What place for competition to develop the power transmission network?

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WHAT PLACE FOR COMPETITION TO DEVELOP THE POWER TRANSMISSION NETWORK?

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ABSTRACT

Competition is an efficient alternative to regulation for the power transmission network only for peculiar investments in peculiar conditions. The competitive network investments are generally radial and/or create new commercial links in Direct Current between big markets with high and sustainable difference in zonal prices. In these conditions, the impact of the inefficiencies due to economies of scale, lumpiness and externalities of network investments is small enough for a quite efficient transmission market.

To reach these conclusions about competition to develop the power transmission network, we will analyse the assumptions on which "pros" (Hogan (1992), Littlechild (2003, 2004)) and "cons" (Peréz-Arriaga *et al.* (1995), Joskow-Tirole (2005)) ground their theoretical analyses thanks to a survey of the network revenue and of the network cost structure. We also analyse the heterogeneity of the experiences of competitive power transmission network investment thanks to the same criteria, to confront eventually the theory and the practice of competition to develop the power transmission network.

I. INTRODUCTION

Economists debate the introduction of competition to develop the power transmission network as an alternative to the regulation of the power transmission network monopoly. The competition to develop the power transmission network might avoid the challenges associated to the monopoly regulation. It seems that in theory the power transmission network must widely remain a natural monopoly. It is mainly because of the interdependences between the network elements that would be otherwise difficult to deal with in a decentralised way (Joskow-Tirole (2005)). However, considering competitive development of independent network expansions may still be interesting since these investments are not interdependent on the rest of the network. Besides, some experiences of competitive network investments in the USA, in Australia or in Argentina lead to contradictory conclusions about the efficiency of competition to develop the power transmission network.

The heterogeneity of the models and the experiences of competitive network development for the independent network expansions question the specific conditions of efficiency of the competitive transmission market for these investments. In this paper, we aim at answer the question: what are the conditions (if they are some) required for the competitive development of these independent transmission expansion investments to be efficient? For the rest of the paper, we will implicitly consider only the independent transmission expansion investments.

The competition for transmission can be introduced in two ways. The first way is the classical one, that is to say that the transmission investments are assumed to be market driven as are the other competitive activities that a price signal coordinates in a nodal energy market. The second way considers that the decision to develop the network must stay centralised and that the transmission ownership remains a monopoly; but the development, ownership and maintenance of new assets is allocated by an *ex ante* competition similar to "Demsetz (1968) competition" in order to put competitive pressure on the cost of network assets.

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The opinions expressed here are the sole responsibility of the author.

For each kind of competition, we analyse the hypotheses which they ground on thanks to a survey of the network revenue and of the network cost structure. Thanks to the same criteria, we also analyse the heterogeneity of the practices of competitive power transmission network investment. Besides we confront the theoretical views to the practical experiences.

In section II, we make a survey of the state of art of market driven transmission investment. We then show that the theoretical efficiency of market driven transmission investment is based on the hypotheses about the cost structure of power line. The economies of scale and lumpiness[1] in transmission investment define the network cost structure. Market driven transmission investment is efficient as soon as the economies of scale and lumpiness in transmission investment are neglectable (Bushnell-Stoft (1997) and Hogan (2003)) compared to the quantity to be optimised. Property rights called "Financial Transmission Rights" are the ground of market driven transmission investments and transmission market (Hogan (1992)). An independent investor is called a "merchant (line) investor" that builds a "merchant (transmission) line". However, market driven transmission investments are undersized if the assumptions about the network cost structure are more realistic (Peréz-Arriaga *et al.* (1995), Joskow-Tirole (2005)). Besides, FTRs and the energy market do not internalise all the power transmission network externalities (Bushnell-Stoft (1997), Lesieutre-Hiskens (2005), Stoft (2002)). It allows free-riding that may then over- or under-incentivise the merchant line investors.

In section III, we see that a merchant line can be a relevant solution in some niches of network investments. Most of the regulations constrain the technological choice of the merchant investor to Direct Current (DC) lines by the requirement of dispatchability. Merchant lines are then relevant supply solutions when the conventional network investments in Alternative Current (AC) are technically and economically expensive. Besides, economies of scale and lumpiness in transmission investment are relative to the size of the markets connected (Joskow (2005)). It explains for a part the heterogeneity of experiences of merchant lines. Lastly, the difference in nodal prices on both sides of the merchant line must be sustainably high to ensure a sufficient rent to the merchant investor. We see two conditions in which the differences in nodal prices stay sustainably high.

In section IV, we show that even if the Argentine experience of Demsetz (1968) competition can put a competitive pressure on the network investment cost (Littlechild (2004)), its transposition seems however difficult in a meshed network: the same reasons of interdependences between the network elements and of continuing activities of upgrading between maintenance and investment (Joskow-Tirole (2005)) also apply on this kind of competitive network development. Nonetheless, Demsetz competition can be interesting for radial network assets, as it is proposed in the last law of French energy orientations (Loi 2005-781).

II. MERCHANT LINES: TRANSMISSION RIGHTS AND NETWORK COST STRUCTURE

In the following sections (II and III), we wonder if transmission investments can be market driven as are the other competitive activities (generation for instance) in a nodal energy market from a theoretical point of view.

In this section (II) we make a survey of the state of art of the economic theory surrounding market driven transmission investment. We analyse the differences of the pros and cons of market driven transmission investment, mainly the assumptions which they ground their rationale on.

Firstly, we recall what a locational energy market (Schweppe *et al.* (1988)) and transmission rights (Hogan (1992, 2002)) are since they are prerequisites to market driven transmission investment.

Secondly, we show that the network cost structure make market driven transmission investment inefficient (Peréz-Arriaga *et al.* (1995), Joskow-Tirole (2005)). Economies of scale and lumpiness in transmission investment dominate the network cost structure. These features were first implicitly assumed neglectable compared to the size of the transmission capacity to be optimised while they are not.

Thirdly, there are some remaining externalities whose internalisation in the transmission rights market (Bushnell-Stoft (1997)) and in the energy (Stoft (2002)) market may remain difficult if not

[1] In economics, lumpiness means that discrete and non continuous quantities of a commodity can be produced. In our case, it is generally impossible to increase the capacity of a power line by a megawatt; the network development is done by the addition of several hundreds megawatts of power lines.

impossible. It allows free-riding of some market participants; it may then over- or under-incentivise the merchant line investors.

II. A. TRANSMISSION RIGHTS AND TRANSMISSION MARKET

The nodal energy pricing and the transmission rights are prerequisites to market driven transmission investment. The nodal pricing internalises power transmission network externality thanks to differences in nodal energy prices. Market participants need transmission rights to hedge against locational price fluctuations. If a merchant line makes the transmission network capacity increase, it receives some of these transmission rights as property rights. The merchant investors can so be remunerated either directly thanks to the differences in nodal prices, or thanks to the sale of their transmission rights as hedging products to network users.

The efficient sharing of a network as a scarce resource is a well-known and addressed issue in the restructured electricity industry. Schweppe *et al.* (1988) demonstrate that an efficient constrained dispatch could be computed thanks to a nodal pricing system considering network externality as constraints of the market clearing. One generally considers only congestion and losses because of implementation issues and seldom includes voltage constraints (Caramanis *et al.* (1982)). A nodal pricing gives an energy price per node indicating where it is preferable to generate or to consume one more megawatt taking into account both network losses and network limitations. The differences in nodal prices linked to externality generate a merchandise surplus for the merchant line investor, also called congestion rent in the DC lossless approximation[2] (see Figure 1).

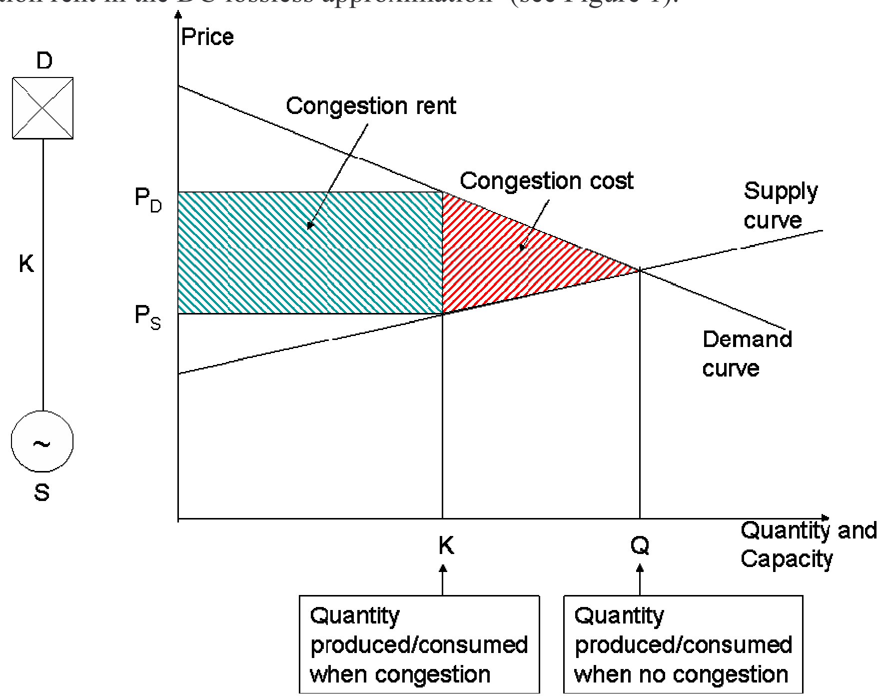

Figure 1 Graphical representation of nodal pricing on a congested two-node network

Nodal prices are very volatile and are a too dubious revenue source for the merchant lines investors as well as for the merchant plant investors. Some financial tools complete the market for the market participants to hedge against the risk of locational price fluctuations.

Hogan (1992) defines such hedging tools as point-to-point transmission rights between a sink node and a source node. These rights, the "Financial Transmission Rights" (FTR) are long term financial rights that allow their owner to hedge against nodal price volatility. FTRs are not physical rights. They do not give a right to flow energy between two nodes. FTRs allow their owners to earn

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[2] The more used approximation, namely DC approximation consists in considering only the real power and in approximating the behaviour of the network to be linear. In this case, only congestion constrains the nodal pricing.

the differences in prices between a sink node and a source node for the contracted quantity of FTR between these two nodes. These rights are allocated thanks to an Optimal Power Flow (OPF) by the System Operator, as is the energy in a nodal market, to take into account long term transmission network externality such as congestion and sometimes losses (Hogan (2002)). As the nodal prices are to the merchant line investors what the energy price is to the merchant plant investors, the transmission rights FTRs are to the merchant line investors what the forward contracts are to the merchant plant investors.

To conclude, depending on its aversion to locational price fluctuations, a merchant line investor chooses to earn money either by receiving the difference in nodal prices associated to its FTRs either by selling its transmission rights (FTRs) to other market participants as hedging tools against these differences in nodal prices.

II. B. TRANSMISSION RIGHTS UNFITTED TO THE NETWORK COST STRUCTURE

The "merchant model" (transmission rights and market driven investments) is efficient only under some stringent hypotheses about the network cost structure. Economies of scale and lumpiness in transmission investments must remain small compared to the size of the system to be optimised. It is the case in generation where a generation unit is much smaller than the size of the market (exempt for some very small markets like insular ones of course). Even a big generation unit that experiences economies of scale to its level is much smaller than the size of the market. It is not the case in transmission where the size of the investment is of the same order of magnitude as the capacity of the network before and after the investment.

We will see how respectively economies of scale and lumpiness make market driven transmission investment inefficient (Peréz-Arriaga *et al.* (1995), Joskow-Tirole (2005)).

Various features and management rules of the power transmission network depreciate the revenue that merchant line investor earns from congestion. Economies of scale of network assets (see Figure 2) induce an "overinvestment" that lumpiness in transmission investment highlights (Peréz-Arriaga *et al.* (1995)). Economies of scale for Alternative Current (AC) transmission lines are present at least until 750 MW (Fuldner (1998)). When the optimal capacity investment is under this threshold, congestion rent is insufficient to cover the investment cost.

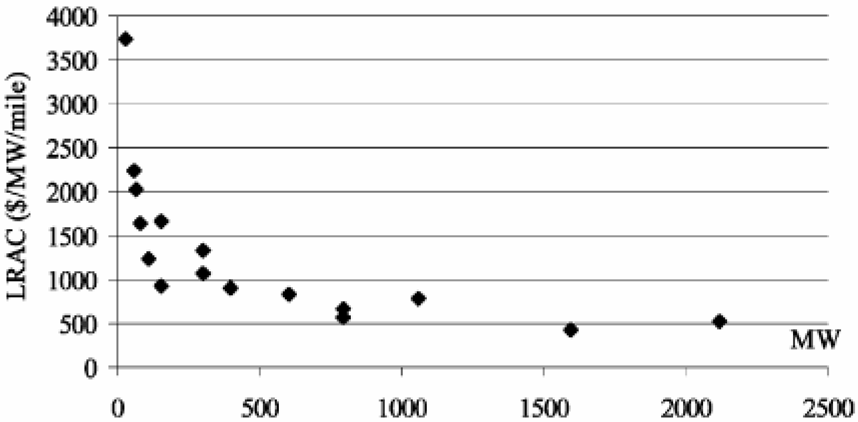

Figure 2 Economies of scales of AC transmission assets (Brunekreeft (2004), Fuldner (1998))

Indeed congestion rent covers only 20 to 30% of the network cost (numerical simulations from Peréz-Arriaga *et al.* (1995)). The hedging financial products equal in average the economic value of their underlying assets, without taking into account any risk premium. Therefore, except any risk premium, FTRs are normally valuated to the average of differences in nodal prices. As a consequence, FTRs cover in average only 20 to 30% of network investments costs. By contraposition, merchant line investor is incited to undersize merchant line so that congestion rent would be more important than if the size of the line was optimal and congestion rent would cover its cost.

Lumpiness in transmission investment prevents merchant line from being incentivised proportionally to the social welfare that it creates (Joskow-Tirole (2005)). Lumpiness in transmission investment means that the capacity of transmission line is not continuous but discrete. Lumpiness in transmission investment induces an underinvestment vis-à-vis the optimal capacity. An overinvestment of a merchant line is indeed improbable because of the classical underincentive to invest in transmission while being rewarded by congestion rent. Besides, lumpiness and scarcity of *rights of way* to accommodate transmission lines also lead to an underinvestment in order to pre-empt the available corridors.

To conclude, market driven transmission investment cannot be efficient because of the network cost structure. Economies of scale and lumpiness in transmission investments opportunities are of the same magnitude as the capacity to be optimised. The optimal capacity is then such that congestion rent does not cover the cost of the congested line. The network cost structure prevents merchant line investor from being proportionally incentivised to the social surplus it creates. The merchant line investor is so under-incentivised to invest optimally.

II. C. REMAINING EXTERNALITIES AND TRANSMISSION RIGHTS

The transmission rights market and the energy market do not suitably internalise all the externalities that the transmission investments undergo. It may not be a critical issue for the entire system if transmission remains a monopoly. But it is a critical issue if transmission investment is market driven. If transmission investment is market driven, these remaining externalities allow free-riding whose merchant investor can be the beneficiary or the victim. These market failures induce an inadequacy between the real congestion rent and the paybacks from FTRs that the FTRs' owners must receive.

First, we will see that the energy market does not always suitably internalise reliability. It depreciates the energy price during tight situations. It can then drastically reduce congestion rent. However, the arbitrage between capacity markets can provide a complementary rent to the merchant line investors (Joskow (2005)). Second, we will see that loop flows cause externalities of market driven investments such that profitable investments may be inefficient and inversely efficient investments may not be profitable. The transmission rights market can be completed to internalise suitably these externalities (Bushnell-Stoft (1997)). But, it requires centralised process that is quite contradictory with the paradigm of the merchant model. Third, we will see that the design of FTRs is based on approximations of the states of the power system where some physical properties are not dealt with. The effects of these approximations are unclear as they may over- or under-incentivise the merchant line investors.

Various network investments (maybe most) are motivated by system reliability rationale more than by physical constraints that some locational price differences make apparent; even if these two causes of network investments are narrowly interdependent (Joskow (2005)). The resolution of reliability issue generally implies a decrease of congestion and inversely. The network reliability is a notion that still needs to be specified in an economic term (Brunekreeft-McDaniel (2005)). Loss of Load Expectation (LOLE) is generally associated to reliability. However, reliability and LOLE being public goods makes the measure of the cost of LOLE and its internalisation difficult (Stoft (2002)). A lack of demand response to energy price implies a free-riding of some market participants and a lack of revenue for the merchant line investor that could otherwise receive an important part of their rent during tight periods. Even when the cost of LOLE is known, the probability of loss of load and so the probability for the energy price to reach the cost of LOLE is quite low. It would be risky for a merchant investor to ground its investment on this criterion.

Without more demand response, more administered market mechanisms can be implemented to internalise reliability. The capacity markets implemented by the ISO/RTOs in the United States are an example of such mechanisms. Consumers must so cover their peak consumption over 100% to a defined rate of generation capacity (for instance 118% in the PJM area). A merchant line can then earn part of its rent from the arbitrage between the capacity markets or zones of a single capacity markets that it connects. However, remarks previously formulated about the impact of the network cost structure remain valid; others must be added as for the internalisation of loop flows.

The impact of a new line on a network may not be limited to the increase of the transmission capacity between the two nodes that the line "newly connects". Adding a new line to a transmission network modifies the whole set of feasible injections and withdrawals. Not only does a new network investment create the FTRs between the two nodes newly connected but it can also make the transmission capacity vary (increase or decrease) from the point of view of other couples of nodes and so make the quantity of associated feasible FTRs vary too positively or negatively.

This is because of loop flows. If one megawatt is injected to a node and withdrawn to another, it is divided between all the topological paths that go from the source node to the sink node. Any new lines modify how this megawatt is divided between the paths from the source node to the sink node.

Allocated FTRs between the two nodes that the merchant line newly connects does not internalise the modification of loop flows that the transmission investments provoke. It is the modification of the whole set of FTRs that reflects the value of network investment in term of social surplus. Attributing to an investor a portfolio of FTRs that contains the modification of the whole set of FTRs that its investment induces can correct this market failure due to loop flows (Bushnell-Stoft (1997)). Therefore, the allocation of FTRs to a merchant line investor for its investments needs a centralised process to determine what portfolio of FTRs must then be awarded to the merchant investor. Such an ex ante centralised process is quite contradictory with the paradigm of the merchant model.

Ex post centralised heuristics are also necessary to deal with a potential inadequacy between congestion rent and the FTRs paybacks that the FTRs' owners must receive. The approximations made to auction long term FTRs have unclear effects. These approximations cause inadequacy that may over- or under-incentivise the merchant investors. FTRs are long term rights that are not state-contingent while the state of the network is variable and even stochastic. We mention here three current approximations for FTRs auctions that interfere with the balance between congestion rent and the FTRs paybacks and so with the incentive of the merchant model.

Firstly, the FTR auctions are generally made under the DC approximation while reactive power can be important during the network operation. Secondly, the dispatcher may modify the network configuration compared to the one assumed for the FTRs auctions. The power may then flow differently during the network operation compared to what was assumed for the FTRs auctions. Lastly, FTRs are long term rights that do not take into account the stochastic variation of line capacity during its operation.

The DC approximation[2] is currently used to model the power network. Like for any other approximation, the DC approximation is a good model for little variations of the parameters around a point of operation. Besides, the reactive power is neglected in this approximation while it may be noticeable in some parts of the network. The adequacy between congestion rent and the FTRs paybacks is ensured if the set of feasible injections and withdrawals is convex (Hogan (1992)). For a network with a given topology, the set of feasible injections and withdrawals is indeed convex in the case of the DC approximation. But the set of feasible injections and withdrawals is not convex in the conditions of operation with an active and reactive dispatching (Lesieutre-Hiskens (2005)). Therefore, the adequacy between congestion rent and the FTRs paybacks is not ensured.

Besides, during the network operation, the dispatcher modifies the network topology if needed by the fusion or the separation of nodes. These actions are zero-cost ones for the System Operator that can so increase the social welfare (by decreasing congestion or losses). But it may greatly modify the way the power flows through the network. The change of the network topology modifies the set of feasible injections and withdrawals. The balance between congestion rent and the FTRs paybacks is then no more ensured because of the modification of the set of feasible injections and withdrawals.

Lastly, FTRs are long term rights that do not take into account the stochastic variation of line capacity during its operation (Joskow-Tirole (2005)). The capacity of a transmission line varies with the external conditions (temperatures, wind, extreme conditions, curative or preventive measures taken by the System Operator, etc…). And this variation depends on the type of lines: overhead, underground, undersea, AC, DC… Therefore, not only can these variations of capacity induce an inadequacy between congestion rent and the FTRs paybacks, but also, FTRs cannot value the diversification benefit of a merchant line (see Joskow-Tirole (2005) for more details) depending on its technology.

Some heuristics have been implemented in nodal markets (PJM, NYISO, ISO-NE …) to reallocate the difference (positive or negative) between congestion rent and the theoretical FTRs paybacks. These heuristics obviously modify the investment incentives in an unclear way, according to whether the assumptions formulated by the System Operator about the transmission capacity for the FTRs auction are either generous or conservative.

To conclude, the transmission rights and energy markets are incomplete as far as the merchant model is concerned. Therefore there are some remaining externalities whose impact on the merchant investment incentives is not always clear. The FTRs are known to be practically and theoretically (Sun (2005)) useful to the nodal energy markets. Capacity markets can quite well internalise reliability in a pragmatic way. Capacity markets can then complete congestion rent from the energy market for the merchant line investors. But loop flow creates externalities when a new merchant line is built. These externalities can be internalised thanks a centralised reallocation process of the FTRs. But the merchant investor cannot then know the value of its investment unless to submit its project to this centralised process. It is obviously quite contradictory with the paradigm of decentralisation of the merchant model. Similarly, the FTR pricing must be corrected ex post to deal with the multiple states of the network that the FTR auctions approximate to one state only. The correction of the imbalance between congestion rent and the FTR paybacks may over- or under-incite the merchant investor according to whether the System Operator uses generous or conservative assumptions to frame the FTR auctions.

II. D. CONCLUSION: TRANSMISSION RIGHTS UNFITTED TO TRANSMISSION INVESTMENT

Transmission rights (FTRs) that are thought as the ground of transmission market in a nodal energy market are unfitted to the features of network. Economies of scale, lumpiness, loop flows and system reliability and approximations needed to auction the FTRs cause inefficiency, mainly underinvestment of market driven transmission investment.

Even if the solution of a transmission monopoly is not optimal, there exists an asymmetry of costs and benefits between network over- and under-investment (Brunekreeft-McDaniel (2005)) that leads to prefer transmission monopoly and over-investment compared to market driven transmission investments and under-investment.

III. MERCHANT LINES PROJECTS: MISTAKES OR SPECIFIC CONDITIONS?

So in theory, market driven investments are not efficient. However, merchant lines exist, others are planned and they do not seem so inefficient, which contradicts our previous idea. The study of merchant lines projects in Australia and in the United States moderates our theoretical point of view. We can then formulate specific conditions of existence and efficiency of merchant lines.

First, we will see that the dispatchability imposed on the merchant lines constrains the merchant investors to consider only Direct Current (DC) lines. Then, merchant lines are valid only when specific conditions of investments increase the cost of installing classical Alternative Current (AC) lines such that it is prohibitive. Second, we will see that the underinvestment of a merchant line must be compared to the size of the markets hence linked. This underinvestment may be indeed relatively small. Third, we will see that a merchant line is profitable if the difference in nodal prices on both of its sides is high and sustainable which is very rare. Lastly, we will see that even if there are risks of hold-up by regulated transmission owners, the institutional compatibilities between zones are some entry barriers harder to overcome for regulated Transmission Owners than for merchant investors. Besides, long term contracts can be a hedging tool for a merchant investor against uncertainty like locational price fluctuations or a hold-up.

III. A. TECHNOLOGICAL CHOICES OF MERCHANT LINES

Regulations (as in Europe or in Australia) constrain the technological choice of merchant investors. So a merchant line is generally a Direct Current (DC) line (HVDC – High Voltage Direct

Current). Therefore, a merchant line is only possible when the cost of installing an Alternative Current (AC) line is prohibitive.

The regulations of the power transmission network (in Europe – the EC (2003), article 7 – and in Australia – ACCC (2001)) generally impose the merchant lines to be dispatchable. The dispatchability is the physical attribute to control the power injected to or withdrawn from the network. The dispatchability of a merchant line consists in controlling the quantity that flows through this merchant line. The classical electrical lines, so-called Alternative Current (AC) lines, are not dispatchable. However, new technologies of network assets are dispatchable. The investor can choose among various solutions[3] but he generally elects the Direct Current line solution (HVDC).

This technological constraint limits the investment opportunities of the merchant investors. The investment costs of DC lines are generally superior to those of AC lines, in particular because of the conversion station from AC to DC and inversely. However, when the conditions surrounding the investments make the cost increase, the DC lines are cheaper than the AC lines. In particular, it is more advantageous to choose a DC line rather than an AC line when its length increases (Hartley (2003), Rudervall *et al.* (2000)). Besides, when burying lines is necessary over distances greater than some kilometres, a DC line is the unique technical solution. In particular, this is the case of most of the undersea cables. This advantage can be a double-one when the hiding of the lines eases the public acceptability of the lines. This decreases the costs of capital by decreasing the risk of delaying the project. The DC lines globally have some advantages as for thermal losses, for land needs and for hiding and burying costs (Rudervall *et al.* (2000)).

The dispatchability of a merchant line eases the work of the System Operator by creating an analogy between the merchant lines and the dispatchable generators and consumers. Therefore, the merchant lines are more like traders arbitrating between an import zone and an export zone than like classical AC lines. We saw previously that loop flows create externalities on the AC network that are hard to internalise in transmission rights (FTR). When a merchant line is dispatchable and so controls its flow, it is less exposed to these externalities. The constraint of dispatchability ensures less risky revenue to the merchant investor and a merchant line with an optimal capacity (Brunekreeft (2004)).

To conclude, the DC lines and so the merchant lines are limited to investment conditions where the AC lines are not a technologically and economically acceptable solution, that is to say for long distance lines and cables that must be hidden or buried (for instance undersea).

III. B. ECONOMIES OF SCALE AND LUMPINESS: NOTION RELATED TO THE SIZE OF THE MARKETS

We saw in section II that the economies of scale and lumpiness prompt the merchant investor to undersize its investment. However, Brunekreeft (2004) moderates this issue that the merchant model faces up against. The inefficient underinvestment of the merchant lines must be compared to the size of the markets that the merchant lines connect.

The capacities of investments in the electrical system are generally lumpy and have economies of scale. Lumpiness means that it is impossible to add only one megawatt of capacity to a generator or to a line. As for the generation investments, lumpiness and economies of scale interferes little with the power market. Of course, lumpiness in generation investment prevents the generation capacity of the market from reaching its optimal value and so creates inefficiency. However, if the power market is big enough, inefficiency stands for far less than 1% of the cost to the end-users (Stoft (2002)). The effects of economies of scale and lumpiness in transmission investment must similarly be compared to the size of the markets hence linked (Joskow (2005)). The underinvestment of the merchant lines that we previously notice (see II) may be small compared to the size of the connected markets. One must also consider the impact of this underinvestment on the difference in locational prices. Besides, a new technology of HVDC lines so-called "light", the "HVDC light" allows to imagine the use of HVDC

[3] See Marinescu-Coulondre (2004) for a paper about "merchant phase shifters".

lines for smaller capacities, about 200 to 300MW (Rotger-Felder (2001)), capacities that are similar to those of CCGT plants, decreasing so the impact of lumpiness and economies of scale.

Therefore, even if the capacity of interconnectors between market areas can be important in some cases (up to thousands MW), it is small compared to the size of these markets. So such merchant lines can be quite efficient. The examples of regional markets hence connected are numerous: interconnectors between regional markets in Australia[4] (Basslink, and to a lesser extent Directlink and Murraylink as we will see it afterwards), between France and England, or some projects of interconnectors between the Netherlands and Norway (the NorNed), between The Netherlands and Great Britain (the BritNed), between New-York City and close areas (New Jersey or states of New England).

On the contrary, the capacity of lines between the nodes of a nodal market is generally of the same order of magnitude as the capacity of the generators and the consumers connected to these nodes. Indeed, in a nodal market, each node is a market area in itself. So, even network investments of small capacity greatly impact the difference in nodal prices and so the revenue of these investments (Joskow (2005)). Besides, as we mentioned it in introduction, market driven investments are not efficient in the core of the network because they require important transactions costs to avoid "moral hazards in team" (see Joskow-Tirole (2005) for more details). New AC interconnectors between already connected network and market areas are also concerned. Therefore, what we see in II applies to the transmission investments in a nodal market: the merchant lines are then inefficient.

It is confirmed in practice. The PJM (2004) "Market Window" for network investments gains only a limited success. There are only two small merchant investments in the PJM area. During this market window, PJM lets one year for the market participants to take the initiative to build a market driven transmission investment. After that one-year delay, PJM as a System Operator imposes a last resort regulated network investment.

To conclude, if market driven investments can be efficient in some situations, the distinction between merchant lines and regulated lines must be based on the capacity of investments compared to the size of the market areas hence connected; one must also consider the impact of investments on the evolution of difference in nodal prices.

III. C. SUSTAINABLE DIFFERENCES IN NODAL PRICES

A merchant investor must consider a third parameter beside the technological choice and the size of the connected markets. The source of revenue of a merchant investor comes from the arbitrage between a zone where the energy price is high and a zone where the energy price is low. The difference in locational prices on both sides of a merchant line must so be sustainable. In a competitive environment, the difference in locational prices may not be sustainable. Specific conditions of supply of primary energy may be at the origin of the differences in locational prices.

First, we will see that the merchant lines in Australia illustrate weak and unsteady differences in prices between zones. Second, we will see that the merchant lines that are operated or planned around New York City illustrate sustainable differences in zonal prices that some difficulties of supply in primary energy maintain. Third, we will draw general conditions for sustainable differences in zonal prices from these two examples.

III. C. 1. Merchant lines in Australia: non sustainable difference in zonal prices

TransEnergie, subsidiary of HydroQuébec for power transmission, built two merchant lines in Australia to collect the congestion rent between market areas. The first one called Directlink connects the states of Queensland and New South Wales and the second one called Murraylink connects the states of South Australia and New South Wales. These two merchant lines grounded their revenue on a deficit of production in the states of South Australia and Queensland that was expected to last. This assumption has not concretised with disastrous consequences on the revenue of these merchant lines.

[4] The Australian market NEM is organised similarly to the Nordpool with market splitting.

For a reasonable rate of return on Murraylink, a difference in zonal prices between 12 and 15A$/MWh between the states of New South Wales and South Australia was needed at full utilisation. Similarly, to ensure the profitability of Directlink at full utilisation, a sustainable difference in zonal prices between the states of Queensland and New South Wales of at least 11A$/MWh was needed (Booth (2003)).

Figure 3 Difference in prices (A$) between the states of South Australia (SA) and New South Wales (NSW) and between Queenland (QN) and New South Wales (NSW) (own calculus – data from www.nemmco.com.au)

Required differences in zonal prices are huge and seem hard to maintain in a competitive environment. The differences in zonal prices between on the one hand the states of South Australia (the more expensive area) and New South Wales and on the other hand the states of New South Wales and Queensland (see Figure 3) show that it is difficult to maintain sustainably high differences in zonal prices between close areas, unless there is a political willingness to resort on power import. There are indeed few differences between the marginal generation technologies from a region to another if these regions have access to the same primary energy resources and if the public powers do not want specific energy mixes. Therefore, during investments periods, it is probable that the prices of two close areas tend to balance.

To conclude, the investments of Murraylink and of Directlink were profitable in static (1999-2000) but not in the competitive dynamic. These two interconnectors were indeed involved in a boom of investments as well in South Australia as in Queensland that led the market to an excess margin of generation of 34% in South Australia. Merchant lines are such risky investments unless finding a huge and sustainable difference in zonal prices.

III. C. 2. Merchant lines around New York City: sustainable difference in zonal prices

Several merchant lines are planned or operated in the USA. Most of them are around New York City (NYC). Their number and the diversity of interested or involved investors indicate that NYC presents some peculiar conditions that make these merchant investments far less risky in this case than what we noticed before. The urban density makes the building of new generation capacities in NYC or of new classical transmission capacities quite impossible. Merchant lines are a solution to the energy supply issue of NYC.

The Cross Sound Cable that was developed for the distributor LIPA connects Long Island (in the control area of NYISO) with Connecticut (in the control area of ISO-NE). The Neptune Cable that is also developed for the distributor LIPA will connect Long Island to New-Jersey (in the control area of PJM); the planned Empire Connection was thought to connect New York City with the region of Albany; the planned Harbor Cable was thought to connect PJM to the Queens district. These projects benefit from the impossibility to install new generation capacities to supply NYC or to build new AC lines toward NYC. Therefore, NYC undergoes a shortage of cheap power that allows to maintain local high prices without local solutions. And merchant lines can be then attractive supply solutions.

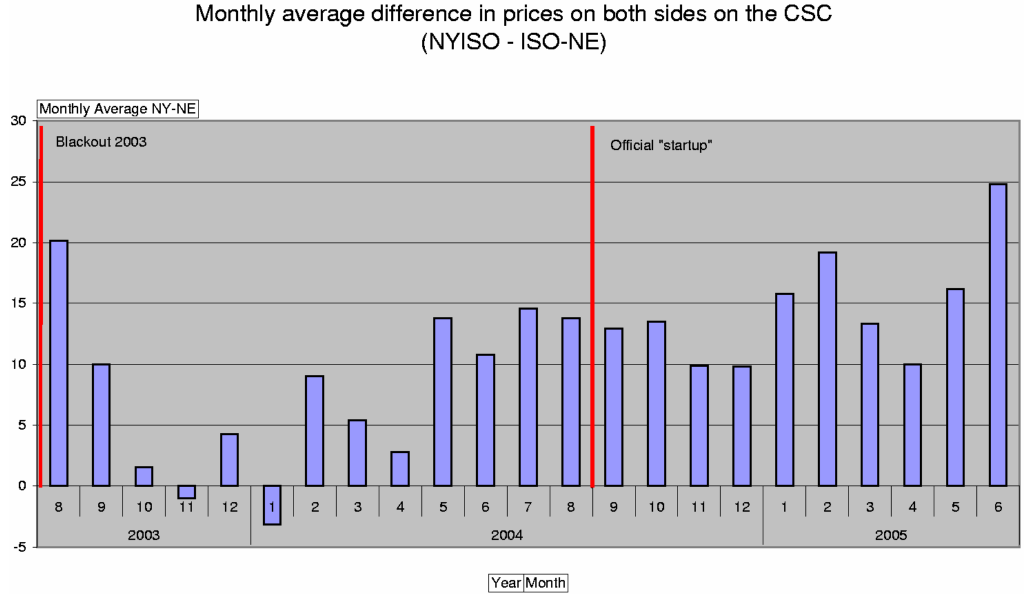

Figure 4 Monthly average of the difference in prices on both sides of the Cross Sound Cable (own calculus – data from NYISO and ISO-NE)

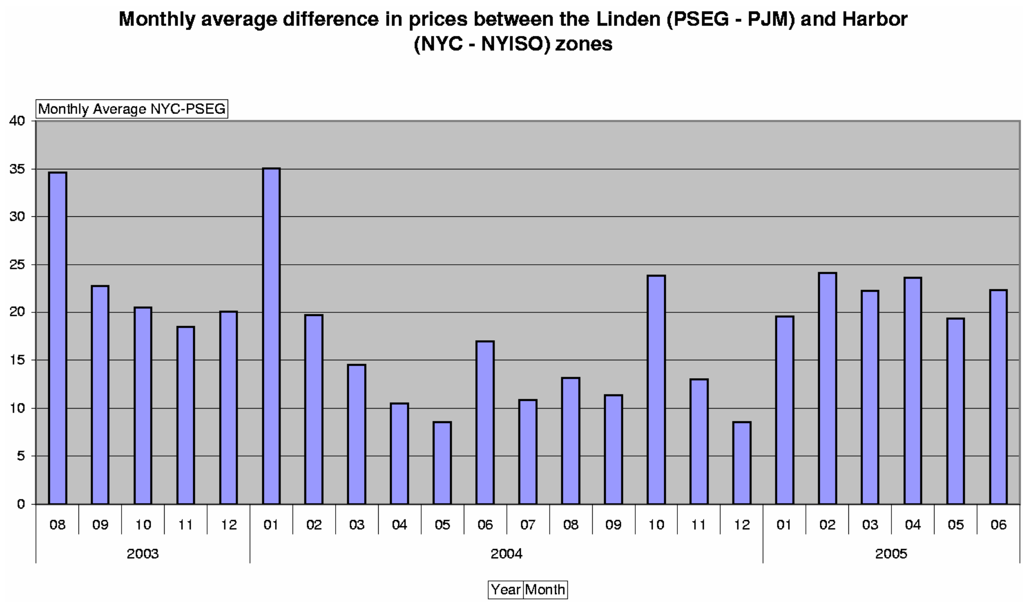

Figure 5 Monthly average of the difference in prices between the PSEG zone (PJM) and the NYC zone (NYISO), both sides of the thought Harbor Cable (own calculus – data from NYISO and PJM)

We notice indeed that there exist high and sustainable[5] differences in prices between NYC and the close areas, such as ISO-NE or PJM, or even areas inside NYISO. Besides, merchant lines earn money not only thanks to differences in energy prices but also thanks to capacity prices. Capacity prices are an important source of revenue for generators in NYC. They can earn 30% of their revenue thanks to the capacity market (FERC (2005)). So, it can also be an important source of revenue for the

[5] The energy price in NYC has stayed high and volatile since the beginning of the nodal market in 2000 with an average price of 57$/MWh between March 2000 and July 2005 and a volatility (variance) around 30$/MWh (data from NYISO).

merchant lines that can then arbitrate between the capacity markets hence connected. It is a way to internalise reliability that a merchant line provides to the power system.

To conclude, from the study of operated or planned merchant lines projects, we see some common denominators essential to the relevance of these investments emerge. Financing these investments requires a high and sustainable difference in locational prices on both sides of the merchant lines. The Australian experiences show that sustainable differences in locational prices are seldom. The experiences around NYC show that it is nevertheless possible to find particular conditions where high differences in zonal prices can be sustainable.

III. C. 3. Conditions for a sustainable difference in zonal prices

The merchant model discussed in section II informs quite well about the general conditions of profitability and efficiency of a merchant line. But there exist peculiar cases where a merchant line can be a relevant solution. Some supply constraints or some technological choices enforced by the public power of a market area can ensure a sustainable difference in zonal prices and so a sufficient revenue to merchant investors.

Topological constraints can induce an energy insularity of a market area. Supply difficulties can be linked to difficulties in installing new generation capacities as well as to difficulties in creating new interconnectors with close areas. NYC is an example of an impossibility to build new generation capacities or to expand interconnectors with the rest of the NYISO area through classical terrestrial ways because of the urban density. Therefore, energy and capacity are expensive in this area. A merchant investor can benefit from this isolation to connect this isolated area to a close one thanks to non conventional means such as HVDC lines. Such a merchant line can then benefit from a high and sustainable difference in zonal prices.

Another possibility to ensure that the difference in zonal prices lasts consists in connecting close areas with different energy mixes. For instance, the NorNed (the future cable between Norway and the Netherlands) exemplifies that a merchant line can benefit from the complementarity between a hydroelectric power system and a thermal energy system (Bugten (2004)). The cables that connect West Denmark to Norway and Sweden allow to limit the effects of wind power volatility by compensation thanks to the flexibility of hydrological power system (Nordel (2004)). It is also possible if there is a missing power technology in an energy mix. This situation is a common one when nuclear programs have been suspended.

Let's be careful because the differences in zonal prices in this case are subject to political decisions. Therefore, investing in a merchant line in such a case implies an important risk all the more this risk is not quantifiable. The Australian experience is an example where the regulatory uncertainty maintained then decreased the difference in zonal prices. In Australia, the states indeed lead the deregulation process. So the deregulation process follows different dynamics and application speeds from one state to another with a noticeable impact on the price formation (Littlechild (2003)).

To conclude, the merchant lines seem to be limited to some very specific investments where the huge difference in zonal prices can be sustainable because of some constraints of energy isolation.

III. D. HOLD-UP OF A MERCHANT LINE

If a merchant line cohabits with a transmission owner, there is a risk of hold-up of the merchant line. The incentives of the two investors are indeed different. The objective of capacity of regulated lines tends to be greater than the objective of capacity of merchant lines. However, regulated transmission owners faces up against more issues of institutional compatibilities in building interconnectors. And long term contracts can hedge the merchant investor against uncertainty like a hold-up.

A merchant investor maximises the congestion rent by maximising its benefit. This objective makes the capacity of the merchant lines suboptimal.

A regulated transmission owner maximises its profit under regulatory constraints (with or without incentives). The regulator tries to make the objective of maximisation of social welfare coincide with the transmission owner's objective. In this case, the investments of a regulated transmission owner are near to the optimum.

Therefore, an efficient investment by a regulated transmission owner in parallel of a merchant line automatically induce the loss of an important part of the congestion rent that is needed to the merchant line's profitability (see Figure 6). Reliability criteria that motivate most of the regulated investments highlight this effect (Joskow (2005), see II. C).

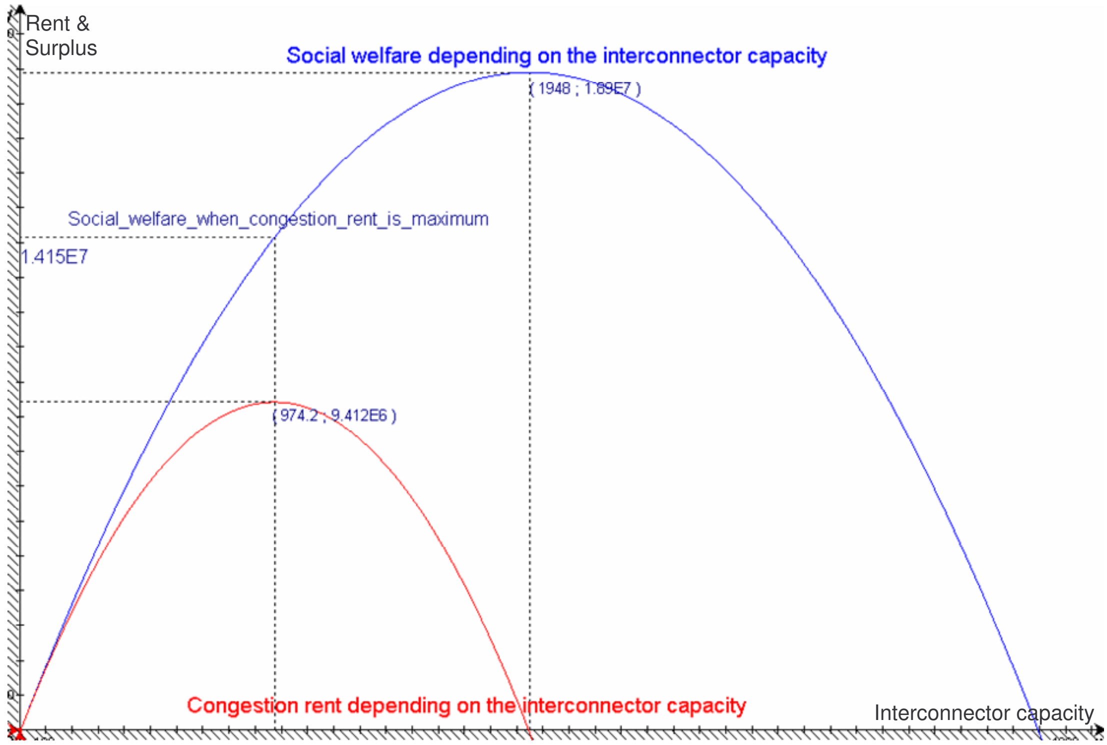

Figure 6 An example of variation in congestion rent and social welfare vis-à-vis the interconnector capacity between two zones for linear demand and supply curves

However, sitting on an institutional border, that is to say between two market areas, the merchant investors increase the transaction costs of the transmission owners in their negotiation process to justify such an interconnector (Joskow (2005)). Transmission owners must so not only justify their interconnector to their regulator but also involve the transmission owner of the second market area and so the regulator of the second market area. Since the merchant investor is the only to bear the investment risk, he does not have to justify its investment to the regulators, only to be licenced as any other market participants.

The example of the merchant line Murraylink in Australia is eloquent. The time between the investment decision and the operation of the line was only 18 months. The regulated investment SNI between the two same market areas failed to proceed although it was submitted to the regulator before the investment decision of Murraylink.

Besides, a merchant investor can protect itself against market risks, uncertainty and the risks of hold-up by building its merchant line in the framework of a long-term contract with other market participants such as producers or consumers that would like to use the transmission capacity. Indeed, merchant lines obviously undergo strong spatial asset specificity. We previously saw that they may also suffer from market uncertainty. In this context, a long term contract may be the best governance choice for a merchant line investor as a hybrid form of Williamson (1991). This formula was adopted by the two merchant lines projects connecting Long Island with 20-year contracts. These contracts are quite similar to FTRs that the merchant investor would have sold to market participants for 20 years. The merchant lines Murraylink and Directlink also tempted to adopt similar strategies before the fall of the difference in zonal prices, without any success. The Empire Connection was not built because not enough long term contracts were signed.

To conclude, the independent merchant investors face up against a risk of hold-up from the regulated transmission owners. However, sitting between two market areas, the merchant investors raise some kind of entry barrier for the transmission owners that must deal with a four-player negotiation, that is to say the transmission owners and the regulators of each area. Besides, the merchant investors can protect themselves against the risk of hold-up and market uncertainty thanks to long-term supply contracts.

III. E. CONCLUSION: WHERE MERCHANT LINES ARE POSSIBLE

The constraint of dispatchability that most of the regulations impose set the merchant investors more like traders that arbitrate between two markets rather than like any classical transmission owners that cannot control the power flowing through its line. Besides, the technological choice of merchant lines limits the investments conditions to cases where the cost of installing AC lines is prohibitive. Then, lumpiness and economies of scale are less present. And their effects are all the less important that the connected markets are big. Some supply conditions or some choices of public powers can ensure a high and sustainable rent to the merchant investors. The risks of hold-up of a merchant line are limited because the regulation exposes more the regulated transmission owners to institutional incompatibilities than the merchant investors. In brief, the power transmission network globally remains a natural monopoly. If the conditions previously mentioned are gathered, the merchant investors can build some relevant investments. A merchant line may sometimes be the only way to overcome some institutional incompatibilities between market areas to build an interconnector between these market areas.

IV. DEMSETZ COMPETITION LIMITED TO RADIAL NETWORK INVESTMENTS

The competition to develop the power transmission network can be introduced in the “market of the transmission network monopoly” thanks to the Demsetz competition rather than in the energy market (see sections II and III). The Argentine power industry applies a kind of Demsetz competition to reduce the network investment costs. The regulatory evolution in Europe let us foresee similar approaches for the radial network investments.

IV. A. DEMSETZ COMPETITION AND POWER TRANSMISSION NETWORK

The power transmission network globally remains a natural monopoly because of the network cost structure. Even under this assumption, the competition to develop the network can be introduced in the “market to be the transmission monopoly”. Demsetz competition or “franchise bidding” grants the right to develop new power lines. However, the interdependences between the network assets might require to limit Demsetz competition only to radial or little meshed networks.

The network cost structure dictates the resort to monopoly rather than to a market but do not have obvious effects on the practiced price level. It is the potential exercise of market power by the monopoly that creates the social welfare loss. Regulation classically allows to limit the informational rent that monopoly can extract, to obtain a price near to the competitive level and so to limit the social welfare losses.

Rather than resorting on monopoly regulation to limit the monopoly market power, Demsetz (1968) proposes to organise an *ex ante* market to grant the right to be a monopoly. The company that offers the lowest price for the monopoly services receives a franchise to ensure these public services. It is an efficient mechanism since the ex post price will be near of the competitive price without any public resort. The public power is so an auctioneer rather than a regulator. The competition for the right to be the monopoly dissipates the monopoly rent because it decreases the price and increases the produced quantities.

However, only a variant of Demsetz competition has been (and may be) applied on the power transmission network. Demsetz competition is applied on the new investments whose owners are then regulated; the whole network is not auctioned off. Nevertheless, as we previously mentioned, in the framework of a meshed network, the balkanisation of transmission ownership whereas there are strong interdependences between each network element might increase transaction costs (Joskow-Tirole (2005)). In the case of franchise bidding applied to the power transmission network, two things raises some issues. First, if maintenance scheduling is let to the transmission owners’ discretion, the maintenance timetables might interfere between themselves because of the interdependences of the network elements, create congestion and decrease the network reliability. Second, in the core of the network, there is a continuum of upgrading activities between maintenance and investment that make these interdependences more critical.

To conclude, "regulating" the power transmission monopoly by Demsetz competition is known to be quite easily possible, investment by investment, on radial or little meshed networks, because the interdependences between network elements can then be quite clearly identified and quantified.

IV. B. ARGENTINE AS A MODEL OF FRANCHISE BIDDING FOR THE POWER TRANSMISSION NETWORK

In Argentina, since the deregulation of the power industry in 1992, the development of a power transmission line follows an accurate process. This process ends with Demsetz competition to grant the right to build and maintain a transmission line. The franchise bidding to develop the power transmission network seems satisfactory to reduce the network cost although the investment criteria were criticised.

In the Argentine power industry, the System and Market Operator CAMMESA is unbundled from the transmission owners that are themselves unbundled from the generators[6]. CAMMESA is an Independent System Operator (ISO); the Transmission Owners are not "merchant investors" as we previously defined this term since they are regulated. Transener is the Transmission Owner that owns and maintains the network that existed before the reform. New network investments can be developed by other Transmission Owners than Transener.

Network developments follow the process presented hereafter. First, the ISO CAMMESA identifies[7] the need for a network investment following a demand from network users. Second, the regulator ENRE validates the economic interest of the investment from the data provided by the ISO. Third, the network users vote for or against this transmission project.

Lastly, the project is auctioned to grant the right to build and maintain this asset. The line owner is paid to build the line and undergoes an incentive regulation (RPI-X) to maintain the line. The line owner is regulated and earns a network tariff as any other common transmission monopoly.

Even if the method to evaluate and validate the investments was criticised (Chisari *et al.* (2001)), Demsetz competition to grant the right to build and maintain new lines is satisfactory since it allows to reduce the cost of some lines by 30% (Littlechild (2004)).

To conclude, the ISO CAMMESA and the regulator ENRE centralise the decision to develop the network and competition "regulates" the network development cost thanks to franchise bidding. The reduction of cost of some lines shows the feasibility as well as the efficiency of this approach in the Argentine system.

IV. C. FRANCHISE BIDDING TO DEVELOP RADIAL PART OF A MESHED NETWORK

There are peculiar conditions in Argentina that have allowed to auction the network investments. The Argentine transmission network is indeed almost radial or little meshed. Therefore, most of the investments can be considered as network expansion with little interdependences with the rest of the network. The Argentine experience may not be directly transposed to meshed networks, in Continental Europe or in the USA for instance, where there are a lot of interdependences between the network elements. However, the connection assets are generally radial with little interdependence with the other network elements. Franchise bidding could then be applied to develop these network assets. Some new regulations give the possibility to generators to choose who build their connection assets is similar to an "Over-The-Counter franchise bidding".

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[6] Even if generators generally create subsidiaries or joint ventures to develop network in the Argentine system.

[7] Whatever the criterion. For more details about the investment criterion and the voting rules see Chisari *et al.* (2001)

Radial investments are seldom on the core of the meshed networks in Continental Europe or in the USA. But, the network users are not generally connected directly to the core of the network but through a so-called “connection line” (see Figure 7). A connection line is generally dedicated to the need and use of one network user. This line is interdependent from the rest of the network. So, competition might be applied to develop the connection assets.

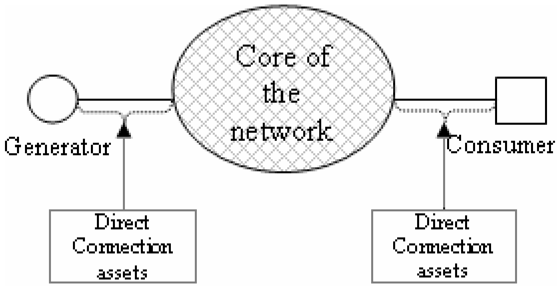

Figure 7 Connection lines and the core of the network

The Argentine experience can then be repeated for the connection assets. The article 63 of the French law (2005-781) that sets the energy policy orientations henceforth allows the generators to do by themselves the building work of their connection assets. Two conditions are nevertheless required: the generator must obtain the agreement from the French TSO RTE and follow the schedule of conditions set by RTE. Contrary to the Argentine case where the System Operator centralises and organises Demsetz competition, in the French case, the organisation of the franchise bidding for the connection assets is let to the market participants that want to be connected under the supervision of the System Operator. That’s why we call it an “Over-The-Counter franchise bidding”.

In brief, the Argentine experience may be repeated at least for the connection assets in meshed networks that are quite independent on the rest of the network. Besides, the Argentine example might also inform us about the feasibility of franchise bidding to develop a little meshed network when the Argentine network would be looped southward and westward (Littlechild (2004)).

V. CONCLUSION

What place for competition to develop the power transmission network?

Some drastic views envision competition as a remedy to the regulatory failures to “regulate” the power transmission network (Hogan (1992, 2003), Littlechild (2003, 2004)). However, competition is efficient only in some niches of investment, even more in some niches of investments for independent network expansion investments. We consider only these independent network expansion investments since the interdependences of network elements may not allow a competitive development in the core of the network. We studied two kinds of competition to develop the power transmission network. In the first case, transmission investments are market driven as are the other competitive activities such as generation on a nodal energy market. In the second case, the transmission network remains monopolistic but an ex ante competition called Demsetz competition grants the right to be a monopoly.

Market driven transmission investments in the framework of a nodal energy market completed by transmission rights (FTRs) are not efficient. Market driven transmission investments are undersized because of the network cost structure that economies of scale and lumpiness feature. The transmission rights as property rights for market driven investments require centralisation. Otherwise, loop flow cannot be internalised in FTRs. Centralisation also allows to deal with the imbalance between congestion rent and the FTR paybacks caused by the necessary network approximations made for the FTR auctions.

However, in practice, these inefficiencies must be moderated. The constraint of dispatchability imposed to the merchant lines reduces the exposure of merchant lines to loop flows. Besides, dispatchability makes the network approximations of the FTR auctions more realistic. The underinvestment caused by economies of scale and lumpiness may be quite small compared to the size of the connected markets. Nevertheless, the conditions to develop merchant lines are still peculiar ones since they require a high and sustainable (around 10 to 20 years) difference in nodal prices. These conditions are seldom and unsteady. The risk of hold-up by a regulated transmission owner is not that important since the regulated transmission owners may face up against more issues of institutional compatibilities between two market areas. Besides, the merchant investors can hedge against uncertainty while the merchant lines are "asset-specific" thanks to long term supply contracts.

It is hard to say if Demsetz (1968) competition can be applied on a meshed network because of the interdependences between the network elements. However, one knows that it can reduce costs of connection lines or of radial lines.

Eventually, in the absence of appropriated property rights and methods to allocate the network cost, the competitive network investments are generally radial and/or create new commercial links between big markets. Competition to develop the network remains limited to where the inefficiencies due to economies of scale, lumpiness and externalities of transmission investments are small enough.

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