INVESTMENT IN ELECTRICITY TRANSMISSION INFRASTRUCTURE: THE ROLE OF MERCHANT LINES

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ABSTRACT

The progressive opening of electricity markets in Europe will also be attained through increased levels of trading of power between Member States. This means that actual networks must be upgraded, especially with reference to cross-border links. The latest trend seems to be an attempt by Regulators to stimulate the development of transport capacity by allowing third parties to invest in the network: the so-called "merchant (or market-based) transmission investment". The European Regulation 1228/2004 on cross border exchanges in electricity opens the door to unregulated merchant transmission investment in the EU, although with some restrictions. Economic theory provides strong arguments in favor of merchant investment. It has been shown that, under some strict assumptions, efficient transmission investments that create transmission rights satisfying certain simultaneous feasibility constraints will be profitable; therefore, inefficient transmission investments will not be undertaken. In reality, though, imperfections in the competitive wholesale electricity markets lead nodal spot electricity prices to depart from their efficient levels, thereby distorting investment incentives. More generally, efficient investment in networks will only occur when appropriate network pricing exists. This precondition is at the moment totally absent in the European electricity markets. Is it then possible for market-based transmission investment to produce its virtuous effects when a system of locational marginal pricing is not in place that provides the right signals to investors? The absence of a market exasperates the distortions created by market imperfections. In sum, merchant investment is not a panacea, and its role in transmission networks expansion cannot be exclusive, as the few existing experiences have demonstrated. The role of regulators remains critical in this segment of the electricity industry, where an authentic decentralization is not yet feasible.

INTRODUCTION

In the strategy paper published by the Directorate-General Energy and Transports of the European Commission and containing the "Medium-term vision for the development of the internal electricity markets" [1], one reads:

"The Community is seeking to create a competitive market for electricity for an enlarged European Union, not only where customers have choice of supplier, but also where all unnecessary impediments to cross border exchanges are removed. Electricity should, as far as possible, flow between Member States as easily as it currently flows within Member States.

Improved cross border flows will increase the scope for real competition which will drive economic efficiency in the sector, leading to benefits for customers both in the business and the household sector in terms of lower energy prices, improved service and products tailored to their own needs. These benefits will feed through to higher overall economic growth in the European Union.

Competitive electricity markets must deliver a secure, reasonably priced and continuous service to final energy customers. The electricity market will need to be carefully monitored and appropriately regulated in order to ensure that this objective is delivered."

It is thus clear that, in the eyes of European regulators, one of the most important objectives that should be achieved through the progressive opening of electricity markets to competition is that of favoring cross border trade and increment its level. And indeed, liberalized electricity markets are likely to require increased levels of investment in transmission in order to accommodate these greater volumes of electricity trade. For this reason, there is an unambiguous need, across all European Countries, to develop electricity networks further and reinforce cross-border links. In a 2003 study by the International Energy Agency [2], it is estimated that transmission investment requirements in the European Union amount, for the period 2001-2030, to 120 billion dollars: definitely a considerable figure. Moreover, investment in efficient transmission can be an effective way to lower costs to consumers and increasing reliability of power supply, while reducing emissions of power generation-related pollutants. The problem is that all institutional and organizational changes which characterized European electricity markets in the past few years have made transmission planning a lot more complicated. In particular, efficient investment in networks will occur only when appropriate network pricing exists that sends signals to the market to invest.

In sum, it may be affirmed that transmission policy stands at the very center of electricity market design, and the special complexities of electric power transmission require nothing less than a paradigm shift in order to support a restructured competitive electricity market. Unlike for other commodities, successful electricity markets require new institutional infrastructure with a "visible hand" to support competition: it is only when a coordinated spot market with consistent pricing exists that most decisions can actually be left to market participants. But while reliance on market participants to make most (or all) investment decisions for generation and demand alternatives seems both natural and much like other normal markets, extending this same policy to the realm of transmission investments is less obvious and may in some cases be problematic. The result has been a growing controversy about the relative roles of merchant vs. regulated transmission investment, and about the implied proper policy for the transmission investment part of the overall electricity market design. The choice of the right mix of regulated and market-driven transmission investment could reverberate throughout the rest of electricity market design. With the right choice, merchant transmission investment could play a significant (although not exclusive) role in efficient transmission expansion. With the wrong choice, the unintended consequences could undermine the whole foundation of electricity market restructuring.

The purpose of the present work is that of analyzing the true possibilities of successful merchant transmission investment in the European Union under the current regulatory structure. The first section will be dedicated to an overview of the recent legislation on conditions for access to the network for cross-border exchanges in electricity. Regulatory issues regarding the specific features of merchant transmission investment will be addressed, and an attempt will be made to assess what would constitute a consistent policy with respect to this topic. Then, some real-world experiences are reported. In the second part of the work, a basic theoretical model of market-based transmission investment is presented, which draws heavily from the well-known normative analysis of transmission pricing. The paragraph which follows will provide the means to understand how, in a context where markets are not as ideal, equilibrium conditions change together with the incentives to invest. In other words: what can the role of merchant transmission investment be in a market such as that of the European Union, where the liberalization process is still incomplete? The very last section tries to summarize the results and presents some conclusions.

THE NEW ELECTRICITY DIRECTIVE AND THE RULES GOVERNING NETWORK ACCESS AND CROSS-BORDER TRADE

For a variety of reasons, among which the fact that the responsibility of investment in infrastructure is no longer an exclusive right of transmission system operators, but expansions of the grid are fundamental to achieve a successful functioning of electricity markets, regulators attempt to stimulate the development of transport capacity by allowing third parties to invest in the network. This practice is what is now commonly referred to as "merchant (or market-based) transmission investment". The idea is that the improved possibilities of trading between differently priced markets should guarantee adequate revenue to those who build the lines.

The European approach to merchant transmission investment is laid down in the "Regulation EC No. 1228/2003 of the European Parliament and the Council" on cross-border exchanges in electricity, which entered into force on July 1st this year. In first instance, the regulation prescribes rules for scarce capacity on existing cross-border interconnectors[1], but art.7 of the regulation states that, under some conditions, "new direct-current interconnectors may, upon request, be exempted from the provisions of Article 6(6) of this Regulation and Articles 20 and 23(2), (3) and (4) of Directive 2003/54/EC". What does this mean? Article 6(6) of the Regulation specifies regulation of the revenues stemming from the allocation of scarce interconnection capacity, while Article 20 of the new electricity Directive requires "the implementation of a system of third party access to the transmission and distribution systems based on published tariffs, applicable to all eligible customers and applied objectively and without discrimination between system users"; Article 23 provides guidelines for designing a methodology to calculate such tariffs. Therefore, with this provision, the European Regulator in effect paves the way to unregulated merchant transmission investment, although it requires that a specific set of conditions be met. First, the "investment must enhance competition in electricity supply". Second, the level of risk attached to the investment must be "such that the investment would not take place unless an exemption is granted". Third, following the unbundling requirements of the electricity Directive, "the interconnector must be owned by a natural or legal person which is separated at least in terms of its legal form from the system operators in whose systems that interconnector will be built" (notably, ownership separation is not required). It is very remarkable that the exemptions of Article 7(1) exclusively apply to direct current (DC) lines, although Article 7(2) states that exceptions are made for alternating current (AC) lines, in cases where DC technology would be prohibitively costly. Although this seems a reasonable clause, it carries the danger that one technology unduly crowds out the other. The next paragraph will analyze in details all these conditions.

REGULATORY ISSUES: A BRIEF DISCUSSION

The first requirement imposed by the law to new interconnectors which apply for exemption is that "the investment must enhance competition in electricity supply". This criterion raises a significant number of problems. First of all, it is unclear whether the regulator refers to competition on one side only or on both sides of the line, or to an increased level of competitiveness overall. A further difficulty is that demand elasticity of electricity may be (and in fact usually is) quite low, implying that the welfare effects of increased competition would be rather small, relative to the total capacity. There are a number of reasons why a social cost-benefit analysis may underestimate the desired competition effect: increased competition may decrease regulatory costs; market power might induce excessive entry; unequal social weight assigned to consumers and producers (higher relative social weights for consumers increase the competition effect, ceteris paribus). In addition to that, the European regulation is silent on the criteria that should be used for determining whether such change of competitiveness actually took place and to what extent. A concept which might be helpful in deciding on that, and is quite appealing for power markets, is the Residual Supply Index (RSI). With the RSI, competitiveness increases due to the additional transmission capacity, even if a dominant generator owns the new line. The Residual Supply Index for firm j is formally defined as:

$$RSI_j = \sum_{i \neq j} Q_i \Big/ D \qquad (1)$$

where $\Sigma_{i \neq j} Q_i$ is the sum of capacities of all firms others than firm j, and D is market demand. If $RSI_j < 1$, then firm j is pivotal, meaning that this firm on its own could reduce available capacity below demand. The concept, which gained interest in the course of examination of the price spikes in California (see [3] and [4]), reflects the idea that competitive pressure increases with excess capacity (expressed as capacity-over-demand ratio) and vice versa. A more fundamental problem is that a line can improve competition and lower welfare at the same time, because a positive competition effect may be at the expense of high importing costs. An example borrowed from a study of Brunekreeft (see [5]) can help understand this point.

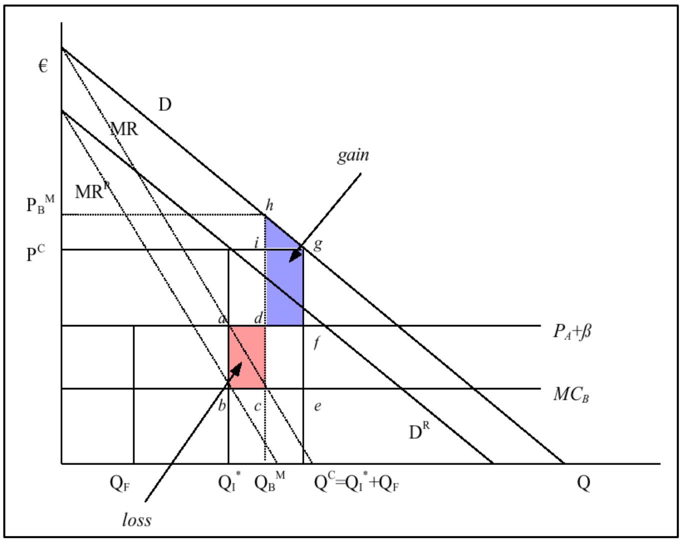

Figure 1:
Market power on the low-cost market (Brunekreeft, 2004)

Consider a market formed by two regions, A and B, where region B is the net importing region. A new line with capacity Q_F connects the net exporting market A and the importing market B. Market A is assumed to be enough large that the new line has no impact on its equilibrium conditions. The price in B of imported power is P_A and the line's constant long-run marginal capacity costs are β. The marginal cost of producing power in B is MC_B. D is the demand for power in market B and MR is the marginal revenue. The key assumption for the argument is that the generator in B is a monopolist and is able to exercise market power, setting a high price which induces construction of the line with the aim to import power from A to B. Now, suppose that marginal costs in A (equal to the price in A: the market is perfectly competitive) plus the long-run marginal line capacity costs β are higher than the production costs in B, i.e.:

$MC_A + \beta = P_A + \beta > MC_B$

In order not to add any useless complications to the example, the marginal costs in B are assumed to be constant. As can be easily seen in Figure 1, the pre-entry monopoly outcomes are Q_B^M and P_B^M.

Now, assume that a "merchant investor" invests in a fixed amount of capacity, Q_F. Observing this new line capacity, the incumbent generator in B marginalizes its own residual demand. The incumbent's post-entry output is Q_I^*. Total post-entry output is $Q^C = Q_I^* + Q_F$ and corresponding price P^C. Since:

$P^C > P_A + \beta$

the line can be profitable. In this scenario, the new line would trade high-cost power from region A to the low-cost, but high-priced region B. The market power in region B drives a wedge between cost and price in region B to which traders respond. This results in a negative import effect, which may offset the positive competition effect; if so, then the line would be detrimental from a social welfare perspective. In the figure, the negative import effect is the area *abef* and the positive competition effect is the area *hceg*. Thus, the area *dcef* cancels out. The areas to be compared are the shaded areas: if *abcd* is larger than *hdfg*, the over welfare effect is negative.

As it can be seen from the figure, the overall effect of a capacity addition is determined by a number of factors. The first thing is that the higher the difference between generating costs in the two regions (which include the costs of building the line, embedded in β), the more likely it is that the overall effect is negative. Next, elasticity of demand is very closely related to the competition effect: if demand is relatively inelastic, the competition effect of the line will be small, whereas the import effect remains. Third, if the weight on producer surplus gets smaller, the welfare effect is more likely to be positive: this reflects the fact that the overall price falls and the import effect is transformed into a change of producer surplus. The change in consumer surplus is the area $P_B^M P^C gh$, which is obviously always positive when the price falls. Last, as the size of the line increases, the increase in welfare brought about by the competition effect decreases (due to downward sloping demand) whereas the decrease in welfare due to the negative import effect is constant (with the assumption of constant marginal costs). Thus in this scenario, the overall welfare effect is likely to be welfare decreasing beyond some critical size of the line capacity.

In sum, the condition in the EU regulation that the investment should increase competition is problematic for different reasons. As the example clearly illustrated, not only it is not so obvious how to verify such change in competitiveness, but also an increase in competition need not be the same as an increase in welfare.

As far as the ownership issue is concerned, the key question is whether a regulated Transmission System Operator (meaning one which owns the grid) at one of the connecting points should be allowed to be the owner of an unregulated line. The unregulated revenues of the line depend on the flows on the line and the price difference between the connected markets, as will be shown in the next section. Obviously, power flows can be influenced quite strongly by the TSO. It seems natural to expect that the TSO will have incentives to manipulate the dispatch to increase profits at the unregulated line at the expense of the revenues in the regulated part. The short-run effect will be a distorted dispatch leading to higher production costs, while the long-run effect will be distorted investment. Under strict separation of the System Operator (SO) and Transmission Owner (TO), though, the above argument is longer valid, and it would seem natural to allow a regulated TO to invest in unregulated merchant lines. A second ownership question concerns participation limits of dominant generators. In most cases it appears intuitive that an additional line will increase competition in the importing generation market, but this is not always the case. For example, one of the reasons that might lead a dominant generator to invest in a new line which increases competition in its own market is to prevent someone else from doing so.

As seen above, Article 7 of Regulation 1228 effectively exempts new interconnectors from the so-called Third Party Access (TPA) provision. Normally, the TPA rule prescribes that network owners are required to make access to the grid possible to virtually any third parties, with the explicit purpose of fostering competition on the network. For unregulated merchant transmission investment, it can be claimed that a third party access regime is unnecessary: given that line revenues are unregulated, it must be in the interest of the line owner to handle line-usage efficiently, since this maximizes line profits. Therefore, not allowing efficient third parties to access the grid is usually profit decreasing for the line owner, in a market-based transmission framework. Unduly restricted access to the interconnector implies restricted competition in the trade between the two interconnected areas, whereas supply competition in the respective areas is hardly affected. For these reasons, while a provision to enforce third party access should be required if the line revenues are regulated, when the line revenues are unregulated it is enough to leave the access question to the competition authorities, who might in turn solve any controversies by applying the essential-facilities doctrine.

SOME REAL-WORLD EXAMPLES

Merchant transmission investment seems to have become a widespread fashion, and more and more countries decided to rely on it to try to answer to the growing concern of under-investment in network capacity. It is interesting to understand how many lines have so far been realized and where, and what kind of difficulties, if any, those experiences highlighted.

In the USA, for example, currently planned unregulated merchant transmission investment (MTI) projects include the New York Harbor Project, the Lake Erie Link, the Neptune Transmission System and the Empire Connection Project. All these lines go into the New York region importing cheap hydropower, because alternatives in this area are expensive. None of them is actually in operation yet, and it must be emphasized that none has succeeded to get long-term funding yet. The US projects are fairly large DC projects, ranging in scale from about 200 to 2000 MW.

In Europe the first explicit example of an unregulated MTI relying on Article 7 of Regulation 1228 is still to come, but an interesting case, called BritNed, is in preparation. BritNed is a planned project of a 250 km submarine DC cable connecting the UK and the Netherlands, aiming at trading between the Dutch power exchange, APX, based in Amsterdam and the British one, UKPX, based in London. Planned capacity is between 1000 and 1300 MW. BritNed is a legally separated joint subsidiary of the transmission system operators of both sides: National Grid Company (NGC) in England and Wales and TenneT in the Netherlands. The next possible candidate will be the project, dated early 2004, of a cable which should connect the Netherlands with Norway (NorNed), although it is as yet unclear whether this will be market-based project.

It is in Australia, though, that the attempt of making of merchant transmission investment a true and viable alternative went the furthest away, and not without troubles. In fact, in the Newest Continent several relatively small projects, among which Directlink and Murraylink, raised serious regulatory controversy. In particular, it was the option to shift from an unregulated to a regulated status, granted by the law and exercised by Murraylink, to raise a fierce debate (see [6] and [7]). Until its conversion in October 2003, Murraylink was an unregulated 180 km long underground 220 MW DC merchant line connecting Victoria and South Australia. While Murraylink was under construction, the designated transmission system operator, Transgrid, requested building a regulated interconnector, denominated SNI, between South Australia and New South Wales, which is largely parallel to Murraylink. SNI would decrease the price differential between Victoria and South Australia and thereby decrease the revenue base for Murraylink. Regulated network investment usually requires a regulatory test of some sort to determine whether such expansion is actually beneficial for society. The test compared the two options: "bundled SNI" vs. "unbundled SNI". The latter would have upgraded the network in especially New South Wales without an additional line between the two areas. The bundled SNI, instead, planned to build the line. Cost-benefit analysis suggested that the unbundled option resulted in a higher net benefit than the bundled option; i.e. upgrading the network in New South Wales and not building the line was more efficient than building the line, given the existence of Murraylink. The critical point of the "unbundled SNI" option, as argued by Transgrid, was that network upgrading without building the line would leave the new investment vulnerable to market power of Murraylink. This risk, still according to Transgrid, would make the unbundled SNI commercially unfeasible and could thus not qualify as an alternative project. Transgrid was able to convince the authorizing institution and won: by lack of a better alternative, the bundled option was approved and built. Subsequently, Murraylink requested conversion from an unregulated to a regulated status which was granted, as said above, in October 2003 and signed the end of the most pioneering merchant experience.

In sum, reliance on market-based solutions even in the electricity transmission segment seems to be the latest "popular" policy statement. But on what theoretical grounds the argument for merchant transmission investment is built? The next section will help understand this point.

IN THEORY: THE REGULATED TRANSCO VS. THE MARKET-BASED TRANSMISSION APPROACH

Traditionally, the literature on competitive wholesale electricity markets envisioned, for the organization of the transmission segment, the creation of independent regulated regional transmission and system operating entities (TransCos, or regulated transmission companies) that would be responsible for building, owning and operating transmission facilities and would be subject to economic regulation, given the natural monopoly features of the electricity transmission activity. More recently, economic research has focused on the study of the attributes of incentive regulatory mechanisms that could be applied to such regulated transmission monopolies to integrate energy price (congestion) signals with transmission investment. The regulated TransCo model is necessarily subject to the classical challenges of regulated monopoly, namely how to specify and apply regulatory mechanisms that provide good performance incentives to the regulated firm while minimizing the economic rents that the regulated firm can derive from its superior information. The investment incentives in this framework have been explored for example by Lèautier (see [8]), who proposed the design of a regulatory contract that induces the network operator to optimally expand the grid, while also satisfying other traditional regulatory objectives, building on the institutional arrangements governing transmission operation and investment in England and Wales. Vogelsgang, instead, focused on the problem of designing a price structure for electricity transmission services in such a regulated context, concluding that under a system of two-part tariffs where the variable part would reflect congestion charges and the fixed part capacity costs, the firm would have incentives to trade-off congestion against capacity expansion in such a way that it becomes profitable to expand whenever the average costs of congestion exceed the average costs of expansion (see [9]).

An alternative approach to the regulated TransCo model is the merchant investment model, which relies much more heavily on competition, free entry, decentralized property-rights based institutions, and market-based pricing of transmission services to govern transmission investment. The theoretical work around this approach is due mainly to Hogan [10], Bushnell and Stoft [11], [12], Chao and Peck [13] and Tirole and Joskow [14], and builds crucially on the framework developed by Schweppe et al. [15]. It is this approach that will be followed in the present analysis.

THE MERCHANT PARADIGM: A MODEL

The so called “market-based approaches” to the restructuring of electricity markets envision new transmission investment creating transmission rights (either physical or financial) for the merchant investor based on the increased capacity of the network of transferring power from points of injection to points of consumption. The value of these transmission rights, which is typically equal to the expected congestion charges either avoided, as is the case of physical rights, or rebated by the system operator, when a financial rights scheme is in place, over the life of the transmission investment, should then provide the financial incentive for incumbent suppliers or new entrants to invest in new transmission capacity. This is what is called the “merchant transmission model” and its attributes are the focus of a recent study by Joskow and Tirole whose findings will be used in this work (see [16]). The two results that are the primary economic foundation for relying on a merchant transmission model are those obtained by Hogan in 1992 and Bushnell and Stoft in 1996 (see again [10], [11]). Briefly, those authors showed that under some (strong) assumptions[2], efficient transmission investments that create transmission rights satisfying certain simultaneous feasibility constraints will be profitable and that inefficient transmission investments will not be profitable. While those same authors recognized that relaxing those assumptions might undermine key results regarding the optimality of merchant investment, little analysis of more realistic cases has been forthcoming.

Joskow and Tirole were the first who tried to examine the performance attributes of this new merchant transmission investment and ownership framework when assumptions that better reflect the physical and economic attributes of real transmission network are introduced. In their model it is assumed that an independent system operator (ISO) operates a real-time balancing market and allocates scarce transmission capacity using bids from generators and consumers to increase or decrease generation or demand at each node, solving an optimal dispatching program that obviously takes transmission constraints into account. This way, the ISO establishes day-ahead quantity commitments and nodal prices that vary by location when there is congestion. Generators may also choose to enter into bilateral contracts with marketers or load serving entities (LSEs) and schedule supplies with the ISO separately from the organized day-ahead market. However, they still have to pay any congestion charges associated with their schedules based on the difference in nodal prices between the injection and receipt points. Anyways, all these day-ahead schedules, nodal prices, and congestion charges are, as said above, “commitments”. They can be adjusted in real time by submitting adjustment bids to the real time balancing markets (which again rely on bids, a security constrained dispatch and nodal prices) to allow these schedules to be changed based on real time physical and economic conditions. New investments in transmission are anticipated to be made by competing merchant investors whose compensation is based on the value of Transmission Congestion Contracts (TCCs) created by their investments. Once again, these financial rights represent the right to receive congestion revenues defined as the difference between the locational prices between the two nodes (point-to-point) covered by the relevant TCC times the quantity of TCCs held.

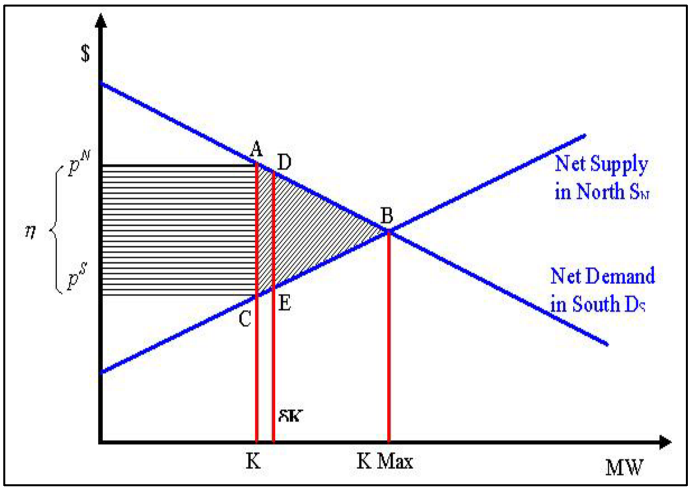

Figure 2:
Merchant Investment (Joskow, Tirole 2004)

Formal results: the perfect competition benchmark

Having said that, it is now possible to present the theoretical case for merchant transmission investment in the basic framework of a two-node network. The situation is simple: LSEs of any kind (distribution companies or marketers buying on behalf of retail consumers, or large industrial customers buying directly) are all located in the South and buy as much power as they can from cheap generation sources in the North and the remaining from more expensive sources in the South. The capacity of the line from North to South is limited to K, and always congested, so the system operator is forced to dispatch “out of merit”. This means that the ISO is forced to call on expensive generators in the South while generators in the North would be willing to supply this amount at a lower price if more transmission capacity were available. The rationing of the scarce North-South capacity is implemented by setting two nodal prices, p^S and p^N that clear the markets in the South and the North, respectively. The difference, $\eta = p^S - p^N$ is the shadow price of the transmission capacity constraint. In Figure 2, the area ηK is the congestion rent, whereas the triangle ABC is what is defined as the “congestion (or redispatch) cost”, and represents the cost of running more costly generation in the South because less costly imports from the North are limited by transmission congestion.

Now, consider a marginal (unit) increase in transmission capacity (δK). This unit increase allows one more KWh to flow from North to South, replacing a marginal generator in the South with cost p^S by a cheaper generator in the North producing at cost p^N. That is, the social value of the investment is given by the reduction in the area ADEC in fig. 2. Assume that the builder of this marginal capacity, whether it is a new entrant or the incumbent transmission network owner (TO), is rewarded through a financial transmission right that pays a dividend equal to the shadow price of the transmission constraint. A non-incumbent merchant company will enter to build this extra capacity as long as:

$\eta > C(\delta K)$

i.e. the congestion rent on every unit of additional capacity exceeds the cost of building it. By contrast, if an incumbent grid owner is compensated through the payment of congestion rents, it may not want to make this marginal investment as it must compare the extra revenue η net of the cost of expanding the capacity with the reduction in the congestion rent on its inframarginal transmission units. In other words, the incumbent will invest in additional transmission capacity only when:

$\eta - C(\delta K) > -K d\eta/dK$

Market imperfections and distorted investment incentives

What happens when there exist some imperfections in energy markets that create a distortion in price signals? The reasoning above assumes that the prices that clear the markets in the North and the South reflect the marginal cost of production (and the marginal willingness to pay) at each location, so that the congestion rent perceived by merchant investors does actually reflect the social savings brought about by the investment. That is, potential investors in new transmission capacity are able to see the correct locational price signals in the wholesale markets. As Joskow and Tirole suggest, tere are a number of reasons why this is unlikely to be the case. Market power, regulatory interventions like the imposition of price caps, the absence of a complete representation of consumer demand in the wholesale market, discretionary behavior of the ISOs: these are some of the possible reasons why market prices might turn out not to be the optimal ones.

Suppose for example that there is a generator with market power in the South, where import is constrained. When the generator exercises market power, he will do so by withdrawing capacity and driving the price in the South up. The market will therefore clear at a price in excess of marginal cost of generation in the South, i.e. at $p^S > c^S$ (where c^S denotes the marginal cost of production in the South). In such a situation, the measured congestion rent will then overestimate the cost savings associated with the replacement of one unit of power generated in the South by one unit of power generated in the North, suggesting an over-incentive to reinforce the link, ignoring the potential impacts of other market imperfections. As a result, market power in the importing area produces enhanced incentives for transmission investment. Conversely, a generator with market power in the North may (while still making full use of the link) be able to raise price p^N by withdrawing production capacity (perhaps to the level of p^S if it faces no competition in the North). In this case, the congestion rent underestimates the gain from expanding the line's capacity, resulting in an under-investment by merchant transmission investors. At the same time, it could lead to inefficient entry of generating capacity in the North in response to the short run monopoly rents created there.

But price distortions might also be due to different reasons than market power. A more realistic example of what could happen in the real world is a situation where prices may not clear supply and demand in real time because market clearing processes are not fast enough to respond to rapid changes in supply and demand conditions while maintaining physical requirements for frequency, voltage, and stability on the network. In this case, in order to maintain physical network parameters, administrative rationing is then substituted for prices to balance supply and demand, as a consequence of what is effectively a problem of incomplete markets. And even more realistic is a situation where markets are not only incomplete, but almost (or totally) absent, for example due to the predominance of an administrative approach to the problem of transmission pricing. This is the case of Europe, and it is interesting to see what are the effects in terms of incentives to investment in merchant transmission lines when a system of locational marginal pricing is not in place.

MERCHANT INVESTMENT WITHOUT A MARKET: CAN IT WORK?

All theoretical findings reported in the above paragraphs rely on the key hypothesis that an efficient market exists which produces, at any time, optimal nodal spot prices. Nothing seems less realistic when one explores real-world electricity markets: with some exceptions, the models implemented in practice adopt simpler solutions which, of course, depart from the most efficient one. Most commonly used tariffs are a mixture of two main classes:

i. in the "Open Market model", payment at one point gives access to the whole network. The "point-of-connection tariff" could be "nodal", but it is actually based on the accounting costs of assets.
ii. in the "Transportation model", tariffs are related to distance. For example, in the "contract path", entry and exit points are specified and the price refers to the cost of the assets on the agreed transmission path. But because of parallel flows, the contract path is, as explained above, a fiction.

In both cases, tariffs can be time varying and voltage dependent.

"Zonal pricing" aggregates many locations into a small number of zones: it is a solution proposed for the first time by Hogan in [17]. In a way, it combines the two methods described above. Under zonal pricing, the power system is divided into several zones and the costs are evaluated within each zone. Within each zone the price of access to the grid is uniform (like in the "Open Market model"), while the price of transferring energy from one zone to the other is related to distance (like in the "Transportation model"). The optimal size of the zones should be the result of a trade-off between more competition among generators (and users) and the loss of efficiency in the dispatching of the grid. In the European Union, transmission system operators are progressively implementing a "postage tamp" system, which has hardly any reference to nodal prices. Like the postal service, it does not depend on the distance; the price is independent of the connection point and it is not directional. All nodes are viewed as belonging to a wide unique zone, which is often identified with the national territory. The main argument in favor of this kind of pricing is that it is very simple to implement and, supposedly, maintains some sort of "equity" between all system users. But it is obvious that such a scheme cannot be efficient. Furthermore, although "postage stamp" tariffs continue to be the preferred solution for the union of European transmission system operators (ETSO), the most recent guidelines contained in the Regulation 1228 seem to go in the exact opposite direction: that of economic sense. Indeed, it is stated in that law that "a proper system of long-term locational signals would be necessary based on the principle that the level of network access charges should reflect the balance between generation and consumption of the region concerned" ((12), page 2), and that "it would not be appropriate to apply distance-related tariffs" ((14), page 2). Moreover, the regulation makes clear that "congestion management methods implemented by Member States shall deal with short-run congestion in a market-based, economically efficient manner, whilst simultaneously providing signals or incentives for efficient network and generation investment in the right location" (*Annex*, Art. 1, page 9), and "price signals that result from congestion management systems shall be directional" (Annex, Art. 4, page 9). In other words, while the European Commission, the Parliament and the Council auspicate that a system of nodal spot pricing emerged, able to deal efficiently with the problem of optimal dispatching and to provide the exact long-run incentives for investment, the ETSO implements a solution to the issue of transport pricing which goes miles away from the "ideal", benchmark one.

CONCLUSIONS

With a growing need for investment in additional transmission capacity to favor and support increased levels of electricity trade, allowing for-profit transmission companies to invest in the network sounds like a sensible idea. Merchant investment's appeal is that it allows unfettered competition to govern investment in new transmission capacity, placing the risks of investment inefficiencies and cost overruns on investors rather than consumers, and bypassing planning and regulatory issues associated with a structure that relies on regulated monopoly transmission companies. In addition, in theory, it allows investment in new generating capacity in the constrained area to "compete" with new transmission investment that reduces the import constraint. All these desirable properties convinced also European regulators that an attempt should be made in this direction. Unfortunately, the optimality of the market-driven approach depends on a number of strong assumptions and conditions that are likely to be inconsistent with the actual attributes of transmission investments and the operation of wholesale markets in practice. When there are imperfections in the competitive wholesale electricity markets that lead nodal spot electricity prices to depart from their efficient levels, investment incentives will be distorted. For example, when unregulated generators have market power, nodal energy prices will be distorted from their efficient levels. These distortions may lead to over-investment or under-investment depending upon where on the network electricity generators have market power. Imperfect government interventions to control market power in competitive wholesale electricity markets may also distort investment incentives. Finally, the absence of a spot market which provides the correct locational signals to investors exasperates the distortions. In sum, although merchant transmission investment would certainly be an "economist dream" in an ideal market setting, it is much less likely to produce the desired effects in the real world, as the few experiences so far attempted have shown. For this reason, it is fundamental that competent authorities keep their surveillance at a high level once they have given the green light to such initiatives.

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[1] Interconnectors are transmission lines which cross or span a border between Member States and which connect the National Transmission Systems of the member States.

[2] These are, precisely: transmission investments are characterized by no increasing returns to scale, there are no sunk cost or asset specificity issues, nodal energy prices fully reflect consumers' willingness to pay for energy and reliability, all network externalities are internalized in nodal prices, transmission network constraints and associated point-to-point capacity is non-stochastic, there is no market power, markets are always cleared by prices, there is a full set of futures markets, and the TO/SO has no discretion to affect the effective transmission capacity and nodal prices over time.