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FACTORS THAT INFLUENCE THE TARGETS AND CRITERIA FOR ELECTRICITY INTERCONNECTOR INVESTMENTS

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Abstract

This paper analysis various factors that influence electricity interconnector investments. It shows that several features linked to zonal market design, in particular the possibility to favour market participants in the own country compared to those in the neighbouring countries, distort the investment signals for interconnectors. Uncertainties on investments in both transmission and generation have a big influence in interconnector investment decisions.

The paper proposes that flaws in market design, capacity calculation and capacity allocation need to be addressed to provide efficient signals for interconnector investments. It proposes to reduce price zone flaws by forming more natural price zones for Europe. Regarding asymmetry in cost and benefits of interconnector investments this paper proposes a two tier mechanism to rebalance the costs and benefits for the involved parties.

Keywords

Electricity transmission networks, investments

1. Introduction[1]

It is generally recognised that it is possible to use social welfare as the main criterion for interconnector investments. Social welfare is often calculated through price arbitrage benefits. Security of supply and competition benefits of interconnector investments are part of the social welfare function even though they are seldom included in the social welfare calculation. Probably the reason for this is that estimating these other benefits is more difficult than estimating price arbitrage benefits.

The costs and benefits of interconnector investments are influenced by many factors. This paper identifies the most important factors to be taken into account in interconnector investment decisions. In a network, each new investment affects existing investments which makes welfare calculations particularly complicated. In this paper influence of capacity calculation and allocation methods, factors linked to zonal pricing, tariffs and subsidy mechanisms, uncertainty and asymmetry between sharing of costs and benefits are explored. Finally, a mechanism to allocate costs and benefits in a way which promotes interconnector investments is proposed.

2. Influence of capacity calculation

Interconnection capacity calculation is a complicated matter. To agree on a bilateral Net Transfer Capacity (NTC)[2] between two countries, only two TSOs are involved. If transmission capacities are defined regionally, the number of TSOs involved is already significant.

One complication in the capacity calculation is the fact that interconnections are usually composed of several individual lines. The full thermal capacity of any line can only be used in special circumstances because of redundancy requirements.[3] The N-1 rule requires that the network shall be able to face the breakdown of a single network element without supply interruption.

Another complication in the capacity calculation is the inherent disconnection between commercial schedules and physical flows in the zonal price system. The maximum commercial schedules that can be allowed from network security point of view are calculated relying on simplified network models which treat interconnections as bilateral flow gates between price zones. A NTC value is calculated for each flow gate, this is the upper limit for a commercial schedule at that interconnection.

The actual physical flow can differ radically from the commercial schedule, sometimes it is even in the opposite direction. This is due to the fact that each cross-border commercial schedule creates a whole pattern of physical flows spreading over several interconnections. This means that the capacity of those other interconnections will be affected as well even if one schedule appears commercially

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1 Matti Supponen is working for the European Commission. However, the views expressed in this study are personal views of Matti Supponen. They have not been adopted or in any way approved by the European Commission and should not be relied upon as a statement of the European Commission's views.

This paper is based on the dissertation of Matti Supponen for Aalto University (Espoo, Finland): "Influence of national and company interests on European electricity transmission investments". The dissertation is available at: http://lib.tkk.fi/Diss/2011/isbn9789526042701/

Drawings: Outi Supponen

2 ETSO, transfer capacity definitions, 2001; NTC, Net Transfer Capacity, is a bilateral cross-border capacity value indicating the maximal commercial flow between two countries.

3 DC lines can be loaded up to their full thermal capacity if the rest of the network can secure the breakdown of the line for example through redundancy in the AC network or through the reserve power arrangements at both ends of the line. This is important for the profitability of DC lines as the costs are relatively high. The situation becomes more complicated when high capacity DC lines will be added in parallel of the existing AC network.

only in one interconnection. Thus the NTC value of an interconnection is dependent on the NTC defined for other interconnections in the region.

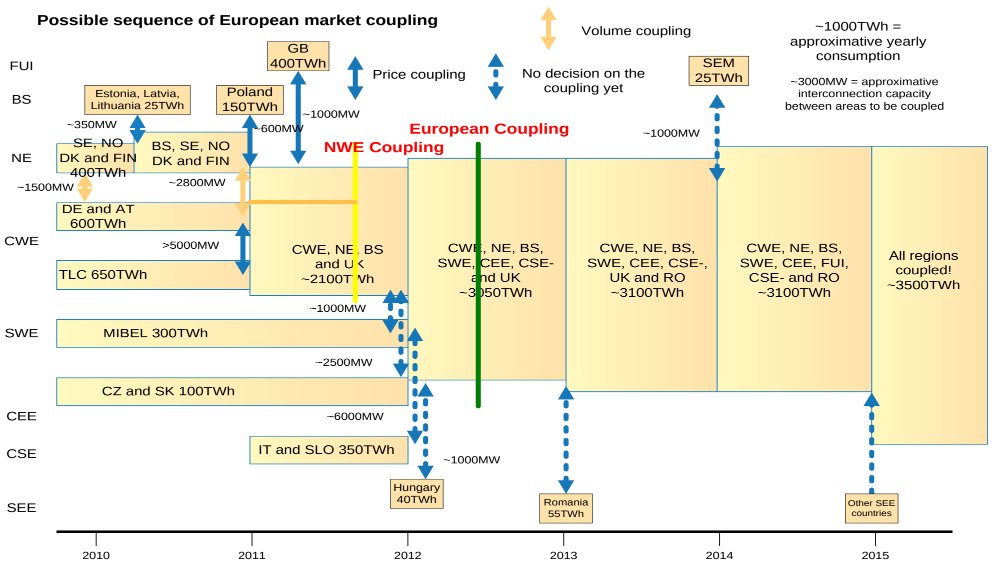
To catch the whole pattern of power flows spreading in a meshed network, a system of Power Transmission Distribution Factors (PTDF) has been developed. PTDFs indicate how a commercial flow will be spread between each possible path between the price zone of origin and the price zone of destination. This approach helps to analyse which combination of commercial flows is optimal, with the possibility to set the overall social welfare as the objective function.[4]

3. Influence of capacity allocation

Regarding capacity allocation, it is well known that the current methods used in many interconnections in Europe are not optimal even if there has been a lot of progress in recent years.[5] There are still many interconnections which only use explicit auctions instead of more efficient implicit auctions.[6] There are still interconnections without intra-day capacity allocation even if this has been required by the European legislation from the beginning of 2008.[7]

One of the main reasons why more efficient capacity allocation methods are not used is due to differences in national electricity markets. These differences make it difficult to apply methods which require a higher level of harmonisation. Another reason is the lack of liquid day-ahead spot markets necessary for implicit auctions.

Figure 1 A tentative timetable for the day-ahead market coupling in Europe[8]



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[4] ETSO, co-ordinated auctioning, 2001

[5] EC, congestion management, 2002

[6] Frontier Economics and Consentec, congestion management methods, 2004

[7] EC, infringements, 2010

[8] EC, day-ahead market governance, 2010. In addition to country names, the following abbreviations have been used: BS= Baltic States, CWE = Central Western Europe, NE=Northern Europe, SW=South Western Europe, CSE=Central South Europe, CEE=Central Eastern Europe, SEE=South Eastern Europe, SEM=Single Electricity market (Ireland), MIBEL=Iberian Electricity Market, FUI=France, UK and Ireland, TLC=Trilateral market coupling (France, Belgium and the Netherlands).

An advanced capacity allocation method called flow based capacity allocation has been developed by the TSOs.[9] This method identifies critical network branches, independently whether they are at the borders of or within price zones, and uses the maximum flow allowed in these branches as the basis for managing the cross-border flows. With this method, capacity can be allocated more precisely and consequently the network can be used more efficiently without endangering the security of the network.[10]

Flow-based capacity allocation with implicit auctions has been accepted as the target model for electricity cross-border trade.[11] Figure 1 presents a time-table for implementing implicit auctions for day-ahead capacity allocation in Europe. Applying these methods will significantly improve the efficiency of interconnector utilisation as indicated by the reports of the European regulators, the French regulator Commission de Régulation d'Énergie (CRE) being the most active one in reporting on this topic.[12] Reasons for inefficiencies listed by CRE are (i) difficulty to anticipate the market situation day-ahead to make explicit auctions efficient, (ii) market imperfections at both sides of the interconnection and (iii) mismatch of long term products with the hourly resolution of interconnection capacity. Another source of inefficiency is the uncertainty on the exact location of the electricity produced and consumed. Sub optimally, this gives the TSO an incentive to use a higher security margin in the capacity calculation and allocation phase than what would be necessary if the location of generation and load was known more precisely. Also strategic behaviour of trading companies in the way they use or withhold interconnection capacity can be a source of inefficiency.[13]

Network capacity calculation poses an important question of transparency. European legislation requires TSOs to communicate bottlenecks in order to enable the market to better understand how the network behaves in different situations. However, only in rare cases bottlenecks, at the borders or inside the control area, are published and made so transparent that even another TSO could share the congestion analysis and confirm the results of capacity calculation.[14] This means that for an external observer without access to network models it is practically impossible to make a meaningful analysis on congestion patterns and whether the TSO manages the network in a neutral and efficient way, following requirements of the EU legislation.

4. Influence of the difference between the commercial and physical flows

As explained above, in an electricity market using zonal pricing, differences between the commercial schedules and the physical flows are inevitable. Some differences are because of the network topology, others are because of a deliberate choice made by the TSOs on the commercial capacity value at each border. The freedom of choice for the TSO is particularly high if the cross-border capacity limits are due to congestion inside the national network. This is usually the case for large countries such as France, Germany, Sweden and Poland, but also applies to many smaller countries such as the Netherlands and Austria as well.

An example of the use of this discretion on commercial capacities are the France – Italy and France – Switzerland interconnections in which the commercial capacity is set to a very high level on a common agreement between the countries involved. Another example is the Austria – Germany interconnection which is declared to have unlimited capacity. The German internal North – South flows are a further example of this discretion as there is no explicit limit to these flows even if they are

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[9] ETSO, vision congestion management, 2002

[10] Consentec, comparison between ATC and FB, 2008

[11] ETSO and EuroPEX, Flow based market coupling, 2004; AHAG

[12] CRE, interconnection 2007, 2009; CRE, interconnection 2008, 2009; ERGEG, CWE, CS and SW report on 2008, 2010

[13] TUD, Zachmann, inefficiencies, 2009

[14] ERGEG, compliance monitoring report, 2010

heavily using the networks of the neighbours.[15] These unilateral or bilateral decisions by the TSOs create problems regarding an objective allocation of cross border capacity. There is usually no publicly available information which would enable to judge whether these unilateral or bilateral decisions can be justified based on underlying fundamentals. None of the above mentioned countries are transparent regarding the internal bottlenecks or the bottlenecks towards the partner country.

There are several places in Europe where the difference between commercial and physical flows has a strong influence on transmission investments decisions, in particular when transporting electricity long distances. The most important transmission axis in Europe is from North to South and is used here as an example to illustrate this phenomenon.

In the North-South axis, surplus electricity flows first from Norway and Sweden to South mainly through Denmark, partly using DC links. In Northern Germany this electricity joins the wind surplus electricity produced locally and in the North Sea. This combined surplus travels more than 1000 km to Southern Germany and Northern Italy using the Central European AC meshed network. The electricity flow uses all possible transmission paths, namely the direct path through Germany and Switzerland but also the side paths. In the West the side path goes through the Netherlands, Belgium and France and in the East through Poland, the Czech Republic, Slovakia, Hungary, Austria and Slovenia. All these parallel transmission paths are under stress in high wind conditions. This is why all countries on the side paths of this North South dipole, except France, have complained about these parallel flows, often called loop flows.

One important issue at the European scale related to these loop flows is that the method applied by the TSOs for congestion management does not yet take sufficiently into account the interregional commercial and physical flows. TSOs still apply bilateral NTC values allowing nominations of commercial capacity in a chain which potentially deviates considerably from the physical path used by this commercial flow. To improve the situation, a flow-based capacity allocation system has been developed but not yet applied in Europe.[16]

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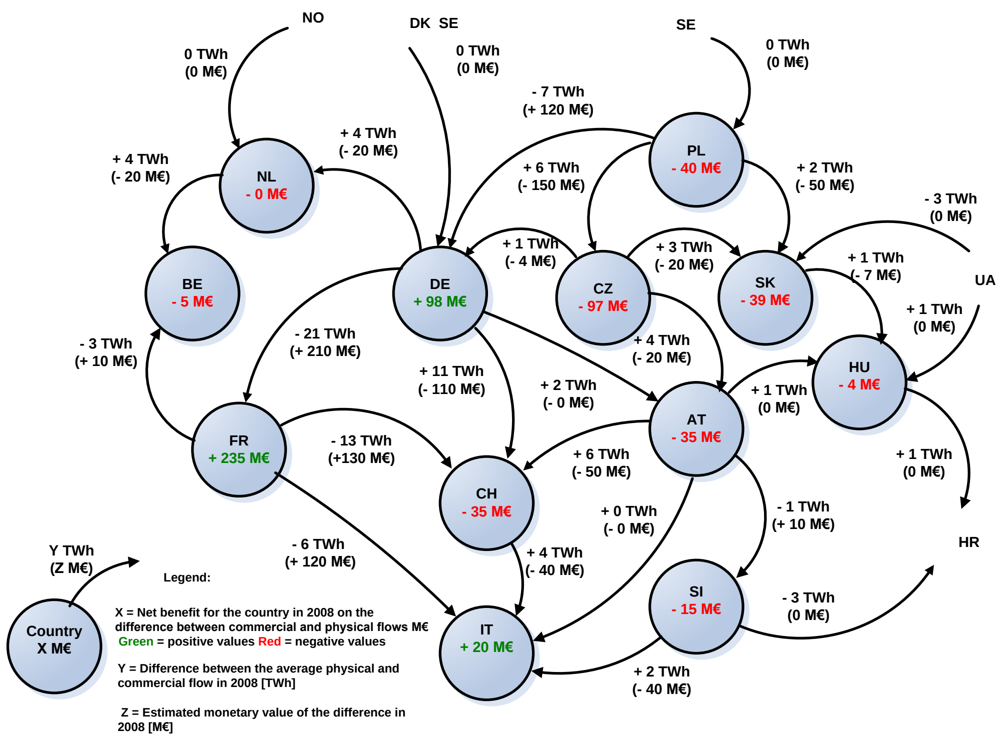
15 EWIS, European Wind Integration Study, 2010

16 TSOs are working on a European capacity calculation system in the framework of Capacity calculation Working Group of Ad Hoc Advisory Group, initiated by the Florence forum.

Figure 2



The difference between yearly average physical and commercial flows and the estimated monetary value of that difference in 2008 in Central Europe. A positive value of the difference, expressed in TWh, means that there has been more physical flows than commercial flows. The arrows indicate the prevailing direction of commercial flows.[17]

If the commercial flow is higher than the physical flow, the country wins as the congestion rent is based on the commercial flow but the costs are based on the physical flow. If the physical flow is higher than the commercial flow, the country is on the losing side. Figure 2 illustrates the difference between commercial and physical flows in the interconnections in Central Europe in 2008. The estimated positive or negative monetary value of this difference for each interconnection based on the congestion rent at that interconnection is also shown. The sum of these differences is calculated for each country, taking into account half of the value at each interconnection, assuming that the benefit or loss is shared equally between the two countries. This is justified as the benefit or loss is realised as an increase or decrease in congestion rents which are usually shared equally between the two TSOs.

In Figure 2 the influence of the North-South dipole is clearly visible.[18] It seems also evident that the flows from North to South are over proportionally nominated through the Central Western Europe and under proportionally through the Central Easter Europe. This explains why France is the biggest winner regarding the difference between commercial and physical flows, the biggest loser being the Czech Republic together with other countries on the Eastern path.

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17 The value given in the picture indicates the yearly average net difference between physical and commercial (nominated) flows in 2008 and the estimated commercial value of the net difference (potential congestion rents not received or received in excess) based on the congestion rent collected at the same interconnection in 2008. For commercial and physical schedules data from Entsoe.net is used for the calculation.

18 The graph does not include the Nordic countries, even if they are part of the North-South dipole, because most of the connections are DC lines in which there is no difference between physical and nominated commercial flows.

The TSOs' data portal Entsoe.net contains for some countries information about the difference between commercial and physical flows. The way the information is presented is symptomatic regarding the importance of this issue. Ironically, instead of relaying the true picture of the situation as in Figure 2, the information is presented with such an aggregation that the difference between commercial and physical flows is practically not visible.

The difference between commercial and physical flows and all uncertainties linked to this issue can seriously hamper cross-border investments. If an investment which would be beneficial for the European welfare does not benefit the investing country either through an increase of capacity at its own borders or through an increase of congestion rents, or through any other form of compensation such as increased inter-TSO compensation revenues, it is clear that there is little motivation for investing. In order to unblock the situation perhaps more innovative approaches are needed, including opening up transmission investments for other companies than TSOs. Economic theory has addressed similar issues, for example in papers on social cost by Coase.[19]

This question of sharing of welfare and investment burden between countries is already acute and is becoming more and more important because of the investments needed for the integration of the increasing wind power in the European transmission system. The reaction of ČEPS, the Czech TSO, to the EWIS study is highly recommended reading for anybody interested in this topic.[20] It illustrates in concrete terms what kind of national interest elements are at stake, both regarding sharing of costs between countries and regarding the influence of cross border flows on the need to limit the access of domestic generators and consumers to the network.

5. Technical versus commercial solutions to the loop flow problem

The uncertainty of the benefit for an individual TSO for its investment calls for a European approach in planning, financing, operating and sharing the costs and benefits of the common network. Figure 3 gives a schematic example on how important co-ordination of investments is at the European scale. The picture illustrates the challenge of adding new lines in a meshed alternative current network with resemblance to the situation of the North – South dipole in which many countries are involved.

[19] Coase, The problem of social cost, 1960

[20] CEPS, comments of EWIS study, 2010

Figure 3 Options to increase capacity of a transmission path in a meshed AC network[21]

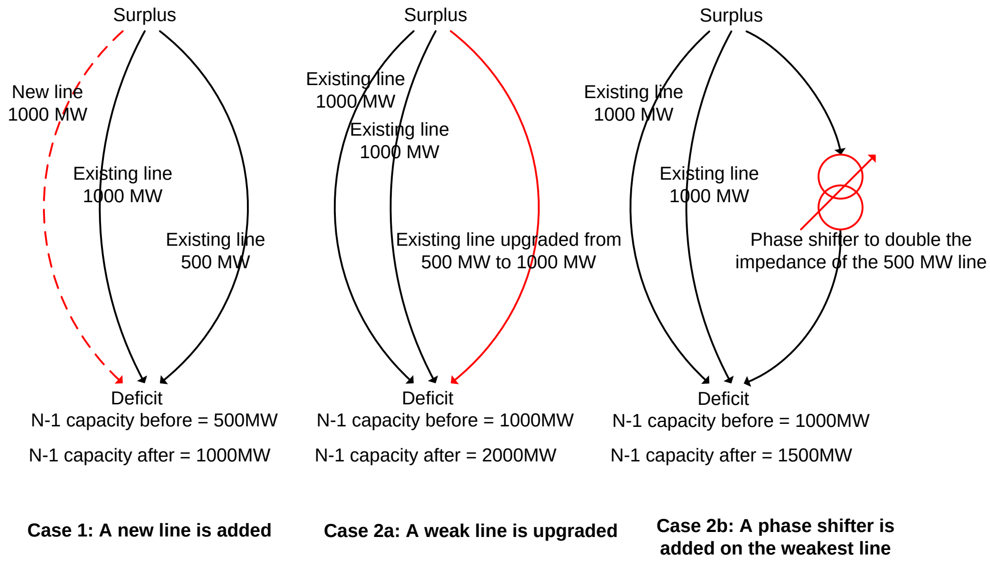

Figure 3 shows how the overall capacity is limited by the weakest line in the system. In Case 1, adding a new line to the system results in a relatively small increase in the overall commercial capacity as there is a weak line on the parallel path. This is because the maximum flow in the system is determined by how much electricity can be transported in a situation when the strongest line is not in operation. This is the consequence of applying the N-1 rule. To increase capacity from Case 1, it is efficient to upgrade the weak line as illustrated by Case 2a. The TSO can also invest instead in a phase shifter on the weakest line as in Case 2b. Phase shifter transformers are able to increase the impedance of lines, thus it deviates physical flows to the other parallel lines. Phase shifters can thus be efficient in alleviating the flow in one line but they tend to shift the problem to the other lines. In the example, the line upgrade, Case 2a, results in a higher overall capacity than when installing a phase shifter, Case 2b.

Countries on the side paths of the North-South dipole have already taken action against loop flows. Belgium has invested in three phase-shifting transformers thus pushing part of the electricity back to Germany. Poland has refrained from reinforcing interconnectors with Germany as this would attract more loop flows and might further endanger the safe operation of the Polish grid. Instead, the Polish TSO will install a phase shifter at the existing interconnector with Germany. Slovenia has invested in a phase shifter at the Italian border and the Czech Republic has considered installing them. [22]

One idea to solve the North-South dipole issue is to bridge it with DC technology.[23] This would indeed be interesting as DC solutions are capable of transporting big volumes long distances. However, for building a meshed DC network on top of an existing AC network some technical challenges still exist, such as development of a protection and control strategy for a combined AC and DC network and development of DC circuit breakers. If appropriate solutions to these challenges are found, using a DC overlay network seems to be a promising way to develop the European transmission system in the future.[24]

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[21] It is assumed that all parallel lines have the same impedance and N-1 rule is respected. Individual capacities of the lines are thermal capacities. A phase-shifter is a transformer that can control the impedance of a transmission line when connected in series with that line, thus allowing to control the flow over that line.

[22] CEPS, comments on EWIS study, 2010

[23] Amprion, Kleinekorte, DACH 2010, overlay grid, 2010

[24] GIGRE, Bergen conference documents, 2009

There are also commercial solutions to the loop flow problem. The main solution is to influence the generation dispatch in such a way that loop flows are avoided. This would mean that some generators in Northern Germany will be turned off when the production from wind is high. To make this happen in a market based manner, Germany should probably be divided into several bidding zones along the North-South axis, with a limited capacity between zones. Even nodal pricing could be envisaged. The disadvantage of this commercial solution is that it would reduce the pressure on the TSOs to make optimal network investments. It would be a poor man's solution to survive day by day with a weak grid with potentially important welfare losses due to congestion.

6. Influence of congestion management inside the control area

If a TSO can guarantee free dispatch of generation and load in its control area, the control area forms a single price zone. In a single price zone every generator and load has the same market price. Historically, transmission networks have been stronger inside control areas than between control areas. This has led to a situation where most control areas form a single price zone. However, some price zones include several control areas. Germany has a single price zone in spite of four control areas. Additionally, Austria has declared to be part of the single price zone of Germany. The Czech Republic and Slovakia as well as the island of Ireland have also formed a common price zone, each of the zones including two control areas.

If there are transmission constraints inside a control area, the TSO has three possibilities to act. Firstly, the TSO can redispatch generation, in some cases also load, to relieve congestion. This means that the TSO pays separately for some generators to produce more or to produce less, or analogously it pays some consumers to consume more or to consume less. The generators and loads to be redispatched need to be chosen in a way that the redispatch relieves congestion, more generation in the deficit areas and less generation in the surplus areas, for the load vice versa.

As a second possibility, if redispatching is not enough, the TSO can split the control area into bidding zones. By defining how much electricity can flow between the newly created bidding zones, the TSO can manage the congestion exactly as described above for cross-border flows. Evidently, there will be a different price in each bidding zone when there is congestion between zones.

Network constraints have already forced some countries to split the control area into several bidding zones. In Norway there are up to five bidding zones, Italy has six bidding zones and the UK two bidding zones, namely Great Britain and Northern Ireland. In Italy bidding zones are used to give geographically differentiated price signals only to generation units. For load, prices are averaged for the purposes of equal treatment of consumers and for facilitating the retail market. Thus Italy is a single price zone from the end consumer's point of view. A negative consequence of this price equalisation is that it does not provide incentives for the consumers in high price zones such as Sicily to attract power plant investments.[25]

As a third possibility for the TSO to relieve congestion inside the control area is to reduce cross-border capacities offered to the market. It is worthwhile to note that EU law prohibits excessive limitation of cross-border capacity to defend the integrity of the price zone because limiting cross-border capacity usually favours market players inside the price zone compared to the ones outside the zone. Limiting cross-border capacity is allowed for temporary actions needed for reasons of operational security or for actions which can be justified based on cost-effectiveness and minimisation

[25] Redispatching has been raised as a temporary solution for Sicily before a new line under the Messina strait has been built. A proposal is made to virtually mix some generation bids from cheaper price zones to Sicily even without having the underlying transmission capacity, and then redispatch some generators in Sicily. In this way the overall payments to Sicilian generators could be reduced. MF, virtual transmission lines, 2010

of negative impacts on the internal market in electricity.[26] On this issue Danish consumers complained about the behaviour of the Swedish TSO claiming that the Swedish TSO Svenska Kraftnät discriminates Danish consumers by reducing cross-border capacity at the Swedish – Danish border.[27] The Swedish case was solved by the commitment of Svenska Kraftnät to introduce in Sweden four price zones in 2011, to use more redispatching before the price area splitting is effective and to solve the congestion in the longer term by investing in new transmission lines. Other similar cases have been raised in the context of infringements against Member States because of non-compliance with Regulation 1228/2003 on cross border trade of electricity and with congestion management guidelines.[28]

The split into price zones does not mean that each price zone has always a different price than the other zones. In periods when there is no congestion the prices converge. Only when congestion appears, there is a price difference between zones. For example in the Nordic market there are price zones which share prices more than 90% of the time.

It is not easy to evaluate in which cases it is still possible to keep a single price zone through redispatching and when a split into several bidding zones is necessary. Regarding redispatching, it is difficult to make a transparent system to optimally select the generators to be redispatched. Redispatching also invites the units which expect to be redispatched for gaming. Texas introduced nodal pricing partly because of the risk of gaming.[29] Regarding price zone splitting, decisions on the limits of the zones may have distributional effects which could make it difficult to get the necessary political support for these decisions. The generators in the price zone with a lower price after the splitting will suffer as well as the consumers in the price zone with a higher price. Smaller price zones could also affect retail markets as an increase in market power could reduce competition and make risk hedging more difficult.[30]

As price zone splitting decisions have radical consequences on the market, TSOs seem to use limiting cross-border capacity to avoid price zone splitting even if cross-border capacity limitation to manage internal bottlenecks is against the European rules. This limitation can significantly reduce the overall social welfare and in any case has important effects on distribution of welfare between the two countries involved. The Danish complaint against Svenska Kraftnät was mainly based on the important welfare loss for the Danish end consumers due to the limited cross-border capacity allocated by the Swedish TSO towards Denmark.[31]

Another important factor is the timing of these measures. Price zone splitting is a structural measure which needs to be in place permanently or semi-permanently as applied in Norway. Cross-border trade limitations can be decided in a more flexible manner, latest before the day ahead capacities are announced to the market. At that stage the uncertainty of generation and load schedules is still relatively high. Redispatching is planned and operated closer to real time when there is a much better view on congestion.

Redispatching costs give an indication to what extent the network is supporting maintaining a single price zone. High redispatching costs would suggest that splitting into several bidding zones should be considered. Table 1 gives an estimate of redispatching costs in some control areas in Europe. It is very difficult to get comparable information on redispatching costs, thus Table 1 is not

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26 Regulation EC/714/2009 of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity

27 SVK, commitment, 2010

28 EC, infringements, 2010

29 PUCT, impact assessment, 2008

30 Fingrid, price areas in Finland, 2009

31 Copenhagen Economics, capacity limitations, 2006

complete and shall be considered as indicative only. The TSOs and regulators should work on publishing relevant information on this important topic.

Table 1 Costs of redispatching in selected EU Member States[32]

Control area	Redispatching costs in year 2008 [M€]	Remarks
Austria APG	24 M€[33]	Redispatching costs have decreased after 2008 due to completion of the 400kV ring in the East.
Belgium	3.6 M€[107]	Phase shifters are important for keeping the cross-border flows in control and to avoid internal bottlenecks.
Finland	1 M€[34]	These costs are used for countertrading between Sweden and Finland, not for internal bottlenecks.
France	40 M€[107]	RTE has a contract with EdF which allows decisions on dispatching of nuclear generation taking into account the network constraints. Redispatching is applied both to manage internal bottlenecks and to guarantee cross-border capacity.
Germany – sum of costs for all four TSOs	45.6 M€[107] [35]	The figure does not include the costs for redispatching in cases when the German legislation allows redispatching without compensation to redispatched units.
Italy	85 M€[107]	These redispatching costs are used for redispatching inside Italy to guarantee the cross-border capacity at the Northern border. There are additional redispatching costs due to managing of internal bottlenecks in Italy.
Sweden	4 M€[36]	Limiting cross border capacity at Southern interconnectors has been used to keep redispatching costs relatively low.
UK	263 M£ (about 300 M€)[37]	263 M£ constraint costs in the financial year 2008 – 2009.

Investigating redispatching costs only does not give a reliable picture on whether bidding zones are appropriately defined because reducing cross-border capacities is a common way to reduce redispatching costs as explained above. For this reason, the amounts used for internal redispatching remain generally small and usually are only a fraction of the congestion rents collected from

32 Redispatching costs are not always published. A reason for this might be that as TSOs need to provide redispatching from the market they are not willing to disclose how much they have to pay for it for commercial reasons. In Germany redispatching costs are considered as politically sensitive information because it is linked to the definition of price areas and to the priority dispatch and subsidies for wind generation.

33 ERGEG, CWE, CS and SW report on 2008, 2010

34 Source: Fingrid

35 TUD, Waniek et al, redispatching, 2008

36 EMI, price zones in Sweden, 2007; The figure is an estimation of average redispatching costs based on historical data.

37 Source: National Grid

interconnectors. TSOs do not generally provide information on what basis it is decided when to use redispatching and when cross-border trade is reduced.[38]

If the critical network elements are inside the national network, there is often a wide set of possible commercial cross-border capacity combinations that are feasible. Thus the TSO can decide at which interconnection it limits the capacity. By analysing duration curves of available cross-border capacities one could get an idea how often the TSO limits cross-border capacity for congestion management purposes.

If there are three short term solutions for a TSO to manage congestion discussed above, namely redispatching, splitting the price zone into bidding zones and limiting cross-border trade, the long term option is naturally to build more transmission capacity. The investment signal for infrastructure building for a TSO is dependent on which one of these three short term options is used. When using redispatching, the TSO could try to reduce redispatching costs by strengthening the transmission network at the internal bottleneck. When using curtailing cross-border capacity, there might be no incentive for the TSO to do anything if this limiting of cross-border trade increases congestion rents.[39] Splitting the control area into bidding zones will generate congestion rents from inside the control area. This could reduce interest in investing in the network. To put the choice of the congestion management method into perspective, the benefits or disadvantages of smaller bidding zones for the network operation is probably a far more important factor for the TSO than a possible increase or decrease in congestion rents.

To achieve the necessary investments in the grid for a well-functioning market it is very important that the regulator gives the TSO proper incentives and does not focus only on limiting the costs and profits of the TSO.[40] In general reducing congestion will require investments both within and at the borders of the price zone. Thus interconnector investment calculations need to take into account also the necessary internal transmission line investments.

7. Locational signals and optimal size of price zones

Zonal pricing gives an important signal for the investors where to locate generation plants. Zonal pricing promotes generation investments in high price zones. The system of zonal pricing has, however, an inherent flaw regarding locational signals. It will not use the transmission system as efficiently as a system with a finer geographical resolution such as nodal pricing. In the zonal system, generators close to the border of a neighbouring zone with a lower price are favoured as they get a higher price than they objectively should, seen their use of the transmission network. Similarly, generators close to the border of a high price neighbouring zone are disfavoured as they just get the price of their own zone.

In large price zones this price zone flaw is more important than in small price zones. Large price zones are thus in conflict with the scarce nature of transmission capacity. This is true in particular if there is an important surplus of generation or load in some locations inside a large price zone, for example due to fuel resources or due to concentration of population or industry. Inside a single price zone neither generators nor an end consumer have an economic signal to behave according to the transmission constraints because all generators and consumers respond to the same market price.

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[38] SEA, handling of bottlenecks in Sweden, 2005

[39] However, in other cases, depending on the level of price convergence, increasing interconnection capacity might increase the income for the TSO and would thus give an incentive to invest.

[40] The EU 3rd internal market package includes this task for the national regulators in Electricity directive 2009/72/EC Art.36 (c).

It is generally considered that large price zones are more beneficial for retail competition than small zones, as there are more market players in a large zone. Small zones have usually less market players and require more effort in market surveillance. However, it has been proven that market power is linked to physical properties of the network and not to the size of the price zone.[41] If a generator is necessary for the secure dispatch of the system because of network constraints, it can potentially abuse its position in spite of the existence of other generators in the same price zone.

A single price zone is the preferred solution for many countries including big countries such as the UK, France and Germany. In these countries it has been considered as an important basic right for citizens that every generator and final consumer is equally treated independently of their geographical location in the country.

Particular attention to this issue of lack of locational signals in big price zones has been given in Germany. The single price zone of Germany does not incentivise locating new generation investments to the generation deficit areas in the South but most investments are planned to be located in the Northern harbours where there is already a surplus due to wind generation.[42] German market participants have been hesitant even to think about splitting the country into bidding zones as the outlook for competition in smaller zones allegedly would be worse than in the single German price zone. However, discussion on splitting Germany into bidding zones and on other methods such as nodal pricing has already started.[43] The Central Western European regulators have agreed to make a regional study on optimal bidding zones. This study will probably constitute a real laboratory for analysing national and company interests, starting from the terms of reference, through input received from stakeholders, to interpreting the results. For example, concentrated interest groups such as generation companies or retailers might be better equipped than dispersed tariff payers for providing a good quality input for the study to achieve the result they prefer.[44]

In some countries, instead of splitting the country into bidding zones, other locational signals are applied. The UK utilises grid access tariffs which are modulated based on demand and supply balance in each area, high access tariffs for generators in surplus areas and low, even negative tariffs in deficit areas, and vice versa for loads. Also Norway and Sweden have locational access tariffs. Norway even applies an hourly modulation of the losses component of the access charge. For Norway and Sweden these measures are additional to the bidding zone split. For Great Britain it remains to be seen whether network investments can be done fast enough so that the modulation of grid access tariff and redispatching will allow maintaining the single price zone in the future or whether a splitting of the single price into bidding zones becomes necessary.

Locational connection and access tariffs are an interesting way to promote building generation and consumption units in places which are beneficial for the grid. There are, however, serious design issues linked to these locational tariffs, such as for how long time the tariff remains fixed, what happens if a new plant is built in the neighbourhood or how the tariff is changed when the flow patterns change. A volatile system of locational tariffs can be an important source of uncertainty for the investor. Locational tariffs can distort the market if they are applied locally without taking into account the need for European investment signals.

Transmission network congestion will increasingly constrain dispatch in the future. Power flows from wind power including off shore wind generation in the North Sea and the Baltic Sea reserve a

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41 Bye and Hope, market power due to network constraints, 2005

42 Frontier Economics and Consentec, locational signals, 2008; BNA, decision on redispatching, 2008; TUD, Dietrich et al, location of power plants, 2010

43 Consentec and Frontier Economics, German bottlenecks, 2008; German TSOs, Regionenmodell « Stromtransport 2012 », 2008; RWTH, IEAW, Mirbach, DACH 2010, German price zones, 2010; EC, Florence forum conclusions June 2010, 2010; DENA, grid study II, 2010

44 Becker, pressure groups, 1984

growing share of network capacity. For this reason good locational signals for both short term dispatch decisions and long term investment decisions for locating new generation are very important. Thus in the future there will probably be smaller bidding zones in Europe and even a certain level of harmonisation of the size of these zones.

To design price zones, at least five criteria should be used. Firstly the bidding zone borders need to align to the physical congestion points of the network. Secondly, one needs to take into account the existing bidding zones and the already decided changes to them such as the splitting of Sweden into four zones. This might not be in all cases ideal but defining price zones just based on technical parameters is not very realistic due to political considerations. Thirdly, the bidding zone split needs to take into account the extreme generation deficit areas such as Brittany and Bucharest where a separate bidding zone would attract more efficiently new power plants. Fourthly countries with important wind power development, namely Germany and the UK, need to be split into bidding zones perpendicularly to the direction of the wind power flow to allow a gradual, stepwise price increase from the wind surplus zone to the main consumption areas. Finally areas which potentially reach full price convergence independently of country borders should be merged into a single bidding zone.

The author's view on future bidding zones in Europe applying these five basic criteria is presented in Figure 4. The design of these five price zones is based on the analysis on price convergence presented in another paper at Florence school of Regulation Working Paper series.[45]

A decision to split large price zones into several bidding zones fundamentally affects price formation inside the country creating high price and low price areas. This makes the decision highly political and is certainly subject to national and company interests. Generation companies are not keen to see their assets situated in bidding zones with potentially low prices, which could be the reason why vertically integrated TSOs are very hesitant to accept price zone splits. Decisions on bidding zones have also direct consequences on price formation in the neighbouring countries.

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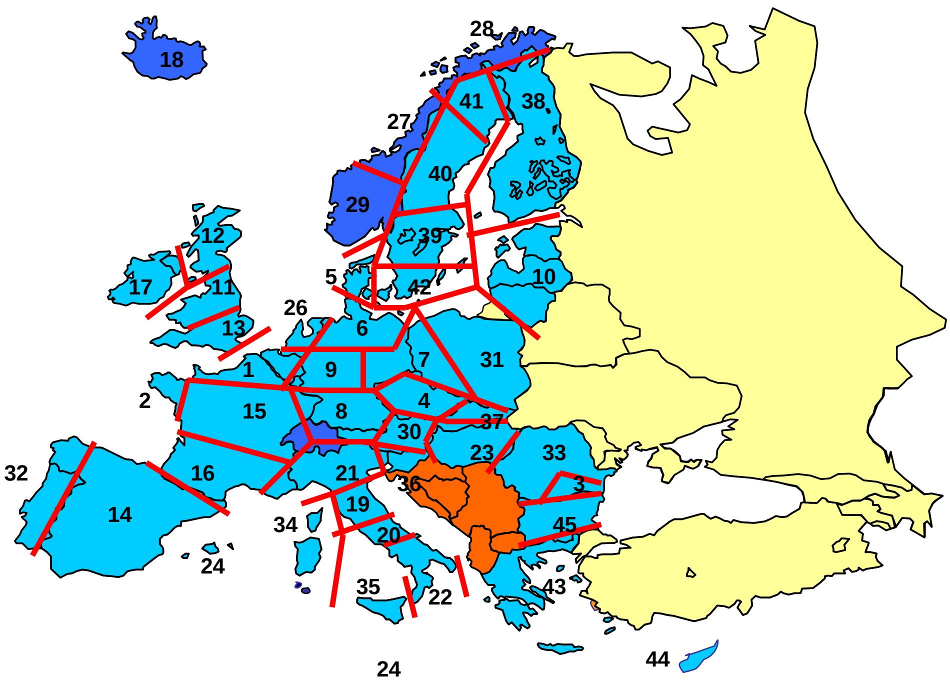
[45] Supponen, Transmission investments, 2012

Figure 4 The author's proposal for future bidding zones in Europe[46]



Bidding zones for Europe			
1	Belgie & France du Nord	23	Magyar
2	Bretagne	24	Mallorca
3	Bucureşti	25	Malta
4	Czech	26	Nederland
5	Danmark Vest	27	Norge Mellan
6	Deutschland Nord	28	Norge Nord
7	Deutschland Ost & Śląsk	29	Norge Syd
8	Deutschland Süd, Alsace, Lorraine, Schweiz, Tyrol & Vorarlberg	30	Österreich
		31	Polska centralna
9	Deutschland West & Letzeburg	32	Portugal & Galicia
10	Eesti, Latvija & Lietuva	33	Romania
11	England Middle	34	Sardegna & Corse
12	England North & Scotland	35	Sicilia
13	England South	36	Slovenija
14	España	37	Slovensko
15	France Centre & Suisse	38	Suomi
16	France Sud	39	Sverige Mellan
17	Ireland	40	Sverige Norbotten
18	Island	41	Sverige Nord
19	Italia Centro Nord	42	Sverige Syd & Danmark Ost
20	Italia Centro Sud	43	Ελλαδα
21	Italia Nord, Svizzera & Cote d'Azur	44	Κύπρος
22	Italia Sud	45	България

[46] EC, Supponen, DACH 2010 Munich, 2010; Senat, Billout et al, security of French electricity supply, 2007

For example if Germany is split into several bidding zones, the Austrian price will align to the new Southern German price instead of today's pan-German price which will disappear. It is also probable that splitting Germany into bidding zones would oblige some of the neighbours to introduce bidding zones as well. Thus any decision to change price zone structure in a country should take into account the influence on other countries.

Splitting Europe into smaller bidding zones does not mean that every bidding zone should have a very different price of electricity. Final consumers have usually contracts which are linked to electricity traded via long term financial products. These financial products are not directly following hourly spot prices but a longer term average of them. This means that even if in short periods there might be important price differences between bidding zones in a region, the long term average prices in these bidding zones can be close to each other. Thus, for the purposes of the financial products, Europe could be divided into much fewer geographical zones, for example into five zones as in Figure 5 based on expected price convergence.

Figure 5
The author's proposal for future price index zones for long term trading of electricity in Europe

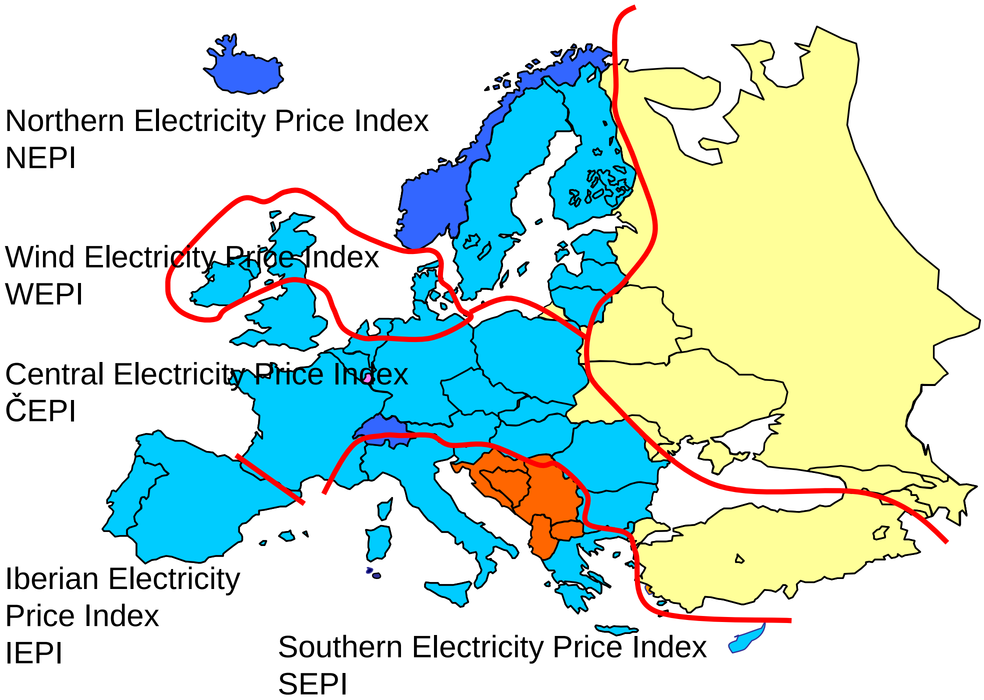


Figure 5 proposes for each zone an electricity price index which serves as the reference price for the long term financial products. Such indexes already exist, namely the system price of Nord Pool Spot and the newly created ELIX price index by EEX. In bidding zones in which the spot price differs significantly from the reference price, this price difference can be taken into account in the contracts with the final consumer as an extra margin. In bidding zones close to the borders of the price index zones the price may correlate with two or more price indexes. In these cases hedging can be made by trading a mixture of long term financial products based on these indexes.

An interesting price reference will be the Wind Electricity Price Index. The area covered by this index will have an important surplus production. This means that the price will be very low in windy periods and the price will align to the Central European level when there is no wind. This area will be a death zone for any fossil or nuclear generator, some gas fired power plants could survive paid by system service charges such as charges for balancing, reserve power and voltage control.

8. Nodal pricing as the solution

Many experts consider nodal pricing to be the best system for taking transmission constraints into account in electricity markets.47 In nodal pricing the market price is calculated for every network node. In the case there is no congestion between two nodes, the price will be the same. If there is congestion, prices differ. The problem often mentioned in the context of nodal pricing is the fear of increasing possibilities for dominant players to manipulate the market. As many European price zones already have from a high to a very high market concentration level in the current zonal system, in a nodal system many nodes would have only one generation company connected. There is, however, evidence that nodal pricing would rather reduce the risk for market manipulation.48 It has also been questioned whether nodal prices provide a sufficiently stable signal for generation and transmission investments.

As nodal pricing has not yet been thoroughly investigated in the European context, it is not proven that it would be worse regarding liquidity and market power than the current zonal system. In any case, nodal pricing should be kept on the agenda, in particular as transmission constraints seem to become worse in the future due to integration of wind power and due to increased difficulties to build new transmission assets. Wind power will cause more price volatility and congestion in the transmission network. Because of the short duration of extreme peak production situations, it is not thinkable that the transmission network is dimensioned to cover them without congestion. The inherent benefit of nodal pricing is to give efficient system operation signals which will be valuable in particular in these peak production situations.

9. Challenges in welfare optimisation and distribution

When welfare optimisation is fully utilised, this can lead to a situation where a high price country such as Italy will attract import flows to such an extent that most of the capacity of the European network is used for bringing electricity to Italy. A similar situation could appear with the wind power flows from the North occupying most of the European transmission network. Even if the overall social welfare would be maximised, this creates a distributional effect which could be felt unfair by countries which have to offer most of their network for the benefit of another country. For example in Belgium the import and export capacity is sometimes strongly reduced because of wind power flows. This can have a big negative impact on price formation and is not easily acceptable neither for the TSO, regulator, government nor the market participants. For this reason the Belgian regulator has claimed minimum guaranteed interconnection capacities for Belgium in the context of the CWE market coupling.49

One way to alleviate this problem could be to distribute congestion rents using a more sophisticated method based on the contribution of each control area to the commercial flows.[50] Currently congestion rents are shared in most cases fifty-fifty between the TSOs at each side of the interconnection. Deviations from this rule have been applied in the Nordic market[51], in the former auctions from Poland and the Czech Republic to Germany[52] and between Switzerland and Italy. [53]

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47 MIT, Joskow et Schmalensee, nodal pricing, 1983; Bruegel, Zachmann, Policy brief, 2010; KUL, Purchala et al, zonal market model, 2005

48 Harvey and Hogan, nodal pricing and market power, 2000

49 Pentalateral forum

50 Todem and Leuthold, congestion revenue distribution, 2006

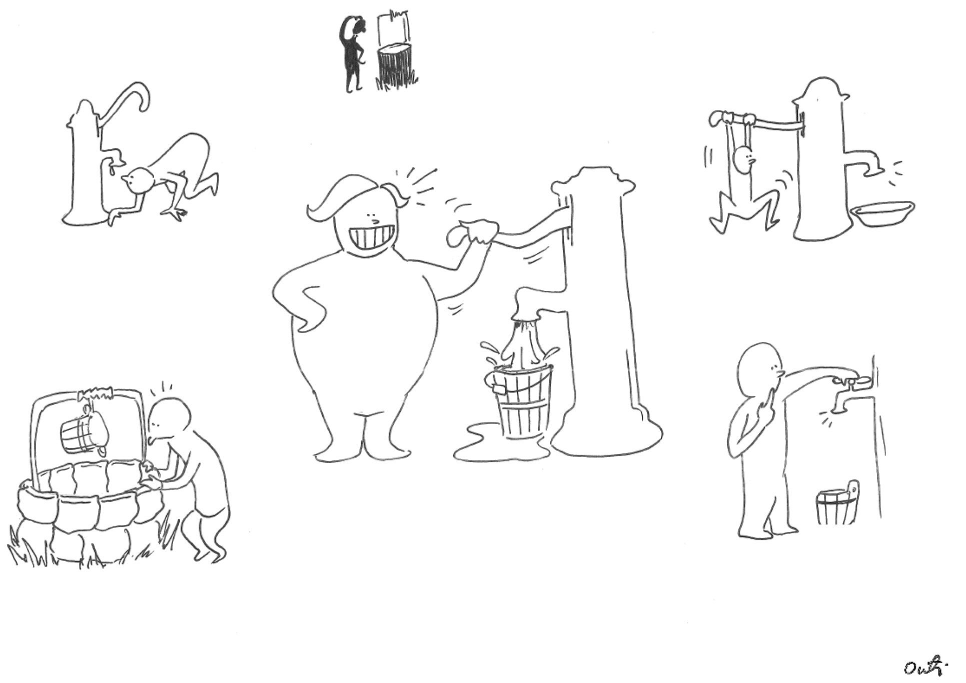
51 The Nordic market applied in the past a distribution key for congestion rents containing several parameters including the load in the country. Now the fifty-fifty rule is applied.

52 German TSOs used to receive a higher share on congestions rents at these borders.

53 Italy receives most of the congestions rents as Swiss generation companies still retain a major share of the interconnection capacity for their own use.

Moving to flow based capacity allocation will require a more refined method to allocate congestion rents. Methods have been proposed already and it is only a matter of agreeing between the TSOs and between the regulators on the distribution key.[54] One proposed method is to distribute congestion rents according to the shadow price that flow based methods calculate for each interconnection. Simpler methods are also proposed, for example using physical or commercial flows in their relative or absolute form, comparing them to the NTC or to the thermal capacity.[55] Perhaps an important precedent for congestion rent sharing will be the method used for the Central Western Europe flow based market coupling when it becomes operational. A method which uses as parameters the physical flows and capacities of interconnectors has been discussed.[56]

Figure 6 The overall social welfare at maximum



Distribution of congestion rents becomes even more complicated when large price zones are split into smaller bidding zones. The split into bidding zones has an influence on congestion rent accrual. For example, if Germany is split into several bidding zones and the prices in the Northern and Southern German zones align with the neighbouring markets, important congestion rents will be generated at the internal bottlenecks inside Germany. This might not be the optimal outcome for example for Denmark, Sweden, Switzerland and Austria.

10. Sharing of investment costs

It is usual that both TSOs involved in an interconnector investment cover the costs in their own control area even if the costs and social welfare benefits for each TSO can be very different. The TSOs and the countries involved in an interconnector project will make their own assessment of the welfare gains. This might lead to a suboptimal investment pattern or to stop the project completely if there are not sufficient benefits for all parties involved. For any interconnector, in particular for subsea cables,

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54 Todem and Leuthold, congestion revenue distribution, 2006

55 Todem and Leuthold, congestion revenue distribution, 2006

56 Pentalateral forum

the cost can be attributed deviating from the fifty-fifty principle. For example in the case of the interconnector between Ireland and Wales, the Irish cover the whole investment cost. By sharing the costs proportionally according to the benefits, both TSOs can be incentivised to join the project. The usual fifty-fifty distribution of congestion rents could also be changed to balance the costs and benefits. This is not yet very common.

11. ITC mechanism

An Inter TSO Compensation (ITC) mechanism is provided by the European legislation57 to compensate countries through which electricity is transited. After a long debate, a simple method was adopted which compensates the network losses caused by transit flows and a reasonable share of the infrastructure costs. It was difficult to agree on many basic assumptions needed to establish the system, such as whether one can differentiate between a transit flow, supposed to pass through the country, and a pair of flows, one entering the country and another of the same size leaving it. It is common that the transit countries benefit from the transit flows through increased trading possibilities and through important congestion rents.

The ITC mechanism yearly net compensation amounts ranged between 48 – 70 M€ in the period 2002 – 2009 for the biggest net beneficiary Switzerland and between 48 – 75 M€ for the biggest net contributor France.[58] Even if the compensation amounts in some cases can have an influence on the economics of an interconnector investment, they are far less important than the congestion rents. This means also that it is not conceivable in normal cases to get an interconnector investment paid through the income from the Inter TSO compensation scheme.

In spite of the fact that the current ITC system might not be perfect and it will not solve the issue of financing future European investments, it gives certainty for making investment decisions. For example the decision of Skagerrak IV cable between Norway and Denmark was probably delayed until the increase of the ITC payments for Norway due to this investment was known.

12. Choice of counterpart

Even if interconnector investments are by definition bilateral investments, the influence of them spreads in a meshed network to a wide area. Sometimes there are options for choosing the most interesting counterpart. This is true for example regarding the cables from Norway. For Norway to sell electricity to Central Europe through Denmark leaves an important part of the added value in form of congestion rent to the Danish and German TSOs. By building a link directly to the Netherlands or to Germany, a much bigger congestion rent is captured by the Norwegian TSO.

Until now the possibility to choose the counterpart has existed mainly for undersea cable projects. In the future this question might become very important when planning the transmission investments needed for wind integration. Transmission corridors will span through several countries and they will be expensive, perhaps using more and more DC technology. TSOs do not want to propose new lines through countries that would unduly profit from congestion rents without investing in a proportionate manner themselves. A caricature situation would be to build a European North-South link from Norway to Italy with Switzerland tolling the congestion rent, a situation that already exists today in the current AC network.

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[57] Regulation No 774/2010 2 September 2010

[58] EC, ITC consultation documents, 2008; Gustafsson and Nilsson, ITC mechanism, 2009

13. Third countries with different rules

The European electricity system is subject to the EU legislation on the internal electricity market. There are, however, countries connected to the system which are not bound to this legislation. Switzerland is in the middle of the European transmission system as an important transit country, Russia and Ukraine export to the EU, Morocco mainly imports from the EU.

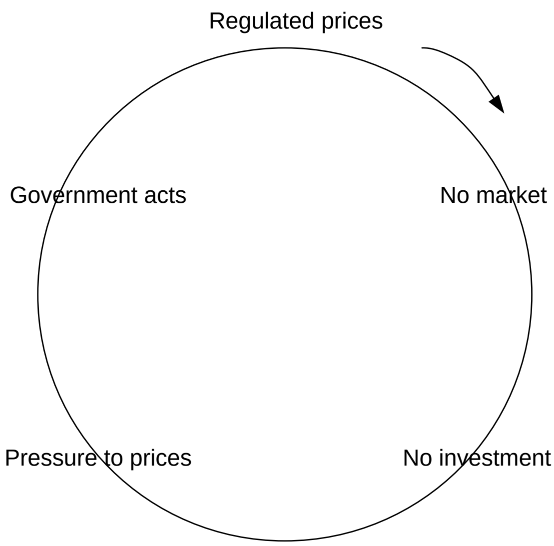
Russia and Ukraine have maintained their export monopoly. An export monopoly can always sell at the EU market price as there is no competition on these exports. Switzerland is a rather similar case. For the transmission capacity towards Italy, which is the most lucrative export direction, Swiss supply companies retain most of the transmission rights.

In all these cases companies receive monopoly rents from the exports. If there was competition for the export capacity, the TSOs would receive the price difference as congestion rents from the interconnection. Thus it is mainly in the interest of the monopoly exporter to invest in new transmission capacity, a situation existing for example for the merchant line projects between Italy and Switzerland. These projects try to capture the potential congestion rent into the developers' pockets instead of these rents going as income to the regulated TSO.

14. Regulated prices

Price for electricity supply is not determined in all European countries through a market even it should be the case according to the European legislation. Many governments still maintain regulated prices in order to prevent the incumbent dominant player from increasing the prices to a politically unacceptable level.

Figure 7 Vicious circle of regulated prices



In most cases regulated prices create a negative incentive to build generation assets. The incumbent might be able to invest either invited by the government or hoping that it can influence the level of the regulated price and thus will be able to recover the investment costs in long term. For newcomers it is usually too risky to invest under these conditions.

Table 2 EU Member States applying regulated prices for electricity with the share of customers with regulated prices in each consumer group in 2010[59]

Country	House-holds	Small businesses	Medium to large businesses	Energy intensive industry
Bulgaria	100%	100%	98%	
Croatia	100%			
Cyprus	100%	100%	100%	100%
Denmark	94%	95%	NA	NA
Estonia	Derogation	Derogation	100%	100%
France	96%	83%	94%	82%
Greece	100%	100%	100%	
Hungary	100%	NA		
Ireland	80%	52%	28%	
Italy	91%	78%		
Latvia	99%	99%		
Lithuania	100%	NA		
Netherlands	100%	100%		
Poland	100%			
Portugal	92%	88%	39%	62%
Romania	100%	NA	NA	
Slovakia	100%	100%		
Spain	91%			

Legend

(orange)	>95 % of customers have regulated prices
(amber)	>50 % of customers have regulated prices
(yellow)	>10 % of customers have regulated prices
NA	Information not available

When there are regulated prices, the export or import price is in most cases not linked to the regulated price. However, the export potential of the incumbent is usually limited because of a supply obligation to domestic consumers which reserves in practise the incumbent's generation portfolio for its national customer portfolio. Only if there is surplus electricity, incumbents are free to export this surplus and they can profit from the higher prices in the neighbouring markets.

Regulated prices easily lead to a vicious circle, see Figure 7. The only sustainable way to keep the price level low is to have sufficient electricity production capacity with reasonable costs. This situation is almost impossible to reach with government tendering or if a monopolistic market prevails. Regulated prices are generally prohibited by the European legislation, with some exceptions for household consumers.[60]

In the Table 2 the share of regulated prices in various consumer groups is shown for the EU countries which still apply regulated prices for electricity.

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59 ERGEG, regulated price report, 2010

60 EU, court decision Federutility C-265/08, 2010

Another potential distortion of electricity price is due to artificial distortion of fuel price, in particular of gas price. The price of gas can differ considerably between two neighbouring countries for example because of differences in gas market functioning or in fiscal treatment of gas. In these situations, instead of locating power plants close to the load, power plants are built where gas is at cheapest. This may require an electricity transmission line investment which would be avoided if artificial differences between countries in gas price were removed. Transporting gas is in most cases much cheaper than transporting electricity.

15. Differences in transmission charges

Network tariffs are in principle supposed to cover only network costs. In practise network tariffs are used for various policy goals. A recent paper from the Massachusetts Institute of Technology by Sakhrani and Parsons is good reading in this respect.61 In many countries network charges are used for collecting funds for supporting renewables or simply for filling the state budget. This additional burden usually takes place in the national context but it has also a cross border dimension. For example high grid tariffs for generators in one country penalise the generation companies in that country compared to their competitors in countries with lower grid tariffs.

There is a big difference between the European countries in the way transmission costs are covered through grid tariffs. Costs vary also considerably, in some countries customers pay a cost related to the historical book value of the assets, in some other countries the transmission grid has been sold to investors and the charges are aligned to how much the investor is allowed to benefit from the investment.

One difference regarding transmission tariffs is how charges are split between consumers and producers. In Central Europe there is a tendency to have low or zero generation charges, network costs are mainly covered by consumers. Opposing to this, the UK, the Nordic countries and Romania have maintained a substantial charge for generators and they are allowed to keep these charges even if for the rest of Europe a much lower upper limit for generation charges has been agreed upon.[62]

Difference in transmission charging is usually not an issue that affects interconnector economics. However, charging systems such as the past Triad-charging in the UK, based on winter peak conditions, could influence interconnector building as there is a risk for high charges to be paid by the interconnector. The UK is currently revising the transmission charging system.[63]

16. Cross-border fees

Some countries still apply cross-border fees even if they are prohibited by the European legislation. For this reason cross-border fees are often dissimulated as something else. Cross-border fees are usually meant to protect the market rather than to cover the investment costs of an interconnector. Cross-border fees are common in particular in the new Member States, for example Bulgaria and Romania apply them.[64] Existence of cross-border fees changes the economics of interconnector investments making them less attractive for the potential users.

[61] CEEPR, Sakhrani and Parsons, tariff design, 2010

[62] Regulation No 774/2010 2 September 2010

[63] Office of the Gas and Electricity Markets (Ofgem) is doing a Transmission Access Review.

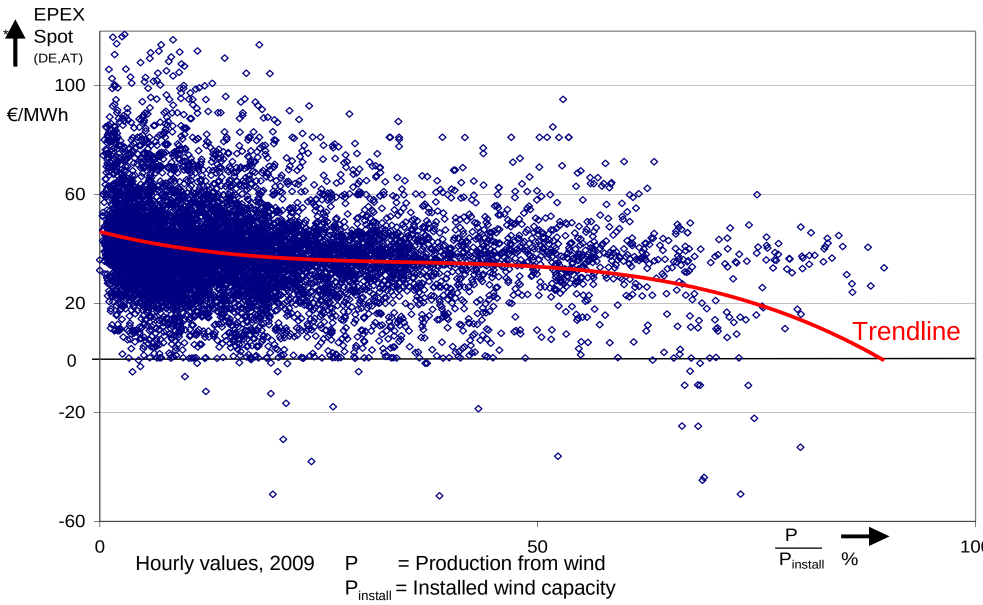
[64] EFET, RO and BG cross-border fees, 2010

17. Feed in systems and other forms of public support

Capacity payments and other type of support schemes for power plants, providing a stream of revenues additional to the revenues from selling electricity in the market, can have an influence in interconnection capacity target setting. These payments and support schemes include a large variety of mechanisms such as payments to compensate availability of generation, feed in tariffs, top-up payments over the market price and direct investment subsidies. These payments are financed either through network tariffs, from separate electricity levies and taxes or directly from the state budget.

Feed in tariffs and other forms of public support are a cornerstone to meet renewable electricity targets in Europe. They give investors a high level of certainty for the investment. There are several types of feed in tariffs accompanied with a varying level of priority regarding network access. The most important feed in systems from the transmission network point of view are the wind power feed in systems because the volumes are high and volatile and the transmission distance is often long. Support systems for wind power differ considerably depending on the country.

Figure 8 Correlation of spot price and wind production as percentage of installed capacity in Germany in 2009[65]



As an example, the German feed in system obliges the TSOs to buy the wind power at the feed in price and sell it through the spot market. Wind power has a strong influence on the market price as shown in Figure 8. Before 2010, selling of the wind power was handled by the trading companies of the vertically integrated TSOs which was not a very transparent arrangement.

The German market has seen low, even negative prices during high wind periods. This phenomenon is called the merit order effect as wind power production reduces the marginal price of the system by pushing more expensive plants out of merit.[66] This effect is important regarding both interconnector and generation investments. In markets in which a high share of investments is financed through feed in tariffs or other types of public support such as capacity payments, the wholesale electricity price has less influence on investment decision and can be significantly lower than in the neighbouring markets. Thus the country on the other side of the interconnector has the

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[65] Source: Amprion

[66] Pöyry, merit order effect of wind power, 2010

opportunity for getting cheap subsidised electricity by increasing interconnection capacity. This might, however, make its own generation investments non-profitable because of the cheap electricity imported from the neighbour.

Even if the possibility to export and import subsidised electricity should increase economic efficiency, some level of harmonisation at the European level is needed on how investments are supported both for renewable and conventional power. Otherwise investment signals will become too varied creating an extra uncertainty for the investors.

18. Influence of security of supply considerations

The role of interconnectors regarding security of supply is not straightforward. In general interconnectors are beneficial for the secure operation of the network as a big system can better digest network incidents than a small system. However, if interconnectors are used to their limits, this can increase the risk for major disturbances as demonstrated by the black-out in Italy in 2003. For some countries interconnectors are vital for sufficient supply of electricity. Italy, the Netherlands and Finland are dependent on imports, at least for keeping the electricity price reasonable. Also Norway is dependent on imports in dry years. For small transit countries, namely Switzerland, Austria, Slovenia and Denmark, imports are necessary to counterbalance the volumes exported.

Transmission investments are closely linked to generation investments. In a deficit area there is in principle always a choice between increasing cross-border capacity and building more generation capacity. Interconnectors have one major advantage compared to generation investments, namely the possibility to flow power to both directions. This allows using the complementarities of the generation systems at both ends of the interconnector. Connections inside the Nordic region, connections from the Nordic countries to Central Europe and connections from Germany to Switzerland and to Austria are largely exploiting these complementarities. The major disadvantage of interconnectors compared to generation investments is that they do not produce any electricity and thus do not improve security of supply in situations when all generation assets at both ends of the interconnector are already in use.

For an exporting country, increasing interconnection capacity often means reducing security of supply at peak load as the neighbour could attract power in times of scarcity by just letting the market price increase. This might be felt unfair, in particular in countries which have introduced capacity payments to maintain sufficient generation capacity. Capacity payments are usually financed from transmission tariffs and are to be considered as a public intervention to ensure security of supply.

In case the share of imports is high, the need to provide reserve power in the own control area might be an obstacle to further development of interconnectors. According to the TSO rules, each TSO needs to be able to ensure that sudden interruptions of transmission lines, including cross border lines, will not cause major disturbances. This question has been raised for example in the Netherlands[67], in the aftermaths of the Italian black-out[68] and in the context of the Finnish Government decision[69] not to allow increasing the import capacity from Russia.

There are past cases of using export restrictions in order to secure supply in the own country. Spain refused exports during the shortage of electricity in France in summer 2003. Similar cases of limiting exports exist also for example with France, Poland and Greece.

[67] ECN, reserve power in the Netherlands, 2003

[68] Terna reduced cross-border capacities after the black-out.

[69] TEM, United Power decision, 2006

The fact that interconnectors could secure supply in the uncertain future also might play in favour of interconnector investments and not only stop them. Electricity is such an important good that no government can afford a major failure in securing electricity supply.

19. Influence of the transmission investment itself

An interconnection capacity increase changes the investment signals for any future investment at this interconnection.70 The obvious effect is the shift of the operation point in the parabolic congestion income curve. 71 This means that a new investment also affects the congestion rent accrual for the existing capacity.

A new investment influences the prices on both sides of the interconnector. As the price in the higher price zone will decrease, there is a reduced incentive to invest in new generation capacity in this zone. In the lower price zone, on the contrary, prices increase and thus there is an increased incentive to invest in generation. Thus any addition of interconnection capacity will in longer term potentially cause a further imbalance of generation capacity between these two price zones.

There is no natural end to the development of this generation imbalance if there is a permanent advantage in investing in one price zone compared to the other. This advantage can be for example due to the availability of fuel or other resources, possibility to build nuclear power or difference in taxes or subsidies. Only linking generation and transmission investment signals could create a system which drives investments to an overall optimum. A similar result could be achieved by the TSO making a global welfare optimisation calculation including both generation and transmission investments. Interconnection capacity would be dimensioned according to the global optimum, not only taking into account the costs and benefits of transmission. It is, however, questionable whether TSOs have sufficient competence regarding generation investments and whether it is appropriate that TSOs do this kind of calculations as the results potentially influence the market.

European wide, no method, except the price zone concept itself, has been used to link generation and transmission investment signals across borders. Internally in some countries methods have been used for this purpose, the most advanced example being the system used in Great Britain where the modulated generation and load access tariffs have been reasonably successful in driving the location of power plants and transmission investments. However, investments in renewables seem to override this former system in Great Britain. For new plants the TSO will be obliged to give access to the transmission network with a "connect and manage" principle which guarantees income for the generator even if possibly needed wider network reinforcements are not ready when the generator is connected.[72]

Some TSOs publish how much there is available capacity for connecting new power plants in each grid area.[73] This could become a more important tool in the future to avoid unnecessary transmission investments. Preferred locations could be promoted for example with lower connection charges.[74] This approach requires that the TSO is fully independent of any generation interests and that there is a full regulatory oversight in order to prevent discrimination between potential investors.[75]

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70 Pöyry and Thema Consulting, Nordic study on transmission investments, 2010

71 Congestion rent accrual follows a parabolic curve. When starting to increase cross-border capacity, congestion rents increase linearly with the capacity, they decline and finally disappear when capacity is increased to reach full price convergence.

72 Connect and manage principle is a concept put forward by Ofgem in the Transmission Access Review following publication of the Energy White Paper in UK in 2007.

73 RTE, annual report 2009, 2010

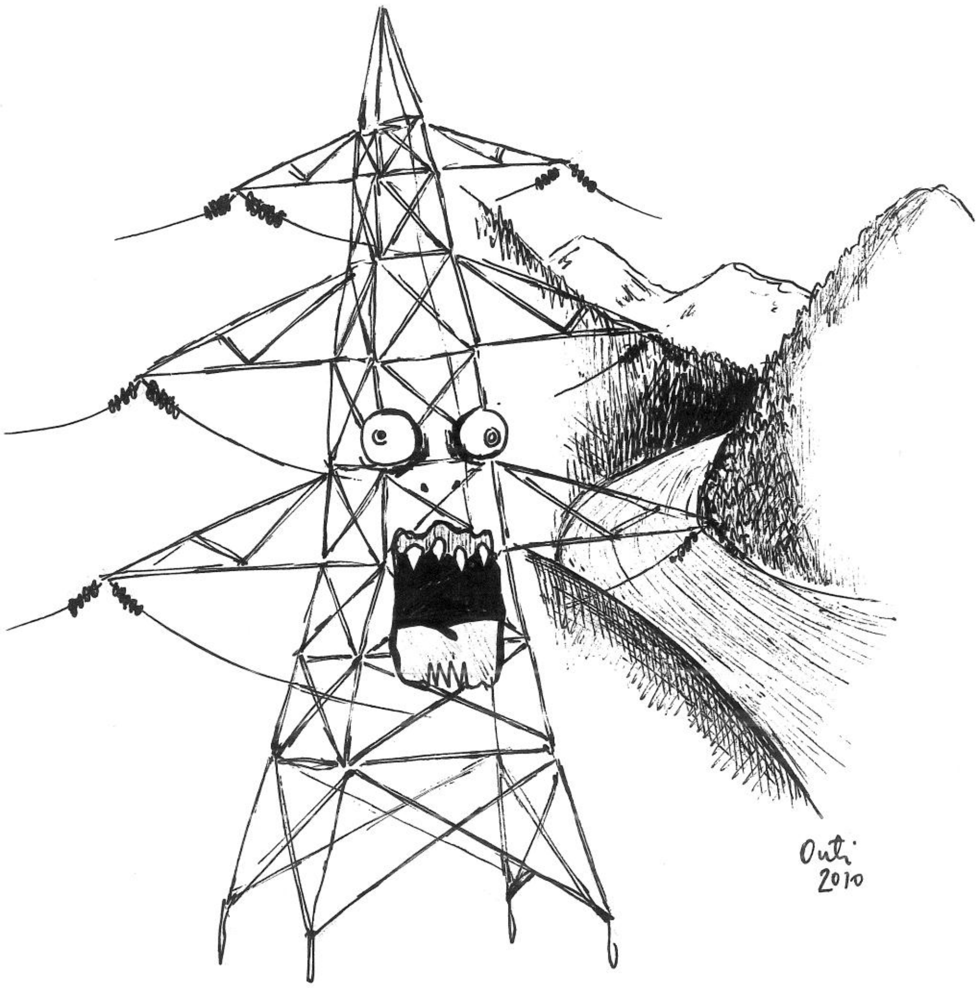
74 In Norway reduced access charges are applied in some locations for the first 15 years.

75 Consentec, EWI and IEAW, security of German electricity supply, 2008

20. Influence of opposition on transmission lines

Transmission investments are often contested by the population living along the planned transmission path. This is perhaps the biggest obstacle to building new lines, and could be far more important than all the other influencing factors together. The gap between the current and the optimum level of transmission capacity might well be explained by the difficulties to overcome local opposition. Even if this issue is of utmost importance, this paper does not try to address it more in detail except to some extent in the empirical country by country analysis.

Figure 9 Monster mast[76]



21. Influence of uncertainty

Interconnector investments usually take several years before they are completed counting from the date of the planning decision. Investments also have a long lifetime, it is normal to consider 25 - 40

[76] Norwegian press reported about "monster masts" planned for the transmission line crossing an arm of the Hardanger fjord.

years when calculating the profitability of a transmission investment. Uncertainty can stop projects as the cost and benefit calculation for such long time periods has a high level of uncertainty.

As the benefits of an interconnector are dependent on many influencing factors as explained above, there is a need to find pragmatic tools to appraise the overall soundness of an interconnector investment. One approach is to use today's generation and grid model and market outcome as the starting point. However, because of the long lifetime of transmission investments, it is necessary to have forward looking tools including scenarios to calculate their profitability. It is usually possible to estimate rather accurately the costs and it is possible to have a rough idea of the price arbitrage benefits of an investment. However, many other influencing factors discussed in this paper are far more difficult to estimate. Thus the optimal capacity based on price arbitrage needs to be adjusted based on tacit knowledge taking into account these other factors. As the optimum is typically on a flat curve in this type of cases, an approach based on the TSOs setting the target for interconnection capacity for a reasonably long period, based on the combination of the best estimate of the welfare optimum by the TSOs and a judgement by the regulators using tacit knowledge, could be justified. Market participants including investors in generation would then have an improved certainty for their decisions.

For this type of approach it is essential how the decision making regarding the target capacity level is organised. The TSOs do not have all the necessary knowledge themselves but they are dependent on the stakeholders. There are several ways how a consultation process could be organised to get the best out of the stakeholders' wisdom.[77]

22. Proposal for a mechanism to redistribute the costs and benefits between countries

The discussion above concludes that distribution of social welfare is an important element to be taken into account in interconnector investments. The welfare effects depend on several parameters such as price elasticity and variability of the market price in the markets to be connected. The effect can be very different on each side of the border, for example the increase in overall welfare for one country can be much higher than for the other.

As already discussed above, there are several ways to readjust the welfare distribution between two countries if needed. Currently each TSO covers the costs in its own territory and the congestion rents are shared fifty-fifty. This does not necessarily make the investment equally desirable for both sides. For bilateral cases rather simple solutions can be applied. Projects in which the benefits are spread regionally require a more sophisticated approach.

Mechanisms to redistribute the costs and benefits between countries can be ex-ante or ex-post. An ex-ante mechanism is to adjust the share of project costs for each country in the investment phase. This approach is clear cut and efficient if the costs and benefits of the project can be estimated with reasonable accuracy. The approach is easy to apply if the main part of the investment is for example a DC undersea interconnector. The application is more difficult if one country would need to pay investments in another country. For the moment, within the EU, national tariff systems do not allow asset base investments in other countries. To address this challenge, a European transmission fee has been proposed for example by the Czech Government in order to finance investment needed for the European grid. Funds collected through this tariff could be used for example to finance projects in the Trans European Energy Networks framework instead of using the EU budget. In this way the amount of funds for these projects could be considerably increased.

A result similar to readjusting cost allocation of individual projects can be achieved by agreeing on a package of projects involving several TSOs. In this case, instead of acting on participation in

[77] Surowiecki, Wisdom of Crowds, 2004

individual projects, one would act on the overall costs and benefits of the package. The package should be constructed in a way that makes all parties involved reasonably satisfied with the overall result.

One of the problems of any ex-ante mechanism to redistribute the costs of an investment is the high level of uncertainty linked to the calculation of benefits. As discussed earlier, a scenario based approach is necessary to estimate the benefits. Calculations for a long time period based on scenarios can be very sensitive for example to the conditions of investment in generation capacity in each of the interconnected countries, to changes in the policy and regulatory environment and to changes in fuel prices.

Mechanisms to redistribute costs and benefits require negotiations between TSOs for each individual project or for the package of projects. Even if negotiations as such might be an efficient way to find a solution, there is a risk of abuse of dominant position by a TSO. TSOs being in a monopoly position in their territory, some of them could try to blackmail other TSOs to get inflated benefits in case they are indispensable for the project. For example transit countries potentially could use their geographical position for this purpose. Thus it is important that the process of redistributing the costs and benefits of an interconnector investment is transparent and there is proper regulatory oversight on it. The same risk of seeking over proportional benefits of course also exists at the level of regulators and governments.

Continuous mechanisms, for example sharing congestion rents based on various welfare distribution parameters, allow readjusting the mechanism along the lifetime of the investment. The ITC mechanism is the currently existing continuous mechanism to redistribute costs and benefits of the electricity transmission system. It addresses network losses and a share of the past investment costs. The main weakness of the current ITC mechanism is that it does not provide sufficient incentives for new investments.

When capacity allocation in a region is flow-based, a specific key is needed how to distribute the congestion rents. The distribution keys applied until now have not been published, there seems to be some mystery in how these keys are generated. This is probably because congestion rents are an important source of income at least for some TSOs. One problem in basing welfare benefit redistribution strongly on congestion rents is the volatility and the potential dependence of the TSOs on these rents. If there is a fear that congestion rents are declining and this possibility is not properly taken into account in the regulatory system applied, the motivation of the TSOs for investing might be seriously affected.

Based on the above discussion, it is proposed that a two-tier system is developed to redistribute costs and benefits targeting in particular new investments. This system should have an ex-ante part which is applied for a project or a package of projects in order to readjust if needed the share of investment costs attributed to each TSO. The criteria shall be transparent and agreed between regulators. The system should have also an ex-post part which will further readjust the share of costs and benefits for each TSO after the investments have been made. This ex-post system can be a development of the current ITC system, but with a more global view of the costs and benefits than in the current system. It should address all the main items of cost and benefit distribution discussed above, such as sharing of commercial capacity and congestion rents, in addition to the items already addressed in the current system, namely network losses and infrastructure costs.

However, it remains to be seen for how many projects it is really necessary. It might be that for a large majority of the projects the old principle that each TSO covers the costs in its own territory is sufficient. It is a well established principle, thus there needs to be good reasons to deviate from it. A more flexible mechanism to share costs and benefits might, instead of promoting investments, introduce in the negotiations arbitrary elements which potentially could delay agreeing on interconnector projects.

23. Conclusions

This paper has discussed which factors influence electricity interconnector investments. It has shown that several features linked to zonal market design, in particular the possibility to favour market participants in the own country compared to those in the neighbouring countries, distort the investment signals for interconnectors. The problem of loop-flows is the most striking example of this. Other distortions are due to differences in tariff systems and existence of subsidies and regulated prices. Uncertainties of investments in both transmission and generation have a big influence in interconnector investment decisions. General opposition against overhead lines reduces the chance for investments getting realised.

This paper makes a proposal to reduce flaws due to zonal market by forming more natural price zones for Europe. These zones should better follow underlying fundamentals such as generation surplus and deficit areas and physically congested borders instead of basing the zones in national borders. For asymmetry in cost and benefits this paper proposes a two tier mechanism in which an ex-ante cost and benefit allocation would facilitate the investment decisions by making costs and benefits better balanced between parties, and an ex-post reallocation would reduce the uncertainty of future costs and benefits.

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