, if the whole gas transmission system is defined and managed as an "entire network" (as in the EU and Victoria) every new investment might have to join this network cobweb and thus to maintain the franchised monopoly effect. It is much more difficult for an investor to challenge an "entire network" (like in the EU) that an isolated "single pipeline" (like in the US).

The differences of efficiency between competitive transmission infrastructures (as single pipelines) and franchised monopolies (as entire networks) depend on the particular costs of coordination[3] in each case. One should reinterpret the Williamsonian "make-or-buy" decision here as a decision based on the coordination of the transmission services delivered by individual pipelines through either decentralized or centralized decisions. Hence, in the analysis of the institutional foundations of gas markets arrangements, the characteristics of gas grids as "networks" are not only derived from their physical architecture, but from decisions framing the network and the market arrangements. Understanding how this occurs and studying how consequential it is is the aim of our paper.

3. Defining a trading system

The next step in our reasoning is to better disentangle the physical and the institutional foundations of open gas markets. In this regard, one might notice that gas transmission grids are characterized by a number of tight technical constraints. Consequently, the transmission services offered to the users by a transporter have several economic specificities. These transmission services are notably "site-specific" (gas flows only in a given gas pipe with no alternative as long as it cannot exit it) as well as "dedicated", meaning as soon as a gas pipe is dimensioned for future gas flows its size is adjusted to the contracted gas flows. Therefore the economics of this gas pipe cannot stay independent from significant changes affecting the contracted flows: the pipe is thus "dedicated" to these flows. Therefore, the contracting architecture that is required to trade and to deliver the gas commodity at different network points and time horizons must necessarily be critical. This can only be seen as an important source of transaction costs. In such an industry the players identity matters and a tendency towards long-term bilateral contracts and vertical integration is expected, see (Williamson 1975) or (Williamson 1985). However it is also true, as shown by (Riordan and Williamson 1985) in a general context, that asset specificity is ultimately a design variable, and it is frequently possible to reduce that specificity at the cost of reducing efficiency. The contractual frame as well as the physical architecture may then vary.

In the context of network industries, reducing asset specificity by design may be viewed as a central idea behind the proposal in (Joskow and Schmalensee 1983) for building the first open power markets. As not all activities in the network industry chain share the same transactional characteristics, some of them should be easier to manage through market arrangements than others. Consequently, one may think of an industry design where some activities are organized with new market arrangements and others with a still centralized command and control. In other words: where to put the border in between?

Creating market arrangements aims at building a comprehensive trade system. (Brousseau and Glachant 2013) identify three key elements in the creation of a trading system: definition of the characteristics of the product; measurement metrics of these characteristics; and registry of the

[3] As opposed to the electricity network, all the externalities of gas transmission are physically controllable, so it is possible to be internalized. However, the costs of internalizing this externalities can be considered higher than the benefits, (Hallack and Vazquez 2013).

property right positions among buyers and sellers. Thus, the creation of a trade system within a gas transmission system requires a definition of the characteristics of the transmission services measurement of the characteristics of the services being delivered and registration of the property right positions of the market players. These elements are not always very strictly defined in an exclusive and rival individual frame of rights. Typically, in the gas industry, the existence of few big infrastructures to be shared by many is efficient, in the sense that it is the cheapest solution. However, actions taken there by one individual might affect the other users of the same infrastructure. In this regard, two issues needs to be taken into account: congestion and its opposite, access[4]. A congestion of infrastructure arises when the maximum volume of services that the infrastructure may offer is reached. In practice the gas flows from a higher-pressure point to a lower-pressure point, both limited by technical characteristics of the pipeline. Particular usages of the flow of transmission services by certain players may even decrease the total amount of available services in a given period: rivalry among players can then be high or very high.

On the other hand, it is always doable to exclude certain individuals from using certain infrastructures. But typically in the EU the liberalization of gas industries started by opening access to all for all transmission infrastructures. As explained by theoreticians of the commons as (Ostrom and Hess 2007), open access is frequently a conscious public policy to avoid exclusion of any into the use of a common resource. That is also the case of many industries depending on large infrastructures. Although the precise meaning of an “open-access” is quite diverse, all variants share the characteristic that the infrastructure owner has no right to discriminate among potential users, and should allow the large number to access the infrastructure[5].

Therefore, despite some variants in the implementation of open access, open access is characterized by the choice of making it difficult to exclude players from accessing the transmission grids. If some type of exclusion is made feasible, however, its actual definition and implementation are the main drivers of the institutional diversity found in open gas markets and networks. The following sections are devoted to describing these key characteristics of gas liberalization alternatives.

4. Opening a market: changing the frame of property rights

To understand the actual design of gas markets, it is key to analyzing the arrangements conceived to coordinate the corresponding transmission services. There is no market trade possible if the transmission facilities do not deliver the transmission services corresponding to each trade.

In liberalized markets, even an “entire network” cannot give unlimited rights to users because of its own asset specificity. However, the transmission services being offered may be more or less flexible (notably regarding the timing and the location of gas entry and exit). Furthermore, the way to offer these transmission services may be more or less competitive: do alternative users and usages actually compete with each other to get access? In fact, the rights to conceive and package the services offered and the rights to use them significantly change depending on the carriage system being used. There is no universal organization of access to transmission in liberalized markets. Of course transmission services with badly defined rights should increase transaction costs and decrease market efficiency in

[4] This can be put in terms of excludability and rival goods as defined by (Samuelson 1954) and (Musgrave 1959). The congestion shows that it is a kind of rival good, as the use of the pipeline by a shipper impacts the use of the other players. The access is the face of excludability, the exclusion to access or the restriction of accessing a service can be higher or lower depending on the regulatory framework. (Ostrom 2009) defined these concepts as subtractablity and excludability).

[5] The differences in open access in gas network can be found in (Hallack and Vazquez 2012).

the allocation of available resources[6]. Thus, it is important to identify what the rights being given in any infrastructure access regime are.

As defined by (Ostrom and Hess 2007), property rights delineate the range of actions that individuals can take regarding an asset. In the open access of pipelines several dimensions of property rights are to be dealt with. They may give rights in different ways: access, withdrawal, management, exclusion and alienation[7]. In completely private pipelines, all these rights are initially allocated to the same agent: the owner. As a non-regulated private owner, he has all the rights to access its property, to use it, to manage it, to exclude others in the usage and also the ultimate right to sell (to transfer) this set of rights to others. On the contrary, with open access rights being equally given to all potential users, the same bundle of transmission rights is allocated from the start among independent players, that is, all the potential users plus the regulated owner[8]. For the potential users “Open Access” is a right to access the transmission facility: a right to be connected to and to become a user. But it does not tell yet what the actual rights to consume the transmission services will be. The right to access is an ex ante right to a connection. The right to use is only ex post. It is a consumption right to withdraw units of transmission services taken from the resources offered by the pipe operator. Symmetric to the user rights, there is an “exclusion” right given to the transmission operator which mirrors the withdrawal right of the users. It is the transmission operator who defines how the network is operated and the actual way in which the usage rights are going to be defined, allocated and transferred among shippers.

The definition of open access is a central element in the organization of any open market. To give open access, a first decision is to choose between “common carriage” and “contract carriage”. Common and contract carriages are two alternative systems defining the basic usage of infrastructures. The key element is the way in which both access systems define the withdrawal rights and the exclusion rights for the users and the operator. In the common carriage system (typically the EU), a withdrawal right is assigned to all potential users but its actual content is to be determined by the operator’s exclusion right. Hence, withdrawal rights assigned to a certain user do not give any guarantee of excluding other shippers for the same usage. Conversely, in contract carriage (the US), each withdrawal right is pretty well defined ex ante and it actually excludes other players to compete ex post for this very same usage. Besides, these rights are also well defined transmission goods that can be traded among shippers in a transmission secondary market.

The key analytical features there are, first, who defines the transmission services and second, how is the operational content of the withdrawal rights defined? The transmission services units offered by the pipelines may be more or less flexible, i.e. with a precise or a loose definition of how to use the infrastructure.

Hence, the definition of these property rights introduces a design variable. If the trade system is implemented by contract carriage, the ultimate combination of all the usage rights is defined through shippers’ negotiations. As shippers have well defined primary rights from the beginning, they can re-sell and re-combine them as they wish. These precise primary rights are defined ex ante and implemented ex post by the pipeline owner acting as a third party vis-à-vis the buying and the selling shippers. It is this neutral player who has the right (confirmed by the federal regulator FERC) to

[6] The works of (Demsetz 1967), (Cheung 1970), (Barzel 1982), (Libecap 1986) provide the foundations to understand the relationship between transaction cost and property rights theory.

[7] (Schlager and Ostrom 1992) identified these five different property rights.

[8] Alternatively, one might consider that gas networks are made up at least of two different products: the resource system (the infrastructure facility) and the flow of resource units, i.e. the services that the system provides, (Ostrom and Hess 2007).

decide how to design the initial property rights for users. For instance, it defines the available capacity; this includes rules ranging from congestion management to the amount of line-pack use[9].

However, from the incentive point of view, primary rights defined ex ante by a third party decrease the incentive to improve the ex post operation efficiency of this party[10]. It is obvious that each pipeline owner cannot be concerned ex ante by the ex post efficiency of the entire system of all the independent pipelines. However, in contract carriage systems, competition among shippers could push to recuperate parts of the system efficiency, incurring lower transaction costs. Moreover, as contract carriages enjoy strong property rights, the ex-ante incentives for assets owners to invest are high. Altogether contract carriages do not allow a reduction of transaction costs in the ex post operation of the entire system of pipelines, they may benefit from a stronger set of incentives to invest in new individual pipelines competing with the already existing ones. In the next section these properties will be analyzed with a study of international experience.

5. The diversity of gas markets foundations: Network access in practice

In this first part of the international experience review, we will look at network access schemes. Access to networks may have different meanings depending on the rules of use. We may classify the different sets of rules under two broad headings: the mechanism to allocate rights of using the transmission services, and the definition of the transmission service characteristics (for instance where and when the contracted gas is injected in and withdrawn from the pipe).

5.1 Allocation mechanisms: the implicit and the explicit

In an implicit allocation mechanism, the transmission rights are given according to a merit order established in the wholesale gas market, so the transmission services are implicitly included into the gas market trade. Implicit mechanisms are already well-established in the EU electricity industry, as well as in economic theory (Schweppe et al. 1988). In that implicit mechanism, the dispatch of electricity production depends on both the power producers' bids and network constraints. However, the methods to allocate network costs to network users may diverge, from cost socialization among users (typically European) to models that allocate these costs to users according to their localization (as PJM). Implicit allocation is supposed to ensure the efficient use of the network in the short term as players need only worry about the commodity market. In the gas industry, the logic behind the Victoria gas market model is implicit[11].

Oppositely, in an explicit allocation mechanism, there is a separated market where the allocation, pricing and trade of the transmission services are made independently from the commodity market. It is up to the traders to see how to coordinate their positions into the two independent markets. The US can be seen as the most representative model of this kind of mechanism, as the rights to access pipelines are separated ex ante from the actual trade of the commodity in the gas market. That is, gas wholesale prices do not define who is entitled to use the infrastructure. It is absolutely contrary to the Victoria gas market model where the market clearing algorithm decides who will flow his gas through an optimization of the use of the "entire network" infrastructure among all bidding shippers.

---

9 One example of this kind of rule constraining the amount of line-pack that can be used by the pipeline operator is implemented in the UK.

10 In the UK some regulatory incentives to increase operational efficiency have been utilized, and they try to recover the economic incentives to improve operational efficiency.

11 (Ruff 2012) describes the clearing mechanism as a model that could optimize up to 24 hours period each day. It takes into account the ability to transport and to store inside the line-pack in order to determine amounts of shadow prices of gas withdrawal at multiple locations. Even if it may have potentially strict constraints of time and localization, the gas market in Victoria is currently unconstrained.

For the sake of illustration, consider two players, A and B, that want to carry gas to C by using a pipeline with capacity to carry just the amount equivalent to one of the players' volume. In the Victoria implicit access model, the gas carried will be the cheapest offered. In the US model, it will depend on who has bought the right ex ante to carry his gas. If this right is owned by the player with the most expensive commodity offer, both the expensive and the cheap players may bilaterally negotiate for the gas itself (before entering the pipeline) or for the right to use the pipeline. If it is made in a significant hub, this ex-post bargaining of access rights might become multilateral. However the bargain in that type of secondary market will never calculate how to optimize the "entire network". It only spots what is feasible between one buyer and one seller.

When it comes to the UK, the mechanism seems at first glance to be an explicit allocation of transmission services. In order to transport and trade gas, players in the UK need to have the right to use the system, which is made up of two rights: the right to enter and the right to exit. Hence, in order to carry gas from A to B, it is necessary to have two complementary rights: the right to enter in A and to exit in B. With a wider view of these rights, we nevertheless find significant differences to the US model. The first regards the role of the network operator in the case of congestion. In practice -in the UK transmission services- one strongly simplifies the physical characteristics of the network and the rights of using the system are allocated according to a model of expected flows through the "entire network". Consequently, actual flows often do not correspond to the expected flows and action by the system operator is needed. One of the most commented tools for the operator to manage the actual flows is buying or selling gas. When doing so, the actual use of the network is re-integrated into the gas commodity market. So while transmission rights are allocated explicitly, they are still in practice allocated according to a simplified contract that the system operator keeps under control according to the actual "entire network" flows.[12]

In Brazil the rights of use are designed closer to the US model, where shippers must contract for transmission capacity in a separated contract and with separated pricing. In practice the absence of competitive players and alternative transmission routes made this model appropriate because of its simplicity. Currently, with the potential increase of players and the potential development of new capacity, a set of regulatory changes are being discussed, and some proposals are based on a mechanism of allocation derived from a simplified network modeling with a model closer to that of the UK.

5.2 What is allocated: Flexibility

Transmission services have two key dimensions that strongly impact the gas market: the spatial and temporal dimensions. They define the place and time of gas market trade, i.e. where and when alternative gas trades can be considered as the same product. The larger the area of injection/withdrawal and its time frame, the higher the liquidity (by increasing the number of players and of deals in the same market). However the more the gas traded in the market differs from the actual flows in the network, the more the gas system operator has to offer ancillary transmission services to reconcile the virtual market trade and the actual network flows. (Vazquez, Hallack, and Glachant 2012).

The temporal characteristics of the transmission service depend on the time lag allowed for gas injection and gas withdrawal. Players may be allowed to inject into and withdraw from the system at different time horizons without affecting the market characteristics and value of their trades. In such a market & network arrangement, the temporal specificity of the gas flow can be decreased to ease trade.

[12] For more about the simplification of the network on the entry-exit model with virtual hub, see (Hallack and Vazquez 2013) and (Vazquez, Hallack, and Glachant 2012).

The spatial characteristics of transmission services draw the set of grid points where users may inject and withdraw after having bought a standard transmission service, that is, the set of points where the shipper may trade without any extra costs. It literally draws the limits of the market. In such market/network arrangements, the spatial specificities of gas may be decreased by giving the traders rights to homogeneously operate in larger zones. It decreases the transaction costs associated with trading gas at different locations. Correspondingly, transmission services may be defined the same for all different feasible physical paths, so the transaction costs associated with tailoring transport services are decreased from the traders' point of view.

This is what the UK's 'virtual hub' provides to gas trade. It builds a virtual place of trade where any point connected to the physical "entire network" is treated as part of the same virtual hub. Besides, the daily balancing principle allows players to keep their injections and withdrawals unbalanced until the end of the gas day, i.e. it allows players to buy and sell intraday gas within the day to cover for their imbalances. Notice that this does not mean that the gas price is the same throughout the day (as players' expectations may change), but it does mean that the gas having been nominated for transmission one day ahead can be acquired in the different hours of the day with no other cost that its market price.

In the Victoria system there is also a single gas price for all locations and for the entire day. If unexpected congestion occurs, the system operator re-schedules the flows and makes ancillary payments (based on market bids) to the shippers concerned. In the Brazilian network, until now, there has been only a low level of simplification benefiting to gas trade. This low favor for trade can be understood by the crude topology of the network (a mere Y). Until now, the localization of the transmission services being offered is determined by contract and all changes in flow localization call for a renegotiation of these contracts. However, renegotiation in Brazil is especially easy as there is just one main shipper (Petrobras), so renegotiation and adaptation among shippers can be seen as an internal decision. For temporal simplifications Petrobras uses the flexibility of the supply contract unless the system is at full[13]. In the US, the spatial and temporal characteristics of the transmission services offered are defined ex ante by the contract terms and conditions. As the contractual frame is set up pipeline by pipeline, with no "entire network" effect taken into account, the spatial flexibility of transmission and trade is low to very low. Frequently the contracts are defined point- to-point. But contracts from a set of entry points to a set of exit points (usually in the same region) also exist. Notice that in the US, transmission services with higher flexibility (taking into account a set of points) frequently have higher costs than point-to-point. The standard contracts also define the temporal characteristics of injection and withdrawal. The only restriction imposed by FERC is that if the pipelines do not allow significant time flexibility to the shippers, they must offer them the opportunity to buy some other complementary transmission services [14] (FERC 2008).

[13] It became an anti-trust case in Brazil in 1998 when Petrobras was using part of the pipeline to store gas (by line-pack) and another company (British Gas) asked for available capacity. For details see CADE (1998).

[14] We do not have data regarding what the rate of pipelines is offering higher and lower temporal flexibility (higher timing difference between injection and withdrawal). What we observe is the increased offer of services of flexibility in US, for some examples of services and related data see (Hallack 2011), chapter 6.

Table 1 - Network access: comparison of cases studies

	Allocation of the transmission rights	Spatial characteristic of transmission services	Temporal characteristic of transmission services
United States	Explicit	Heterogeneous with low level of simplification	Heterogeneous with different levels of simplification
United Kingdom	Explicit (with some degree of implicit allocation)	Homogenous and simplified	Homogenous and simplified
Victoria (Australia)	Implicit	Homogenous and simplified	Homogenous and simplified
Brazil	Explicit	Homogenous with low level of simplification	Homogenous with high level of simplification

Source: Authors elaboration

These examples show how the network access may be allocated in different ways and based on different rules of use. These access features are key elements for defining the functioning of the gas market in each country as it defines what is traded as much as where and when. Defining the transmission services allocation process and its temporal and spatial characteristics means defining a substantial part of the market design.

6. The diversity of gas market developments: network investment processes

The use of transmission capacity is central to trade among market players. The development of the infrastructure moves the foundations of this market while keeping the pre-existing infrastructures in action. The investment mechanism may be defined in different ways. Part of this definition depends on how the network is already being used or will be used in the future because in turn it impacts the expectations about the feasible future use of the new infrastructure. Besides, the investment mechanism also depends on the definition of who has the right to decide (how much capacity, where, when, etc.). The third key element is the allocation of the investment risk.

There are two extreme processes to decide about investment: decentralized shippers can demand capacity and routes and commit to use the new infrastructures as this will back an investment to be made by an investor, or a central planer makes flow forecasts according to scenarios and decides on the necessary investments to optimize the forecasted gas system.

Let start by comparing the US and Victoria (Australia) models, the former being an example of investment based on shippers contracts and the latter of a central plan. In the US, all transmission contracts are negotiated between the investor and the shippers and tariffs and settled according to the cost of service (depending on the pipeline costs and the characteristics of the service contracted). The construction of any new pipeline requires a certificate of "Public Convenience and Necessity", which allows the federal regulator to oversee if competition is not raising some economic inefficiencies and too highly-fixed-cost businesses[15]. One of the main proofs of the economic convenience and necessity of a pipeline is the commitment of shippers' demand. In the 2000's, FERC started to accept that pipeline investors could also bear a part of the utilization risk in order to build more capacity to be sold in the future. For this purpose, pipeline owners must guarantee that the costs will not be socialized among the different waves of customers[16]. The procedure for approval of new pipelines is

15 (Kahn 1988) has a nice example of gain of economy efficiency by merging two different pipeline projects in the US.

16 "In the Policy Statement, the Commission explained that as the natural gas marketplace has changed, the Commission's traditional factors for establishing the need for a project, such as contracts and precedent agreements, may no longer be a sufficient indicator that a project is in the public convenience and necessity. The Commission, therefore, changed its

formalized. Proponents must declare an "open season" where users are invited to seek capacity (still without a price)[17]. Initially, in the US model, the right to decide on investments was in the hands of pipelines. However, in order to have the authorization of investment, it is necessary for them to get the firm commitment of the shippers. Hence, the right to decide on investments ultimately depends on a negotiation among the users and the pipeline promoters. On the other hand, players negotiating over investments are also the ones who must bear the risk. One of the main principles of FERC is to avoid cross-subsidies among users, especially between the shippers using existent capacity and the shippers committing to added capacity. Thus, each new investment needs to be fully paid by the buyers of the new transmission services offered by the new infrastructure. Of course, the present use of existing pipelines impacts the investment decision through shippers' willingness to buy new transmission services. If shippers are willing to buy more transmission services and are not able to find them in the secondary market[18], they are inclined to look for new investments, as is frequently the case because the existing infrastructure has already allocated all its transmission services to its existing shippers. The process of investment in the US is a consequence of the well-defined property rights on the transmission services: its famous "single pipeline contract" (Makholm 2012)[19].

The other extreme case is the Victoria model (in Australia[20]), where transmission services are allocated according to market gas prices differences. In this model, one cannot ask shippers about the capacity to be used in the future as shippers cannot decide on the actual use of the "entire network" capacity. Thus, the investment plan is made by a central planner. It is the market operator, the publicly owned Australian Energy Market Operator (AEMO), which[21] determines the quantities the pipelines might carry and the amount of gas to be stored inside these pipelines. By changing their inside pressure the pipes can store more or less gas, called the "line-pack"[22] . Moreover, AEMO is responsible for determining whether the capacity should be expanded, (Moran 2002). The network investment is driven by this government agency that takes into account the current use of the network and various scenarios forecasting the future of the gas market. The risks are nevertheless borne by all the shippers and put into the network tariffs.

(Contd.)

policy regarding the pricing of construction projects so that market decisions by pipelines and shippers, as opposed to regulatory tests, would better reveal whether there is sufficient support for the project and whether the project is financially viable. The Commission established a threshold requirement that the pipeline must be prepared to financially support the project without subsidy from its existing shippers. This will usually mean that the pipeline would have to price the project using incremental rates in which the full costs of the project are recovered solely from the shippers subscribing to the new capacity. Under this policy, the pipeline and its expansion customers could share the risks of the project, but they could not shift any of those risks onto existing customers." (FERC, 2000, p. 3) http://www.ferc.gov/legal/maj-ord-reg/PL99-3-001.pdf

17 There is an initial tariff proposed by the pipeline which is reviewed after the investment (plus a test period). The pipelines must publish rates for firm carriage and rates for interruptible service. Tariff rates must be approved by FERC and are normally strictly in line with costs, which are full costs in the case of firm access and operating costs for interruptible service. The US approach effectively transfers the equity in the pipeline to the firm capacity holders.

18 Note that US shippers (owning the right to transport gas) have the right to trade their capacity on the secondary market, where the price is not regulated.

19 The USA carriage system is frequently called contract carriage, in the sense that the shippers´ rights and duties depends on the contract.

20 In Australia the National Gas Law and Rules set out regulatory framework for the gas pipeline sector. The AER (Australian Energy Regulator) regulates pipelines in jurisdictions others than Western Australia. The pipelines can be regulated or not and among the regulated different models (and level of regulation) are applied. The Victorian Transmission System has been regulated since 1997.

21 The Australian Energy Market Operator (AEMO) was created by the Council of Australian Governments (COAG) and developed under the guidance of the Ministerial Council on Energy (MCE). AEMO is responsible for guaranteeing the electricity and gas market functions, NEM National Electricity Market) system operations, management of Victoria's gas transmission network and national transmission planning.

22 The carriage system observed in Victoria (Australia) is called market carriage, as the rights and duties depend on the gas market. And on the investment decision side, the decision has a big hand in the gas market operator forecast.

In the UK, the investment decision may come from both centralized and decentralized mechanisms. The centralized mechanism is traditional and the most important one.[23] The network owner and operator (National Grid) propose a development plan to the regulator. If accepted, the assets are introduced into the regulated asset base and for the allowed revenue to be recovered by the transmission tariffs. However, because this planning process lacks of incentives to always build an efficient network, the UK process includes some commitment of the users. This commitment is implemented through auctions of entry capacity. Nevertheless, the UK model does not mimic that of the US for two reasons. On the one hand, this entry capacity does not give strong property rights over the use of the capacity[24]. On the other hand, the capacity built is not strictly the amount committed by shippers. In that process, a risk is still borne by all shippers through tariffs of the future.

Table 2 - Network investment: comparison

	Who drives the investment?	**Who bears the investment risk?**	**How uses impact on investment decision?**
United States	Investors and Shippers	Shippers committed to the new capacity	Through the shippers willingness to contract
United Kingdom	Government agency (+ mechanism to grasp at shippers information)	All network users[25]	Through the network development plan
Victoria	Government agency	All network users[26]	Through the network development plan
Brazil	Government agency (+ mechanism to grasp at shippers information)	Shippers committed to the new capacity (until now)	Through the network development plan and existing contracts

Source: Authors elaboration

In Brazil, network development until the Gas Law in 2009 was mainly based on contracts, as in the US. Forecasts, risks and duties were placed in the shippers' and pipeline owners' hands. With the new law, the government takes over (through the public agency EPE[27]) the planning of network development. The objective is said to be to promote investment, but it is still unclear how it will effectively work, who will actually bear the risk and how the actual use will affect network development.

The transmission investment is at the core of network development and of market enhancement. The mechanisms used in deciding on investment are quite different in these countries. The role of shippers, pipelines owners and central planners in deciding the investment and bearing the risks are also much contrasted. It goes from a public choice supposed to look at everything ex ante but puts all

---

23 The carriage system in UK is frequently called regulated carriage system, where the rights and duties of shippers depend on a set of rules (network code).

24 Entry capacity is separated from the exit capacity as explained above, so the actual path that the shipper may use can change. There is a model forecasting the demand/offer and flows, but it brings us back to the centralized model.

25 The regulator determines how to share the cost among all the users through tariffs definition. Different participation in the costs can be allocated among a set of sippers according to the tariffs structures. For instance, one possible choice could be set to zero participation in the cost allocation for some subset of users.

26 The regulator determines how to share the cost among all the users through tariffs definition. Different participation in the costs can be allocated among set of sippers according to the tariffs structures. For instance, one possible choice could be set to zero participation in the cost allocation for some subset of users.

27 Empresa de Planejamento Energético.

the ex post risks on all future users to a private choice with all risks borne by decision-makers always ignoring the system effects of their private choice.

7. Final remarks

The gas transmission system can be a natural monopoly here or there, but not necessarily. It depends, on the one hand, on the architecture of the gas network, and on the other on the trade system implemented. Observing several cases of liberalization in the gas industry, one observes significantly different choices in the design and implementation of trading arrangements. Of course one common feature of all liberalized gas industries is open access. Open access may have different practical shapes, but in all the cases it means a rearrangement of pipelines property rights. In an open access regime, the pipeline owner cannot discriminate anyone anymore asking in due time to use the network paying the price. The mechanisms implementing open access rights are actually the roots of the diversity of designs, which then seems an "à la carte" policy. The gas trade –i.e. selling/buying gas- is utterly dependent on the way gas has to be injected and withdrawn from the transmission infrastructure. On the one hand this dependence comes from the architecture of the existing infrastructure. On the other hand this also depends on the rights given to shippers to use the infrastructure they have access to.

In the US each pipeline sells its long term contracts of point to point transportation. It is up to the buyers and the sellers to combine their several point to point contracts into something more flexible to enlarge their trade with other players. Here market players can create secondary markets among them, organized or with brokers. However, the primary transportation contract is itself still rigid (or "well defined"), conceived as a long term "point to point" contract. All reconfigurations of the set of existing transport contract obligations are on the sole responsibility of buyers and sellers. They draw their own arrangements and bear the transaction costs that each type of new transaction occurs. They hence trade what is feasible according to the transaction costs of their transport contracts reconfiguration.

In the EU the pipelines also sold long term point to point transportation contracts for decades as it worked so well with long term gas buying contracts upstream and franchise distribution monopolies downstream. When time came to open a European-wide market for gas, substantial parts of the former monopolized regime were still in place, such as upstream long term gas contracts and long distance transportation contracts. However, the EU did look for a new common open market arrangement which had to "Europeanise" the national markets. The choice made has been to create several trading zones all over Europe corresponding to a socialization of transaction costs inside the zones and a bidding mechanism to cross the zones (hence called "Entry/Exit" system). Inside the zones any gas arriving at an entry point is said to have arrived everywhere in this zone. There is no transaction cost for the buyer and the seller. Of course it is not true from the point of view of gas flows. The EU reform then also created gas system operators which are regulated entities obeying a vast set of directives, regulations, codes and laws and are responsible for the reconciliation between the virtual market trade and the actual gas flows.

The Brazilian model has features close to the US system. However in the last years policy-makers have been increasingly worried about the lack of entry in the market and liquidity in the offer of transmission services. Thus, they are considering changing the system and traveling the path set by European design. In Australia, the Victoria model is closer to a typical power market design than to any other gas market. This model prioritizes efficiency in the short-term allocation of capacity according to commodity price differences (efficiency is defined as allocating capacity to whom values the commodity the most). Here the right to use the transmission service directly depends on the commodity market. We may consider this as the opposite to the US model, as the transmission service in Victoria is not a well-defined, tradable and separated product. However, as the right is allocated according to a liquid gas market, it guarantees that the gas market being efficient will be the short term capacity allocation. On the contrary, incentives to invest in new capacity are weaker as transmission property rights are weaker for shippers in the long run.

The European Union has copied the UK system of trading zones, socialized transaction costs, dominance of a franchised system operator and weak individual transmission property rights for shippers. The world of open gas markets and open access to the transmission assets still do not converge into a common set of rules and of economic properties. It is still a market world “à la carte”.

References

Barzel, Yoram. 1982. "Measurement Cost and the Organization of Markets." *Journal of Law and Economics* 25 (1): 27–48.

Brosseau, Eric, and Jean-Michel Glachant. 2013. *Manufacturing Markets : Legal, Political and Economic Dynamics*. Cambridge University Press (Forthcoming).

Cheung, Steven NS. 1970. "The Structure of a Contract and the Theory of a Non-exclusive Resource." *Journal of Law and Economics*: 49–70.

Correljé, Aad, Martijn Groenleer, and Jasper Veldman. 2013. "Understanding Institutional Change : the Development of Institutions for the Regulation of Natural Gas Transportation Systems in the US and the EU". Working Paper. http://cadmus.eui.eu/handle/1814/26057.

Creti, Anna, and Bertrand Villeneuve. 2004. "Longterm Contracts and Take-or-Pay Clauses in Natural Gas Markets." *Energy Studies Review* 13 (1): 1.

Demsetz, Harold. 1967. "Toward a Theory of Property Rights." *The American Economic Review* 57 (2): 347–359.

FERC. 2008. "Order 712."

Glachant Jean-Michel, Hallack Michelle and Miguel Vazquez 2013 . Building Competitive Gas Markets in the EU, Edward Elgar, (Forthcoming).

Hallack, Michelle. 2011. "Economic Regulation of Offer and Demand of Flexibility in Gas Networks." *Universite Paris-Sud* 11. http://www.theses.fr/2011PA111009.

Hallack, Michelle, and Miguel Vazquez. 2012. "The Impact of Who Decides the Rules for Network Use: A'common Pool'analysis of the Investment Dynamics in Different Gas Network Regulatory Frames." http://cadmus.eui.eu/handle/1814/23928.

———. 2013. "European Union Regulation of Gas Transmission Services: Challenges in the Allocation of Network Resources through Entry/exit Schemes." *Utilities Policy* 25 (June): 23–32. doi:10.1016/j.jup.2013.01.003.

Hubbard, R. Glenn, and Robert J. Weiner. 1991. "Long-Term Contracting and Multiple-Price Systems". Working Paper 3782. National Bureau of Economic Research. http://www.nber.org/papers/w3782.

Joskow, Paul, and Richard Schmalensee. 1983. *Markets for Power*. MIT Press.

Kahn, Alfred Edward. 1988. *The Economics of Regulation: Principles and Institutions*. MIT Press.

Libecap, Gary D. 1986. "Property Rights in Economic History: Implications for Research." *Explorations in Economic History* 23 (3): 227–252.

Makholm, J D. 2012. *The Political Economy of Pipelines: A Century of Comparative Institutional Development*. University of Chicago Press.

Masten, Scott E., and Keith J. Crocker. 1985. "Efficient Adaptation in Long-term Contracts: Take-or-pay Provisions for Natural Gas." *The American Economic Review* 75 (5): 1083–1093.

Moran, Alan. 2002. "Natural Gas in Australia after the 'Hilmer Revolution'." *IPA Energy Paper*. http://ipa.org.au/library/Energy26.pdf.

Musgrave, Richard Abel. 1959. *The Theory of Public Finance: a Study in Public Economy*. McGraw-Hill New York. http://library.wur.nl/WebQuery/clc/983804.

Newberry, David M. 2002. *Privatization, Restructuring, and Regulation of Network Utilities*. MIT Press.

Ostrom, Elinor. 2009. *Understanding Institutional Diversity*. Princeton University Press. http://books.google.com.br/books?hl=en&lr=&id=LbeJaji_AfEC&oi=fnd&pg=PR11&dq=understanding+institutional+diversity&ots=ku8BVPkr2R&sig=Uae2XRaJ8RBPjmpuXb2pehVDtvM.

Ostrom, Elinor, and Charlotte Hess. 2007. "Private and Common Property Rights." *Political Theory* 2: 1–116.

Riordan, Michael H., and Oliver E. Williamson. 1985. "Asset Specificity and Economic Organization." *International Journal of Industrial Organization* 3 (4): 365–378.

Ruff, Larry E. 2012. "Rethinking Gas Markets--and Capacity." *Economics of Energy & Environmental Policy* 1 (3) (July 1). doi:10.5547/2160-5890.1.3.1. http://www.iaee.org/en/publications/eeeparticle.aspx?id=28.

Samuelson, Paul A. 1954. "The Pure Theory of Public Expenditure." *The Review of Economics and Statistics* 36 (4): 387–389.

Schlager, Edella, and Elinor Ostrom. 1992. "Property Rights and Natural Resources: A Conceptual Analysis." *Land Economics* 68: 249–262.

Schweppe, F. C., M. C. Caramanis, R. E. Tabors, and R. E. Bohn. 1988. "Spot Pricing of Electricity." *Kluwer Academic Publishers*.

Shy, Oz. 2001. *The Economics of Network Industries*. Cambridge University Press.

Vazquez, Miguel, Michelle Hallack, and Jean-Michel Glachant. 2012. "Designing the European Gas Market: More Liquid & Less Natural?" *Economics of Energy & Environmental Policy* 1 (3) (July 1). doi:10.5547/2160-5890.1.3.3. http://www.iaee.org/en/publications/eeeparticle.aspx?id=30.

Williamson, Oliver E. 1975. "Markets and Hierarchies." *New York*: 26–30.

———. 1985. *The Economic Intstitutions of Capitalism*. Simon and Schuster.

Authors contacts:

Miguel Vazquez

Federal University of Rio de Janeiro

Energy Economics Group (GEE), Economics Institute

Av. Pasteur, 250

Urca, Rio de Janeiro - 22290-240

Brazil

Email: Miguel.Vazquez.Martinez@gmail.com

Michelle Hallack

Fluminense Federal University, Economics Department

Rua Tiradentes, 17

Ingá, Niterói - 24210-510

Brazil

Email: MichelleHallack@gmail.com

Jean-Michel Glachant

Director of the Florence School of Regulation and holder of the "Loyola de Palacio" Chair

RSCAS, European University Institute

Villa Malafrasca, Via Boccaccio, 151

50133 Firenze

Italy

Email: jean-michel.glachant@eui.eu