Transmission Investments in Deregulated Electricity Markets technical report

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Transmission Investments in Deregulated Electricity Markets

Technical Report

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1 Introduction

Traditionally, vertically integrated companies were responsible for both the generation and the transmission of electric power. Thus, decisions on network investments were usually taken explicitly considering the generation side, i.e. the construction of new power plants. Such an integrated investment process reflected the interdependencies between generation and transmission, as additional power flows from new generators always have to be accommodated by the transmission network. After the restructuring of electricity markets, the former vertically integrated companies were split into segments to reflect the unbundling of the value creation chain. In doing so, generation and transmission are nowadays two distinct activities with different companies generating and transmitting electricity. In a further step, the generation market was liberalized.

The transmission network remained a natural monopoly, operated by an independent body (the Independent System Operator or ISO), which was placed under the supervision of a regulating authority (the Regulator). Two transmission network operating schemes emerged. In the first, the independent system operator assumed also the ownership of the network. The company that both owns and operates the electricity transmission network is usually called Transmission System Operator (TSO). The TSO, supervised by the Regulator, has to carry out the network maintenance and guarantee network access in a non-discriminatory way. At the same time, it must invest in the transmission network in order to ensure service quality (i.e. minimize outage times).

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In the second operating scheme, the ownership of the network remained with its incumbent owner, as it has been before the unbundling. In this case we distinguish between the ISO and the Transmission Owner (TO). While in the first scheme the TSO can decide on, and carry out transmission investments, in the second scheme, the investments are usually carried out by the transmission owner (Balmert and Brunekreeft, 2008). In this new environment, transmission investments have become a demanding task for mainly two reasons. First, although investments need to accommodate new power flows, they are handled independently from investments in new generation. Secondly, investments must prevent possible exertion of market power from generating companies. An example, which combines both operating schemes, is the National Grid Company in the UK. National Grid acts as the Transmission System Operator in England and Wales, as it owns and operates the transmission network. At the same time, it is the Independent System Operator of the Scottish power system. The Scottish network is operated by National Grid but the network ownership has remained with the Scottish utilities.

In the following paragraphs the possible investment schemes with respect to the electricity transmission network are described. Two main investment options are in focus: the regulated investment, and the merchant transmission investment. Two additional investment alternatives, which are already provided in electricity network regulations, are also briefly mentioned.

2 Regulated Investment

Regulated investments are the most common kind of transmission investments. They are subject to a cost-benefit analysis procedure and are supervised by an independent authority (e.g. the Regulator). Interested parties apply for a regulated investment project to e.g. the Regulator. The Regulator performs a cost-benefit analysis study of the proposed investment and examines also alternative investment possibilities that could have an impact similar to the proposed investment. The solution that maximizes the social welfare receives permission to be built. Eligible for investments with regulated revenues have traditionally been the owners of the transmission infrastructure, or the incumbent owners of the transmission grid after the restructuring [e.g. the Transmission System Operators (TSO)]. Recently, a European Union directive (EC, 2009, Art. 22(7)) also allowed the participation of third parties in regulated investments. For instance, if the Regulator identifies an investment as necessary, but the TSO is reluctant to undertake it, the Regulator can initiate a tender procedure, where third parties can participate and carry out the investment. In the second operating scheme, where both an ISO and a transmission owner exist, the ISO or the Regulator are responsible for identifying the investment and the transmission owner is willing (or reluctant) to undertake it. In case of a reluctant TO, the Regulator can initiate a tender procedure, where, except for third parties, also the ISO can participate as potential investor (EC, 2009, Art. 13(5b)). Cases where third parties invest in the network and become eligible for regulated revenues exist also in other regions, such as Australia (Littlechild, 2003).

Remuneration schemes for regulated investments range from "cost of service" to "price cap" mechanisms. Until recently, the most common regulation scheme has relied on the so-called "cost of service" mechanism. This stipulates that the transmission line owner is assured that he will be compensated for all of the costs that it actually incurs and no more (Joskow, 2006b). As the "cost of service" mechanism requires no managerial effort from the TSO[1] in order to operate efficiently, consumers might experience higher prices than optimum. Therefore, in several countries, the reform agenda has included the introduction of "incentive regulation" mechanisms for the regulated segments of the electric power industry, among them the transmission network (Joskow, 2006a). The "price-cap" mechanism, lying at the opposite extreme of "cost of service", is an incentive mechanism, which involves the setting of a fixed price ex ante that the regulated firm will be permitted to charge going forward. In such a case, the transmission company has the incentive to reduce costs and operate the firm more efficiently in order to increase its profits (Joskow, 2006b). With the TSO being paid a fixed price, the consumers may not enjoy any benefits from the cost reduction, while the TSO has also no incentive to improve service quality as it focusses on maximizing its profits. The optimal regulating mechanism will probably lie between these two extremes, with a form similar to a sliding scale regulatory mechanism. In this case, the price that the regulated firm can charge is partially dependent on changes in realized costs and partially fixed ex ante (Joskow, 2006b). A successful example of such a mechanism has been implemented in the UK (OFGEM, 2005).

3 Merchant Transmission Investment

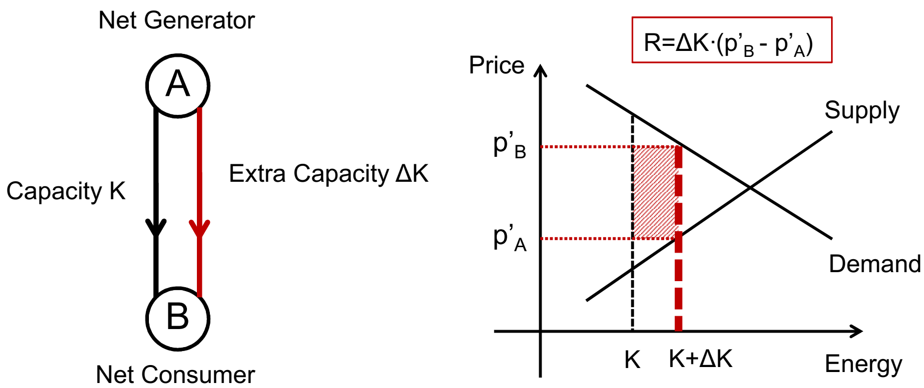

Figure 1: Illustration of the revenue generation for the Merchant Transmission Investment scheme.

[1]In the case of the ISO operating scheme, the term TSO corresponds to the Transmission Owner (TO) in this paragraph.

Merchant transmission investment (MTI), in comparison with regulated investments, does not need to be coordinated from a central authority, is not subject to regulation, and its profits derive mainly from trading electricity between the two areas that the transmission line connects. As a result, any interested party, including the TSOs or transmission owners, can undertake a merchant investment as long as the difference in the electricity prices between the two areas allows for a profit margin. The merchant transmission investment model emerged with the restructuring of the electric power industry, and has already been incorporated in the electricity regulations of several regions such as the European Union (see EC, 2003, Art. 7), Australia and the USA (see Brunekreeft, 2004, and the literature quoted therein). Joskow and Tirole (2005) further mention that such a market driven transmission investment is an "economist's dream", solving the problems associated with imperfect regulation of a 'natural monopoly' transmission company and aligning competitive transmission investments with the newly developed competition in the generation segment. In Europe, DC interconnections seem to follow rather successfully the MTI model, such as NorNed or BritNed. NorNed is the DC submarine cable that connects Norway with the Netherlands. BritNed connects the UK with the Netherlands. NorNed generated revenues of €50 million in the first two months of operation, about 8% of the of the invested capital. In the business plan drawn for the project, the expected revenues were initially estimated at about €64 million. (data exist at the moment only for the case of NorNed; data for the subsequent operation of NorNed were not available; the interested reader can refer to Stattnett (2008); Parail (2009)). Unsuccessful merchant investments have also existed earlier in Australia (i.e. Murraylink) but for reasons not directly associated with the investment model itself. In that case, after the building of Murraylink, the designated TSO Transgrid received the permission to construct an interconnector (regulated investment) largely in parallel to Murraylink, decreasing Murraylink's revenue potential. The decision for the permission of the regulated investment was considered controversial, as other alternatives had a larger effect on the increase of the social welfare (the interested reader can refer to Littlechild (2003); Brunekreeft (2005)).

4 Additional Investment Schemes

Two additional types of investment can also be anticipated in a deregulated electricity market environment. First, a mix of the two aforementioned investment schemes, with part of the capacity subject to regulation and the rest available for generating profit from trade (i.e. as in a merchant investment) could be possible. Such an option is already provided in the EC regulations (see EC, 2003, Art. 7.(4b)). Alternatively, the building of a new transmission line could also be funded by the consortium that builds a remote generating power plant, in order to connect the power plant to the network.

5 Regulated vs. Merchant Transmission Investments

This section will focus on the two main investment schemes and will attempt a comparison highlighting their merits and weaknesses. The regulated investment scheme exhibits shortcomings, which are reflected in the two main reasons leading to the introduction of the merchant transmission model.

The first reason for the introduction of MTI is to tackle the underinvestment problem in the electricity network; this occurred partly because of the inefficiencies of the regulated investment scheme. Before the electric power industry reform, utilities had the objective to guarantee the quality of service and minimize power interruptions rather than minimize operating costs. Operating under a "cost of service" scheme, they tended to overinvest in the network. After the deregulation, however, the transmission owners had also to operate efficiently. For instance, under an incentive regulation mechanism such as "price cap", the main objective of the transmission owners became the minimization of their costs. As a result, they tended to neglect transmission investments for a certain period. With both the power demand and the electricity trade increasing, the system was gradually put into increasing risk. Merchant transmission investment was considered as an alternative that could stimulate investments in the transmission network.

Additionally, a regulated transmission model will necessarily face inefficiencies resulting from "asymmetric information" (Joskow and Tirole, 2005). In theory, the regulators are assumed to be completely informed about the technology, costs and consumer demand attributes facing the firms they regulate (Joskow, 2006a). As fully informed regulators do not exist, the regulated firm (e.g. the TSO) may take advantage of its superior information in order to derive additional economic rents. The Regulator in this case faces the challenge of how to minimize these economic rents although it might not have access to similar sources of information. Further reasons leading to the emergence of the merchant transmission model include the mitigation of political interference, which could take place in a regulated investment regime, as well as the introduction of competition in the transmission system.

Nevertheless, the merchant transmission model has raised considerable discussion about its feasibility and effectiveness with both proponents (e.g. Hogan, 2003; Littlechild, 2003) and skeptics (e.g. Joskow and Tirole, 2005; Brunekreeft, 2005). Brunekreeft (2004) argues that HVDC links[2] overcome possible inefficiencies of the MTI model and can be eligible for merchant investment. In the following, the main concerns regarding the MTI model will be mentioned.

Joskow and Tirole (2005) refer to preemption as a problem for the merchant transmission model. For example, in transmission expansion investment there might exist a 'scarcity of rights of way'. If, for instance, there exists only one corridor that connects two regions, it is possible for a merchant to install a small capacity on the corridor to gain a toehold. Later he might expand this

[2]High Voltage Direct Current overhead lines or (submarine) cables.

capacity. Such a case would lead to a 'preemption and monopoly' situation as well as underinvestment. This is true for the fully uncoordinated merchant transmission investment. However, Brunekreeft (2005) suggests that if a call for tenders for merchant transmission investments is organized, and the bid proposing the highest capacity is selected, this problem can be mitigated; but, in this case, the decentralized nature of MTI would partially be lost. It should also be noted, that with respect to the submarine interconnections, as are the NorNed or BritNed cables, the specific matter does not seem to pose a problem, as there must exist no scarcity of rights of way underseas.

An additional issue, mentioned by Joskow and Tirole, refers to the competition between transmission and generation investments, which can lead to preemption issues. Merchant transmission projects, which connect a high price with a low price area, act actually as substitutes for generation projects in the high price area. This can lead to preemption, as usually a generation project requires a shorter licensing procedure and construction time. Here again we should distinguish between the different types of power plants. For all the conventional power plants this holds true. But assuming that we are moving to a more "green" electricity production, this does not appear to be a problem for power plants producing electricity from renewable energy sources (RES). RES power plants are location-dependent on the resource potential, and, therefore, cannot be built in any area. Nevertheless, possible new generation is a parameter which should be taken into account during the design of new interconnection.

Concerns have also been expressed about the fact that an MTI can lead to a monopoly situation, mainly in AC systems. The investment of a second parallel line may be deterred from the uncontrollable power flow in AC lines. For example, a contracted power transfer for the first line is bound to be divided over both lines, and would not allow the full capacity use from the second investor. A proper remuneration would emerge from the allocation of financial transmission rights. This would require a nodal pricing system, which, however, does not exist in every region (e.g. Europe) (Brunekreeft, 2005). Interarea parallel DC lines, though, can actually be competitive because of the total power flow control they offer.

A further problem of the uncontrollable flows, is the so-called loopflows. Loopflows occur because of the meshed structure of a high voltage power system and Kirchhoff laws. As illustrated in Fig. 2, assume points A and B are connected through a direct line, but also through an additional path which crosses point C, i.e. A $\rightarrow$ C, C $\rightarrow$ B. All paths, A-B, A-C, and C-B have the same impedance[3]. A contracted power transfer of 900 MW from point A to point B will actually result in a power flow of 600 MW over the path A $\rightarrow$ B and 300 MW over the path A$\rightarrow$ C $\rightarrow$ B. A business plan for the investment on the line A$\rightarrow$ B would assume revenues for the total power transfer of 900 MW, although only 600 MW flow through the line. Additionally, while the rest of the lines are also influenced, they are not being compensated for their "service".

[3]Impedance is the complex sum of the real ohmic resistance and the imaginary reactance of a line. Example taken from Brunekreeft (2004).

As Brunekreeft (2004) also suggests, controllable flows through HVDC lines do not need to make such considerations. A mitigation of the loopflows problem with respect to the AC network and the pricing of the power transfer can also be the flow-based allocation. For more information about the flow-based allocation scheme, the interested reader can refer to e.g. Krause (2007); Kurzidem (2010).

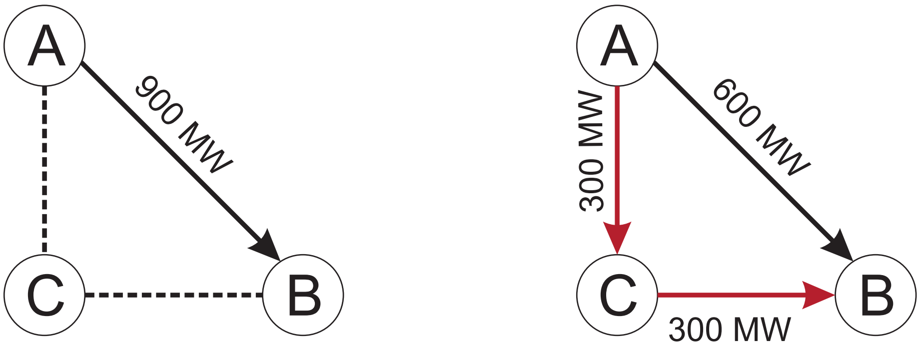

Figure 2: Illustration of the loopflows in a meshed AC grid.

An additional limitation of the merchant investment model is that it requires the electricity market to operate according to the nodal pricing system (Joskow and Tirole, 2005). Although some ISOs in the US, such as the PJM or the New York ISO, have organized the market operation based on the nodal pricing system, there exist also other operating schemes. For example, in Europe zonal pricing prevails. Nevertheless, if merchant investments connect neighboring grids, i.e. neighboring TSO areas, even a zonal pricing scheme should present no barrier. This, for example, has been the case of NorNed or BritNed.

Merchant investments present, however, problems that still need to be addressed. The most important is probably the exertion of market power from existing generators which can distort the nodal prices in one area, or both areas, that the line wishes to connect. This can lead to under- or overinvestments in the transmission line. A regulated investment might also face this issue during the cost-benefit analysis, but the transmission company's income would not be significantly influenced by the distorted price signal. An additional problem Joskow and Tirole identify concerns complementary investments undertaken by separate parties. Imagine two projects, connecting point A with B and B with C. In this case, each owner has the incentive to dimension his project slightly smaller than the other owner's project; the former project is then the bottleneck and receives the entire congestion rent while the latter exhibits excess capacity and generates no income. In the context of DC interconnections or an HVDC Supergrid, a DC network is superimposed on the regional AC networks. The price signals at each DC node could then be generated from the underlying AC networks, in which case the problem with the complementary investments could be avoided. If, however, an alternative pricing mechanism is employed for the HVDC network, then this parameter would need to be taken into account.

An additional problem, identified by Brunekreeft (2005), is the ownership of the transmission line in a merchant transmission investment, and in particular the participation limits of dominant generators. The author argues that if generators on either side of the line own a significant share of the interconnector, they could exert their market power on their respective regions in order to maximize their profits (e.g. withhold capacity in the high price area in order to profit from increased imports). He further mentions that Australia requires the line owners to control less than 35% of the generation capacity on either side of the line. This ownership problem, of course, would not apply to remote generating units which wish to construct transmission lines in order to transmit their produced energy.

With respect to the European supergrid, E.ON UK (2011) expects that regulated investments would also be necessary. Their reasoning stems from the fact that the initial interconnections will cause the prices among regions to equalize. As a result, the incentive for a merchant investment will decrease, not allowing the full benefits from an integrated European grid to be realized. This also reflects a shortcoming of the MTI model. Although it can stimulate transmission investments, an MTI usually achieves a suboptimal maximization of the social welfare. Optimal maximization of the social welfare means, in effect, the elimination of all congestion costs, so that the net supply and demand curves can intersect and energy prices equalize. Such a case, however, would imply a zero congestion rent for the merchant investor, thus rendering the investment unattractive. On the other hand, it should be also noted here that studies showed that the NorNed interconnector had no significant effect on prices during the first two years of operation, concluding that a substantially larger capacity might be necessary (Parail, 2009).

6 Concluding Remarks

From the discussion above it has become evident that the different transmission investment models tackle successfully different inefficiencies but also exhibit their own shortcomings. The discussion about which model is more appropriate has led to significant controversy, while the answer is most probably not straightforward. Literature concludes that developing good regulatory mechanisms which will also provide opportunities for merchant investors to develop projects seems to be a good solution, but at the same time a significant research challenge (Joskow and Tirole, 2005; Brunekreeft, 2004). Brunekreeft further suggests that controllable flows, namely HVDC lines and FACTS[4], can operate sufficiently well under a merchant transmission investment regime, overcoming several of its inefficiencies. His arguments seem to lie on a sound basis.

Concerning merchant transmission investments, due to the benefits that interconnections offer, more such projects are expected to follow in the coming years, connecting different regions and electricity markets[5]. Due to the size of

[4] Flexible AC Transmission Systems

[5] In the future, it can also be envisioned that transmission investments could connect regions

the regional electricity markets, it could be envisioned that parallel lines from different owners can be built, thus facilitating competition not only between the areas, but also between the lines[6].

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that have the size of continents.

[6]Peak electricity demand is in the range of several hundreds of GWs for each region (e.g. Europe, North America, China, etc.), while an interconnector capacity usually lies around a couple of GWs. Cases can exist where an additional parallel line would reduce insignificantly the price difference between the nodes and as a result be a profitable investment. Assuming controllable flows, if a contracted energy transfer between points A and B can flow along two different paths, the corresponding line owners could compete over which path the energy will follow.

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