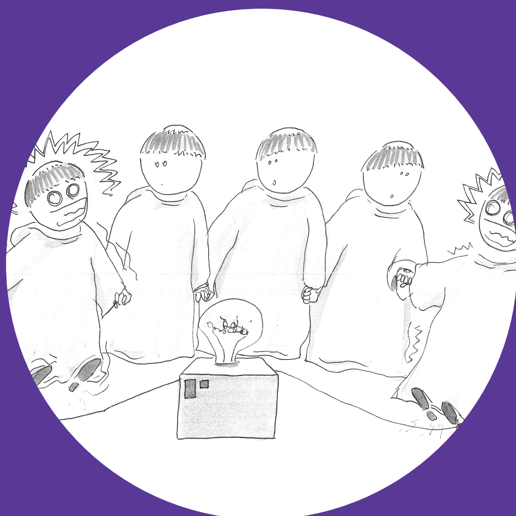
Department of Electrical Engineering

Influence of National and Company Interests on European Electricity Transmission Investments

Matti Supponen



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Influence of National and Company Interests on European Electricity Transmission Investments

Matti Supponen

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Abstract

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Abstract

The objective of this study is to analyse to what extent national and company interests prevent electricity transmission investments which would be beneficial for Europe. The study has provided strong evidence that national and company interests have influence on cross-border transmission investments. It indicates that national and company interests have contributed to serious underinvestment in the European transmission network from the overall welfare point of view. Vertically integrated TSOs prioritise investments for increasing exports which increase income for their owner, while profitable interconnectors in import direction are often not developed at all. The behavioural pattern is less clear with the majority of the TSOs which are publicly owned and can be considered as semi-independent. The study has demonstrated that there is an important dimension of welfare distribution between the countries connected but also within the countries due to the change in the market outcome when an interconnector is built.

There are a number of factors that potentially influence the motivation of a TSO for investing to increase cross-border capacity. The study shows that it is possible to develop objective criteria for interconnector investments. Social welfare benefits from price arbitrage should be one criterion but several other criteria should be used as well including price convergence, security of supply and competition benefits. Flaws in market design, capacity calculation and capacity allocation need to be addressed to provide efficient signals for interconnector investments. This should include designing of price zones, on which a proposal is made in this study, and working on the loop flow problem which is already acute for some countries in Europe. The study proposes an approach for addressing the cost-allocation of future transmission investments in order to take into account European wide the costs and benefits of those investments.

Keywords Electricity transmission network, investments, national interests, company interests

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Tiivistelmä

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Tiivistelmä
Tämän tutkimuksen tarkoituksena on analysoida, missä määrin kansalliset ja yritysten intressit estävät koko Euroopan kannalta hyödyllisten siirtoverkkojen rakentamista. Tutkimuksessa on löytynyt vahvoja todisteita siitä, että kansalliset ja yritysten intressit vaikuttavat rajajohtoinvestointeihin. Se osoittaa, että kansalliset ja yritysten intressit ovat osasyynä merkittävään siirtoverkkoinvestointien puutteeseen yhteiskunnallisen hyvinvoinnin kannalta katsottuna. Vertikaalisesti integroituneet kantaverkkoyhtiöt asettavat viennin lisäämiseen tähtäävät hankkeet etusijalle, koska ne lisäävät tuloja omistajalle, tuontiin tähtääviä hankkeita ei usein kehitetä ollenkaan. Käyttäytymismalli on vähemmän selkeä valtaosalle kantaverkkoyhtiöitä, jotka ovat julkisessa omistuksessa ja joita voidaan pitää osittain riippumattomina. Tutkimuksen mukaan hyvinvoinnin jakautuminen sekä kyseessä olevien maiden välillä että niiden sisällä on merkittävä tekijä rajajohtoinvestoinneissa johtuen rajajohdon vaikutuksesta markkinahintoihin.

Tutkimus osoittaa, että monet tekijät vaikuttavat kantaverkkoyhtiöiden halukkuuteen investoida rajakapasiteetin lisäämiseen. Se osoittaa myös, että on mahdollista kehittää tasapuolisia kriteerejä rajajohtoinvestoinneille. Yhteiskunnallisen hyödyn hintaerojen hyödyntämisestä tulisi olla yksi näistä kriteereistä. Sen lisäksi useita muita kriteereitä kuten esimerkiksi hintojen konvergointia, toimitusvarmuutta ja kilpailun edistämistä tulisi käyttää investointipäätöksissä. Vääristymät markkinamekanismissa, kapasiteetin laskemisessa ja kapasiteetin jakamisessa markkinoille tulee korjata, jotta rajajohtoinvestoinneille saadaan tehokkaat investointisignaalit. Näiden toimenpiteiden tulisi kohdistua hinta-alueiden määrittelyyn, josta tässä tutkimuksessa on tehty ehdotus, sekä kiertovirtaongelmaan, joka on jo hälyttävä joissain Euroopan maissa. Tutkimus sisältää myös ehdotuksen siitä miten tulevien kantaverkkoinvestointien kustannukset voitaisiin jakaa paremmin ottaen huomioon niiden kustannukset ja hyödyt Euroopan laajuisesti.

Avainsanat Sähkön siirtoverkko, investoinnit, kansalliset intressit, yrityksen intressit

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CONTRIBUTION OF THE AUTHOR

The author has developed the methodology used in the analyses and made all the analyses himself. The results and conclusions are sole work of the author.

DISCLAIMER

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.

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LIST OF ABBREVIATIONS

AC	Alternative Current
ACER	Agency for Cooperation of Energy Regulators
APG	Austrian Power Grid AG
BEMIP	Baltic Energy Market Interconnection Plan
BS	Baltic States
CEE	Central Eastern Europe
CRE	Comission de Régulation de l'Énergie (France)
CSE	Central South Europe
CORESO	Coordination of Electricity System Operators
CSP	Concentrated Solar Power
CWE	Central Western Europe
DC	Direct Current
EdF	Électricité de France
EEX	European Energy Exchange AG
ELES	Elektro-Slovenija, d.o.o.
ELIX	European Electricity Index
EnBW	Energie Baden-Württemberg AG
ENTSO-E	European Network of Transmission System Operators for Electricity
ESO	Elektroenergien Sistemen Operator EAD
EU	European Union
Eurostat	Statistical office of the European Union
EWIS	European Wind Integration Study
FTR	Financial Transmission Right
FUI	France, UK and Ireland
HTSO	Hellenic Transmission System Operator S.A.
ISO	Independent System Operator
ITC	Inter TSO Compensation
ITO	Independent Transmission Operator
LEO	Lietuvos Elektros Organizacija
Mavir	Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság
MIBEL	Iberian Electricity Market
NE	Northern Europe
NOME	Nouvelle organisation du marché d'électricité

NRA	National Regulatory Authority
NTC	Net Transfer Capacity
Ofgem	Office of the Gas and Electricity Markets
PJM	Pensylvania, New Jersey and Maryland
PSE Operator	Polskie Sieci Elektroenergetyczne Operator S.A.
PTDF	Power Transfer Distribution Factor
REE	Red Eléctrica de España, S.A.
REN	Rede Eléctrica Nacional, S.A. (Portugal)
RTE	RTE-EdF Transport SA
SEE	South Eastern Europe
SEM	Single Electricity market (Ireland)
SEPS	Slovenska elektrizacna prenosova sustava, a.s.
SWE	South Western Europe
Tiwag	Tiroler Wasserkraft AG
TLC	Trilateral market coupling (France, Belgium and the Netherlands).
TO	Transmission Owner
TSC	Transmission System Operator Security Cooperation
TSO	Transmission System Operator
VKW	Vorarlberge Kraftwerke AG

1. RESEARCH OBJECTIVE

1.1. Problem identification

Cross-border electricity transmission investments aim to increase social welfare by allowing power to move from cheap areas to more expensive areas. Only investments where the benefits are higher than the costs should be realised. For interconnectors there are always two countries involved. Thus it is necessary to analyse how the costs and benefits are distributed between these two countries. Even if an investment increases overall social welfare, it usually also creates losers by increasing the market price in the exporting area and lowering it in the importing area. Governments and regulators do not promote investments which they consider detrimental to their country, and likewise Transmission System Operators (TSOs) will not invest in projects which would be detrimental to themselves or to their owners.

The objective of this study is to analyse to what extent national and company interests prevent electricity transmission investments which would be beneficial for Europe.

1.2. Scope of the study

The geographical scope of this study is the European Union (EU) Member States, Norway and Switzerland. Luxembourg, Malta and Cyprus are not included in the detailed analysis due to their small influence in the electricity transmission system and due to lack of data. Norway and Switzerland are included as they have an important role in the cross-border trade in the EU.

The study concentrates on analysing the behaviour of Transmission System Operators as investors in the transmission network. The influence of the owner of the TSO is in particular addressed. The role of governments and regulators as authorities who set the framework, and generation companies and final consumers as market participants is also analysed in this study. The role of other stakeholders such as traders and power exchanges will only be discussed indirectly.

The past development of cross border capacities is analysed in the period 2000 – 2010. The analysis on future investments is based on the ten year network development plan of the European Network of Transmission System Operators (ENTSO-E) for the period 2015 – 2020). This study analyses mainly interconnector investments but also discusses internal transmission investments when these are necessary for increasing cross-border capacity.

The study focuses on wholesale markets. Retail markets are discussed only when they are directly relevant to the issue in question.

1.3. Research method

The study is based on analysing the increase in overall social welfare for Europe generated by interconnector investments and the distribution of this welfare. The study identifies the potentially efficient investments and compares them with the realised and planned investments. The results of this comparison are used to judge to what extent company and national interests have influenced investment decisions. Empirical knowledge on real investment cases and on policies of companies and countries is then used to validate the results.

The study follows the sequence presented in Figure 1. After introductory Chapters 1 and 2 the study develops in Chapter 3 criteria for efficient interconnector investment based on social welfare. These criteria are applied to the European transmission system using data from the reference year 2008 and the method developed in this study in order to identify which additional interconnection capacity would have been efficient in that year.

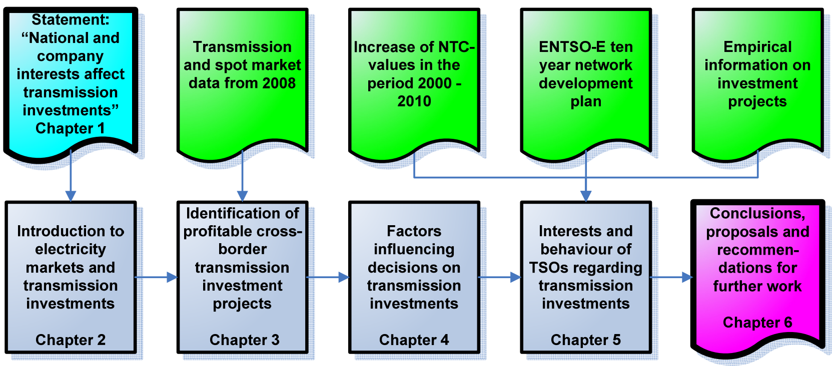

Figure 1 Block diagram of the research method used in this study.

The analysis continues in Chapter 4 with the discussion whether there are other than social welfare targets which interconnector investments aim to fulfil. All main factors influencing interconnector investment are aimed to be identified. Based on these findings, suggestions are made on how the investment framework should be improved in order to optimise the European social welfare instead of the national or company welfare.

In Chapter 5 the study defines what the expected behaviour of the TSO is if the social welfare is optimised for the company or for the country. This assumed expected behaviour is compared to the past realised investments in 2000 – 2010 and future investments planned to be finalised before 2025, basing the analyses on the realised and expected development of the interconnection capacity values and using the method developed in this study.

Finally in Chapter 6 conclusions are drawn on whether national and company interests influence decisions on transmission investments. The chapter also includes an evaluation of the methodology used, summarises other findings of the study and gives recommendations for further research on the topic.

1.4. Scientific overview

There is ample scientific literature on transmission investments. The economics and welfare optimisation targets of transmission investments are well developed for simple interconnector cases such as single lines connecting two hubs or price areas. The concept of merchant lines and the difference of the merchant approach compared to the regulated approach are well documented, for example by Joskow and Tirole.[1] However, there is much less scientific literature on concrete interconnector projects in the European transmission network.

Social welfare benefits of interconnectors including the distribution of social welfare between generation companies, final consumers and Transmission System Operators (TSOs) are also well understood. Distributional effects are recognised to have an important influence on investments. For example Becker has written how pressure groups influence decisions to make them favourable for themselves.[2]

TSOs publish information on transmission investments including the Net Transfer Capacities (NTC) between countries. Development of these capacities is analysed in several studies, but usually with only a limited number of countries or only one region in scope. TSOs have recently made big progress in publishing market relevant data such as commercial schedules in interconnections. This step, partly enforced by the European regulation, allows doing analysis that was possible only for a few countries in the past because of the lack of data.

1 Joskow and Tirole, merchant transmission investments, 2003

2 Becker, pressure groups, 1984

Regarding the influence of the ownership of the TSO, some studies, in particular the impact assessment of the 3rd internal market package[3] and the sector inquiry[4] by the European Commission, have analysed the relation between unbundling and transmission investments. However, to the author's knowledge, no studies exist in which the influence of national interests and TSO ownership on the European transmission system are systematically analysed. The purpose of this study is to fill this gap.

1.5. Scientific contribution

The study shows strong evidence that company interests influence transmission investments. TSOs invest in interconnectors which are beneficial for their owners and stop or delay investments detrimental to their owners even if the investment would bring overall social welfare benefits. Similarly there is evidence that national interests influence interconnector investments. The study shows that welfare benefits are often nationally redistributed to accommodate consumer and producer interests to gain acceptance for the investment. Overall, the study demonstrates that the level of interconnection capacity is far below the overall social welfare optimum.

The results of the study are applicable to the European electricity market based on zonal pricing. Many findings are, however, general in nature and can be applied to any electricity market.

1.6. Other contribution

Price convergence between different price zones in Europe is analysed in the study. This analysis allows understanding the role of interconnectors regarding price convergence which is fundamental for transmission and generation investment decisions. The study proposes how the European zonal pricing system should be improved by dividing Europe into bidding zones which better reflect the congestion pattern in the transmission network. This is important for efficient operation of the grid, for improving the investment signals for transmission investments and for efficient location of generation.

The study identifies the main factors that influence interconnector investment decisions. Based on this analysis, a two-tier system is proposed

---

3 EU, 3rd package, 2009

4 EC, DG Comp sector inquiry, 2007

to redistribute the costs and benefits of transmission investments in order to get all parties needed for the investments motivated to do their share of the work. Such a system could be important to avoid suboptimal investments due to the distorting effect of national and company interests.

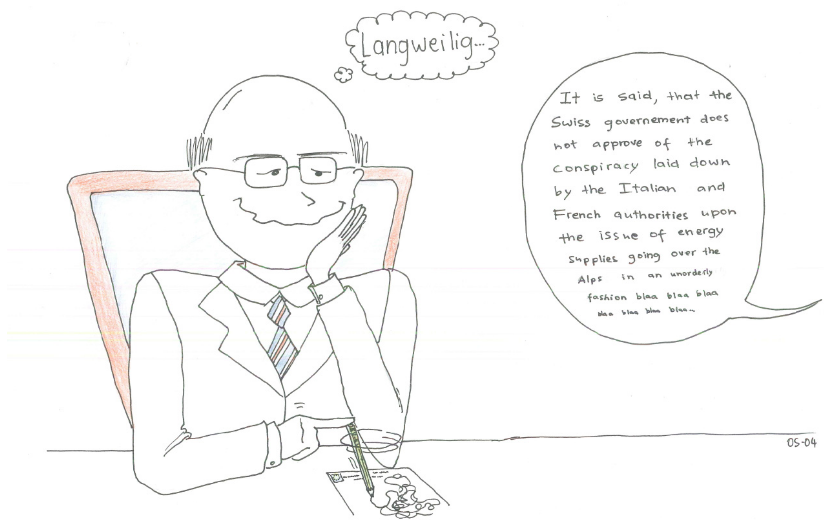

Figure 2 The author in action.

2. INTRODUCTION TO ELECTRICITY MARKETS AND TRANSMISSION INVESTMENTS

2.1. Organisation of network access

The EU electricity market is based on separation of the natural monopoly parts, transmission and distribution, from the competitive parts, generation and supply. The task of the Transmission System Operator (TSO) is to connect and provide access to all loads and generation units which need a connection at the transmission network level. Generators and consumers alike make their own decisions to produce or to consume, depending on their commitments towards their counterparts and market opportunities.

In Europe, this access to the transmission network is organised through price zones which allows any electricity consumer in a price zone to contract with any generator in the same price zone without limitations due to network constraints. The generator is allowed to produce as long as it finds a consumer in the same price zone.

There are exceptions to this rule. In most countries there is congestion inside the price zone, such as in Germany, Great Britain and Sweden due to surplus generation in the northern part of each country. When congestion appears, the TSO asks some generators to start or increase production and some other generators to stop or reduce production, in order to maintain the network security. This is called redispatching.[5] The redispatched generators in most cases get compensation, according to the rules applied in the country in question. These measures are applied to consumers as well, but this is rarer.

This guaranteed access does not usually cover exports and imports between price zones. All electricity that crosses a price zone border requires specific allocation of transmission capacity at that border. This can take place explicitly when the TSO gives or sells capacity for this crossing, or implicitly when the electricity that crosses the price zone border is selected from the bids in power exchanges operating on each side of the border.

Some countries have been divided into several bidding zones, namely Norway, Italy, Denmark, the UK and also Sweden starting from 2011. Opposite tendency also exists as single price zones involving several Member States have been established, namely between Austria and

5 In this study "redispatching" is used for both internal redispatching in which all redispatched units are in the same price zone and for redispatching across price zone borders which is called usually "counter trading".

Germany, between the Czech Republic and Slovakia and the All Island price zone in Ireland.

2.2. Transmission System Operators

One of the key principles in the opening of the electricity sector to competition has been the creation of independent Transmission System Operators. In the past, transmission was part of vertically integrated utilities. It is generally considered that ownership unbundling is the best solution to the independence of the TSOs. In the last European Commission proposal concerning the internal electricity market, the so called 3rd legislative package[6], the intention of the European Commission was to oblige all TSOs to unbundle in terms of ownership. This did not succeed as some Member States wanted to preserve the possibility for vertical integration. For this reason in the coming years there will still be vertically integrated TSOs in Europe.

A Member State usually has one TSO. The exceptions are Germany with four TSOs and Austria with three TSOs. The first cross-border TSOs are the mergers of the former transmission network of Eon in Germany with the Dutch Tennet and the former transmission network of Vattenfall in Germany, now called 50 Hz Transmission, with the Belgian company Elia.

All TSOs are regulated entities. Electricity transmission is considered a natural monopoly. TSOs are regulated at the national level by the National Regulatory Authority (NRA). For regulation at the European level the Agency for Co-operation of Energy Regulators (ACER) started in March 2011.

2.3. Competitive market

An electricity market is based on competition in generation and supply activities. One can differentiate between the wholesale market in which generators sell their products to suppliers and big consumers and the retail market in which suppliers compete for final consumers. This study concentrates almost solely on the wholesale market. Retail markets are indirectly covered to the extent that the consequences of transmission investments will pass on to the retail market through the influence on prices in the wholesale market.

6 EU, third package, 2009

In some European countries the market started to open already before it was required by the European legislation, notably in the UK and in the Nordic countries. In countries where several electricity companies existed before liberalisation, there was historically some level of competition or at least the companies could potentially start competing with each other, as opposed to countries where there was a single state or private monopoly company.

State or other public bodies are still often the owners of electricity companies. In these cases the state has to manage the electricity companies as businesses, while at the same time the state has to decide on the market and regulatory framework to be applied. In an ideal case these functions are properly separated. There is, however, a risk that at the political level these roles are mixed up resulting in non-optimal compromise solutions.

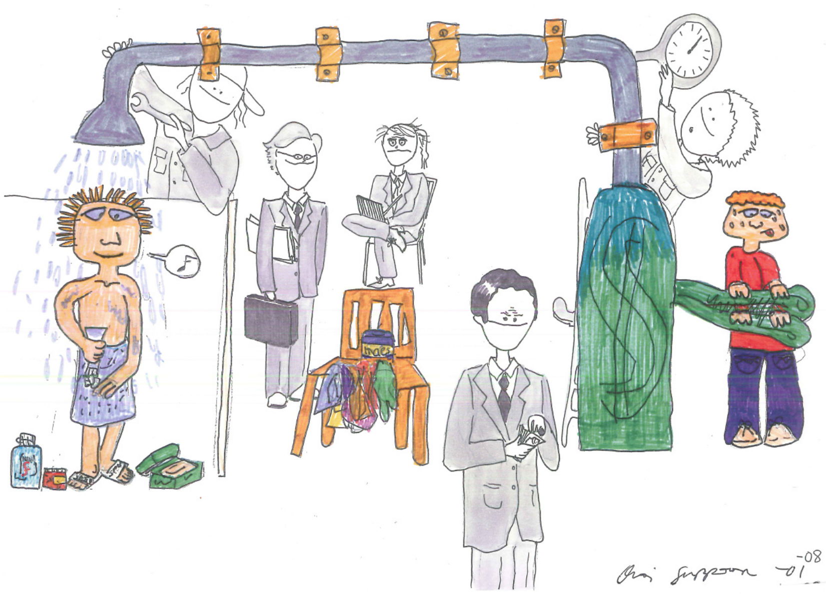

Figure 3 New roles thanks to opening of the electricity market.

Strong structural measures to create the prerequisites for reasonable competition were taken in some European countries. The UK completely restructured the electricity sector in order to make it competitive. Italy obliged ENEL, the state owned utility, to sell a large part of its generation assets. Other approaches were also taken. Germany and Austria believed that the existence of several companies active in the country would be enough to start competition. The UK, the Netherlands, Sweden, Finland, Hungary, Germany and the Czech Republic allowed important foreign acquisitions to happen to improve competition.

Unfortunately, in spite of these partial measures to restructure the sector and to bring in newcomers, the list of countries with the old monopoly company in a strong dominant position is long: France, Belgium, the Czech Republic, Slovakia, Slovenia, Denmark, the Baltic States, Romania, Bulgaria, Greece, Italy, Portugal and the smallest Member States.[7]

In these markets life can be very hard for newcomers. For example in France the position of Électricité de France (EdF) is so strong that only marginal investments are feasible for competitors. Newcomers can only hope that the regulator protects them for example from predatory pricing by the dominant player. Dominant positions are also difficult for the governments as it is almost impossible to keep control on these companies without regulating end-user prices in one way or another.

2.4. Price zones

For the European electricity market, the elementary cell is the price zone as already explained above. When there is no congestion between two price zones, the price in both zones is the same. When congestion appears, the prices differ. An electricity consumer can only contract with a generator in the same price zone without the risk of extra costs due to a price difference between zones. Relying on imports includes the risk of cross-border congestion and the consequent price difference at the border. Price zones can be subdivided into bidding zones. These bidding zones act as price zones, they have their own price if there is congestion at the bidding zone border. The name bidding zone comes from the fact that bids on the spot market are made referring to these zones.[8]

Bidding zones should be formed so that the congested parts of the network are at their outer borders and that inside the zones transmission from any generator to any load can be guaranteed with reasonable certainty. However, price zone borders in 2011 are still following country borders even if they in many cases are no more the congestion points of the network. This is mainly due to the wish to keep the country as a single price area.

Large price zones are advantageous for competition in case there are no internal bottlenecks inside the zone. This is due to large price zones usually having more producers and consumers than small ones. Single price allows

7 EC, benchmarking reports, 2000 – 2010 ; Gapgemini, Market observatory, 2009

8 In this study the term "bidding zone" is used when a price zone is split into several subzones such as in Italy.

the market participants to act on the market on equal conditions. However, small price zones could be more advantageous for network operation as small zones give additional tools for the TSOs to manage the flows in the network. One can think about an optimal design of price zones taking both elements into account, but the task is not an easy one.[9]

A system where zones are reduced to cover only one network node is called nodal pricing. Nodal pricing is applied in the area of the Regional Transmission Operator in Pennsylvania, New Jersey and Maryland (PJM) and in Russia. There are supporters for introducing nodal pricing also in the EU.[10] The opponents of nodal pricing are against a mandatory pool which has been considered necessary to make nodal pricing work in PJM. The opponents also argue against the perceived unfair treatment of consumers in the nodal pricing system because the prices differ inside the country depending on the node. To alleviate this, it is possible to use the nodal pricing only for generators and to equalise the prices for end consumers. This kind of an arrangement is in use for example in Italy in the context of the Italian zonal market system. Nodal pricing is also opposed due to the perceived higher risk of market power abuse compared to zonal pricing because of the limited number of market participants in each node. This argument is contested as the possibility to use market power depends on the capacity of the underlying infrastructure and can equally exist in a zonal and a nodal system.[11]

2.5. How cross-border flows are managed

The transmission network of a TSO is often designed to allow a free dispatch of generators and load most of the time, as discussed above. Generators are just obliged to inform the TSO which units they want to run to enable the TSO to check whether the network can accommodate the resulting flows safely. However, at the European level a similar freedom of transporting electricity between any generator and any consumer is generally not possible due to transmission network constraints. Thus a congestion management method is needed to allocate the limited transmission capacity between control areas.

9 ERGEG, capacity allocation and congestion management, 2011

10 MIT, Joskow et Schmalensee, nodal pricing, 1983; Bruegel, Zachmann, Policy brief, 2010

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

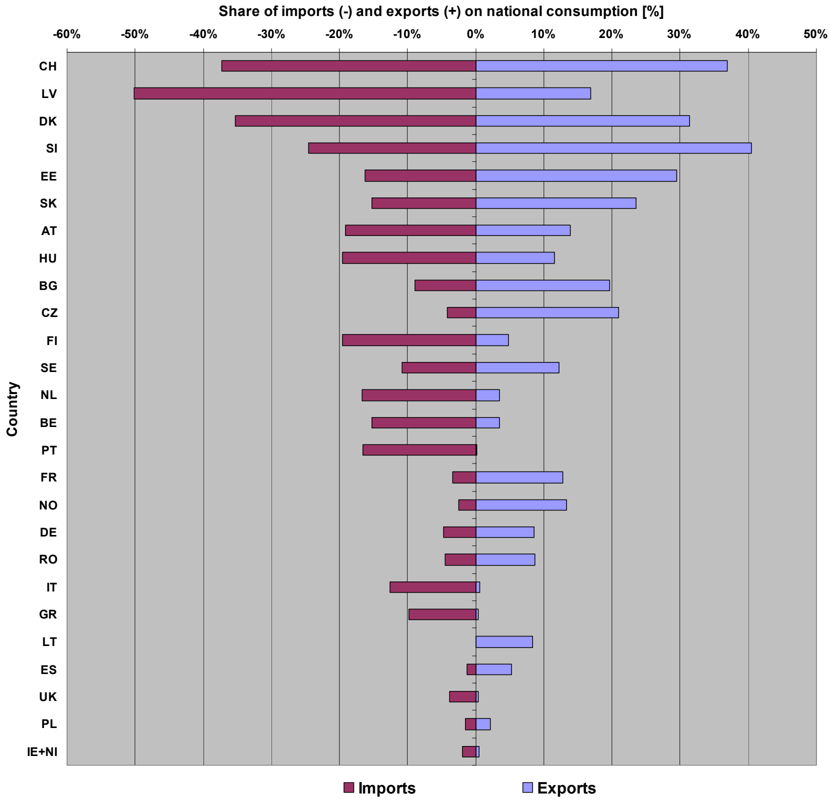

Figure 4 Share of electricity imports and exports of national consumption in Europe in 2008.[12]

Cross-border trade is enabled by allowing a generation surplus in the exporting control area and a corresponding generation deficit in the importing control area. TSOs manage the cross border flows by first calculating in a network model how big this surplus and deficit can be taking into account the technical constraints of the cross-border infrastructure and of the upstream network. Then the TSOs transform these results into a cross-border capacity value called Net Transfer Capacity (NTC)[13]. This capacity is offered to the market. Market participants then bid for the amounts of cross-border flows they wish to transport from one area to another. The market will attribute the available cross-border capacity to the highest bidders.[14] When the market result and the resulting cross border

12 Source: statistics on commercial flows of ENTSO-E and the former TSO associations. Some values are estimated as there is missing data in the ENTSO-E dataset.

13 ETSO, transfer capacity definitions, 2001

14 EU Regulation 714/2009 requires that when there is congestion, the capacity is allocated using market base methods. Accepted market based methods are

nominations are known, the TSOs will double-check in the network model the feasibility of these flows and transform them to a scheduled surplus or deficit in each control area. The task of each TSO in real time is to ensure that the surplus or deficit in the own control area follows this schedule.[15]

For some European countries cross border trade is a large share of their domestic load, for some countries cross border trade is marginal. This is illustrated in Figure 4.

From Figure 4 one can identify the typical transit countries Switzerland, Latvia, Denmark and Slovenia. Import countries (FI, NL, BE, PT, IT and GR) and export countries (BG, CZ, FR, DE, NO and RO) are also easy to recognise.

2.6. Need for transmission investments

A transmission network is needed to bring electricity from where it is produced to the place where it is consumed. Transmission networks take care of the higher volumes, be it shorter or longer distances. Transmission systems directly connect the biggest power plants, the distributions networks and in many countries also the biggest industrial consumers. The purpose of distribution networks is to bring electricity to final consumers and to connect smaller power plants.

Electricity is not very easy to transport long distances with today's systems based on Alternative Current (AC) technology. For longer distances the use of Direct Current (DC) technology is cheaper. For a single overhead transmission line the break even distance between AC and DC is about 400 – 600 km.[16] This does not mean that electricity can not be traded over longer distances. Surplus areas can be far away from deficit areas if there are in-between areas which are reasonably neutral in their power balance. In a way, electricity can be floated over these neutral areas with the help of their power plants maintaining the voltage and reactive power in the system at a proper level.

When possible, power plants should be built close to consumption to minimise transmission needs. However, often the location of the power plant is decided on other grounds such as availability of the resource (for

explicit and implicit auctions. In explicit auctions the TSO sell cross-border capacity separately, in implicit auctions the capacity is allocated together with energy bids in organised markets. These bids are utilised to transfer electricity from the lower price zone to the higher price zone.

15 UCTE, Operation Handbook, 2004 - 2010

16 Prof. Andersson in the DACH 2010 conference in Munich organised by VDE

example hydro, wind, coal, lignite, gas, cooling water and harbour facilities), taxes, subsidies, permits, construction and labour costs or stance on nuclear power. Often there is a need to keep a minimum distance to residential or vulnerable areas.

In times before market liberalisation each country wanted to be self-sufficient regarding electricity production. The longest distances to transport electricity were from the surplus areas to the deficit areas inside the country. Sweden, Finland and the UK are typical examples of this evolution with hydro resources in the North and consumption in the South. In the Soviet Union transmission distances were even longer.

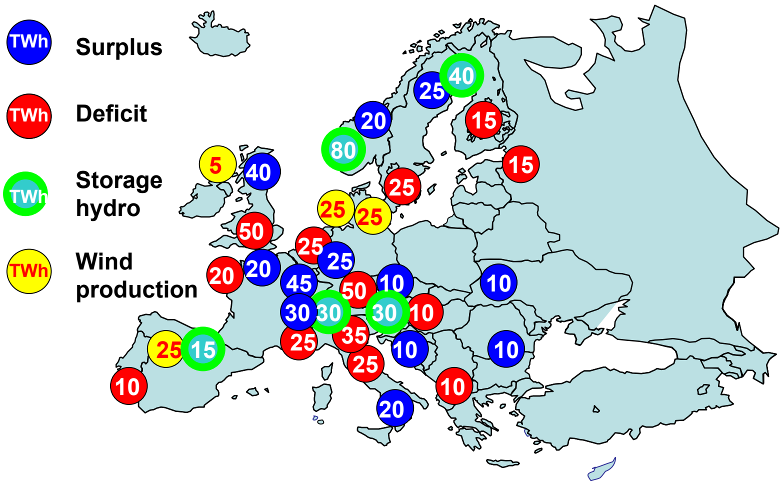

Figure 5 Main electricity surplus, deficit, storage and wind production areas in Europe in 2008.[17]

For cross-border transmission in Europe the pioneers were the Alpine countries and their neighbours. Hydropower from Austria and Switzerland was consumed in Germany and Italy thanks to interconnectors dating back to the 1920s.[18] Later on, cross-border exchanges were significantly increased with the construction of nuclear power plants. Italy, the Netherlands, Switzerland and the UK, not being able to construct enough nuclear plants themselves, contracted nuclear power from France which

17 The map shows the realized power balance in Europe in 2008. This balance is based on economic dispatch of generation within the network constraint limits. The map should not be mixed up with generation adequacy maps which indicate how much could be produced based on installed generation capacity. Data is collected from European and national electricity statistics sources. Data for storage hydro plants is from reference: Swissgrid, Tillwicks, hydro storage, 2010. Data for Nordic hydro storage capacity is from Nord Pool Spot.

18 VDEW, history, 1984

was prepared to increase nuclear capacity far beyond its own needs. These import contracts were made between vertically integrated monopolies.

Today markets are open and anybody can trade electricity and transport it cross the borders from one control area to another, subject to getting cross-border transmission capacity from the TSOs. In spite of this freedom, today's transmission flows are still largely inherited from the past. The same surplus and deficit areas formed in the times of vertically integrated monopoly utilities are still clearly visible in the transmission pattern. The following map shows those electricity surplus and deficit areas.

The biggest combined deficit area in Europe is formed by Northern Italy, Southern Germany and South Eastern France. Deficit in Southern England is also important. The biggest surplus areas are in Northern and Eastern France. Also Scotland and Scandinavia have an important electricity surplus in rainy years. Wind power surplus is mainly located in Northern Germany, Denmark, Spain and Scotland. Development of off-shore wind parks in the North Sea will further increase the Northern wind surplus.[19]

2.7. Cost of electricity production

Need for transmission is not only due to surpluses and deficits of generation capacities but it is also influenced by the search of the most economic dispatch. In particular in low load periods there is a lot of idle generation capacity available and methods are needed to decide which unit will run. In the old monopoly times the dispatch was made by establishing a merit order. Power plants were ranked according to their marginal cost of production and they were centrally dispatched starting from the cheapest one. In the electricity market the same principle applies, but now the power plant owners make their own dispatching decisions, based on the market price and their expectation on its development. In principle, both systems should result in the same dispatch of power plants. However, optimisation of dispatch is a rather complex task which makes it difficult for example for the TSOs to predict which plant will run and which not until the generators have confirmed their dispatching decisions.[20]

2.7.1. Hydropower

Historically hydro resources have allowed supplying electricity at an affordable price. Transmission lines have been built to exploit hydro power

19 EWEA, wind production forecast 2020 - 2030, 2009

20 Wood, Wollenberg and Sheblé, Power systems operation and control, 2010

sometimes far away from consumption. Hydro power is usually very flexible. Flexibility allows hydro power to participate in balancing and regulating power markets in which prices are usually higher than in the longer term markets.[21] The amount of energy produced by hydro power plants is dependent on the rainfall. Thus there is an interest to use the limited amount of water in the periods when the price is high. Storage power plants, common in Norway and in Alpine regions, are capable for daily and seasonal production patterns which enable this optimisation of production.

2.7.2. Nuclear power

Nuclear power is currently the cheapest alternative for base load electricity.[22] As all countries do not accept nuclear power plants in their country, this creates a business opportunity for cross-border trade and is currently the main reason for cross-border flows. In 2008 net exports from France were 48 TWh, net imports to Italy 40 TWh and net imports to the UK 11.5 TWh.[23] Switzerland's imports from France in the same year were about 18 TWh, Switzerland exported nearly the same volume to Italy.

It remains to be seen whether comparable nuclear surpluses will be maintained in the future or whether nuclear capacity will be limited to the base load needs of each country using nuclear power. This question concerns France in particular. The capacity factor of the French nuclear plants in year 2009 was only around 71% and in 2010 around 74%, which is low in international comparison.[24] The main reason for this is that at night and in summer vacation periods the nuclear production capacity in France exceeds consumption and thus the production from nuclear plants needs to be curtailed in those hours. To manage this challenge, the French nuclear plants are designed for this load following operation.

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21 Regulating power, often also called balancing power, is bought by the TSO to keep the load and generation in balance in its control area. TSOs need both positive and negative regulating power for upwards and downwards regulation. Upwards regulation is usually more expensive, the cheapest source being hydro power which can rapidly increase production. To provide upwards regulation in thermal systems there needs to be spinning reserves which are not producing at full capacity. For downwards regulation almost any power plant in operation can participate by reducing the output.

22 Tarjanne, generation costs, 2010

23 Source: ENTSO-E

24 Platts, Nucleonics week, 2010, 2011

2.7.3. Gas power

Combined cycle gas turbine is today the technology often setting the market price. The biggest share of the marginal cost for these units is the gas cost. Thus gas availability and price are important factors influencing the electricity price and the investments in gas turbines. As most European countries have gas and gas power plants are usually not considered particularly harmful by the citizens, gas turbines can be located close to consumption.

2.7.4. Wind power

Wind power, like hydro and nuclear, has a low short term variable cost of production. In some cases, depending on the subsidy system, wind generators have an interest to produce even when the market price is negative.

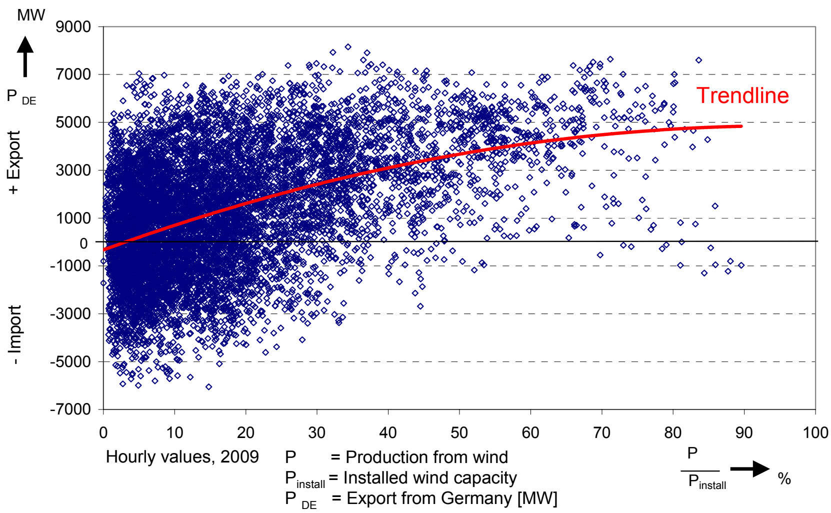


Figure 6 Correlation of exports of Germany and wind production as percentage of installed capacity in 2009.[25]

Windy days create important export opportunities for countries with a high share of wind power, see Figure 6. With high wind, the market price decreases as there is less need for conventional generation. Low price will lead to exports to neighbouring price zones, in particular if the price in the neighbouring zone is less affected by wind power. Germany and Spain are good examples of this phenomenon.

25 Source: Amprion

2.7.5. Other renewable electricity

Until now, renewable electricity has been mainly generated from hydro, biomass and wind. The outlook to increase hydro power is rather modest. The bulk of the increase in electricity production to meet the 2020 renewable targets will come from biomass and wind. From the other renewable sources the outlook for solar power is the most promising. Solar photovoltaic power has increased rapidly in some areas thanks to powerful subsidy schemes. Concentrating solar power technologies[26] have been brought forward in the context of the North African and Mediterranean solar power projects. Deep geothermal energy could also be feasible for large scale exploitation in the future.

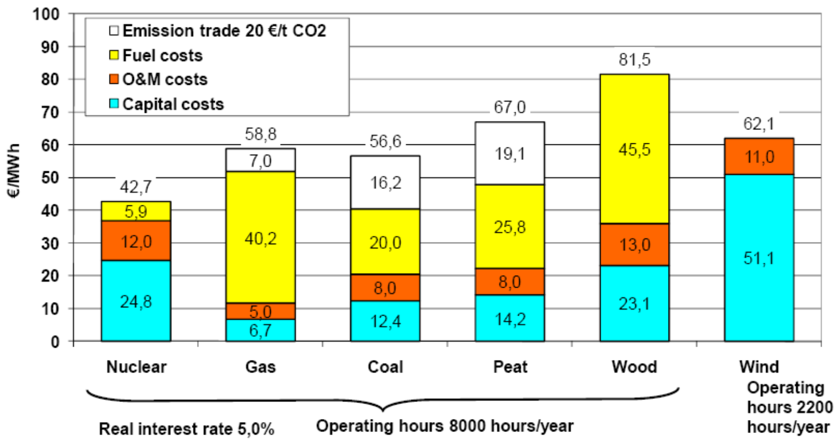


Figure 7 Electricity generation costs with emissions trading.[27]

2.7.6. Market price

Cross-border exchange of electricity is ultimately driven by market price differences between price zones. The market price in each price zone is dependent on market fundamentals such as the level of demand, generation capacity availability and cost of production. The market price can also be influenced by company and authority decisions such as a lift up enabled by market power or administered prices imposed by regulators. Finally, cross-

26 Concentrating Solar Power (CSP) is a technology in which the solar radiation is concentrated to elements which will produce steam for a conventional thermal cycle.

27 Based on February 2010 prices. Wood and wind are without taking into account subsidies; Tarjanne, generation costs, 2010

border exchange of electricity itself influences the market price, decreasing it in high price zones and increasing it in low price zones.

Figure 8 indicates the average spot price for each price zone in Europe in 2008 and the prevailing commercial flows following the price difference.

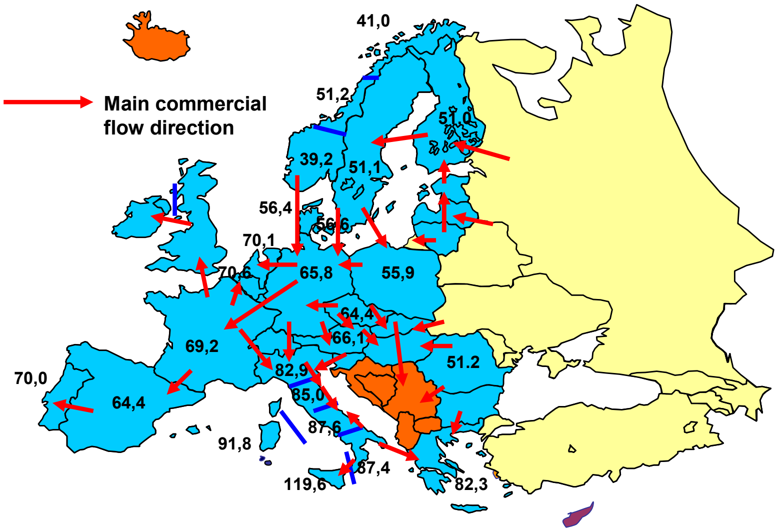


Figure 8 Average hourly spot prices and the main export directions following the price differentials in Europe in 2008. [28]

[28] Source: Power exchanges' websites. In France the yearly average spot price was higher than in Spain. However, the net commercial flow was predominantly towards Spain because Spain was more expensive in more hours than France and probably because of an existing long term contract from France to Spain. The flow in the Greece-Italy interconnector was predominantly towards Greece which is against the average spot price difference. The assumed reason for this is market imperfections in Greece. The price differential between Great Britain and Ireland is difficult to establish because of the lack of comparable spot markets. The flow, however, in the Moyle interconnector is predominantly from Great Britain to Ireland.

3. CROSS-BORDER TRANSMISSION INVESTMENTS

3.1. Economic principles

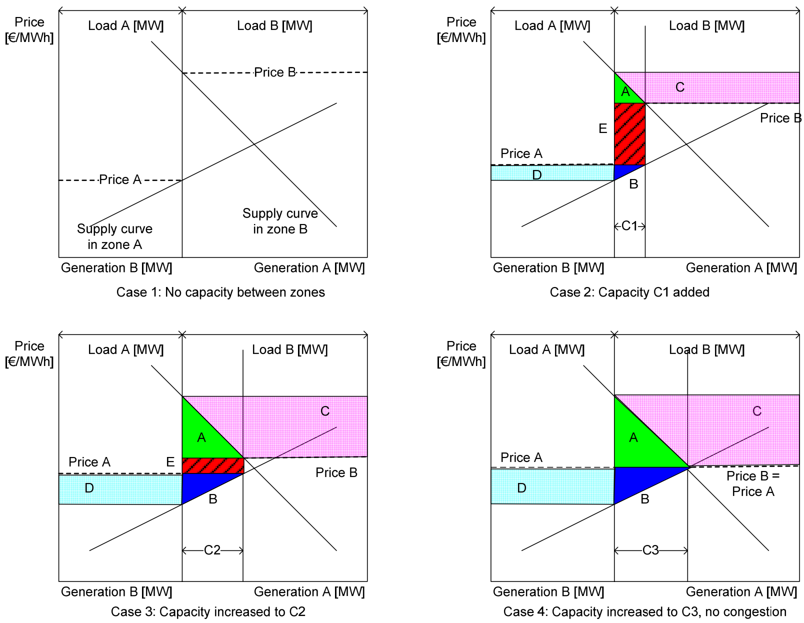
It is obvious that any TSO should make only beneficial transmission investments. The challenge is to identify which transmission investments are the most beneficial and how to prioritise them.

Inside a control area, transmission investments are needed to connect power plants, distribution systems and industrial consumers to the transmission network. Without a connection, a power plant, distribution system or consumer is not able to operate. Regarding investments in interconnectors, there is an option not to build anything at all as they are usually not absolutely necessary for the functioning of the system. The need for interconnectors is reduced by the common political wish of many sovereign states to have a high degree of autonomy in the electricity supply. For large countries a certain level of autonomy is necessary from the technical point of view, at least with currently used transmission technology. Only small countries could be entirely supplied from the neighbouring countries, Luxembourg being an example. This means that even if it is well possible to optimise European electricity production by transporting electricity from surplus areas to deficit areas, it is not possible in practise with current transmission technology to cover the consumption of the whole Europe by producing only in a small number of countries.

Thus the main role of interconnectors is, in addition to providing system security back-up to national systems, to optimise the overall system by allowing some higher cost generators to be replaced by lower cost generators in the regional dispatch. This means that an approach based on optimising social welfare when deciding on building an interconnector is very appropriate even if the political wish for autonomy might in some cases overrule the social welfare calculations. The assessment of the increase in social welfare due to building new interconnectors is developed in this chapter.

3.2. Social welfare

An interconnector between two price zones with a price difference will allow generators in the low price zone to supply load in the high price zone. This will result in an increase of overall social welfare if the net increase in producer surplus, consumer surplus and congestion rent is higher than the investment costs. However, there can be important distributional effects. In the low price zone, part of the consumer surplus will be transferred to the producer surplus as the price increases. Equally, in the high price zone part of the producer surplus will be transferred to the consumer surplus, as the price decreases. This phenomenon is illustrated in Figure 9.



A: An absolute increase in consumer surplus due to increased transmission capacity
B: An absolute increase in producer surplus due to increased transmission capacity
C: A transfer from producer surplus to consumer surplus
D: A transfer from consumer surplus to producer surplus
E: Congestion rent

Figure 9 Social welfare effects of an interconnector investment.[29]

As shown in Figure 9, the transfer of surplus from producers to consumers and vice versa is dependent on the slope of the demand and supply curves. If the supply curve is gradual, a capacity increase will cause only a modest transfer of surplus. If it is steep, the transfer of surplus is important. Regarding prices, a steep supply curve will cause prices to change faster when increasing cross-border capacity than in the case of gradual supply curves.

In large price zones supply curves are more gradual than in small price zones as there are more power plants forming the supply curve. Thus building an interconnector between a large and a small price zone will

[29] UCB, Lesieutre and Eto, 2003; CRE, interconnection 2008, 2009

influence the level of prices more in the small zone. However, the transfer of surplus can also be important in the large price zone as the price change applies to bigger volumes.

Also, in peak load conditions supply curves tend to be steeper than in base load conditions. This means that the influence of interconnection capacity to prices during peak load times can be more significant than during base load hours.

Figure 9 is simplified by leaving out the effect of demand elasticity. Demand is usually inelastic in short term. In longer term, demand is elastic in all electricity markets and needs to be taken into account when analysing transmission investments.[30]

Consumers are particularly interested in congestion costs for consumers[31] which are equal to the area of zone D as shown in Figure 9 subtracted from zone C +A. It is interesting to note that increased interconnection capacity does not automatically lead to increased welfare to consumers when summing up the effect on both sides of the border. For example if the supply curve in the exporting country is very steep and in the importing country very gradual, the result of building an interconnector is a substantial price increase in the exporting country but only a slight price decrease in the importing country. In these circumstances, overall social welfare for consumers will be reduced while overall social welfare for producers will be increased. An inversed slope of the supply curves would give the opposite result.[32]

3.3. Congestion rent

TSOs are particularly interested in congestion rents, zone E in Figure 9. Congestion rent is collected by the TSO in the form of auction revenue from selling interconnection capacity as already discussed above. This can take place explicitly when the TSO sells interconnection capacity and the traders

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[30] In this case the welfare effects will be even bigger as deadweight loss is reduced.

[31] Congestion cost for consumers is the difference in overall costs for consumers between the congested situation and the situation without congestion.

[32] This analysis only takes into account the effect on the electricity market in the respective countries caused by the new interconnector. The long run general equilibrium consequences of any voluntary trade are always beneficial. This is due to the fact that resources in the importing country can be reallocated to be better used in other sectors, and in the exporting country resources will be allocated to the electricity industry from less value creating sectors (comment by Mats Nilsson).

organise themselves how to use this capacity, or implicitly when cross-border electricity flows are decided based on bids in power exchanges.

Welfare effects in function of the increase of cross border capacity are shown in Figure 10. When the capacity of an interconnection is increased from zero, the amount of congestion revenues received from selling transmission capacity first increases rapidly as shown by the parabolic congestion rent curve. With a further increase in capacity, the increasing flow in the interconnector reduces the price difference over the interconnection and the congestion rent will grow slower until it reaches its maximum. From that point onwards a further increase of capacity will reduce the congestion rent until it becomes zero at the full price convergence point.

The increase in producer and consumer welfare is almost opposite to the increase in congestion rent. With small capacities the increase in producer and consumer welfare is small but they increase exponentially with the increase of capacity. Thus the first megawatts are interesting for the TSOs' income and the last megawatts are interesting for the producer and consumer welfare. However, it is important to note that the biggest influence of an interconnector capacity increase is usually through the transfer between the producer and consumer welfare within each country as shown in Figure 10. This transfer increases almost linearly with the capacity increase until the full price convergence point.

In Figure 10 it is assumed that a linear capacity increase is possible. In practise the main capacity increase option is adding new transmission lines corresponding large capacity steps. However, smaller intermediate steps are often possible such as upgrading existing lines to higher capacity ratings.

From Figure 10 interesting observations can be made regarding the optimum outcome for various parties. A merchant investor would aim to maximise the net revenue for the interconnector owner which is reached with the capacity of 1500 MW. The overall social welfare maximum of the investment corresponds to the capacity of 3000 MW or 3500 MW which has almost the same overall social welfare as 3000 MW. In the case of 3500 MW the TSO would make a loss. Country A would choose a capacity of 2000 MW because at higher capacities the social welfare for Country A decreases. Country B would invest up to 4500 MW, which is the capacity needed for full price convergence, because this gives the maximum welfare for Country B.

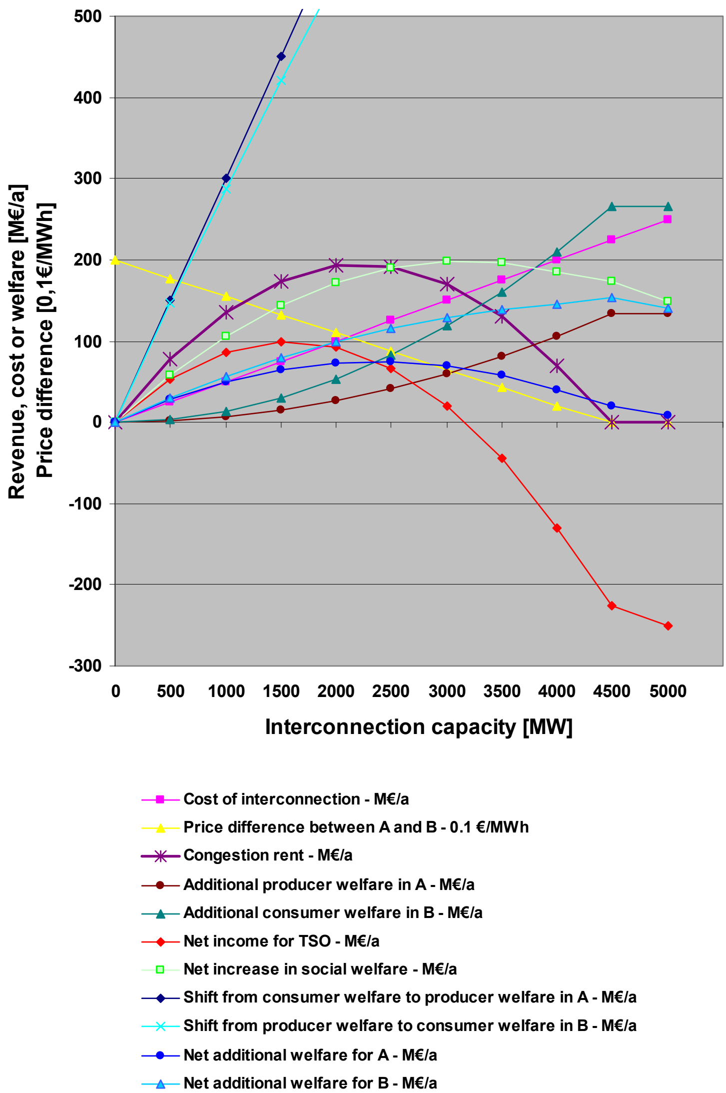

Figure 10 Welfare effects of an interconnector investment in function of capacity. Detailed data is presented in Table 1 in Appendix 2. [33]

Figure 10 illustrates the importance of the transfer of social welfare between producers and consumers. The negatively affected parties potentially seek for limiting the capacity of the investment far below the overall welfare optimum level.

33 Discussions with Peter Jørgensen, Energinet.dk in 2002; EPFL, Duthaler and Finger, congestion revenues, 2008; ESRI, Valeri, IE-UK interconnector, 2008

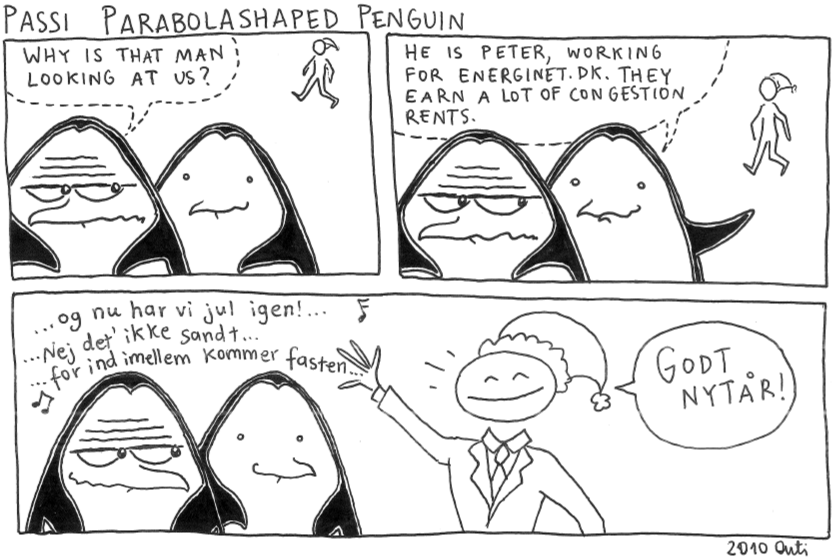

Figure 11 Congestion rent accrual follows a parabolic curve.

Congestion rents have increased constantly after the introduction of implicit and explicit transmission capacity auctions. Year 2009 was an exception. In 2009 congestion rents dropped due to consequences of the economic crises reducing electricity cross-border trading. It is, however, foreseeable that the overall congestion rents in Europe will increase again when the economic crisis is over. There are also some borders on which congestion rent is still not collected but capacity is given for free based on historical long term contracts. This applies in particular to the Swiss borders. In the EU priority allocation of cross-border capacity for historical contracts is forbidden.[34] Table 1 gives the development of congestion rents in Europe in 2006 – 2009.

It is important to understand how congestion rent is accumulated as a function of the price difference and the capacity of interconnection. In most interconnections in Europe the price difference and hence the commercial flow is predominantly in one direction as illustrated in Figure 12.

On average only about 10% of the commercial flows are in reverse direction. Only in the Finnish-Swedish, German-Swiss and Belgian-Dutch interconnections both directions were almost equally used in 2008.

The price difference can change direction in different time patterns. Daily or seasonal price difference patterns are usual between thermal and hydro systems. Thermal systems have typically a high price difference between day

34 EU, court decision C-17/03, 2005

and night. Hydro systems have a smaller price difference between day and night because of the storage capability.

Table 1 Annual congestion rents collected by the TSOs in Europe in 2006 - 2009.[35]

TSO	Country	2006 [M€]	2007 [M€]	2008 [M€]	2009 [M€]
Verbund APG	Austria	26.3	44.5	63.2	49.45
Elia	Belgium	58.1	40.3	29.2	28.6
ESO	Bulgaria	0	2.3	23.6	19.1
Swissgrid	Switzerland	35.3	40.1	78.1	59.4
CEPS	Czech Republic	102.0	59.8	34.6	26.2
EnBW (DE), RWE (DE), EON (DE), Vatenfall (DE), VKWNetz (AT)	Germany	316.3	220.6	222.5	167.9
Energinet.dk	Denmark	79.5	95.2	129.9	58.3
OÜ Pohivork	Estonia	0	0	0	0
REE	Spain	25.8	61.8	78.0	41.6
Fingrid	Finland	11.9	22.6	23.2	4.9
RTE	France	342.0	376.5	380.6	257.0
HTSO	Greece	22.0	5.1	30.9	35.5
Mavir	Hungary	29.4	47.1	76.4	49.0
EirGrid	Ireland	6.2	13.1	0	0
Terna	Italy	89.8	333.8	299.6	187.8
AB Lietuvos energija	Lithuania	0	0	0	0
Cegedel	Luxembourg	0	0	0	0
AS Augstsprieguma tikls	Latvia	0	0	0	0
Tennet	Netherlands	107.6	54.0	105.9	59.0
Statnett	Norway	18.0	31.9	112.9	45.6
PSE Operator	Poland	70.2	40.9	28.1	13.4
REN	Portugal	0	23.2	32.3	5.5
Transelectrica	Romania	10.7	17.7	36.7	22.1
Svenska Kraftnät	Sweden	35.4	67.8	85.3	28.2
ELES	Slovenia	3.1	25.9	32.6	33.0
SEPS	Slovakia	22.48	44.39	36.2	27.9
National Grid	United Kingdom		61.14	106.0	66.1
TOTAL [M€]		**1412**	**1730**	**2046**	**1286**

35 EC, ITC consultation documents, 2008 ; ENTSO-E, congestion rents 2008, 2009; ENTSO-E, congestion rents 2009, 2010; CRE, interconnection 2007, 2009

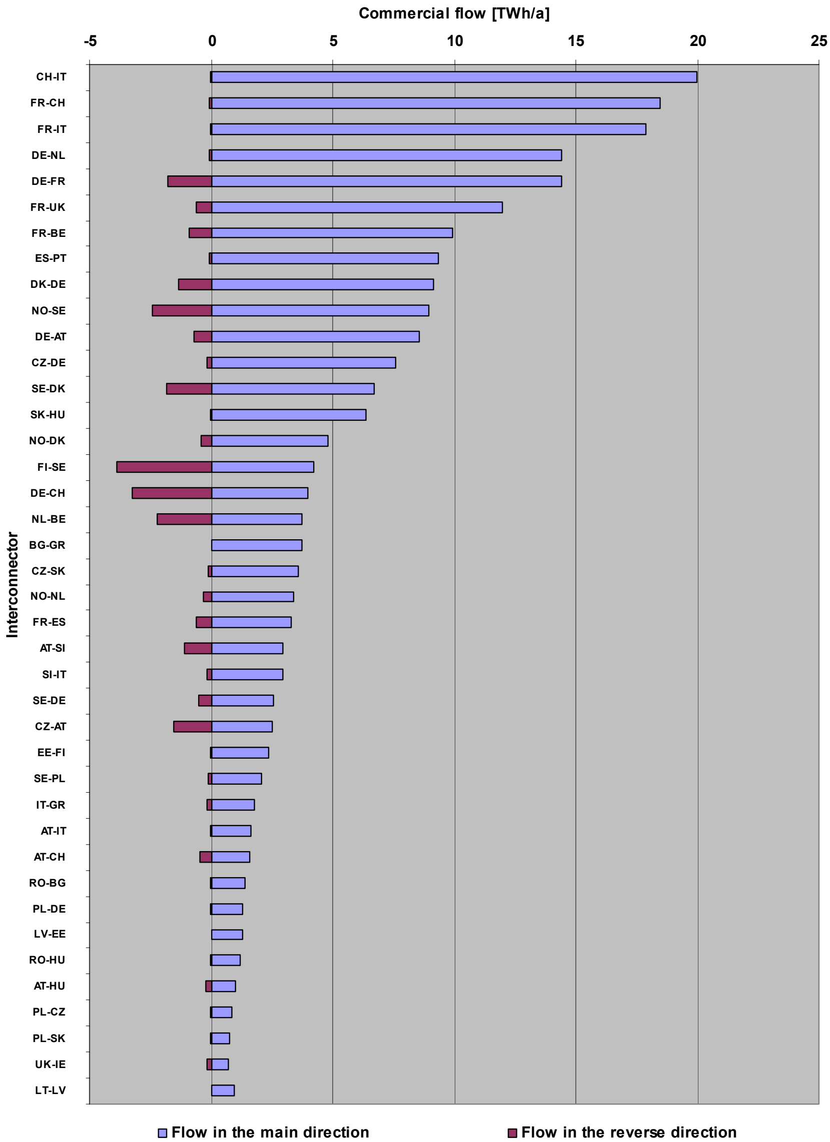

Figure 12 Net hourly commercial flows in each direction at the European interconnections in 2008.[36]

A usual seasonal variation in hydro systems is low prices in spring when snow is melting and high prices in winter when there is less water available. As an example, the price difference pattern between Norway and Germany is shown in Figure 13. This dynamic price difference pattern is one

36 Source: ENTSO-E. Some values are estimated as there is missing data in the ENTSO-E dataset.

important part of the economic basis for a cable investment between these countries.

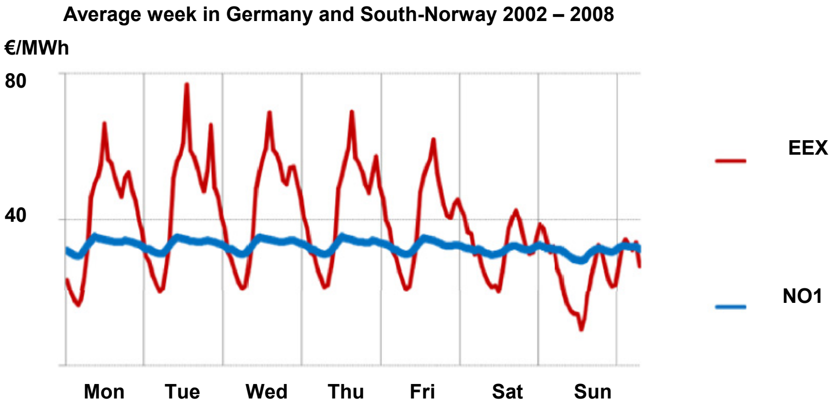

Figure 13 Average weekly pattern of the hourly spot price difference between the Norwegian price area NO1 in the Nord Pool Spot power exchange and the German spot price in the European Energy Exchange (EEX) in the period 2002-2008.[37]

Real congestion rent usually remains below the theoretically possible congestion rent. There are several reasons for this. Capacity is not always available due to outages or due to curtailment of capacity for network security reasons. Another reason is that in most European interconnections congestion rent is not gathered from implicit auctions but from explicit auctions or from a combination of these two types of auctions. Explicit auctions give a congestion rent based on traders' estimate of the price difference, not on the final price difference. Usually implicit auctions give a higher rent for the TSO as in explicit auctions the uncertainties for traders are higher.[38]

A comparison between the real congestion rent accrual with the theoretical accrual, calculated by multiplying the hourly price difference with the maximal flow, is presented in Table 2 for some European interconnections. From the table it can be seen clearly that in some cases the real congestion rent is close to the theoretical congestion rent but in some others both the utilisation ratio and the congestion rent is far below the theoretical maximum. Explanations for this lack of efficiency are further explored in this study.

As congestion revenues indicate how much market participants value the possibility for cross-border trade, congestion rent could be a good criterion

37 Statnett, Bente Hagem, transmission investments, 2010

38 Frontier Economics and Consentec, congestion management methods, 2004

to determine at which interconnection capacity should be increased.[39] Congestion rent can be easily compared with the cost of any potential investment to remove congestion.[40] TSOs are obliged to publish the commercial flows and congestion rent at each interconnection which allows any stakeholder to have a view whether a higher capacity might be justified. The analysis needs to be based on an estimation of future congestion rents for which the current rents are not necessarily a good proxy.

Table 2 Comparison of the realised congestion rent with the theoretical congestion rent at some European interconnections in 2008.[41]

Exporting country	Importing country	Capacity [MW]	Commercial flow in the interconnector [TWh]	Utilisation ratio of the interconnector [%]	Absolute price differrence [€/MWh]	Congestion rent in 2008 [M€]	Theoretical congestion rent [M€]	Share of real congestion rent of the theoretical rent [%]
DE	FR	2675	16	69%	10	156	232	67%
NO	NL	700	4	60%	27	113	168	67%
FR	IT	2525	18	81%	21	300	454	66%
FR	ES	1300	4	35%	17	93	192	49%
DE	NL	3925	14	42%	10	65	329	20%

It has been discussed whether the whole transmission infrastructure could be financed through congestion rents. A general conclusion of this discussion has been that even if a considerable share of the investments can be made using congestion rents, it is usually not possible to cover all transmission costs from them.[42] From Tables 1-2 one can observe, however,

39 For interconnector projects between countries with no existing interconnectors there are no historical congestion rents, so other methods need to be used for assessing the profitability of a possible interconnector.

40 In many countries congestion rents are collected from several borders. An interconnector investment affects the market price and thus also affects congestion rents at all borders, not only at the border at which the new interconnector is built. Thus it is necessary to take into account the combined effect, not just the increase of congestion rents at one border.

41 ENTSO-E, congestion rents 2008, 2009; ENTSO-E, NTC winter 2007 – 2008, 2007; Price data from Power exchanges' websites. Theoretical congestion rent calculation is based on hourly spot price differences. Yearly average absolute price difference is the average of the absolute values of the hourly spot price difference

42 Rubio-Odériz and Perez-Arriaga, marginal pricing of transmission, 2000; Duthaler and Finger, congestion revenues, 2008

that for small transit countries situated at a high price gradient, namely Switzerland, Slovenia and Denmark, this might well be possible.[43]

The congestion rent declines when the cross-border capacity is close to the price convergence level, as illustrated in Figure 10. This decrease in congestion revenues could discourage TSOs to invest up to the overall welfare optimum level. It is important that this phenomenon is taken into account by the national regulators when setting incentives for the TSOs and by the ACER when giving an opinion of the ENTSO-E ten year network development plan.[44]

3.4. Identification which interconnector projects would be profitable

To identify which interconnector projects would be profitable from the overall social welfare point of view in Europe, a method is developed in this study. This method is illustrated in Figure 14 and a detailed description of the method together with the input data and calculation results are presented in Appendix 1.

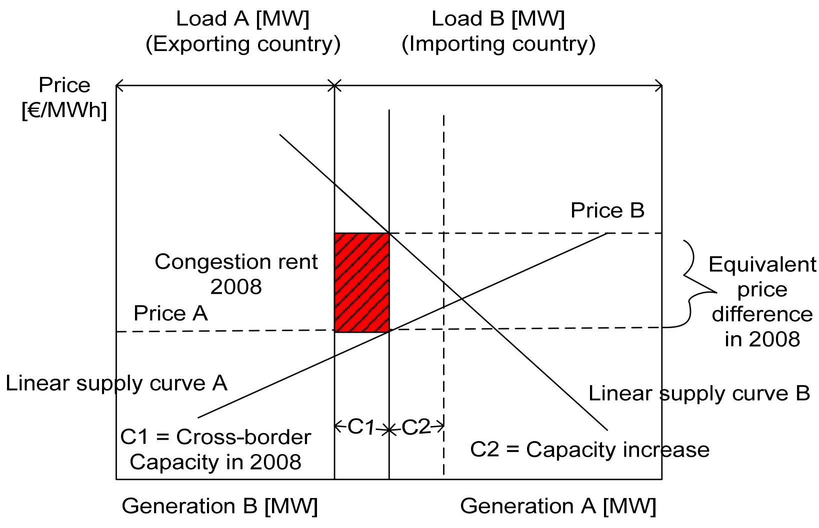

Figure 14 Approximation of the supply curves on both sides of the interconnection by using linear supply curves as a proxy and estimating the relative position of the supply curves through the congestion rent. [45]

43 See also Table 3 later in this chapter as well as Tables 2 - 5 in Appendix 1.

44 According to Electricity regulation EC/714/2009 one of the tasks of the ACER is to give an opinion on the ten year network development plan of ENTSO-E.

45 It is assumed that both the supply curve and the load in each country are fixed. Trade between the two countries moves the operation point in each

The method is based on a model using as input parameters (i) supply curves with the slope equal to the linear regression line of correlation between spot price and load in 2008 (2009) for each price zone as illustrated in Figure 15, (ii) the cross-border capacity and trade between countries in 2008 and (iii) the congestion rent collected from each border. An equivalent price difference between two countries is generated by dividing the congestion rent in 2008 by the corresponding cross-border flow. The linear supply curves are set in the model to a distance corresponding to this equivalent price difference. The changes due to increasing the interconnection capacity are then calculated by assuming that the additional capacity is fully utilised and that the flow at the interconnection reduces the price difference in function of the new supply balance in each zone as illustrated in Figure 14.

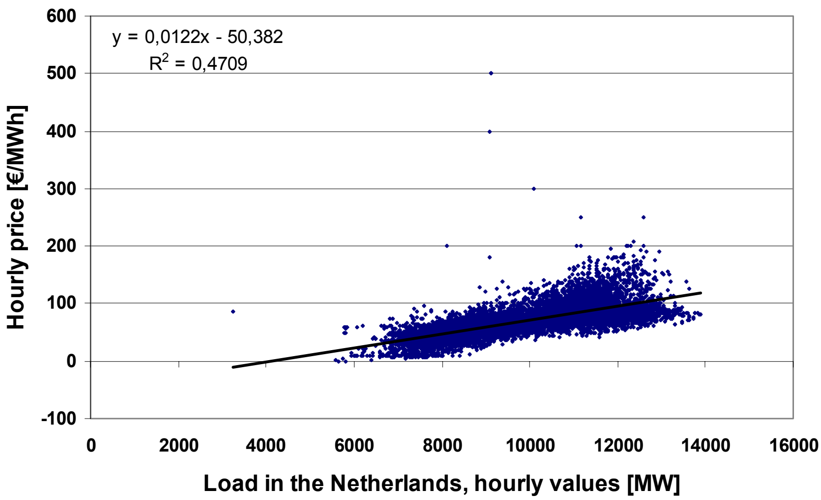

Figure 15 The regression line of correlation between the hourly spot price in APX Power NL power exchange and the hourly load in the Netherlands in 2008, used in this study as a proxy for the slope of the supply curve in the Netherlands.[46]

The model allows calculating all relevant parameters for an interconnection capacity increase. The calculation in Appendix 1 includes the optimal increase of capacity and the change in congestion rent and social welfare. Summary results of this calculation are shown in Table 3 below.

country along the supply curves as part of the load in Country B is served by generators in Country A. The linear regression line of correlation of spot market price versus load is used as a proxy for the supply curves in the calculations. Detailed description of the method is in Appendix 1.

46 Source: APX Power NL.

The first conclusion of the calculation shown in Table 3 is that there is clearly potential for many profitable interconnector projects in Europe. In particular links between the Nordic countries and the Central Europe, investments at the borders of Italy and the UK are extremely profitable even if they would be DC interconnectors with an annual cost in the range of 50 – 100 k€/MW/a.[47]

Also many investments inside Central Europe are potentially profitable. Even if price differences in Central Europe are not as important as between Central Europe and the other regions, the possibility to build relatively cheap overhead lines makes them interesting from the social welfare point of view.

The fact that building overhead lines has become very difficult because of public acceptance issues means that this potential is not easily realised. Most of the interconnectors that have been successfully finished in the past years are expensive undersea projects which are less sensitive regarding public acceptance.

The results presented in Table 3 are based on a method using rather heroic assumptions.[48] One needs to be particularly careful when interpreting the results for the highly meshed Central European transmission network. Interconnectors often have influence on several countries, not only on the two countries between which it is built. This is a main limitation of the method used in this study. The increase in flows and the changes in market prices are assumed to take place only in the two price zones between which the interconnector is built. In the case of a small increase of capacity, this is accurate enough, but if the increase of capacity is large, also the flows in the other interconnections of the two countries in question are affected.

When capacity increase in one interconnection affects several interconnections, it is necessary to analyse what would be the optimal combination of capacity increase in all these interconnections. This is particularly true for transit countries.

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47 Costs of DC interconnectors vary depending for example on technology, capacity and length of the interconnector. The range of 50 – 100 k€/MW/a corresponds to such recently finalised or planned investments as BritNed (1300 MW of capacity, about 600 M€ of investment costs), NorNed (700 MW, about 650 M€) and France-Spain interconnector (1400 MW, about 800 M€). Shorter interconnectors such as Estlink (350 MW, 110 M€) have lower annual costs.

48 The method is based on calculating the optimal capacity for interconnections one by one, all other borders remaining unchanged. Thus the welfare calculations do not try to reflect a simultaneous optimisation of the European grid.

Table 3 Summary results of the calculation of welfare gains of potential interconnector investments in Europe using the method developed in this study. The method is presented in Appendix 1 and the detailed results in Table 5 in Appendix 1.

Exporting country	Importing country	Capacity in 2008 [MW]	Optimal additional capacity from the social welfare point of view [MW]	Increase of social welfare at optimal capacity [M€/a]
NO	UK	0	9159	992
NO	DE	0	4673	383
SE	DE	600	3665	229
FR	ES	1300	4343	215
FR	UK	2000	4488	203
NO	NL	700	1818	197
NO	SE	2825	2349	127
FR	IT	2525	2563	124
DE	FR	2575	2699	97
AT	HU	500	895	96
PL	DE	1150	1273	87
SE	PL	600	1967	80
AT	IT	210	1024	56
PL	SK	475	567	49
RO	HU	800	562	46
PL	CZ	1630	724	43
BE	UK	0	731	40
NO	DK	750	677	37
CH	IT	3525	604	25
DE	CH	1900	628	23
NL	UK	0	574	20
FR	CH	3100	588	20
ES	PT	1200	793	20
DK	DE	2050	454	18
BG	GR	550	313	12
DK	NL	0	302	12
RO	BG	625	303	11
AT	CH	1000	335	10
AT	SI	350	143	6
UK	IE	410	254	5
CZ	SK	1150	150	3
DE	NL	3925	224	3
NL	BE	2150	161	3
CZ	DE	2275	201	2
SK	HU	1000	97	2
HU	SI	0	52	1
FR	BE	2950	69	0
SE	DK	1980	41	0
SI	IT	380	20	0
CZ	AT	250	10	0
IT	GR	500	1	0
DE	AT	1500	0	0
FI	SE	1600	0	0
EE	FI	350	0	0
LT	SE	0	0	0
LT	PL	0	0	0
LV	EE	750	0	0
LT	LV	1100	0	0

For example for Switzerland, Denmark and Slovenia, the only possibility to considerably increase exports is to increase imports.[49] A simultaneous increase in imports and exports gives a much higher overall welfare gain potential than if the effect of imports and exports are calculated separately. For example for a line passing through Switzerland, the figures calculated for the interconnection between France and Italy give an order of magnitude for the potential overall gains. Similarly, figures for the interconnection between Austria and Italy can be used to estimate the potential gains for Slovenian interconnector projects and for Denmark the figures for projects between Norway and Germany are relevant.

It is also important to notice that our static linear model only approximates the potential of dynamic changes in prices. Dynamic changes are particularly important for countries which have similar yearly average prices but still have different price volatility patterns in the seasonal and hourly prices. Additionally, the model excludes the gains from the shorter term markets, such as from the intra-day and regulating power markets, in which prices and thus social welfare values per MWh are usually much higher than in the day-ahead spot market. Intra-day and regulating power markets do not currently generate congestion rents as the transmission capacity for these markets is allocated for free.

For the investment and operating costs of interconnectors, standard costs per capacity unit based on estimation by the author are used in the calculations in this study. For DC lines the standard cost is 50.000 €/MW/a and for AC lines 10.000 €/MW/a.

The method developed in this study could be utilised for analysing the combined effect of several interconnector investments by using an iterative calculation which combines projects for example by region. This study does not include such calculations. Instead, a calculation of the optimal interconnection capacity between regions is performed by assuming that there is full price convergence inside each region. Even if this is a heroic assumption, it is clear from Table 3 that the largest welfare potential for price arbitrage exists between regions. For the calculation, Central Europe is considered as one block, the Nordic countries, the UK and Ireland, the Iberian peninsula, Italy and Central Eastern Europe are each one block.

Capacity increase is assumed to be made with DC links except for the connection between Central Europe and Central Eastern Europe. The results are shown in Figure 16.

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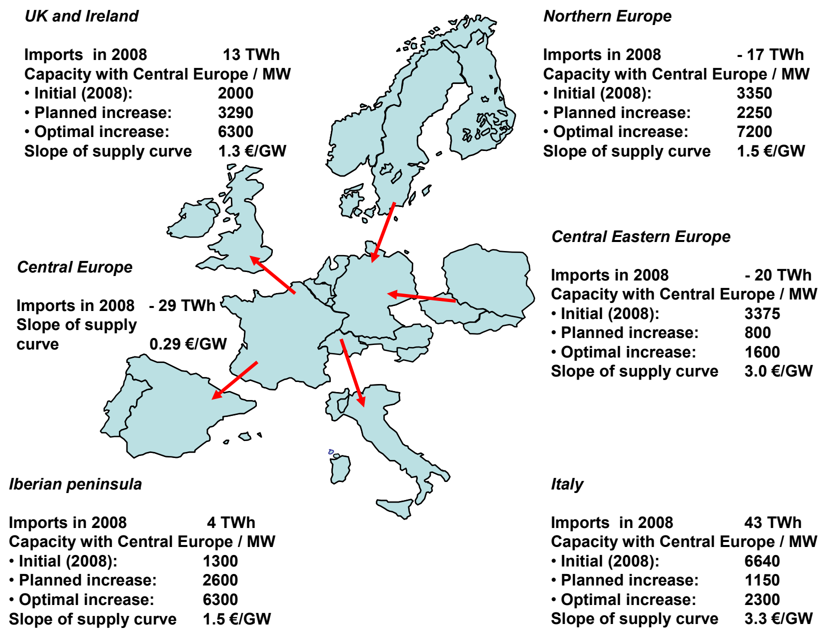
49 CESI, CIGRE, Venturini et al, exchanges between IT, CH and DE, 2008



Region	Additional imports with planned capacity [TWh/a]	Additional imports with optimal capacity [TWh/a]	Initial price difference with Central Europe in 2008 [€/MWh]	Price change with planned capacity [€/MWh]	Price change with optimal capacity [€/MWh]	Social welfare increase with planned capacity [M€/a]	Social welfare increase with optimal capacity [M€/a]
Central Europe	-35	-53	NA	1.2	1.8	348	86
Northern Europe	-20	-63	-14.8	5.2	12.6	93	358
Central Eastern Europe	-7	-14	-4.1	3.8	6.6	17	45
Italy	10	20	15.2	-3.0	-5.8	22	41
Iberian peninsula	23	55	16.9	-3.5	-7.7	116	255
UK and Ireland	29	55	16.0	-4.1	-6.4	128	225
Sum						**724**	**1009**

Figure 16 Welfare calculation of increasing interconnection capacity between regions in Europe using year 2008 as the reference year.

The results from the pan-European optimisation of interconnections are very striking. The calculated optimum capacities are substantially higher than the current capacities indicating that at least the first projects to increase capacity will be highly profitable. The results suggest that annually more than one billion euro of overall welfare increase could be reached.

The price effect for Central Europe is modest. On the contrary, the prices in the peripheral regions change substantially when interconnection capacity increases. It is important to note that an interconnector capacity increase always reduces the absolute price difference between the connected areas. The change in the average price depends on whether the price difference is always in one direction, as assumed in the model used in this study, or whether the price difference changes direction over time for example daily or seasonally. In the latter case, the increase of interconnection capacity can result in a lower average price for both zones. In addition, the welfare distribution effect is mitigated by the changing import-export pattern which might be important for getting acceptance from the stakeholders.

Interconnections in which this changing pattern is important are the interconnections between Central Europe and the Nordic countries and the interconnection between the Iberian Peninsula and France.

The interconnectors included in the ENTSO-E ten year network development plan yield an increase of overall social welfare of about 700 M€/a. At this level of interconnection capacity most of the increase in social welfare is captured by the TSOs in form of congestion rent and only a smaller part is in the form of absolute increase in producer and consumer surplus. At the optimal level of interconnection capacity a much bigger share of increase of social welfare is in form of producer and consumer surplus.

The interconnectors in the ENTSO-E ten year network development plan result in only relatively modest changes in price differences. However, in the optimal interconnection capacity case price effects in the form of price convergence are already significant. In spite of this, even with the optimal capacity, significant price differences between regions remain as shown in Figure 16. This reflects the high costs of building DC transmission lines. Thus for the profitability of DC interconnectors a substantial remaining price difference is necessary if the profitability is judged based on price arbitrage.

The calculations confirm the importance of distributional effects in optimising the European interconnectors. Both in the planned interconnector and welfare optimum case there is a huge redistribution of social welfare in favour of producers in the North and consumers in the South and in the UK, amounting to several billions of Euros.

There are several ways to improve interconnector welfare calculations. One possibility is to construct supply and demand curves based on power plant and load data and to use these synthetic supply curves in a market model.[50] This allows forecasting prices in each price zone and calculating profitability of interconnectors. A major problem with this approach is the time span. It is very difficult to forecast the generation mix for the lifetime of a transmission investment. Also, the supply curve is dynamic in time, for example the gas, coal and emission allowance price fluctuations modify the supply curve continuously. Further, the merit order of power plants can change over time. Thus we have chosen not to base our method on generation and load scenarios.[51]

One limitation of the method used in this study is the use of one single base year 2008 in the calculations. The choice was made because the availability of data for earlier years was not sufficient in particular regarding congestion rents and commercial flows. Year 2009 was influenced by the economic crises, this is why it was not used in the calculations. For 2010 no complete data set was available yet. When comparing the data for the period 2008 – 2010 and also the data for earlier years to the extent available, it is clear that there are important differences between the years for example regarding congestion rents and commercial flows. For example 2008 was a wet year in the Nordic countries resulting in low prices in particular in Norway. However, in Europe the overall trading patterns and price differences remain relatively stable over time which gives confidence in the results presented in this study. It is left to further work to investigate to what extent the results might change if the calculations were based on a longer observation period.

It is important to note that, contrary to power plant profitability, interconnector profitability is not dependent on the absolute levels of market prices but on the price difference between two markets. This influences how modelling should be done. For example if fuel costs have a high correlation on both sides of the interconnector, they will not drive profits. Price peaks are particularly interesting when they appear only at one end of the interconnector. For example the high price period in the Nordic market in 2003 should have had a positive impact on profits for the SwePol link between Sweden and Poland and for the Baltic cable between Sweden and Germany.

Another approach to calculate the social welfare is to base the analysis on historical bids made in the market. One of the problems in using bid data is

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50 Frontier Economics and Consentec, transmission investments, 2008; KEMA, transmission investments in Eastern Europe, 2005

51 Baltso et al, Baltic interconnector study, 2009; ENTSO-E, ten year network development plan, 2010; EC, comments on ten year network development plan, 2010

that only part of the electricity traded is covered by these bids. There is also the problem that historical bids do not necessarily sufficiently reflect future prices. However, the advantage of using real bids instead of synthetic supply curves is that they include the strategic behaviour of companies.

The calculations in this study have confirmed that there are potentially many profitable interconnectors missing in Europe. This results in a loss of social welfare which could reach one billion Euros just taking into account the price arbitrage between spot markets. This conclusion calls for a more accurate analysis. Such an analysis could start with building a demand and supply scenario, accounting for the EU wide and national scenarios. Plans to fulfil the renewable targets should give a good estimate of the new generation capacity to be installed in the coming years. The European Transmission System Operator's organisation ENTSO-E is indeed making such scenarios as part of the ten year network development plan.[52]

3.5. Role of the regulator in the transmission investments

Regulators have a key role regarding transmission investments. At the end of the day, even if the national law sets the general framework for the transmission investments, the regulator approves directly or indirectly which investments are accepted to be covered from transmission tariffs. The regulatory treatment of transmission investments varies widely. In some countries practically all projects proposed by the TSO are allowed to be passed on to the asset base. In other countries regulators or governments need to approve all investment projects before they are allowed to be financed via tariffs. An exception to this rule is merchant interconnectors.

There is quite a lot of discussion how to incentivise TSOs to build interconnectors, for example by offering a higher rate of return linked to the delivery time. The general trend is that incentive schemes for TSOs are getting increasingly sophisticated. Incentives are more often performance based which means that the TSO is rewarded if it meets the output targets, not just the cost targets.[53] For example performance based schemes are used with success to reduce congestion costs in Great Britain. Germany allows higher rates of return for selected transmission lines considered important for integrating wind power to the system.[54] However,

52 ENTSO-E, scenarios for 2020, 2011

53 EMV, annual report, 2010

54 Frontier Economics and Consentec, transmission investments, 2008

performance based schemes have probably not yet been used in any Member State to incentivise interconnector building.

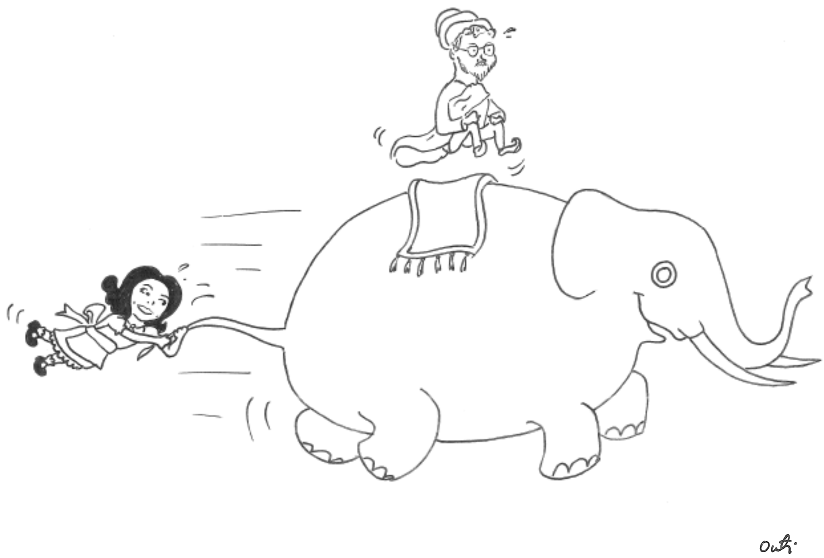

Figure 17 Regulator's work is not always easy.

The third legislative package strengthens the role of regulators regarding transmission investments and gives the new TSO association, ENTSO-E, the important task to plan the European transmission network. In particular, for the transmission systems which remain vertically integrated, namely ITOs (Independent Transmission Operators) and TOs (Transmission Owners), the national regulator has to approve the investment plan. The regulator has the powers to impose investments in the transmission network by third parties if the ITO or TO refuses to invest.[55] The ACER has to give an opinion on the ten year network development plan and to verify that the national plans are coherent with the European ten year plan. If they are not, The ACER shall make recommendations to amend either the national plan or the ten year plan. ENTSO-E and the ACER shall monitor the implementation of these plans.

It remains to be seen whether these institutional changes are sufficient for successful development of the European transmission system. Decisions on investments still remain in national hands. Even if binding decisions on investments have been made, without a proper political backing to overcome local resistance the result is not guaranteed. Stakeholders can not differentiate which projects are serious and which are cheap talk, using

55 EU, third package, 2009; EC, interpretative note on unbundling, 2009

academic terms by Farrell and Saloner.[56] There is a real risk for a big discrepancy between good intentions and concrete results.

Good reading regarding institutional changes needed because of technology development in networks is provided by Finger and his colleagues.[57]

3.6. Merchant interconnectors

Merchant interconnectors are allowed in the European legislation, subject to approval of the regulators concerned, the ACER and the European Commission. Merchant interconnectors have to cover their costs through the income from selling interconnector capacity.

In the UK there are limitations for the TSO to recover interconnector costs from UK tariffs. This has in practise left merchant investments as the only interconnector option for the UK. It is unclear to what extent this merchant system has been an obstacle to interconnector investments between the UK and the neighbouring countries. There are only two projects in construction, one between the UK and the Netherlands, the Britned cable and another project connecting Ireland to Great Britain. The Irish project is fully paid by the Irish and the European Recovery Fund.[58] However, some new thinking is being developed in the UK which might explain why the number of planned interconnectors has increased recently.[59] In the past, interconnectors had to pay a tariff as if they were a generator and a load in the UK, now this has been removed.

In principle merchant lines should be economically efficient. Merchant investors would compete for projects until an appropriate level of interconnection capacity has been reached. Merchant investments would be done efficiently under competitive pressure. However, it has been shown that many features of an interconnector investment do not favour merchant approach. For example according to Joskow and Tirole, distortion in price signals and some features of transmission investments such as lumpiness, the stochastic nature of the income and the strong link with system operation could lead to suboptimal merchant investments. [60]

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56 Farrell, cheap talk, 1987

57 EPFL, Finger et al, governance and technology, 2005; EPFL, Finger et al, institutions, 2010

58 ESRI, Valeri, IE-UK interconnector, 2008

59 Ofgem, interconnectors, 2010

60 Joskow and Tirole, merchant transmission investments, 2003

In Europe merchant line projects are exceptional as an exemption is needed from certain provisions of the European legislation to make such investments. Exemptions are possible for DC lines and in exceptional cases also for AC lines. Most Member states do not favour merchant lines as they do not consider them necessary. There is a fear that the whole transmission system will become more difficult to design and operate if there are several owners each willing to optimise the use of their own network.

Until now the European Commission has accepted exemptions for all projects that have reached the Commission, namely Estlink between Estonia and Finland, Britned between the Netherlands and the UK, two East-West links between Ireland and Great Britain and the Arnoldstein – Tarvisio line between Austria and Italy. However, the conditions imposed on these projects have been strict. For example in the BritNed case the Commission imposed a revenue cap which makes the project resemble a regulated interconnector. In the Estlink case the fact that the investors are committed to sell the cable to the TSOs after a limited period of time was important for granting the exemption. Regarding the two East West projects the Commission's acceptance was conditional on Eirgrid building a regulated interconnector between Ireland and Great Britain which has a major impact on the profitability of these two other interconnectors.

A generation company or a big consumer would be a natural candidate for building merchant interconnectors. They could themselves benefit from the interconnector capacity for additional exports or imports. Even more important could be the influence on prices in the price zones which the interconnector is connecting. A generator would build export capacity to increase the price level in its own zone. Thus the logic of a generation company building a merchant line would be quite similar to the logic of a vertically integrated TSO building the line. The difference is in the treatment of congestion rents which in the case of a TSO are considered to be part of the regulated income but in the case of a merchant investor can generate non-regulated profits, depending on the exemption decision.

3.7. Other targets for cross border investments

A transmission system fulfils two functions at the same time. The primary task of a TSO is to transport electricity from generation plants to load in a secure manner including keeping balance between generation and load at all times. The second task of a TSO is to provide a marketplace for electricity in order to optimise social welfare. The first task can hardly be taken away from the TSO. Regarding the second task some people argue that it does not need to be performed by a TSO. Indeed, there are countries such as Spain where a separate body takes care of operating the marketplace. One should recognise, however, that an electricity market is strongly based on transmission networks, and that market operation has strong links with the primary task of a TSO. It is also true that these tasks cannot be performed by the TSO alone. A TSO is dependent on generators, distribution system operators, consumers, traders and power exchanges in performing these tasks, and increasingly from other TSOs as well.

The optimisation of social welfare through price arbitrage, discussed in the beginning of this chapter, is closely linked to the electricity market and thus to the second task of the TSO. In the following it is discussed what other targets could be set for building interconnectors, including targets related to the primary task of a TSO to provide network access for the generators and consumers and operate the network in a reliable way.

3.8. Technical targets

A transmission network should in normal conditions allow all connected generators and loads to access to the network when they so wish. Only extreme conditions such as extreme temperatures or unforeseen outages could justify curtailing generation or load. In other words, the network should enable a secure dispatch of generation and load based on decisions made on economic grounds by the generators and consumers without too much interference by the TSO. This target of unconstrained dispatch of generators and loads is, however, not met everywhere in Europe. Transmission lines often take more time to construct than power plants which has led in some places to serious limitations in grid access.

Historically, interconnectors were usually not technically necessary for allowing access of generators and loads to the network and thus they were not built for this purpose. Their role was to improve system security due to reserve power provided through interconnectors in the case of generation or network incidents. They were also used to increase social welfare through optimising the use of generation assets in Europe by enabling cross-border trade. With increased wind power in the system, this situation has changed. Today, without interconnectors access to network would need to be denied much more often in areas with high wind power production.[61]

Even if interconnectors are beneficial for the European system, they also have some unwanted consequences. In today's transmission system which is

[61] CEPS, comments on EWIS study, 2010

mainly based on the use of alternative current and a meshed network, the flows follow the physical characteristics of the network and ignore country borders.[62] For this reason a TSO in one country could allow an access to generators and loads in such a way that the TSO in the neighbouring country is not able to guarantee a similar access to its own consumers because of the cross-border flows. Then the question arises that if network access limitations are needed, in which country such measures should be enacted and who should bear the costs.

In the context of promoting renewable electricity generation, EU legislation[63] requires positive discrimination schemes for renewable energy by giving it a priority or guaranteed access to the network. This means that in the case of congestion, restriction of access to the network is applied to other forms of electricity production than renewables. A technical target for a transmission system could be minimising this restriction of access.

3.9. Minimum interconnection capacity targets

Heads of states agreed in the European Council in 2002 that every Member State should have at least 10% import capacity compared to the installed generation capacity in the country.[64] This simple target intends to promote interconnectors with the least connected Member States. In 2002 the countries below this target level were Ireland, the UK, Spain, Portugal, Greece, France and Italy. From this group Portugal, Greece and France have already reached the 10% target. Also Ireland will meet the target when the planned interconnector between Ireland and Great Britain is in operation.

Among the new Member States who joined the EU in 2004 - 2007, Poland, Romania, Bulgaria, Malta and Cyprus are below the 10% target. Romania and Italy could relatively easily reach the target level. On the contrary, Spain and the UK will not reach the target in the foreseeable future even when the currently on-going interconnector projects are finalised. The Baltic States are a special region in this respect. There is a lot of transmission capacity between the three Baltic States and the interconnection capacity with Russia and Belarus is also high. However, there is very little capacity to any other EU Member State. This situation

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62 This phenomenon is important in Central Europe where there are parallel paths for flows encompassing several countries, less important in more radial networks in the outskirts of Europe.

63 EU, renewables directive, 2009

64 EU, Barcelona European Council conclusions, 2002

will be corrected with the Baltic Energy Market Interconnection Plan (BEMIP).[65]

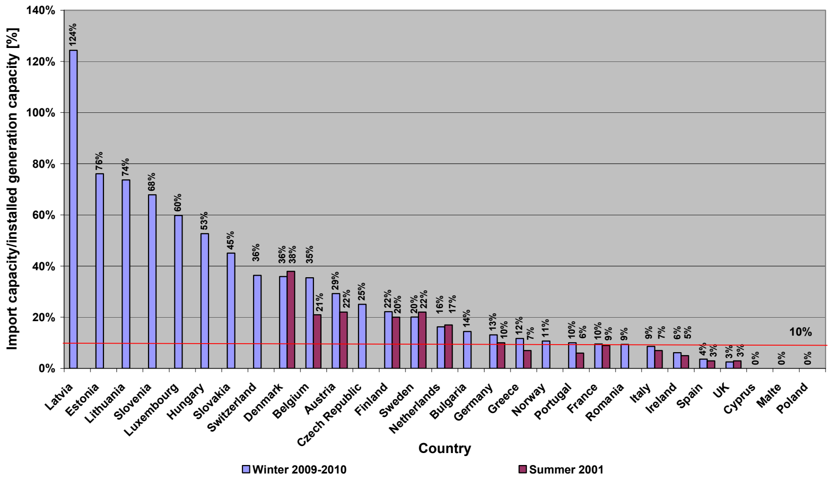

Figure 18 Evolution of interconnection capacity in the EU Member States, Norway and Switzerland since 2001 regarding the 10% target agreed in Barcelona in 2002.[66]

It is evident that the ten percent target is rather simple and does not take into account the specific situation of each Member State. For transit countries the target is obviously less relevant. Transit countries can have a serious lack of interconnection capacity even if they have already reached the 10% target level, as the import capacity serves both transit and import needs. However, overall this target of 10% has efficiently drawn attention to the poor connection level of some EU Member States.

The current level and evolution of interconnection capacity since the Barcelona summit are shown in Figure 18. Some countries have successfully increased the capacity, such as Belgium, Austria, Germany, Greece and Portugal. However, for example for Sweden the import capacity has diminished.

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65 EU, Bemip, 2010

66 The values for Figure 18 have been calculated from ETSO NTC values for summer 2001 (used in EU infrastructure communication, COM (2001) 775, 20.12.2001) and from ENTSO-E NTC values for winter 2009-2010, taking into account overall import limitations when they have been declared. This method tends to give too optimistic values. Also, in some cases there is no agreement between the TSOs concerned on the value to be applied. To calculate more accurate values for aggregated import values, network modelling techniques should be used. The values in this table, however, give a rough indication for the situation of each member state regarding the 10% import capacity target and for its evolvement in time.

3.10. Security of supply targets

Security of supply in electricity is reached when there is sufficient amount of electricity available to the society at all times except for very short periods of non-availability accepted as a trade-off for not making the electricity system overly expensive. The security of supply target can be divided into a short term and a long term target. The short term target is to minimise black-outs and system disturbances through system operation. This target can be called security of system target. The long term target is to maintain a sufficient generation and transmission capacity through investments in power plants and transmission networks. This target is called the system adequacy target, divided into a generation and a transmission adequacy target. Security of supply is a fundamental driver for the design and operation of the electricity system, because even very short incidents can be extremely costly to society.[67]

Interconnections have an important influence in meeting both the short and long term security of supply target. Interconnectors were first built in order to improve operational security and to reduce the cost of achieving a secure network. Today interconnectors are increasingly used for trading purposes in order to better utilise generation resources. The resulting cross-border trade involving longer transmission distances is a challenge for operational security as TSOs are more and more dependent on each other. Co-ordination between TSOs did not develop sufficiently in the beginning of market liberalisation to meet the new requirements including intensive loading of interconnectors. The black-out in Italy in 2003 confirmed this as the main reason for the black-out was the lack of co-ordination between the TSOs involved.[68]

For generation adequacy, interconnectors generally have a positive effect. If a country does not have enough generation capacity, electricity can be bought from the neighbour. Import possibility, however, can reduce the incentive for investments in generation capacity as it could be cheaper to import electricity than to produce it locally. If many countries take this approach, this may lead to a situation in which generation adequacy in peak demand conditions is not ensured at the European level. Interconnectors do

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67 Consentec, EWI and IEAW, security of German electricity supply, 2008; Frontier Economics, security of German electricity supply, 2008; Eurelectric, power outages 2003, 2004

68 TSO system operation co-ordination has developed strongly in recent years. Coordination of Electricity System Operators (CORESO) and Transmission System Operator Security Cooperation (TSC) are two examples of initiatives between TSOs with the aim of detecting system operation risks and dangerous network situations.

not help if nobody has invested in peak generation capacity. At the moment this risk seems implausible. The ENTSO-E Winter 2010 – 2011 Outlook does not foresee any European wide difficulties to cover peak demand even if some local shortages may exist in extreme weather conditions or in the case of several simultaneous generation outages.[69]

There is academic literature indicating that energy based electricity market does not provide a sufficient business case for generation units to cover peak load. One of the reasons put forward is the short duration of the highest load which is partly due to lack of demand elasticity. The business case is further weakened if there are price caps in the electricity market.[70] Thus a Member State could wait and hope that the neighbour invests in peak plants financed through subsidies or capacity payments collected from grid tariffs. The European legislation requires that the Member States shall take appropriate measures to maintain a balance between the demand for electricity and the availability of generation capacity.[71] However, this obligation is not very precise which makes it difficult to enforce.

One could think that building an interconnector could replace peak generation units for ensuring security of supply. Interconnectors, however, have two features which do not favour this approach. Firstly, the economic case for an interconnector usually can not be based on the peak load because of its very short duration. Secondly, interconnections have not proven to be politically reliable in situations when supply has been tight. Several cases of cutting exports rather than letting correct scarcity prices come into effect have already appeared, using the excuse that the own security of supply is in danger. The national legislation of some countries even explicitly provides for this.[72]

Electricity generation in Europe is to a large extent dependent on imported fuels such as natural gas, coal and uranium. If fuel supplies are cut, generation can be partly substituted by power plants using indigenous sources or by switching to fuels stored for security reasons. Interconnectors can help countries which are more vulnerable for fuel import cuts. This criterion can be taken into account in interconnector planning. However, for the purposes of security of supply, interconnectors can be important

69 ENTSO-E, Winter 2010 – 2011 outlook, 2010

70 Hobbs, capacity payments, 2005; DUT, De Vries and Hakvoort, security of supply, 2002

71 Directive 89/2006/EC 18 January 2006 on security of electricity supply

72 In the past at least Spain, France, Czech Republic, Poland and Greece have applied export restrictions if the national electricity supply balance has been tight.

only for small countries as for most big countries cross-border trade remains marginal, at least with current transmission capacities.

3.11. Competition targets

Interconnection capacity is interesting also from the competition point of view. It allows the producers and suppliers on the other side of the interconnection to compete in the same market as the local producers and suppliers. When the capacity is high enough to reach full price convergence, the connected price zones have the same price and their liquidity is pooled. This positive effect on competition has been welcomed in particular in countries which have allowed the old monopoly company to keep a dominant position in the market. This has helped in particular small countries to avoid splitting the incumbent for competition reasons into uneconomically small entities.

Influence of cross-border competition through interconnections is significant if the cross-border capacity is large enough. For example in Denmark, interconnections define in practise the upper and lower limit of the market price through the influence of the Swedish, Norwegian and German prices. However, in big countries such as in France even considerable interconnection capacity does not bring real competition to the market. A consultant has calculated that to reduce the market power of EdF to a reasonable level, France should have 33.000MW of interconnection capacity.[73] This is of course completely unrealistic with today's transmission technology. Thus to increase competition in France it is necessary to apply structural measures inside the country.

Analogously, there is a risk of exporting market dominance. If a company is active on both sides of the interconnection, increasing interconnection capacity improves the possibility to use market power. This situation exists for example at all French borders.

In some cases target levels for interconnection capacity have been explicitly set following competition cases. For example, in the merger case of Energie Baden Württenberg (EnBW) and Hidrocantabrico in 2002, EdF committed to a target of 4000 MW between France and Spain.[74] In some cases governments have committed to bilateral interconnection capacity targets such as for the capacity between Spain and Portugal which is increased for improving the functioning of the Iberian market.

73 Ramboll and Mercados, electricity infrastructure, 2008

74 EC, competition case EnBW, 2002

3.12. Climate change and sustainability targets

It has been argued that climate change targets should be considered separately from the social welfare targets. This assumes that reducing greenhouse gas emissions and promoting renewable energy contain such externalities which are not captured by the carbon price in the emissions trading scheme or by the subsidies used to support renewable electricity production. Such an externality could be for example improved security of supply resulting from investing in European indigenous energy sources.

A detailed analysis of interconnection capacity targets based on climate change and sustainability criteria can be very complicated. In the author's view, the criteria discussed above could already take sufficiently into account climate change targets and thus they could be a sufficient basis to guide infrastructure investments. Some specific issues such as the trade-off between curtailment of peak wind production and cost of transmission infrastructure could be subject to a separate analysis.

Views that renewables should have an absolute priority independently of the cost of using them do not seem to be economically or even environmentally justified. If carbon is correctly priced, market will guide the system to an optimal dispatch taking into account the climate change targets.[75]

3.13. Price convergence targets

Price convergence has sometimes been advocated as the ultimate target for the internal electricity market. However, full price convergence should not be a target itself. In some cases price differences in short term and even in longer term are justified due to a permanent cost advantage in one region compared to the neighbouring region. If prices were always equal in the whole Europe, this would suggest that too much transmission capacity has been built. Opposite to this argument, there are also factors which call for investing more than what price arbitrage optimisation would suggest. Lumpiness, long lead times and anticipation of generation investments could justify higher capacity than what is indicated by a pure price arbitrage calculation.

Price convergence has important competition benefits as it allows to pool liquidity from a wider area. Trading with long term financial products requires stable price references. Nord Pool system price is the reference for the long term products in the Nordic market. EEX launched the price

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75 Newbery, renewable integration workshop, 2010

reference European Electricity Index (ELIX) in October 2010. ELIX could become important for trading in the Central European market. The efficiency of these reference prices depends on how much the spot price in the individual price zones covered by the reference price differs from the reference price and what are the possibilities to hedge this price difference for example through Financial Transmission Rights (FTRs). Price convergence could thus be one criterion for infrastructure investments. To analyse the influence of cross-border capacity on price convergence, the method developed in this study is used. The results are shown in Figure 19.

In Figure 19, the starting point of each brown bar shows the level of price convergence today and the length of the brown bar corresponds to the increase in price convergence when 100MW of cross border capacity is added. In Figure 19 price convergence is expressed in percentage of full price convergence. The method assumes that the supply curves are linear as explained in Chapter 3.4. This results in a linear increase of price convergence when capacity is increased. Thus for example, 50% price convergence corresponds to the capacity level for the maximum congestion rent.

The calculation shown in Figure 19 is based on increasing the capacity of one interconnection at a time, effects caused by other interconnections of the concerned countries are ignored. In reality all interconnectors have an influence on price convergence and should be taken into account in any detailed calculation. Also, the calculation shown in Figure 19 on price convergence has been made assuming that each country is a single price zone. This is not the case in Italy, Denmark, Norway and the UK which are divided into several bidding zones. However, for the purposes of this study aiming to give an overall view of price convergence, this simplification does not significantly change the results. To make the analysis more accurate, each bidding zone should be modelled separately. This step is left for further studies.

One can make several interesting observations from Figure 19. Firstly, there is a systematic difference between interconnections inside Central Europe compared to interconnections connecting Central Europe with the regions in the outskirts of Europe. In Central Europe there is already a high level of price convergence which could be further increased with a relatively small increase of capacity. In particular Central Eastern Europe (excluding Germany and Poland) is composed of small systems which are sensitive to price influence from neighbours being thus good candidates for full price convergence. Better utilisation of the existing transmission capacity through market coupling will already increase convergence once the coupling is achieved. This means that Central Europe, in particular Germany, will confirm its position as the price reference for the whole Europe.

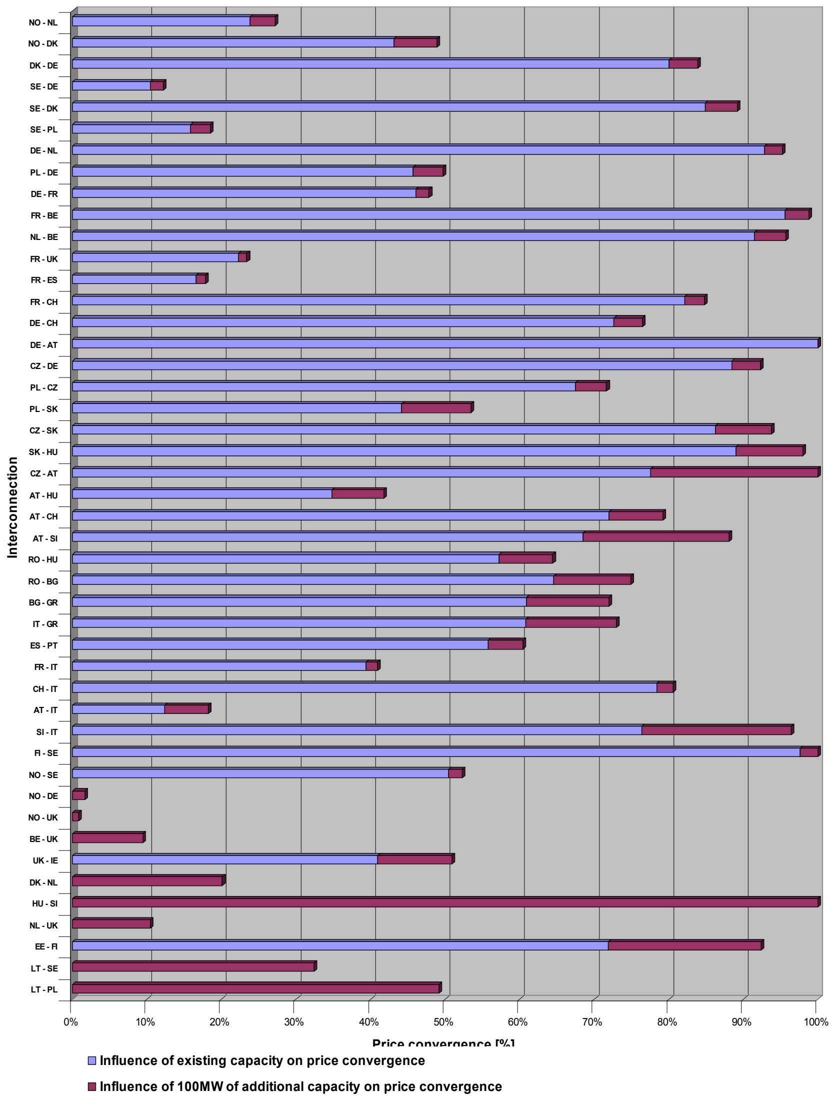

Figure 19 Influence of 100 MW of additional capacity on price convergence in European interconnections. The calculation method is presented in Appendix 1.

Price convergence between the Central European market and the neighbouring regions, namely Northern Europe, the UK, the Iberian peninsula and Italy, does not seem realistic. The interconnection capacity needed for full price convergence is several thousands of MW which would be very costly at least with current transmission technology. This means that in the medium term, taking into account the current and planned transmission network, these regional markets will still have an important price difference with Central Europe, and consequently a rather independent price formation.

Increasing variable wind production will probably inverse the trend of increasing price convergence in Central Europe. Wind power already causes important price fluctuations between zones inside Central Europe. Thus wind power sets new requirements for both system operation and market design. This might require a review of the split of Europe into price zones to allow more efficient congestion management in the network. Smaller bidding zones distribute the overall price difference in smaller steps to an increased number of bidding zone borders and hence give more precise scarcity signals. This could improve significantly the utilisation of the current grid and could also have a big influence on the profitability and the optimal location of transmission investments. This proposal is further discussed in Chapter 4.

3.14. Conclusion on targets and criteria for cross border investments

From the discussion above it is difficult to draw a conclusion regarding the priority of targets for transmission investments. It seems evident that there is a hierarchy of targets similarly as humans need first shelter and food before they can concentrate on arts and sports. Technical targets come first, driven today by investments in renewable generation. These targets need to be met, otherwise generation investments are stranded. Price convergence and competition targets are important for efficiency but not to a similar extent vital for the functioning of the transmission system.

Technical targets such as connecting each generator and load are addressed mainly at the national level. For interconnectors price arbitrage targets are more relevant. The rest of the study uses price arbitrage as the basis for analysing interconnector investments. However, based on the findings later in this study, also some observations are made on how technical targets should be taken into account when deciding on interconnector investments.

4. FACTORS THAT INFLUENCE THE TARGETS AND CRITERIA FOR INTERCONNECTOR INVESTMENTS

4.1. Introduction

The discussion in Chapter 3 concludes that it is appropriate to use social welfare as the main criterion for interconnector investments. Security of supply and competition benefits of interconnector investments are important and part of the social welfare function even though they are seldom mentioned when social welfare is calculated. 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 chapter identifies the most important factors to be taken into account in investment decisions. Concrete examples on how these factors influence the decisions are presented in the empirical country by country analysis in Chapter 5.

4.2. Influence of the capacity calculation and allocation method

4.2.1. Capacity calculation

Interconnection capacity calculation is a complicated matter. To agree on a bilateral Net Transfer Capacity (NTC)[76] 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.[77] The N-1 rule requires that the

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

77 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.

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 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.[78]

4.2.2. 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.[79] There are still many interconnections which only use explicit auctions instead of more efficient implicit auctions.[80] There are still interconnections without intra-day capacity allocation even if this has been required by the European legislation from the beginning of 2008.[81]

78 ETSO, co-ordinated auctioning, 2001

79 EC, congestion management, 2002

80 Frontier Economics and Consentec, congestion management methods, 2004

81 EC, infringements, 2010

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.

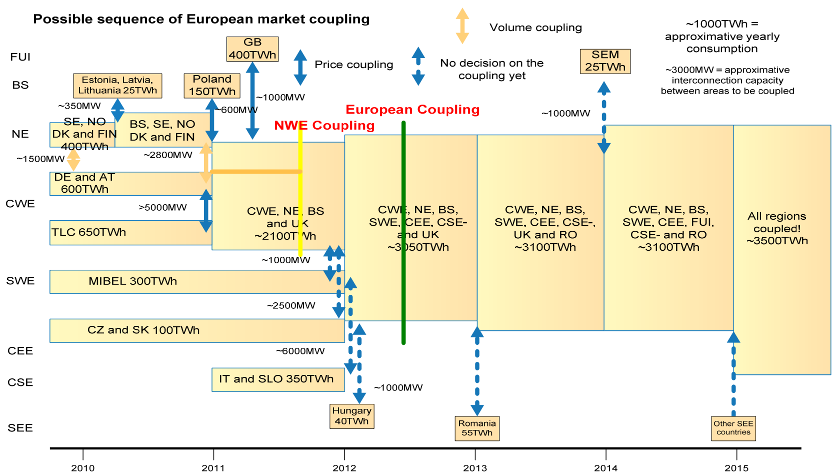

Figure 20 A tentative timetable for the day-ahead market coupling in Europe.[82]

An advanced capacity allocation method called flow based capacity allocation has been developed by the TSOs.[83] 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.[84]

Flow-based capacity allocation with implicit auctions has been accepted as the target model for electricity cross-border trade.[85] Figure 20 presents a time-table for implementing implicit auctions for day-ahead capacity allocation in Europe. Applying these methods will significantly improve the

82 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).

83 ETSO, vision congestion management, 2002

84 Consentec, comparison between ATC and FB, 2008

85 ETSO and EuroPEX, Flow based market coupling, 2004; AHAG

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.[86] 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.[87]

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.[88] 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.

4.2.3. 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,

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

[87] TUD, Zachmann, inefficiencies, 2009

[88] ERGEG, compliance monitoring report, 2010

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 heavily using the networks of the neighbours.[89] 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

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89 EWIS, European Wind Integration Study, 2010

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.[90]

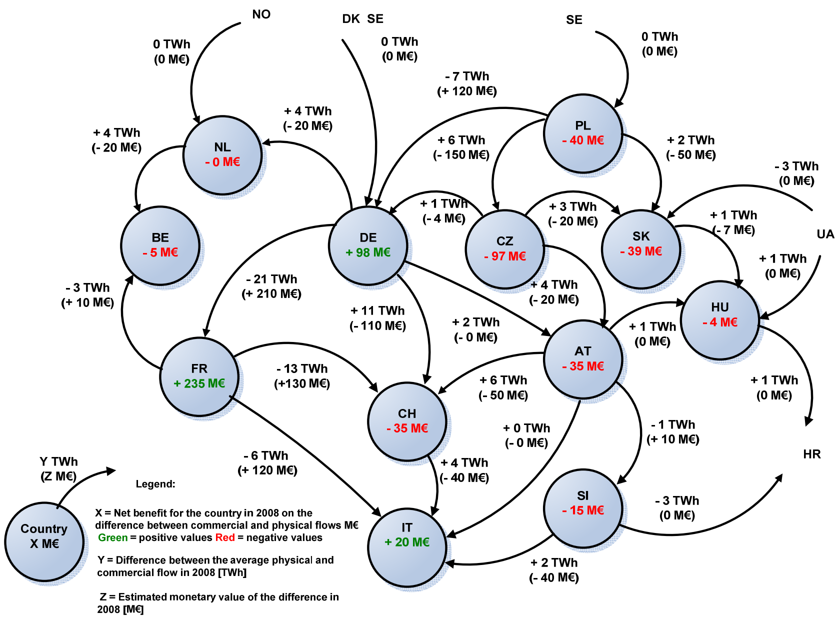

Figure 21 The difference between yearly average physical and commercial flows and the estimated monetary value of that difference in 2008 in Central Europe. A positive value of the difference, expressed in TWh, means that there has been more physical flows than commercial flows. The arrows indicate the prevailing direction of commercial flows.[91]

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 21 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

90 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.

91 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.

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 21 the influence of the North-South dipole is clearly visible.[92] 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.

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 21, 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.[93]

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.[94] It illustrates in concrete terms what kind

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92 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.

93 Coase, The problem of social cost, 1960

94 CEPS, comments of EWIS study, 2010

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.

4.2.4. 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 22 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.

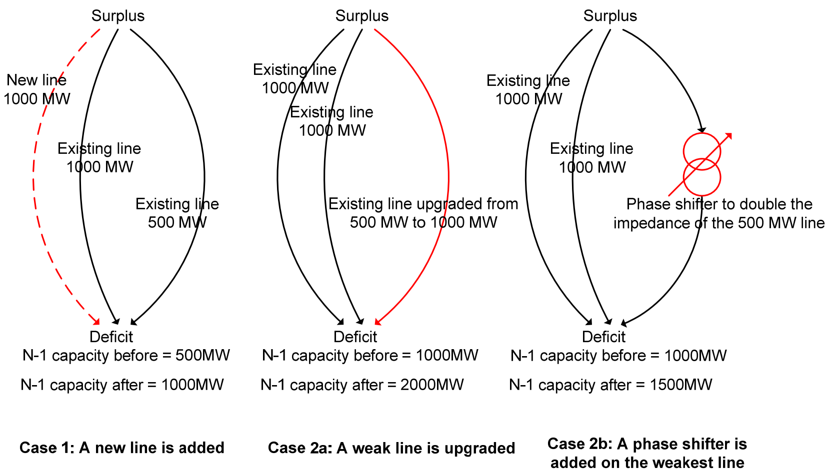

Figure 22 Options to increase capacity of a transmission path in a meshed AC network.[95]

Figure 22 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

95 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.

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. [96]

One idea to solve the North-South dipole issue is to bridge it with DC technology.[97] 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.[98]

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.

96 CEPS, comments on EWIS study, 2010

97 Amprion, Kleinekorte, DACH 2010, overlay grid, 2010

98 GIGRE, Bergen conference documents, 2009

4.3. Influence of the congestion management method chosen

4.3.1. Congestion management inside a 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 as explained in Chapter 2. In a singe 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 lead 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. [99]

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 of negative impacts on the internal market in electricity.[100] 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.[101] 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.[102]

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.

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99 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

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

101 SVK, commitment, 2010

102 EC, infringements, 2010

Redispatching also invites the units which expect to be redispatched for gaming. Texas introduced nodal pricing partly because of the risk of gaming.[103] 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.[104]

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.[105]

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 4 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 4 is not complete and shall be considered as indicative only. The TSOs and regulators should work on publishing relevant information on this important topic.

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103 PUCT, impact assessment, 2008

104 Fingrid, price areas in Finland, 2009

105 Copenhagen Economics, capacity limitations, 2006

Table 4 Costs of redispatching in selected EU Member States.[106]

Control area	Redispatching costs in year 2008 [M€]	Remarks
Austria APG	24 M€[107]	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€[108]	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] [109]	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€[110]	Limiting cross border capacity at Southern interconnectors has been used to keep redispatching costs relatively low.
UK	263 M£ (about 300 M€)[111]	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

106 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.

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

108 Source: Fingrid

109 TUD, Waniek et al, redispatching, 2008

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

111 Source: National Grid

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 interconnectors. TSOs do not generally provide information on what basis it is decided when to use redispatching and when cross-border trade is reduced.[112]

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.[113] 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.[114] 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.

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112 SEA, handling of bottlenecks in Sweden, 2005

113 However, in other cases, depending on the level of price convergence, increasing interconnection capacity might increase the income for the TSO as discussed in Chapter 4 and would thus give an incentive to invest.

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

4.3.2. 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.

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.[115] 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

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

the Northern harbours where there is already a surplus due to wind generation.[116] 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.[117] 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.[118]

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

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

117 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

118 Becker, pressure groups, 1984

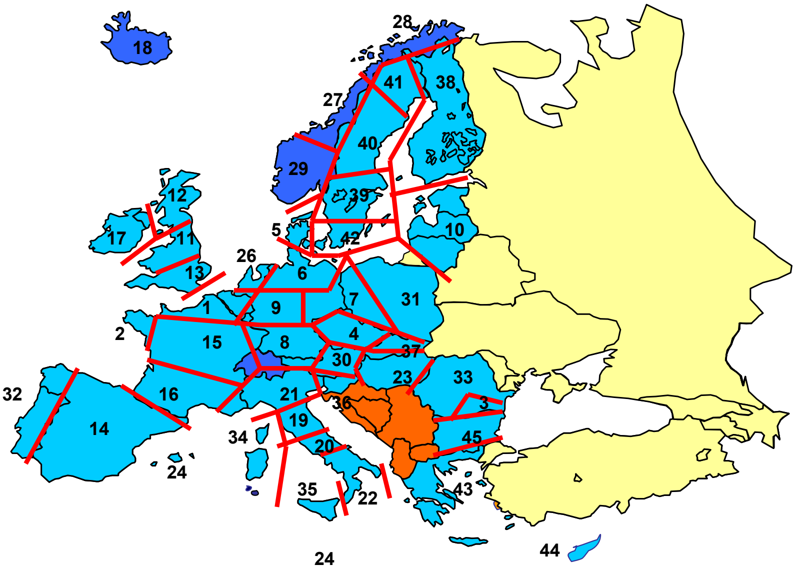
tariffs can distort the market if they are applied locally without taking into account the need for European investment signals.

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 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 23.

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.



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

Figure 23 The author's proposal for future bidding zones in Europe.[119]

[119] 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 24. The design of these five price zones is based on the analysis in Chapter 3 on price convergence.

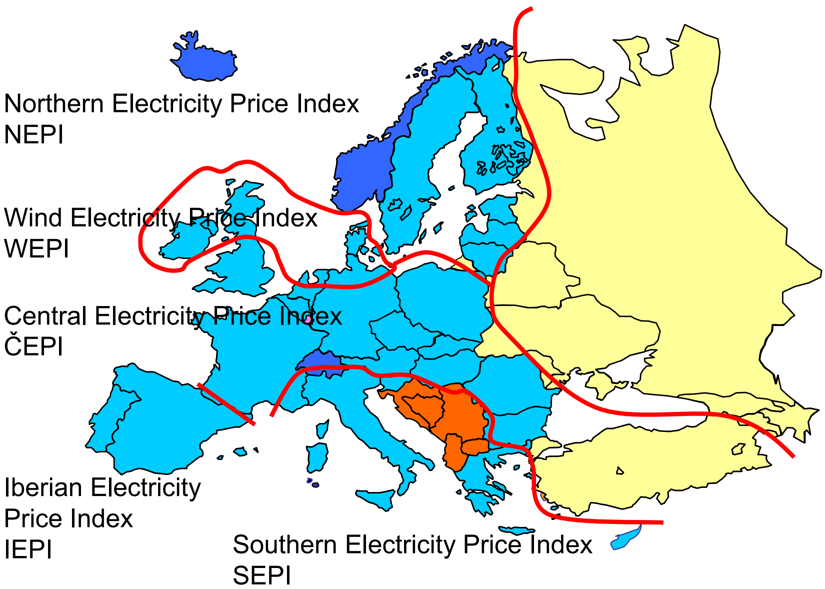


Figure 24 The author's proposal for future price index zones for long term trading of electricity in Europe.

Figure 24 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.

4.3.3. Nodal pricing as the solution

Many experts consider nodal pricing to be the best system for taking transmission constraints into account in electricity markets.[120] 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.[121] 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.

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

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

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.

4.4. Influence of how benefits and costs are distributed

4.4.1. 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.[122]

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.[123] 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[124], in the former auctions from Poland and the Czech Republic to Germany[125] and between Switzerland and Italy. [126]

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122 Pentalateral forum

123 Todem and Leuthold, congestion revenue distribution, 2006

124 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.

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

126 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.[127] 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.[128] 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.[129]

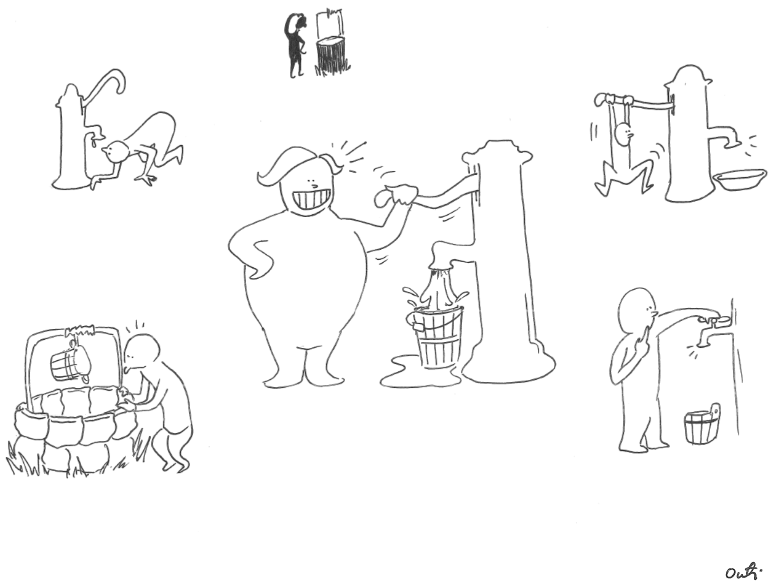

Figure 25 The overall social welfare at maximum.

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

127 Todem and Leuthold, congestion revenue distribution, 2006

128 Todem and Leuthold, congestion revenue distribution, 2006

129 Pentalateral forum

Germany. This might not be the optimal outcome for example for Denmark, Sweden, Switzerland and Austria.

4.4.2. 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, 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.

4.4.3. ITC mechanism

An Inter TSO Compensation (ITC) mechanism is provided by the European legislation[130] 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.[131] 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

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130 Regulation No 774/2010 2 September 2010

131 EC, ITC consultation documents, 2008; Gustafsson and Nilsson, ITC mechanism, 2009

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.

4.4.4. 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.

4.4.5. 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.

4.5. Influence of flaws in price formation

4.5.1. 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.

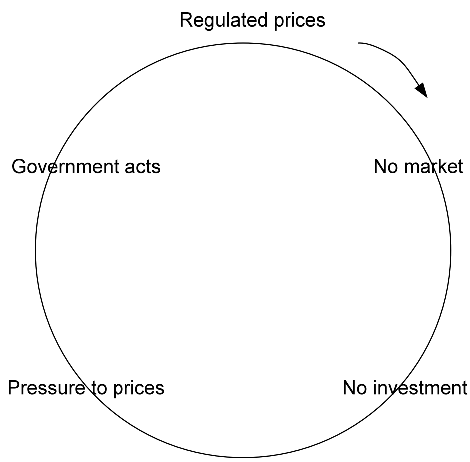

Figure 26 Vicious circle of regulated prices.

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 5 EU Member States applying regulated prices for electricity with the share of customers with regulated prices in each consumer group in 2010.[132]

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 26. 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.[133]

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132 ERGEG, regulated price report, 2010

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

In the Table 5 the share of regulated prices in various consumer groups is shown for the EU countries which still apply regulated prices for electricity.

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.

4.5.2. 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.[134] 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.[135]

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

[135] Regulation No 774/2010 2 September 2010

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.[136]

4.5.3. 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.[137] Existence of cross-border fees changes the economics of interconnector investments making them less attractive for the potential users.

4.5.4. 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.

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

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

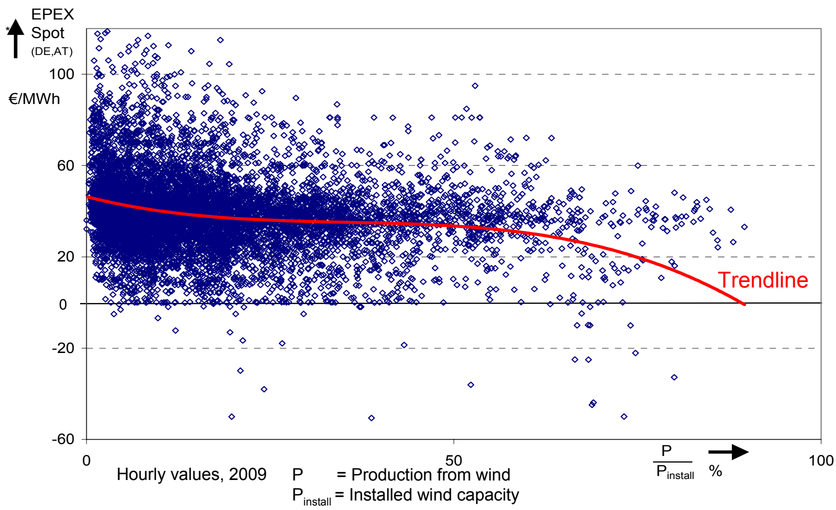

Figure 27 Correlation of spot price and wind production as percentage of installed capacity in Germany in 2009.[138]

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 27. 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.[139] 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 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

138 Source: Amprion

139 Pöyry, merit order effect of wind power, 2010

conventional power. Otherwise investment signals will become too varied creating an extra uncertainty for the investors.

4.6. 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[140], in the aftermaths of the Italian black-out[141] and in the context of the Finnish Government decision[142] 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.

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.

4.7. Influence of the transmission investment itself

An interconnection capacity increase changes the investment signals for any future investment at this interconnection.[143] The obvious effect is the shift of the operation point in the parabolic congestion income curve described in Figure 10. 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

140 ECN, reserve power in the Netherlands, 2003

141 Terna reduced cross-border capacities after the black-out.

142 TEM, United Power decision, 2006

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

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.[144]

Some TSOs publish how much there is available capacity for connecting new power plants in each grid area.[145] 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.[146] 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.[147]

4.8. 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

144 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.

145 RTE, annual report 2009, 2010

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

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

level of transmission capacity might well be explained by the difficulties to overcome local opposition. Even if this issue is of utmost importance, this study does not try to address it more in detail except to some extent in the empirical country by country analysis.

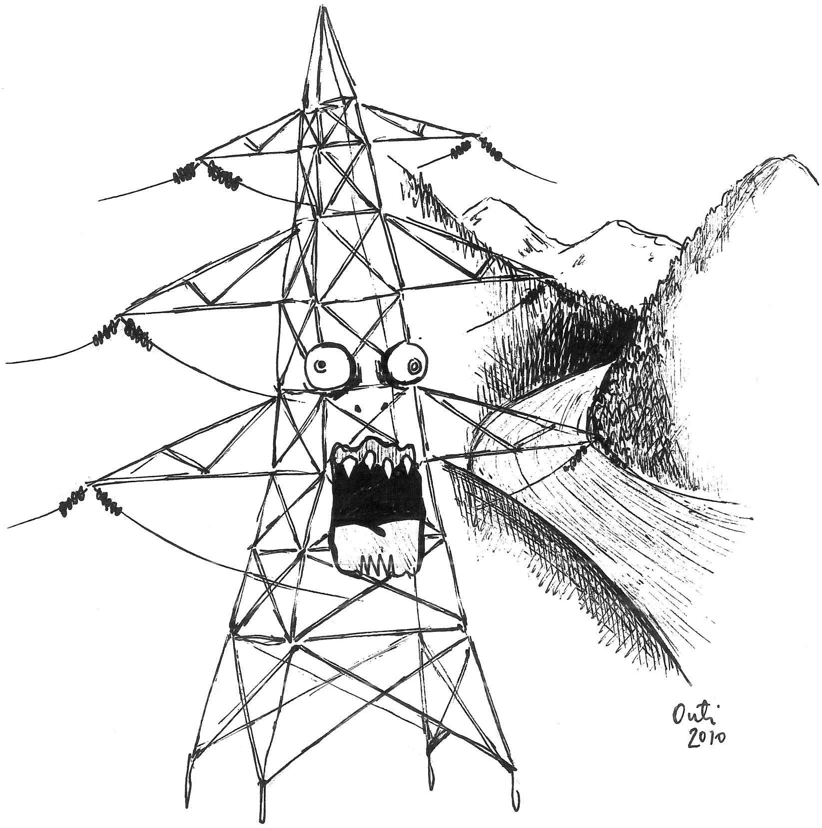

Figure 28 Monster mast.[148]

4.9. 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 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.

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

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 chapter 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.[149]

4.10. 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.

149 Surowiecki, Wisdom of Crowds, 2004

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 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.

This study gives examples in Chapter 5 of the existing cases which have applied ex-ante reattribution of costs and benefits. It also gives indications that there are several potential transmission projects which would benefit from this reattribution. 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.

5. INTERESTS AND BEHAVIOUR OF TSOS REGARDING TRANSMISSION INVESTMENTS

5.1. Introduction

In this chapter a template for a country's behaviour is developed, assuming that each country tries to optimise its own benefits. A similar template for a TSO's behaviour is developed in function of its ownership structure, the main principle being maximising the benefits for the owner of the TSO. It is then analysed whether the past and planned behaviour of the European countries and TSOs follows the templates.

This template approach by definition undermines the influence of differences in the internal dynamic of the TSO organisations and in the attitude of the owners. Some TSOs can be more profit seeking, some others more overall welfare seeking. Also, there can be a big difference between TSOs in the risk attitude regarding investments.

5.2. Expected influence of national interests

Every government is interested in how much their consumers pay for electricity. In particular for energy intensive industry electricity costs are important for its competitiveness. In some countries there is a policy to keep household electricity prices low at least for lower income consumers. As cross-border trade has an influence on electricity prices, any interconnector investment will be judged based on how it affects prices. This means that in principle governments favour links to low price zones but are hesitant regarding interconnectors to high price zones as this will increase prices in their own country.

A possibility to build enough new generation capacity with reasonable production costs in the home country is the key factor to keep the market price at a competitive level. If this possibility exists, the potential price increase due to increased exports can be compensated by building more generation capacity. This allows accepting building an interconnector towards a zone with a higher price.[150] The increase in transmission tariff due to interconnector investments also might be an issue. A sudden increase in transmission tariffs might not be politically acceptable even if transmission costs are only a small share in the final consumer bills. Energy

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[150] Ward, resource nationalism, 2009; Halina Ward develops the concepts of producer and consumer country resource nationalism.

intensive industry is the most sensitive in this respect as the transmission tariff is in relative terms more important for their electricity bill than for other customer groups.

Even if reasonable electricity prices can be considered as a general target for most governments, there are many other, sometimes conflicting targets which influence decisions on interconnectors. For example generation companies have often strong influence on government decisions, in many cases they are state owned. As low prices defer generation investments, generation companies in low price areas are major promoters of interconnectors. For them remaining in a generation surplus pocket reduces their profits and worsens the business case for future generation investments. Some governments might also consider low prices being harmful from the energy saving point of view.

Thus there is a wide range of national interest issues which governments and regulators need to consider when making decisions on interconnectors. Important trade-offs need to be made between the overall increase of welfare and the distribution of welfare between consumers and producers, both within and between the Member States involved. However, it is very difficult to avoid that there are negative effects for some parties.

In some cases a clear win-win situation helps to motivate investments. For example the benefits of the common Nordic electricity market are largely based on complementarities of thermal and hydro power plants in the Nordic countries. It would not be difficult to prove that both generators and consumers are winners in the common Nordic market for which interconnectors are a necessary condition. Perhaps the lower price level resulting from a well functioning market is not beneficial for the generation companies. However, as the profits are already quite high for the main generation companies in the Nordic countries using a lot of hydro and nuclear power, the risk of competition authority interventions and increase in taxes keep these companies interested in a well functioning market and proper interconnection.

Interest for interconnector investments is clear for importing countries. Also countries which need to export their surplus to maintain a reasonable price level to attract new investments are interested in interconnectors. This is in particular true for wind power surplus. Other reasons to motivate interconnector building could be dependence on hydro power which obliges to take special measures to secure the supply in dry years. Small countries might want to mitigate the effect of lumpy generation investments by having a possibility to export temporary excess capacity of a new plant. Price stability can also be an important objective. Interconnections can mitigate price volatility caused by fuel price variation, capacity shortages, wind spikes etc. For the Baltic States an important motivation for building interconnectors is to reduce dependence on the Russian system.[151]

The influence of government decisions regarding final consumer prices can be analysed by comparing prices in different consumer categories. The end user price is composed of several components. Energy price is in most cases market based while all other components in the final electricity bill including the transmission and distribution tariff, charges, levies and taxes are administered price components. Figure 28 compares end user prices in Europe for two categories of customers, households and industrial consumers. Transmission tariffs are shown in the picture as well. For the comparison, prices are normalised by calculating the ratio of the household price, of the industry price and of the transmission tariff to the average spot price in the country. These ratios are then compared with the European average ratio. In this way it becomes clearer which customer groups are favoured and which ones are penalised for example through high taxation.

Figure 29 shows how different electricity price ratios are between countries in Europe. The difference between customer groups within countries is also very visible. For example in France, Greece and Estonia industry is not burdened with additional charges, in fact in France industry pays less than the spot price for the entire electricity supply including the network costs. This indicates that competitiveness of big industry is a concern for these governments or that there is a regulatory capture.[152]

Greece, Bulgaria, Lithuania and Estonia have comparatively low household prices. In the other end Denmark, Norway, Germany and Sweden have relatively high household prices. In all these countries taxes and levies on electricity are high. In Denmark household consumers pay the highest price in Europe. This indicates that probably the priority in Denmark is developing wind power and energy saving and not offering low prices to consumers.

National interests are usually not a single interest but a combination of interests of various pressure groups. Energy policy decisions including decisions on interconnectors depend on which groups have the biggest influence in decision making.

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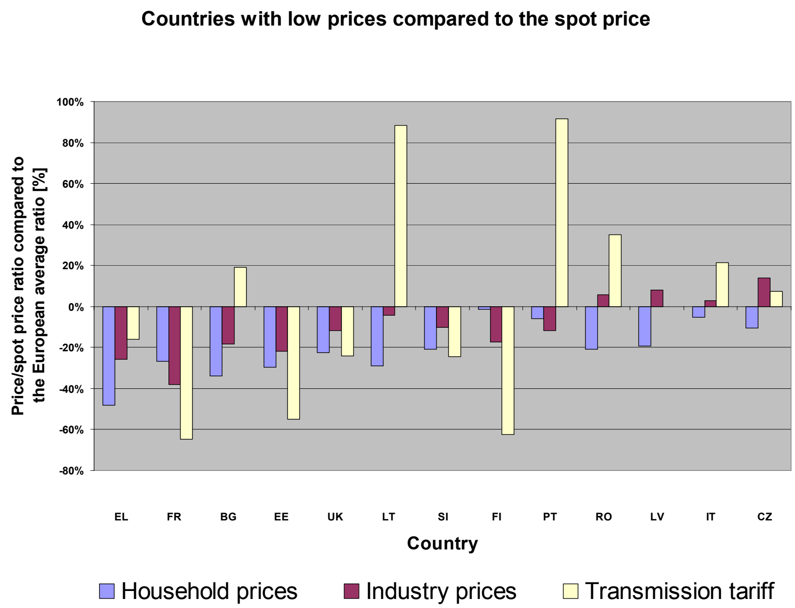
151 EU, Bemip, 2010

152 Stigler, regulatory capture, 1971



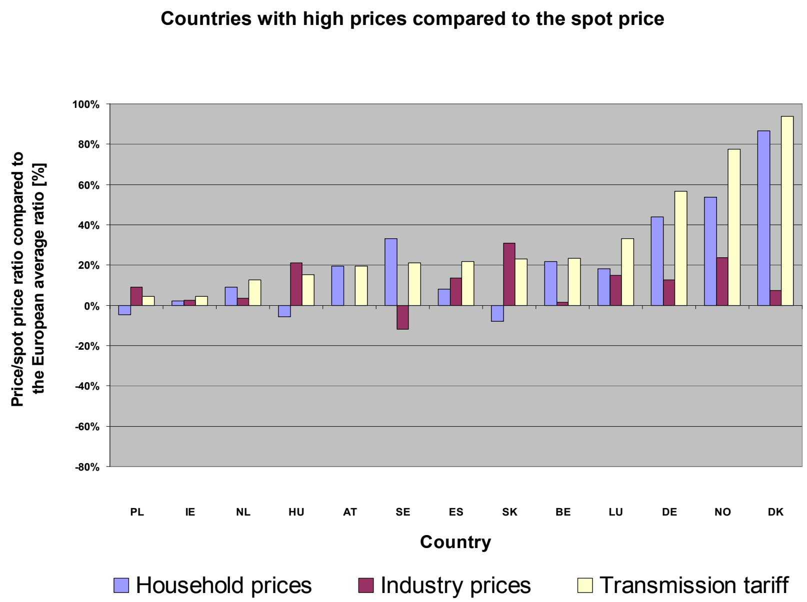


Figure 29 Comparison of the ratio of the household electricity price, of the industrial electricity price and of the transmission tariff to the spot price in the country with the average ratio in Europe. Detailed results of the calculation are presented in Table 2 in Appendix 2.[153]

153 Source: European Statistical Office (Eurostat); ETSO, transmission tariffs 2008, 2009.

5.3. TSO behaviour and ownership interests

Companies have to follow the interests of their owners, TSOs are not an exception of this rule. However, being regulated entities, TSOs have to work in the framework set by the national and the European legislation and the regulator. In the case of vertical integration the owner of the TSO is a generation company which means that in principle investments which increase market prices are promoted and investments which reduce market prices are discarded. Unbundling tries to break this perverse incentive linked to ownership. It is, however, clear that even with extreme functional unbundling measures it is difficult to break this link completely. Seemingly, the owner's voice will always be somehow present. The European Commission tried to achieve a complete ownership unbundling of the European TSOs with the 3rd Energy market liberalisation package. Some Member States opposed this and thus an option to remain vertically integrated remains, even if accompanied with many additional controls to gain the best possible independence of the TSO from the owner.[154]

As shown in Table 6, it is assumed that a vertically integrated TSO maximises profits for the whole business chain including generation and supply. It would seek to increase export capacity to countries with a higher electricity price in order to give the generation arm the possibility to export more and to increase the price in the home country. Similarly, it would try to keep the import capacity low from countries with a lower price, in order to avoid the decrease of the price level in the home country and to avoid competition from abroad.[155] Analogously it is assumed that an independent TSO would seek primarily to keep electricity prices low for consumers in addition to caring for profits for itself. It would maximise imports from cheaper countries and minimise exports to more expensive countries.

For TSOs with mixed ownership including generation companies, industrial consumers, the state and investors, it is more difficult to define a natural behaviour based on ownership interests. This is in particular true for state ownership which is the most common case in Europe. When the state owns both the TSO and a generation company, the state needs to balance between consumer and generation interests. In many countries the state owned generation company has a strong influence on the government.

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[154] EU, third package, 2009

[155] The direction of flows at most European interconnections is predominantly in one direction. It is, however, possible that this predominant direction changes over time. If this happens, the cheap country becomes the expensive one which inverts also the direction of the consumer and producer welfare changes.

Thus the TSO often has to strike a delicate balance between lower prices for consumers and higher profits for the incumbent generation company.

Table 6 The Ownership of the European TSOs and the expected behaviour of the TSOs based on the ownership, situation in 2009.

Independent TSOs (Owner does not have interest in generation business)		Semi-independent TSOs (Owner has interest in generation business)		Vertically integrated TSOs	
State owned without existence of state owned generation business	**Privately owned without interest in generation business**	**State owned with existence of state owned generation business**	**Private or mixed ownership partially with generation companies**	**Vertically integrated with state ownership**	**Vertically integrated with private ownership**
Tennet (NL)	National Grid (UK)	CEPS (CZ)	Elia (BE)	Augstsprieguma tikls (LV)	EoN (DE)
	REE (ES)	Eirgrid (IE)	Fingrid (FI)	Elering (EE)	EnBW (DE)
		Energinet.dk (DK)	REN (PT)	ELES (SI)	RWE (DE)
		Lietuvos Energija (LT)	Swissgrid (CH)	EOS (BG)	Tiwag (AT)
		PSE-Operator (PL)	Terna (IT)	HTSO (GR)	VKW (AT)
		SEPS (SK)		Mavir (HU)	
		Svenska Kraftnät (SE)		RTE (FR)	
		Statnett (NO)		Vattenfall (DE)	
		Transelectrica (RO)		Verbund APG (AT)	
Expected basic behaviour of the TSO based on the owner's priorities					
Low prices to consumers		Balancing between consumer interests and generation and supply business interests		Optimise profits in the generation and supply business	

In reality the picture is much more varied across the three categories of TSOs. For example state owned TSOs might follow closely the government energy policy which is very different depending on the Member State. Also, some TSOs seem to pursue a suboptimal investment policy without any obvious reason for this behaviour.

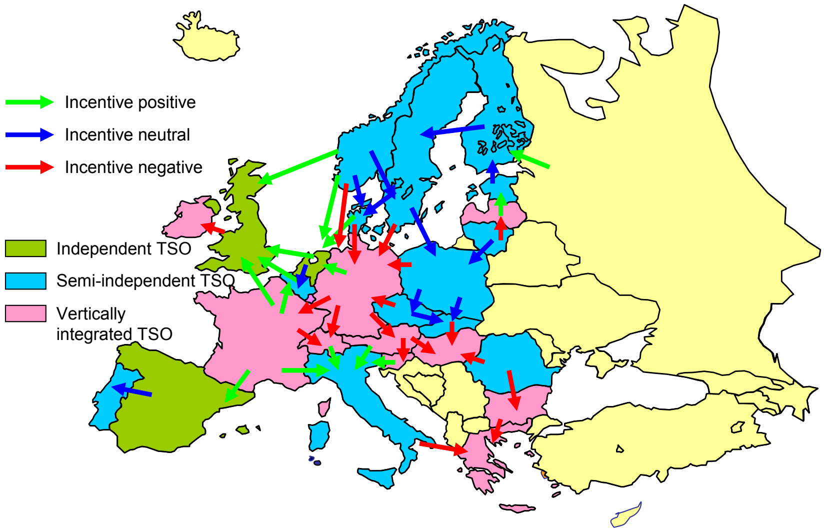

Figure 30 Incentive of the TSOs to build interconnection capacity to meaningful directions in Europe based on the influence of the ownership in 2009.[156]

Figure 30 gives an overview how the expected behaviour of the TSOs depending on their ownership explained above could influence the overall motivation of the two TSOs for building an interconnector. It is assumed that both an independent and a semi-independent TSO accepts increasing capacity if it brings overall welfare benefits. Vertically integrated TSO is assumed to favour investments only in export directions and to stop or delay them in import directions.

According to Figure 30 it is clear that the most difficult area for getting the investments done due to the influence of the owners' interests on the TSOs is Central Europe. There is notably a large joint area including France, Germany, Austria, Slovenia and Hungary in which vertical integration will be maintained. However, the recent sales of the former EoN and Vattenfall transmission networks to independent TSOs could have a strong positive influence on interconnector development as these grids are strategically located in Europe.

Ownership interests among semi-independent TSOs may in particular endanger building the necessary interconnectors from the Nordic countries to Central Europe as the governments in the Nordic countries might

[156] Meaningful direction in this study is the predominant direction of commercial flows in 2008. TSOs are assumed to build interconnectors only to meaningful directions. The incentive of the TSOs to build interconnector capacity is (i) positive from the less independent TSO to a more independent TSO, (ii) neutral between two semi-independent TSOs of from an independent TSO to a semi-independent TSO and (iii) negative to the direction of a vertically integrated TSO.

conclude that it is better to keep cheap electricity for their own citizens. A similar risk exists with the East to West connections from the countries which now have relatively cheap electricity, namely the Czech Republic, Poland, Romania and Bulgaria.

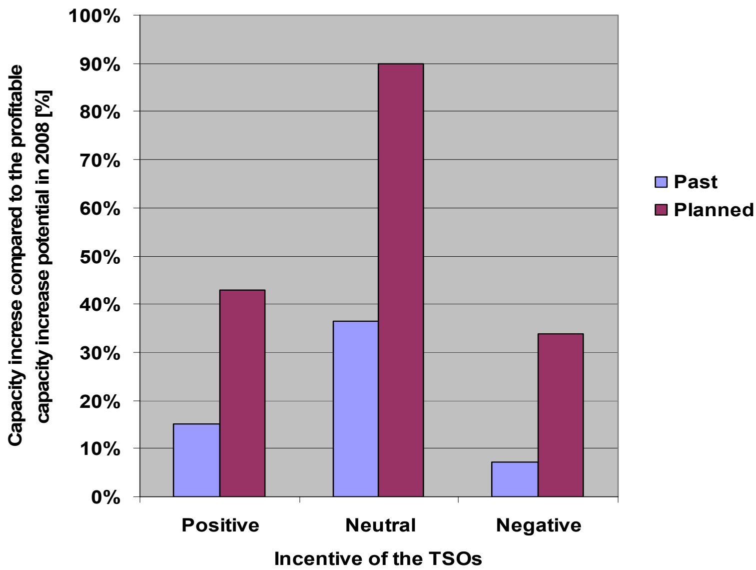

Figure 31 Influence of the ownership of the TSOs on the past and planned interconnector investments. [157]

The evidence from the past and planned investments confirms that there have been fewer investments in interconnectors with negative incentives than for interconnectors with positive or neutral incentives, using the classification in Figure 30. In the period 2000 - 2010, at the positive incentive interconnections the increase of capacity was 15% compared to the potential for profitable capacity increase in 2008 estimated using the method of this study. At neutral incentive interconnections the increase of capacity was 36% compared to the potential. At negative incentive interconnections the increase was only 7 % compared to the potential.

[157] TSOs are assumed to build interconnectors only to meaningful directions. Meaningful direction in this study is the predominant direction of commercial flows in 2008. The incentive for the TSO to build interconnection capacity is (i) positive from the less independent TSO to a more independent TSO, (ii) neutral between two semi-independent TSOs of from an independent TSO to a semi-independent TSO and (iii) negative to the direction of a vertically integrated TSO. The past and planned increase is compared to the profitable potential of capacity increase in 2008, calculated using the method of this study. The overall estimated potential for positive incentive interconnectors was 25900MW, for neutral incentive interconnectors 7400MW and for negative incentive interconnectors 17100MW. Data is presented in Tables 2 - 5 in Appendix 1.

Regarding the future capacity, the ENTSO-E network development plan includes a 43% increase of capacity in the positive incentive category, 90% in the neutral incentive category and 34% in the negative incentive category compared to the potential in 2008. This result is shown in Figure 31.

5.4. Changes in unbundling and TSO Ownership following the new legal requirements

Unbundling requirements of the third package will have a big influence on the independence and ownership of TSOs. Figure 32 gives a preliminary view regarding unbundling and ownership arrangements of the European electricity TSOs. Two vertically integrated TSOs have already been sold to independent TSOs. Several TSOs will remain, however, vertically integrated.

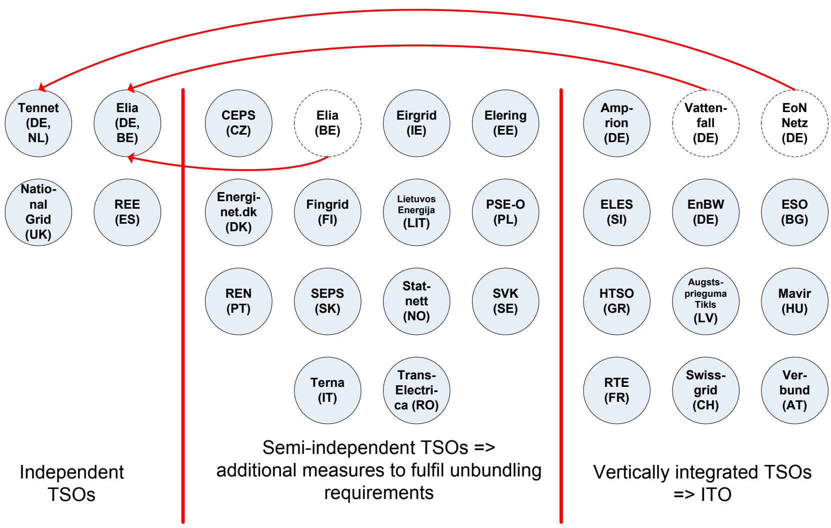

Figure 32 Expected changes in the unbundling and ownership of the TSOs following the implementation of the 3rd internal market package.[158]

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158 The choices made regarding unbundling were not finalised when this study was written. Independent TSO are defined in this study to be companies which are owned by private or public bodies without ownership of generation or supply companies. Semi-independent TSOs have owners who own generation or supply companies without being vertically integrated. Vertically integrated companies host a TSO in a company that has also generation or supply activities.

5.5. Past and planned development of cross-border transmission capacity

Calculation of NTC-values was already discussed in Chapter 4. NTC- values are in principle determined by an objective method applied similarly by all TSOs. In practise, the upper limit of exports and imports are in many cases not defined in a transparent process but TSOs can give preferential treatment to most wanted directions. Consequently, the NTC values, in addition to being indicative, contain an element of choice by the TSOs. A general rule is that the lower value proposed by one of the two TSOs involved is applied. Thus it is interesting to analyse the NTC values also from the point of view of possible influence of national and company interests on the calculation of NTC-values.

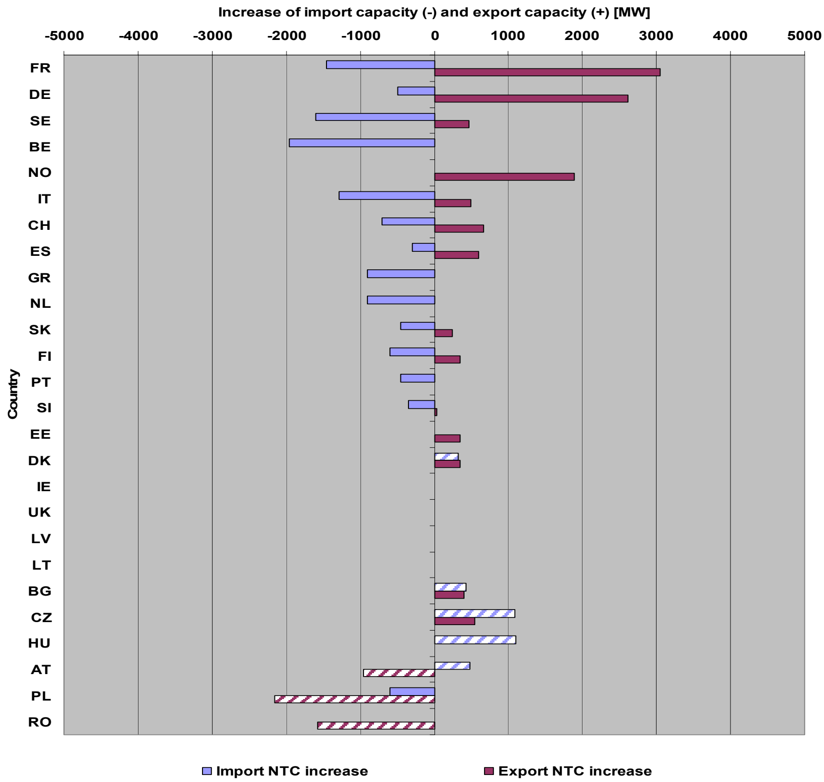

Figure 33 Development of electricity import and export capacity (in NTC) in meaningful directions in Europe between summer 2000 and 2010. Negative values are presented as patterned bars.[159]

[159] Figure 31 compares ENTSO-E NTC values of summer 2000 and summer 2010. Meaningful direction in this study is the predominant direction of commercial flows in 2008.

In most countries, the NTC values have increased only modestly during the time of market liberalisation, in some cases the NTC-values have even diminished as illustrated in Figure 33.

5.6. Projects included in the ENTSO-E ten year network development plan

Regarding the planned transmission projects in Europe the reference is the ENTSO-E biennial ten year network development plan which is one of the key tasks of ENTSO-E.[160] ENTSO-E started to work on the plan immediately when it was founded in 2009, not waiting for the formal establishment in 2011. The first plan, called a pilot plan, was released on 1 March 2010.

The pilot plan was clearly a compilation of national transmission investment projects, without any systematic European modelling to justify the projects. The plan did not try to estimate the capacity increase due to the investments presented in the plan. The number of projects in the plan, altogether 471, was impressive.

When publishing the plan ENTSO-E declared that it was work in progress and invited stakeholders to comment on it in view of developing a proper methodology for the preparation of the future plans.[161] Among the 471 projects there were about 70 cross-border projects, the rest being internal lines. Even if it is clear that also many investments inside the national networks are needed to achieve the targeted cross-border capacity increase, the plan only occasionally showed the interdependencies of the internal and the cross-border projects. Costs of individual projects were usually not indicated.

In the ENTSO-E pilot ten year network development plan no systematic set of criteria was used to choose the projects for the plan. However, the plan mentioned that methodologies developed for some regional plans could be used in the future by ENTSO-E. The appendix of the pilot plan refers to the Baltic Sea regional plan, to the analysis made for the France-Spain-Portugal interconnections and to the work done in Central Western Europe.

The estimated capacity increase following the ENTSO-E ten year network development plan is shown in Figure 34. For many interconnections from which substantial congestion rents are collected today, an increase of interconnection capacity is planned. However, there are also many

[160] ENTSO-E, ten year network development plan, 2010

[161] EC, comment on ten year network investment plan, 2010

potentially highly beneficial interconnectors which could be entirely financed through congestion rents missing from the list. Projects linking neighbouring EU Member States are missing between Romania and Hungary, Austria and Slovenia, France and Germany (only a very modest project is presented), Sweden and Denmark, Poland and Slovakia, Romania and Bulgaria, the Netherlands and Belgium, Poland and the Czech Republic, the Czech Republic and Austria, the Czech Republic and Slovakia, Slovakia and Austria as well as Sweden and Germany. Using the classification given to interconnections in Figure 30 based on the ownership of the TSO, all these missing projects are at the borders with negative or neutral incentives, none at the positive incentive borders. This is strong evidence of the influence of ownership interests on choosing whether to develop an interconnector project or not.

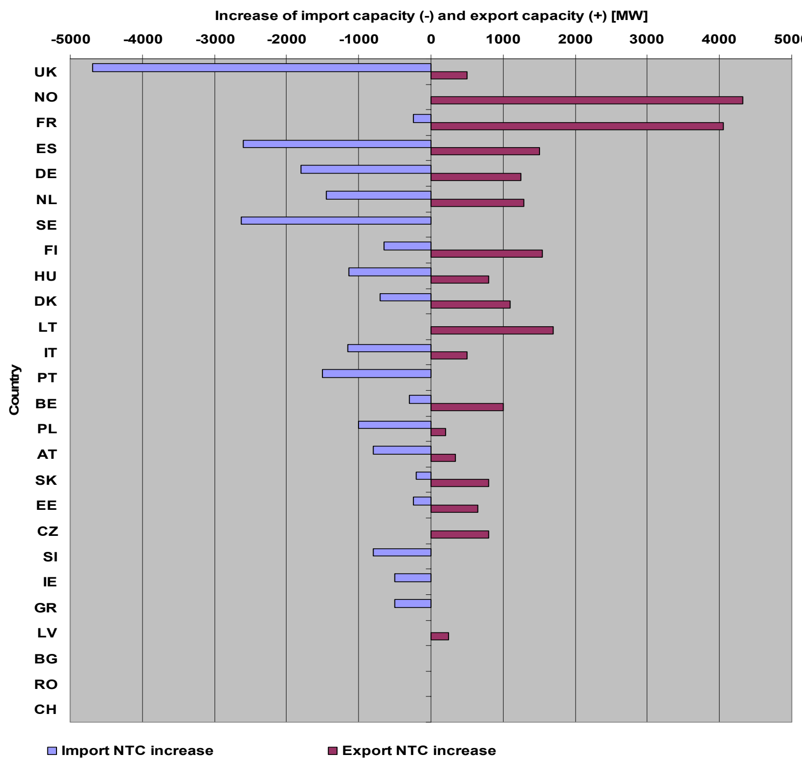

Figure 34 Planned development of electricity import and export capacity (in NTC) in meaningful directions in Europe in 2011 – 2025.[162]

162 Planned additional capacities at interconnections in the ENTSO-E ten year network development plan, are from the study: KEMA, electricity infrastructure, 2010. Additional capacities are shown in Table 4 in Appendix

5.7. Analysis of TSOs' historical and planned behaviour

For analysing the historical and planned behaviour of the TSOs, the past investments of the TSOs in 2000 – 2010 and the planned investments proposed for the period 2011 – 2025 in the ENTSO-E ten year network development plan are compared with the from the overall social welfare point of view optimal transmission investments identified in Chapter 3 and summarised in Table 3. The TSOs' behaviour regarding the past and planned investments is analysed using the method developed in this study, already applied for identifying the optimal investments. To recall the main features of the method, it estimates the price arbitrage potential between two countries by calculating an equivalent price difference based on the congestion rents in 2008. In addition, a linear supply curve for both sides of the interconnection is generated from the spot market data. This allows establishing the optimal interconnection capacity and the corresponding increase of welfare. Equally, the welfare effects of the past and planned capacity increase are calculated.

The main results and observations from these calculations are shown in Figures 35 – 37. The method, input data and detailed results for all countries are presented in Appendix 1.

Even if indicative, the results are very interesting. First of all they indicate which TSOs have been able to increase social welfare in the past and are planning to increase it in the future. They also show, whether this increase of social welfare is taking place through increasing the welfare for consumers or for generators. It is important to note that in the European context both are equally important, there will be no welfare increase for the consumers in the importing country without an increase in producer welfare in the exporting country, which usually means that the consumer surplus in the exporting country is diminished.

In Figures 35 – 37 the past increase of social welfare is converted into negative values for presentational reasons. Thus the lower the point representing the country is in the graph, the higher the welfare increase has been in the past period. For future welfare the opposite is true, the higher the point, the bigger the welfare increase. The middle point corresponds to the planned projects and the end point to the optimal projects. The position of the point in the horizontal scale corresponds to who is benefiting from this welfare gain, producers on the right hand side and consumers on the left hand side of the graphs.

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1. Meaningful direction in this study is the predominant direction of the commercial flows in 2008.

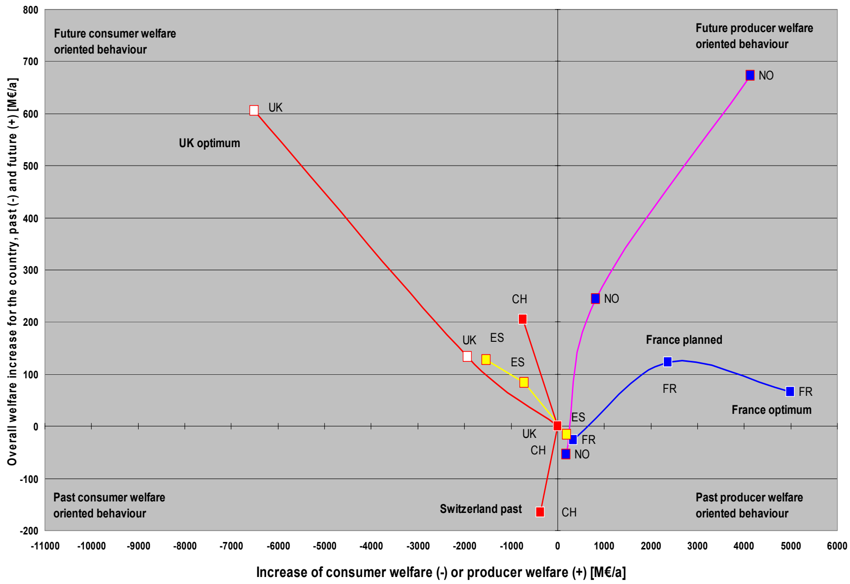

Figure 35 Social welfare increase by the past and future interconnector investments of Norway, France, the UK, Spain and Switzerland. The past investments are based on NTC increase in 2000 – 2010 and the future investments are based on ENTSO-E ten year network development plan. The method used is explained in Appendix 1 and the calculation results for all countries are presented in Tables 6 – 8 of Appendix 1.

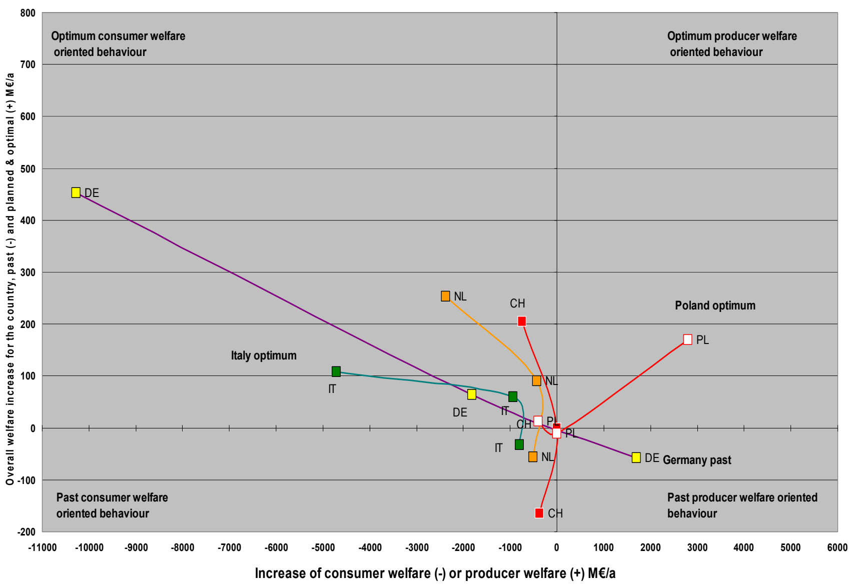

Figure 36 Social welfare increase by the past and future interconnector investments of Germany, Switzerland, the Netherlands, Poland and Italy.

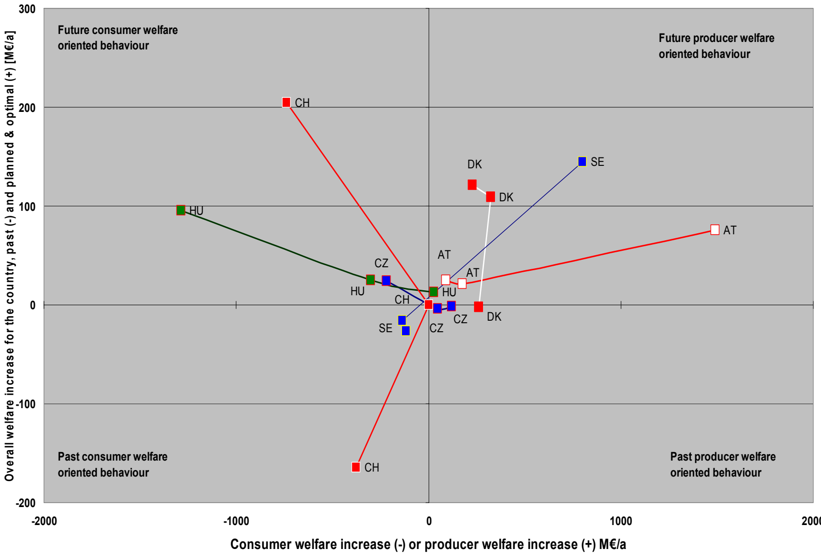

Figure 37 Social welfare increase by the past and future interconnector investments of Austria, the Czech Republic, Hungary, Denmark and Portugal. Switzerland is shown to facilitate comparison with pictures 35 and 36 which have a different scale.

From Figures 35 - 37 one can see the countries with the biggest potential for welfare increase, namely Norway, Germany and the UK, and the ones with somewhat smaller potential, namely the Netherlands, Switzerland, Poland, Italy, France, Spain, Denmark, Hungary, the Czech Republic, Austria and Sweden. Regarding exporting countries, Norway has planned concrete projects to benefit from capacity increase to Central Europe and to the UK. France has also ambitious plans to benefit from its exporting potential. On the contrary, Poland, Austria and Sweden have been very passive and are not even planning interconnectors in spite of their export potential. Regarding importing countries, Germany and the UK are the most potential beneficiaries, both are addressing their import potential in their plans. Portugal, Spain, Italy and the Netherlands also have planned capacity increase for profitable imports. On the other hand Switzerland, the Czech Republic and Hungary seem to be passive in spite of their import potential.

In the past there have been several countries which have promoted producer welfare increase when it would have been more optimal to promote consumer welfare increase, Germany, Spain, the Czech Republic and Hungary are in this category. In addition, the UK has been passive in spite of an important consumer welfare increase potential. On the contrary, Sweden, Romania, Poland and Belgium have promoted consumer welfare increase in the past even if it would have been more beneficial from the overall social welfare point of view to promote producer welfare increase.

Regarding future investments, only the Czech Republic remains slightly wrongly on the producer welfare side and Sweden wrongly on the consumer welfare side. However, in addition to these two countries, Poland, Switzerland, Romania, Bulgaria and Greece are passive regarding planned investments taking into account the welfare potential. Of course it remains to be seen for all countries which of the planned investments will be realised and what is the role of the TSO's motivation or lack of motivation for the achievement or non-achievement of these projects.

In most cases the behaviour shown by the analyses is in line with the expected behaviour of the TSO. Many of the above mentioned TSOs situated in a non-optimal quadrant favourable to producer welfare regarding the past behaviour are vertically integrated companies. This gives strong evidence that vertically integrated companies tend to put the interests of their owner above the increase of the overall social welfare as increasing export capacity increases profits for their generation business. Only the Swedish TSO, remains in the non optimal quadrant favourable to consumers regarding planned investments. The Swedish TSO is a state agency which might well explain the preference for keeping the consumer prices low rather than increasing the overall social welfare.

It seems evident that there is a link between the creation of an independent TSO and the importing nature of the country. All TSOs with a high level of independence from generation interests, namely the Dutch and British TSOs, are in importing countries. Other major importing countries such as Italy and Portugal have semi-independent TSOs. All these TSOs, except the UK TSO, have been rather successful in increasing social welfare through building interconnectors.

Similarly it seems evident that there is a link between being an exporting country and the wish to keep the TSO vertically integrated, such as in France, Germany, Switzerland and Bulgaria. The most common ownership choice for exporting countries is a fully state owned TSO as in Norway, Sweden and the Czech Republic. Two main exporters, France and Germany, are defenders of maintaining vertical integration, both at the company and government level. This can be a sign that export revenues are considered as benefiting not only the company but also the country even if extensive export increases prices in the home country. Also in some of the most important transit countries, namely Switzerland, Slovenia and Austria the TSO will remain vertically integrated.

Transit countries, the most important ones being Denmark, Switzerland, Austria and Slovenia, deserve special attention when drawing conclusions from this study based on whether the TSO's behaviour is consumer or producer welfare oriented. Our analysis is based on summing up the welfare increase of bilateral projects without making connection between all the projects in each country. Such an analysis made separately for each project is reasonably accurate for big countries as a single interconnector only marginally influences prices and flows. However, small transit countries need to develop exports and imports simultaneously for keeping a reasonable energy balance in their country, thus a more integrated analysis would be more appropriate for them. Among these countries Switzerland has focused on increasing significantly export capacity, while Austria, Denmark and Slovenia have increased both import and export capacity, rather modestly though.

In Austria one of the reasons for the modest increase of interconnection capacity has been that it has struggled with its internal bottlenecks. Now finally Austria has been successful in relieving some of these bottlenecks.

5.8. Empirical country by country analysis of TSOs' behaviour regarding historical and planned transmission investments

This empirical part of the study compares the findings obtained using the method developed in the study to empirical knowledge on concrete investment projects. Empirical knowledge is also used to identify the most important success factors of an investment. In particular the influence of the other factors than price arbitrage, identified in Chapter 4, is discussed here. These other factors are not directly taken into account in the method used in this study because the method focuses on social welfare increase through price arbitrage and does not try to quantify for example security of supply or competition benefits of interconnectors.

This chapter is divided into regional sections. In each section the results of the analysis on whether company and national interests have influenced the past and planned investments presented above are used as the reference. Empirical knowledge on real projects is then used to confirm or reject these results.

5.9. Northern Europe

5.9.1. Regional overview

For the Nordic countries it seems that the possibility to build nuclear plants in Sweden and Finland, fulfilling the renewable targets and the development of wind power in the Baltic Sea and North Sea creates so much surplus capacity that the potential increase in electricity prices because of increasing exports is not a problem.[163] On the contrary, interconnectors are necessary to keep a price level that allows generation investments to remain profitable.

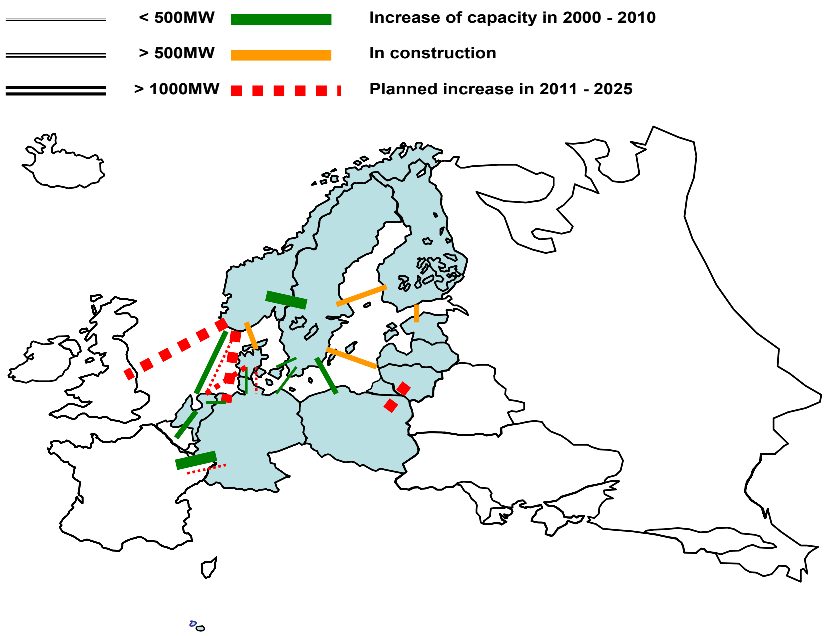

Figure 38 Northern European interconnectors.

For the counterparts of the interconnectors, the Central European countries and the Baltic States, the need for interconnectors is very much dependent on the future development of nuclear and wind power. Wind power has already changed Germany to one of the most important exporters in Europe. The Netherlands will also become an exporter in the future. Because of the wind power, flexibility of the Nordic hydro power will become more and more valuable. Sharing this flexibility with Central Europe seems to increase the profitability of future interconnector projects between the Nordic countries and Central Europe.

163 Vattenfall, Løseth, 2011

5.9.2. Denmark

According to the analysis in this study, Denmark has slightly given priority to producer welfare. However, for Denmark as a transit country, it is utmost important to have a reasonable equilibrium between the capacity in the North and in the South. Denmark has two price zones which were linked with a cable in 2010. The Danish small but well connected market has a price locked between the Nordic and the German price. Whether the price is closer to the former or to the latter depends very much on the behaviour of the main generator in Denmark, state owned Dong.[164]

For imports from Norway, after completion of the Skagerrak IV cable under construction, no further capacity increases are planned. New cables seem to bypass Denmark. The Norned I cable from Norway to the Netherlands has been very profitable and the construction of Norned II has already been decided. There are also two cable projects from Norway to Germany at the planning stage. The main reasons for bypassing Denmark are probably the possibility offered by DC cable technology to connect distant points across the sea without being dependent on permits for overhead lines. Other reasons why Denmark is losing its role as a transit country is the recent decision to underground[165] most of its transmission grid and the lack of progress in building away the bottleneck in the Hamburg area by the German TSOs. A Danish attempt to still benefit from transit is the Cobra interconnector from Denmark to the Netherlands, in this case the bypassed country is Germany.

The Danish TSO Energinet.dk has cared for equilibrium of capacity between the North and the South. Most of the interconnection capacity was built already before the liberalisation of electricity market.

5.9.3. Estonia

Estonia has been very active in interconnector building. One cable to Finland is already in operation since 2006, and a second one is under construction. These projects at the moment show priority to producer surplus as Estonia is an exporting country. However, the development of market price in the Baltic States is difficult to predict in the longer term, the Baltic market could well import from the Nordic market in the future. The analysis in this study shows that when the Estlink II cable is ready there will be high price convergence with the Nordic market. This is no surprise as

[164] KSF, Elsam case, 2005

[165] Energinet.dk, kabelhandlingsplan, 2009

after completion of Estlink II, Estonia will be the most interconnected country in Europe.

The Estonian TSO Elering has worked for integrating Estonia in the Nordic market.

5.9.4. Finland

The Finnish TSO Fingrid has achieved a high level of market integration with Sweden in the context of the Nordic market, measured based on the level of price convergence. In these conditions investments cannot be justified with the method used in this study focusing on price arbitrage, but the behaviour has to be judged based on other criteria such as benefits from increased competition or improved security of supply. If these investments keep market prices competitive, the benefit can be much higher than the investment cost.

Fingrid has a mixed ownership including the main producers but also the main industrial consumers and the state. Because of the new unbundling requirements of the 3rd legislative package the ownership structure needs to be changed. The state is ready to buy the majority of Fingrid.[166]

Fingrid has increased capacity with Sweden in several stages in the past and further increase is planned. Connections with the Baltic States are also developed. The first connection with Estonia, the Estlink I cable, is a merchant investment. The second cable Estlink II, this time a regulated interconnector, has been decided and will be in operation in 2014.

Currently Finland imports annually about 10 TWh from Russia.[167] Building further interconnection capacity with Russia has been refused by the Finnish government based on system security arguments.[168] On the existing DC back-to-back interconnector an upgrade is ongoing in order to allow exports to Russia which is currently not technically possible.

The Finnish TSO Fingrid has pursued a policy of low transmission tariffs and high price convergence with Sweden.

5.9.5. Germany

The past behaviour of the German TSOs according to the analysis in this study shows preference for producer welfare. This is the expected behaviour as all German TSOs used to be vertically integrated. Interconnector

166 TEM, press release on Fingrid, 2011

167 Source: ENTSO-E

168 TEM, United Power decision, 2006

investments in export directions, in particular to the Netherlands, have been favoured and capacity in import directions such as from Poland, the Czech Republic and the Nordic countries has not been developed.

Almost a school book example for this study is the Viking-cable project from Norway to Germany. It was abandoned by Preussen Elektra, one of the predecessors of Eon.[169] Looking backwards, this cable would have been one of the most profitable transmission infrastructure investments in Europe in spite of its high cost. The only understandable reason for stopping the project is the loss of profits for German producers. Now this project is again alive in a different setup.[170]

Future plans show a change compared to the past. For export capacity a modest increase towards France and a substantial increase towards the Netherlands is planned. In import direction there is a capacity increase project with Denmark and two projects to connect Germany with Norway. All these projects are in the control area of Tennet Germany, formerly the transmission grid of the vertically integrated Eon. This would indicate that Tennet together with Elia, the new owner of the former transmission grid of Vattenfall in Germany, now called 50Hz transmission, might develop interconnectors to the North as they do not have their own generation interests in Germany.

For one of the cables from Norway, Norger, the connection point in Germany is Brunsbüttel which is situated to the north of the congestion in the Hamburg area. Intuitively it would be more interesting to connect the cable further south in order to bypass this congestion.

Germany is the biggest market in Europe and already strongly interconnected with the neighbours. Because of its big size, interconnectors can, however, only marginally influence the market price. The focus in Germany has been in connecting wind power and keeping the integrity of the German price zone. Building more capacity to connect Northern Europe makes no sense if internal bottlenecks are not relieved at the same time. Development of wind power in the North-Sea and the Baltic-Sea area increases the North-South flows which will worsen the loop flows in the Dutch, Belgian, Polish and Czech networks as discussed in Chapter 4.

From the four German TSOs, Amprion and EnBW will probably remain vertically integrated. However, the new ownership of the two other TSOs could facilitate splitting Germany into several bidding zones if needed

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

170 Statnett, press release on Norger, 2010

because of the increasing wind power production, as discussed in Chapter 4. A decision of splitting needs to be taken a couple of years ahead of implementation because of the forward contracts sold for the German single price zone and in order to prepare the market participants for the change.[171] In this matter there might be a conflict of interest between the unbundled and the non unbundled German TSOs. In general, the new setup of TSOs in Germany will increase the regulator's role in deciding on transmission investments and in making sure that the approved projects are actually build.

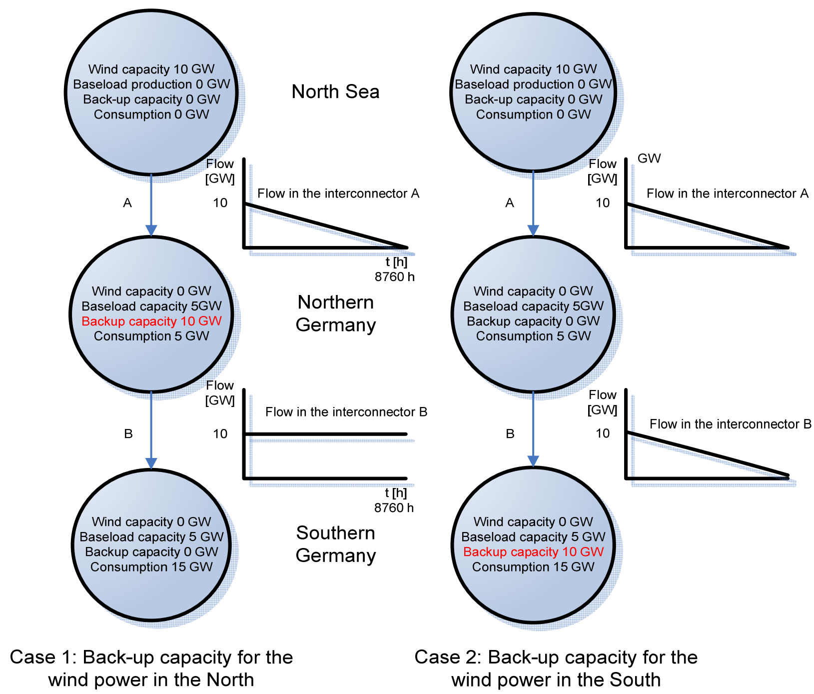

Figure 39 Where to locate wind back-up generation in Germany?

Germany has changed from an importing country to an exporting country in recent years. The export potential comes largely from wind generation which is in steep increase. Because of the big surplus volumes it seems evident that Germany has an interest to export during peak wind production. This surplus requires sufficient transmission capacity towards consumption areas in Central Europe. If all wind power produced in Germany needs to be consumed in Germany, expensive transmission expansion and back-up power plant projects are needed inside the country

171 Consentec and Frontier Economics, German bottlenecks, 2008

to accommodate the variable wind production. Spreading German wind power wider in Europe is most probably the least cost solution for Germany.

For the transmission network it is very important where the power plants used for back-up for wind generation will be located. To illustrate this, Figure 39 presents a schematic example of the German situation. It shows that the back-up capacity should be placed in the generation deficit areas in the South, not in Northern Germany which already has a generation surplus. Thus all new power plants for which the location can be chosen relatively freely such as combined cycle or open cycle gas turbines should be placed in the deficit areas presented in Figure 5, notably in Southern Germany and Northern Italy.

For this reason it is perhaps a historic mistake from the transmission system point of view that it is still possible to build power plants in Northern Germany, even with a guaranteed access to the network.[172] Some investors have already drawn the same conclusion.[173] This area is the crossroads for the wind surplus from the North Sea and the Baltic Sea as well as for the electricity coming from the Nordic market with an expected increasing surplus in the coming years.

In Figure 39 the two main alternatives to build wind back-up capacity in Germany are compared. In alternative A the back-up is located in Northern Germany. This results in a constant loading of the lines from the North to the South, from flows originating either from wind generation or from back-up generation. In alternative B the back-up is located in Southern Germany. In alternative B the line from the North to the South is fully loaded only in peak wind conditions, with no loading when there is no wind. This leaves transmission capacity available for trading purposes when there is less wind. Additionally, in alternative A, Southern Germany is dependent on the transmission line for its security of supply, in alternative B both Northern and Southern Germany can be supplied even if the transmission line connecting them is out of order.

German TSOs have in the past clearly pursued the interests of their owners. Among the four TSOs, Vattenfall was most open to innovative solutions such as introducing implicit auctions to the Kontek cable in 2005.[174] EoN changed its course later and joined the market coupling project between the Nordic countries and Germany in 2008.[175] The TSO

172 BMWi, law on power plant connection, 2007

173 Dong, press release, 2009

174 Nord Pool, Kontek price area, 2005

175 EMCC, market coupling, 2008

landscape in Germany has recently changed radically and it is not clear yet what objectives the TSOs will pursue.

5.9.6. Latvia

The Latvian TSO Augstsprieguma Tikls is part of vertically integrated Latvenergo. The Latvian transmission system is small and technically integrated into the Russian system as the systems of the other Baltic States. Latvenergo is a shareholder in the Estlink-cable between Estonia and Finland. Full price convergence between the three Baltic States and high price convergence with the Nordic market is expected once the Baltic electricity market is fully operational and new interconnectors with the other EU Member States are ready.

The Latvian TSO Augstsprieguma Tikls has followed the interests of the integrated company and the government. The unbundling solution for the Latvian TSO is not yet clear.

5.9.7. Lithuania

The Lithuanian TSO Lietuvos Energija had a rather independent position when it was created. However, for the purpose of building the Visaginas nuclear power plant the government regrouped the electricity sector under Lietuvos Elektros Organizacija (LEO) holding company which was dissolved in 2009.[176] Now a new TSO, Litgrid, will be established as an entity directly owned by the state.

The Lithuanian TSO has actively followed the government policy to increase independence from the Russian system and to connect with the other EU Member States. Full price convergence between the three Baltic States and high price convergence with the Nordic market is expected once the Baltic electricity market is fully operational and new interconnectors with the other EU Member States are ready.

5.9.8. Netherlands

The Netherlands has in the past clearly shown preference for increasing consumer welfare and this seems to continue in the future. In the Netherlands most generation assets are owned by companies from the other EU Member States such as GDF Suez, RWE, Eon and Vattenfall. The TSO Tennet is particularly independent of generation interests as the owner of

176 Lithuanian tribune, LEO, 2009

Tennet, the state, does not own power plants. This is clearly visible in the behaviour of the TSO. It has systematically increased import capacity from the early days of liberalisation. Phase shifters and new lines at the German border, the NorNed cable to Norway and the BritNed cable to the UK are among the most important investments.

Interconnectors have already efficiently aligned the historically high prices in the Netherlands close to the level of the neighbouring countries. The start of the Central Western Europe market coupling has further aligned prices. Netherland is thus a good example how a small country with originally high electricity prices can best utilise its big neighbour. Increasing interconnection capacity with Germany has converged prices providing a substantial absolute increase in welfare and a transfer of welfare from producers to consumers. The price level in the Netherlands is still sufficient to attract generation investments, which has been proven in practise. With the completion of the BritNed cable, and with the two further cables planned, Norned II to Norway and Cobra to Denmark, the Netherlands will become a hub for the future North-Sea wind power with a good possibility to get welfare benefits for the Netherlands in form of electricity subsidised by other Member States.

Public consultation on the Norned I cable[177] is an interesting case for analysing company interest regarding transmission investments. Some generation companies active in the Netherlands were against the investment arguing that it is not profitable. It is difficult to think that major players in the European market could have done such a big mistake in their calculations.

To sum up, the Dutch TSO Tennet has followed a consumer oriented policy by achieving a high level of price convergence with the neighbouring countries.

5.9.9. Norway

According to the method used in this study Norway has shown a strong preference for increasing producer welfare both in the past and even more so regarding future investments. This has been done very consciously with a strong government steer on electricity policy. The state is the owner of the TSO Statnett and the biggest producer Statkraft.

Some parties claim that the Norwegian hydro power should be kept for the Norwegians. Indeed, by closing the borders electricity would be very

177 Dte, Norned decision, 2004

cheap in wet years. However, the potential of Norway to increase social welfare for Norway through the European market is huge. There are four main drivers for this welfare potential, all linked to Norway's storage hydro capacity, biggest in Europe, and interconnectors.

Firstly, the development of the North Sea wind power needs desperately connection to storage. Norway has a lot of storage capacity and can capture a lot of added value with this storage by importing when electricity is cheap and exporting when it is expensive.

Secondly, the whole European system will need in the future much more balancing and regulating power for secure system operation. The same hydro power plants in Norway can offer this service at a reasonable cost.

Thirdly, Norway can exploit its nuclear neighbours, Sweden and Finland, and pass electricity produced in these countries through the interconnectors to Central Europe. This business seems to work well as Sweden has been passive in developing its own interconnectors and Finland is too far away from Central Europe. The profit from this trade for Norway comes mainly in form of congestion rents.

Finally, interconnectors to the Central Europe secure the supply of Norway in electricity in dry years. If there is little water, cables are turned to importing to Norway instead of exporting.

The biggest obstacle to exploiting the huge welfare potential seems to be local resistance against building transmission lines as illustrated in Figure 28. Norway has a relatively weak internal transmission grid, lack of investments in the past decade did not improve the situation. To fully exploit the potential of the European market, internal transmission investments are desperately needed. They are also crucial for offering reliable electricity supply inside the country.

Distribution of welfare internally in Norway regarding electricity should not be a big problem even if it has been discussed extensively in Norway. Most of the producer welfare is captured for the society through selling hydro rights and through imposing taxes and levies. In addition, hydro power is mostly publicly owned. Foreign companies have been kept out of the Norwegian hydro power by protectionist measures.[178]

To exploit the welfare opportunities of Norway, more connections are planned with the most lucrative markets such as the Netherlands, Germany and the UK. Capacity to Denmark will be increased by building the Skagerrak IV cable. Norway is also an active partner for developing the North Sea wind power potential.

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178 IFP, Dong sells hydropower, 2010

Skagerrak IV cable is a good example of how national interest influence investment projects. In 2004 the Nordic TSOs decided on five infrastructure investments in a Nordic package.[179] One of the underlying ideas was that the package will mitigate national interests as all countries will profit from the overall package even if they might consider that their own project in the package is not profitable. All the other projects went ahead rather quickly except Skagerrak IV. Only after negotiations with the Danish TSO on how the costs and benefits are shared and reserving some capacity to regulating power, the project finally was accepted in Norway. This decision was perhaps also facilitated by the agreement on the Inter TSO compensation mechanism, which gave certainty on the additional compensation amount to be paid by the Norwegian TSO because of the exports through the Skagerrak IV cable.

Another example of careful priority setting of Statnett is the hesitation around the new connection from Norway to Southern Sweden. This link might compete with the Norwegian projects connecting directly with Central Europe in case Sweden was to develop interconnectors to the South.[180]

As a founder of the Nord Pool power exchange the Norwegian TSO Statnett has a long history in developing the European electricity market and it has continued to be very active in developing it further. Also regarding interconnectors, in particular DC cables, it is perhaps the leading TSO in the world. Statnett has been completely in line with the government policy and has been seeking with success to increase the Norwegian welfare with its transmission investments.

5.9.10. Sweden

According to the analysis of this study, Sweden has given strong preference for consumer welfare both in the past and in the plans for the future. The increase of Svenska Kraftnät's export capacities has been rather modest, except through the SwePol link, which was already decided between vertically integrated companies before the market liberalisation. In fact, Svenska Kraftnät has continuously limited the export capacity of interconnectors in order to reduce the system security risk and to decrease

179 Nordel, prioritised cross-sections, 2009

180 Ny Teknik, Sydvästlänken, 2010

redispatching costs caused by the internal bottlenecks in Southern and Central Sweden.[181]

Sweden is an important transit country with alternating transit directions depending on the rainfall in the Nordic countries. Sweden has less and less surplus generation capacity, which probably helps to make interconnector projects acceptable both to consumers and generators. However, Sweden could become a major exporter in the future because of the decision to allow replacement of existing nuclear plants once they are at the end of their lifetime and because of the renewable targets requiring substantial investments in renewable generation capacity.

Sweden and Norway realized early the Nordic complementarities in electricity generation and have fully supported the development of the Nordic market. However, the creation of the Nordic market and building interconnectors to Denmark, Poland and Germany worsened the bottlenecks inside Sweden. The situation was further deteriorated by the closure of the Barsebäck nuclear power plant situated in Southern Sweden. In spite of this, Svenska kraftnät has during the last ten years invested very moderately in the transmission network which explains why the bottlenecks have persisted. Only after a long debate in Sweden and in the other Nordic countries, and with the help of a complaint to the EU by the Danish Energy Association, concrete actions have been taken. The main measures are building more lines in the Southern Sweden and splitting Sweden into four bidding zones.[182]

The Swedish TSO Svenska kraftnät is part of the state and thus it is natural that it follows closely the government energy policy. Contrary to Norway, it seems that Sweden lately has adopted a low profile regarding developing cross-border transmission networks even if it would have all the ingredients for being one of the leading countries in the world in this respect. Sweden could get important welfare gains by following the Norwegian example, even if the hydro resources are smaller than in Norway and situated quite far away in the North. Linking the Baltic States is a politically important project, but bigger welfare gains can be expected from links to Germany and Poland which are currently not developed.

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181 SVK, commitment, 2009

182 SVK, commitment, 2009

5.10. Central Eastern Europe

5.10.1. Regional overview

Most countries in Central Eastern Europe are so well connected to Germany and Austria that price convergence within the whole region is easily achieved. In Central Eastern Europe, the Czech Republic is a major exporter and will probably remain an exporter in the future. There are also deficit areas in the region and in the neighbouring countries, namely Southern Germany, Hungary and Serbia.

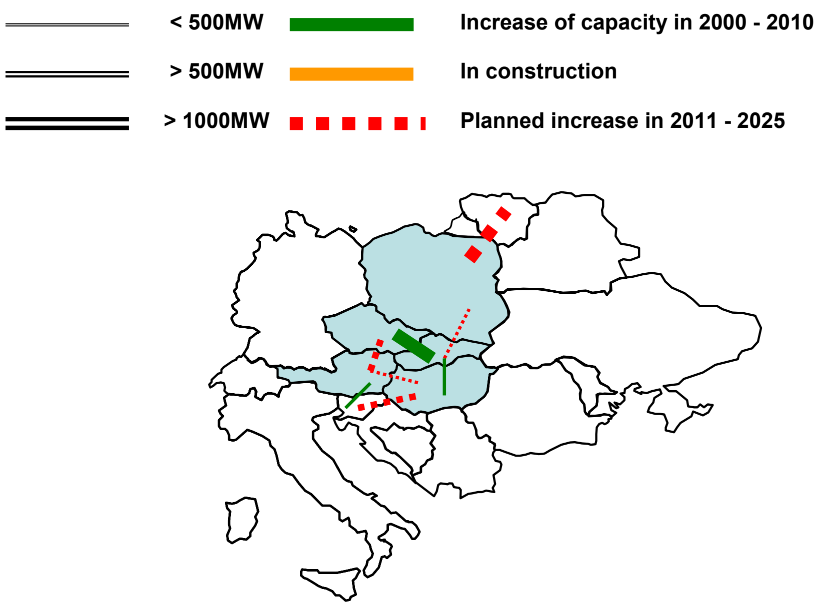

Figure 40 Central Eastern European interconnectors.

5.10.2. Austria

According to the analysis in this study, Austria has in the past favoured increase of consumer welfare. This is implied by the fact that the cross-border capacities of Austria have diminished. Future plans include capacity increase with the Czech Republic and Hungary.

Austria is centrally located in the European transmission network. It is both a transit country and an important provider of regulating power from its storage hydro plants. Austria has historically a weak internal North-South connection which is dealt with by limiting the NTCs towards most of its neighbouring countries. After many years of delays, mainly linked to local opposition, the missing link of the 400kV ring in the East was taken into operation in 2009. This has improved the situation and the capacity in particular towards Slovenia has increased. However, the NTCs with the Czech Republic, Hungary and Italy still remain modest and with Slovakia there is no interconnection in spite of the minimal distance between appropriate connection points.

Austria has declared that there is no congestion between Austria and Germany. If there was a price zone border towards Germany, this would automatically mean that the Western part, which is part of a German control area, would be in another price zone than the Eastern part.

In Austria prices would rise if interconnection capacity to Italy was developed. Perhaps this is one of the reasons why Austria has not succeeded to develop transmission capacity towards Italy even if this interconnection has the highest social welfare increase potential for Austria.

Austria aims to keep its TSO vertically integrated. As there is a good forecast for increasing profitability of regulating power, network expansion will probably concentrate on getting higher profits from the existing and future hydro power plants.

Austria strongly opposed the solution adopted for the ITC mechanism claiming that the compensation for transit countries is too modest.[183] Austria indeed suffers from excessive loop-flows. According to Figure 21 the losses due to loop flows for Austria in form of non received congestion rents is estimated to be 35M€ per year in 2008.

In summary, the Austrian TSO Austrian Power Grid (APG) has finally made progress with the crucial reinforcements of the internal transmission grid, beneficial for the whole Europe and is now putting emphasis on the grid development necessary for exploiting the Austrian hydro power potential.

5.10.3. Czech Republic

The Czech TSO ČEPS has clearly given priority to producer welfare according to the analysis in this study, because the import capacity from the only import direction Poland has been reduced and the export capacity to Slovakia and Austria has been or is planned to be increased. This behaviour is beneficial for power producers but might also be rational from the national interest point of view. The Czech market is so strongly connected to the German market that price convergence is very likely.

[183] APG, annual report 2009, 2010

Price convergence will be even higher when the Czech-Slovak market will be integrated into the North West European market coupling. Thus it could be acceptable for the governments of the Czech Republic and Slovakia that the overall national welfare is increased through the revenues from exports. Consumers will in any case have competitive prices through efficient market integration.

ČEPS is one of the key players regarding the development of the European transmission grid. The Czech Republic is the country which is suffering the most from loop flows. According to Figure 21 the losses for the Czech Republic in form of non received congestion rents is estimated to be almost 100M€ per year in 2008. This might lead ČEPS to invest in protecting itself from external influence for example by installing phase shifters at its borders.[184] Alternatively, ČEPS could also choose to be an active player in building the new European transmission system. The current changes in the ownership of the German TSOs might help choosing this option.

In summary, the Czech TSO's strategy has been fully aligned with the government policy to maintain the role of Czech Republic as a major exporter of electricity.

5.10.4. Hungary

According to the analysis in this study, the Hungarian TSO has shown preference for producer interests, mainly because the capacity from Romania has been reduced. This is the expected behaviour of a vertically integrated company. Future plans show more import oriented investments with Slovakia and Austria and also an export oriented investment with Slovenia.

Hungary is an example of a country where the interest for keeping the electricity price reasonable conflicts with the state owned generation and supply company interest for higher profits. Hungary has a relatively tight demand supply balance so it is dependent on its neighbours. Additionally three of its neighbours, Croatia, Slovakia and Serbia, are also importing countries. Fearing shortage of supply, the Hungarian government has in the past obliged domestic generators to serve Hungarian consumers first.

Hungary struggles between regulating end-user prices and creating a well functioning market with competitive prices. Hungary reversed its unbundling decision by reintegrating the TSO into the incumbent company. Hungary has actively developed its network but the cross-border capacities

[184] CEPS, comments on EWIS study, 2010

are dependent for example on the decisions of Austria on how to distribute NTCs between its interconnections. Developments regarding the power exchange in Hungary and market coupling with the neighbouring countries could be very important for the Hungarian market. As discussed in Chapter 3, end consumers in a small high price country have a strong interest to connect tightly with a big neighbouring low price area.

To sum up, the Hungarian TSO Mavir has been active in developing the network but the obvious gains for consumers from reaching price convergence with the neighbours have not yet been realised.

5.10.5. Poland

According to the analysis in this study, the Polish TSO Polskie Sieci Elektroenergetyczne Operator S.A. (PSE Operator) has in the past given strong preference for consumer welfare. This result is mainly because of the significant decrease of export capacity towards Germany and Slovakia and because the import capacity was increased through taking into operation the SwePol link with Sweden. One needs to note, however, that the export capacity decrease is mainly due to loop flows from German wind power and that the Swepol link was decided between vertically integrated monopolies but started operation only in year 2000. Regarding future investments in cross border capacity, Poland has included a small increase of capacity with Slovakia and the LitPol-project with Lithuania in the ENTSO-E ten year network development plan. Thus no major increase in social welfare through additional interconnection capacity neither for producers nor for consumers is foreseen.

The current price level in Poland does not seem sustainable. Poland needs to renew a considerable part of its generation capacity in the coming years. There are no resources available in Poland to produce cheap electricity taking into account the emission allowance costs. Building nuclear capacity takes at least twenty years as there is no regulatory framework in place yet for nuclear power. Thus an alignment of the Polish electricity price with the Central European price seems evident in the short and medium term.

Poland has regulated prices and has used export restrictions in the past to prevent extreme price spikes and shortage of supply. Poland has historically a weak transmission network with frequent congestion inside the grid. Congestion is aggravated by the injection of German wind power in the North and its return to Germany in the South through Southern Poland and the Czech Republic. The congested grid prevents optimal dispatch of generation in Poland and the full use of interconnectors including the SwePol link to Sweden. The TSO has ambitious plans to reinforce the grid including increasing connections towards Germany and constructing a link with Lithuania, but the progress is very slow. The political backing for getting the necessary permits and financing has not been sufficient.

Finding a solution to the North-South flows originating from wind generation is indeed a European level question. According to Figure 21 the losses due to loop flows for Poland in form of non received congestion rents is estimated to be 40M€ in 2008. If Poland does not consider strengthening the transmission grid to host these flows to be in its national interests, increasing North-South capacity will be difficult as explained in Chapter 4. A careful consideration of the approach is necessary as imported wind power could provide Poland with cheap electricity subsidised by other Member States. As one option, PSE Operator is analysing whether nodal pricing could improve congestion management in Poland.

In summary, the Polish TSO PSE Operator has not managed to develop the grid in pace with the increasing requirements and thus there has been a decrease of cross-border capacities. This has lead, according to our analysis, to a transfer of welfare from the Polish generation companies to the consumers. The obvious downside of the Polish policy in this regard is the generation adequacy problem that Poland faces in the coming years.

5.10.6. Slovakia

According to the analysis in this study the Slovakian TSO Slovenska elektrizacna prenosova sustava (SEPS) has given a slight preference for consumer interests in the past. Interconnection capacity with the Czech Republic has been increased. A substantial increase of capacity with Hungary has been planned.

Slovakia has a relatively strong transmission grid. The Czech Republic and Slovakia have coupled their markets through market splitting justifying it with the strong physical connection between the two countries. There is indeed almost full price convergence. SEP, the old incumbent generator nowadays owned by ENEL, has plans to build new nuclear power plants. The Czech-Slovak price has a strong alignment to the German price which will probably continue in the future. It could be acceptable for the Czech Republic and Slovakia to increase national welfare through revenues from exports rather than through lower prices to consumers. In any case, Slovakia as a small system has already profited from its integration in the regional market which should be further improved when the flow based methods and market coupling with the rest of the region will be implemented.

Slovakia has used export fees to prevent electricity produced in Slovakia to be exported to other countries.[185]

North-South loop flows are strongly affecting Slovakia. According to Figure 21 the losses for Slovakia in form of non received congestion rents are estimated to be almost 40M€ in 2008.

5.10.7. Slovenia

Slovenia has given preference for consumer welfare as it has been able to increase capacity from import directions in the past and is planning to do so in the future. Slovenia's TSO Elektro-Slovenija (ELES) is part of the fully integrated state owned electricity company. Through political decisions at the beginning of the electricity market opening, the benefits of congestion rents at the Italian border were kept with the generation company for some time.[186]

Slovenia has suffered from low level of commercial capacity apportioned to it at the Italian border compared to the actual physical flows through Slovenia. France on the contrary has a commercial capacity exceeding the physical flows at the Italian border, Switzerland and Austria being quite balanced in this respect. Thus Slovenia is a good example of how national interests influence discretionary decisions on commercial capacity. One argument used against Slovenia requesting a higher NTC towards Italy has been its relatively weak connection to Italy. After ELES installed a phase shifter at the Italian border, NTC values have been readjusted in favour of Slovenia.[187]

5.11. Western and South Western Europe

5.11.1. Regional overview

Western and South Western Europe includes three big countries, France, the UK and Spain, three smaller countries, Belgium, Ireland and Portugal and one very small country, Luxembourg. This region is very interesting from electricity point of view. Three major technologies for carbon free

[185] EFET, Slovakian export fee, 2008

[186] Council Regulation (EC) No 1223/2004 of 28 June 2004 amending Regulation (EC) No 1228/2003 of the European Parliament and of the Council as regards the date of application of certain provisions to Slovenia

[187] Source: ELES

electricity production, wind, nuclear and solar power, are strongly prevalent in this region.

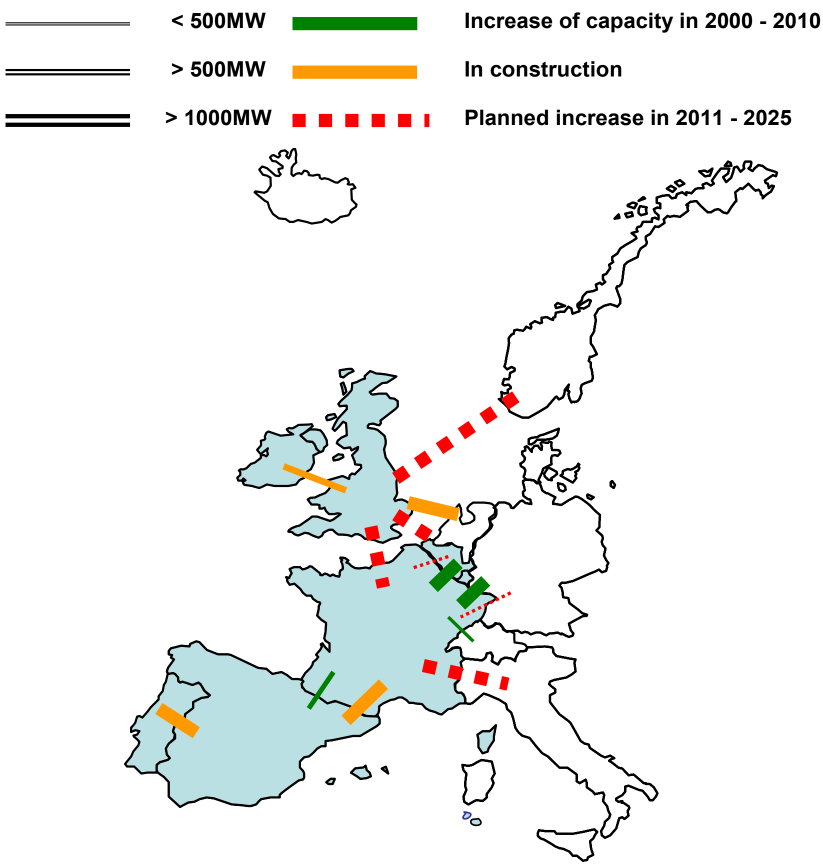

Figure 41 Western and South Western European interconnectors.

5.11.2. Belgium

The past behaviour of the Belgian TSO Elia has been strongly consumer welfare oriented according to the analysis in this study. Elia has pursued a tighter connection with the neighbouring countries. With market coupling with France and the Netherlands already in 2006[188], and with the North West European market coupling from November 2010[189], Belgium is well integrated into the European market. The new project to the UK will have more focus on producer welfare if the flow pattern remains from the continent to Great Britain.

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188 Belpex, trilateral market coupling, 2006

189 Belpex, NWE market coupling, 2010

The Belgian transmission system operator Elia has been transformed from a vertically integrated company to a company with a majority of the shares listed on the stock market and the remaining shares mainly owned by Belgian municipalities. Elia has been able to increase cross-border capacities even if the increased flows from wind power in Northern Germany have strongly influenced these capacities. Some cross-border investments have been relatively easy, such as adding a new circuit to an existing interconnector with France.[190] Elia has invested in three phase shifting transformers which it considers necessary for managing variable wind power flows.

The Belgian market is very concentrated. This could be one of the reasons why Elia has efficiently connected the market with the neighbouring markets, through investments in the network and through promoting market coupling with the neighbours. This development might also have been in the interest of the incumbent which is strongly established in all neighbouring countries as well. Otherwise the risk of regulatory intervention in the incumbent's behaviour would have been even higher than today.

Recent developments have reduced market concentration. GDF Suez and Eon swapped assets in Belgium and Germany in 2009 and EdF sold one of its Belgian power plant projects, both at the request of the European Commission. Also several other companies have power plant projects in Belgium.

With the acquisition of the former transmission grid of Vattenfall in Eastern Germany Elia becomes a major player in Germany. It remains to be seen how the relations with the German government and regulator develop in the future. Elia has a good understanding of the consequences of developing wind power. It could thus lead in finding European solutions to grid development together with other affected parties such as the Dutch, Polish, Czech and Slovak TSOs.

In summary, the Belgian TSO Elia has pursued a policy to become properly unbundled and to integrate Belgium strongly into the European market for the benefit of consumers. Now there are already more challenging targets in sight.

[190] ELIA, Avelin-Avelgem, 2005

5.11.3. France

According to the analysis in this study, the French TSO RTE has in the past sought for both consumer and producer welfare in a rather balanced manner. In addition to substantial increase in export capacity to Belgium, some capacity increase has also been made towards Switzerland and Italy. RTE has been able to increase import capacity from Germany. This capacity increase has been perhaps due to recalculation of the NTC as there has been only one substantial investment project realised between Germany and France in the observation period 2000 – 2010.[191] The fact that Germany has changed from an importing country to an exporting country can also have influenced the cross-border capacity with France.

Regarding planned investments RTE gives clearly priority to producer welfare. There are important interconnector projects to all main export directions in the ENTSO-E ten year network development plan, namely towards the UK, Spain and Italy. The Spanish interconnector development is based on an engagement following a merger case.[192]

The future electricity balance in France, still the biggest exporter in Europe, is uncertain.[193] If France maintains and further develops the nuclear surplus capacity, it could export more than today. If nuclear capacity in France will just follow domestic demand increase, France will become a country with a changing import and export pattern. In this case in peak consumption periods France will import and in low load periods France will export as much as the interconnectors allow.

France has strongly supported maintaining vertical integration. France has until now maintained a monopoly on nuclear power and has not tried to dilute the dominant position of the incumbent through structural measures. EdF has profited from liberalisation being able to make important investments outside France. EdF is present in almost all parts of Europe through acquisitions and shareholdings in several companies.

A dilemma for France is that potentially the electricity price in France could remain lower than in the neighbouring countries because of the high share of old nuclear power. However, EdF is not obliged to offer electricity to the market at the variable costs of the marginal plant even if it has a dominant position in France.[194] Prices in the French market rather align to

191 RTE, Vigy-Uchtelfangen, 2003

192 EC, competition case EnBW, 2002

193 Senat, Billout et al, security of French electricity supply, 2007

194 CRE, market monitoring 2007, 2009

German prices even when demand is low and there is a lot of idle nuclear capacity. In France the nuclear capacity is far higher than the lowest consumption levels and therefore EdF regulates down nuclear plants when consumption is low. The marginal variable cost in those instances could even be negative.

The French government's solution to this dilemma has been to regulate end user prices. As this is against European legislation, a new law, Nouvelle organisation du marché d'électricité (NOME), obliges EdF to sell a considerable amount of electricity to French suppliers at a price linked to production cost with the idea that the price for the French end-consumers would not increase even if the regulation of end-user prices was lifted.[195] The NOME-law will thus in practise introduce a two-price system, a lower price for French consumers and a higher price linked to the German price for any exports and imports.

This system of two prices is a radical way to redistribute social welfare benefits. The system will allow the incumbent company to collect profits from exports but most of these benefits are transferred to French consumers through the regulated electricity price. In this way the overall social welfare for the country is increased without a welfare loss for the French end consumers. It goes without saying that this method does not fit well to the idea of the European internal electricity market.

The French TSO RTE has actively promoted efficient methods of capacity allocation, in addition to promoting new interconnectors. It has the best resources among the TSOs in Europe, it has been innovative and involved in the European co-operation. Well functioning markets and efficient cross-border trade are probably also in the owner's interest.

5.11.4. Ireland

According to the analysis in this study, Ireland has in the past been passive regarding interconnectors thus giving preference for producer interests. Now an interconnector with Great Britain is being built with a promising business case. The role of the existing link between the two islands, the Moyle interconnector, has been adapted to the Single Electricity Market (SEM) which integrates the whole Ireland. Interconnectors between North and South are treated as internal lines in the SEM.

Ireland is another example of a country where the national interest in imports and in keeping the electricity price reasonable conflicts with the

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195 CERNA, Leveque and Saguan, loi NOME, 2010

generation and supply company interest in higher prices. In Ireland the electricity prices are still largely regulated even if there is a plan to introduce competition in the retail market dominated by the incumbent. Ireland has opted for an Independent System Operator (ISO) structure for the TSO Eirgrid.

The Irish TSO has been in the past strongly integrated into the incumbent electricity company. With unbundling and with a new interconnector with the UK the future seems to be increasingly market based.

5.11.5. Luxembourg

In Luxembourg the electricity sector remains vertically integrated. There is a plan to interconnect the Western and Eastern systems, which would mean that the transmission system of Luxembourg could play a role in the European system. Almost all electricity is imported.

5.11.6. Portugal

According to the analysis in this study Portugal has successfully increased consumer welfare by building interconnection capacity with Spain and there are plans to further increase this capacity in the future. The Portuguese TSO Rede Eléctrica Nacional (REN) together with the Spanish TSO Red Eléctrica de España (REE) have acted with a strong political backing to create the Iberian market. The Iberian market was delayed several times but is now operational. One possible reason for the delays was protecting generation company interests in Portugal. Portugal has maintained regulated prices for all groups of consumers.

The Portuguese TSO REN is ownership unbundled but the incumbent generation company has a minority share in it. Portugal is another example of how a small country with a high price level can get important social welfare benefits for consumers by improving connection with a bigger neighbour.

5.11.7. Spain

According to the analysis in this study, Spain has been neutral in the past regarding social welfare to consumers and producers. Capacity has been increased substantially to the export direction towards Portugal with a strong political backing from both countries. The start of the Iberian market after building lines between Spain and Portugal was delayed rather by the governments, for reasons perhaps related to protection of national markets.

Market integration has lead to a high level of price convergence between Spain and Portugal. Capacity from France has increased only modestly. Future plans show a clear preference for consumer welfare through the substantial increase of interconnection capacity over the Pyrenees.

The interconnector project with France has taken a long time to prepare and has only recently started the construction phase. As this interconnector from the outset should be in both TSOs' interest, the main reason for the delays might be the difficulty of crossing the mountains, not the company or national interests. The solution finally adopted is very expensive and will considerably reduce the social welfare benefits from that interconnector even if it will probably still be profitable. If solar power develops in the future in Southern Europe and Northern Africa to the extent some scenarios suggest, Spain could become a major gateway for electricity supply to Central Europe from the South.

The Spanish TSO REE is one of the privately owned TSOs without a direct owner's interest in generation. It is motivated to increase cross-border capacity but the success depends very much on France.

5.11.8. UK

The British TSO National Grid has not increased interconnection capacity at all in the observation period of this study, in spite of the important potential to increase social welfare for consumers in the UK according to our analysis. This has clearly been beneficial for generation companies in the UK. Now finally in 2011 the BritNed project between the Netherlands and the UK, a merchant link constructed by the two TSOs, becomes operational.

The passivity of National Grid and the most evident counterpart RTE is difficult to understand in light of the potential social welfare gains estimated in Chapter 3. A partial explanation for the non-action might be that the UK regulatory regime has been geared towards merchant interconnectors and has prevented financing interconnectors from the UK transmission tariff. Another explanation might be the presence of EdF on both sides of the Channel, even if increased trading possibilities over the Channel should also be in EdF's interests. However, future plans change the picture completely. Almost 4 GW of interconnection capacity is foreseen, not counting BritNed. A second link to Ireland is included among these projects, see the chapter on Ireland.

National Grid is perhaps the most independent TSO in Europe judged based on the ownership structure. Ofgem uses a very sophisticated incentive scheme to regulate National Grid's behaviour. For example, there have been incentives to remove bottlenecks inside Great Britain. The current regulatory regime has favoured merchant interconnectors financed through congestion rents. As the overall social welfare generated by interconnectors is only partially captured by congestion rents, the risk of underinvestment has been evident. The policy seems to be changing towards regulated interconnectors.[196]

To sum up, the British TSO Grid has pursued a producer welfare oriented policy by being passive regarding interconnector development, probably partly due to legal constraints. Now the picture seems to radically change.

5.12. Southern and South Eastern Europe

5.12.1. Regional overview

Italy is the main importer in Southern and South Eastern Europe attracting flows from all possible directions, Switzerland being the hub for these imports. Three South East European Member States, Bulgaria, Greece and Romania are only weakly connected with the rest of the EU. Between these three countries there could be a strong regional market with a lot of complementarities in the energy mix just like in the Nordic market. This situation has clearly not been exploited as cross-border capacities remain very small and there is hardly any new capacity planned. Even the existing transmission capacity is not utilised efficiently. For example, the Italy-Greece interconnector is half empty most of the time. Malta and Cyprus are not yet connected to any other country.

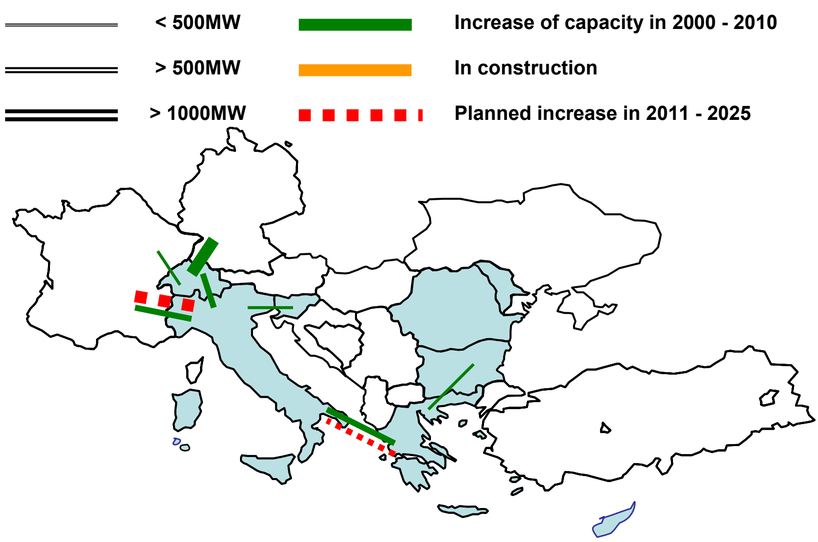

Figure 42 South East European interconnectors.

[196] Ofgem, interconnectors, 2010

In South East Europe, Romania and Bulgaria are potential exporters. However, in the future, the demand in these countries could increase making it difficult to predict the future electricity balance.

5.12.2. Bulgaria

The Bulgarian TSO Elektroenergien Sistemen Operator EAD (EOS) has given priority to generation interests by reducing capacity from Romania, which is an import direction, and increasing capacity to Greece which is an export direction. Overall capacities to both directions remain relatively small.

Bulgaria is only at the beginning of market liberalisation. Electricity is largely in the hands of the vertically integrated state owned company, even if independent power producers exist in Bulgaria. The integrated company held until recently a monopoly for cross-border trade. Cross-border fees have been applied in Bulgaria to protect the market even if they are illegal in the EU. [197] The behaviour of Bulgaria seems short sighted in the light of Bulgaria traditionally being a major exporter in South East Europe. Bulgaria could seemingly profit from investments in power generation and would strongly benefit from interconnectors as well as from a well functioning market. It could supply other countries in South East Europe, many of them having a deficit in electricity supply.

5.12.3. Cyprus

Cyprus does not have any existing or planned interconnectors at the moment.

5.12.4. Greece

The behaviour of the Greek TSO Hellenic Transmission System Operator (HTSO) is difficult to analyse with the method used in this study because there are many special features in the Greek electricity market. The capacity from Bulgaria, which is the main importing direction, remains surprisingly low even if it has been increased in the past. This indicates a preference for producer interests. In Greece the power sector is vertically integrated, very few potential competitors have shown interest to enter the market. Prices remain regulated, except for the biggest industrial consumers.

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

The utilisation ratio of the interconnector with Italy is very low. Capacity on this interconnector has been curtailed when there has been shortage of supply in Greece. The shortage of generation capacity is a natural consequence of having regulated prices, thus lacking proper scarcity signals.

To sum up, the behaviour of the Greek TSO HTSO is aligned to the overall government policy to limit competition and to regulate prices.

5.12.5. Romania

Romania is a large country but the interconnection capacities to the neighbours are very small. For the Romanian TSO, Transelectrica, the analysis in this study shows a preference for consumer interests as export capacities have been considerably reduced in the past and no increase is planned according to the ENTSO-E ten year network development plan. This partly prevents optimal use of resources in South East Europe which has a lot of complementarities regarding the generation mix.

5.12.6. Italy

The Italian TSO Terna has in the past shown preference for increasing consumer welfare by increasing import capacity. Several projects exist to further increase import capacity in the future.

In spite of about 6 GW of import capacity today, the price difference with the neighbouring countries remains significant. One reason for this is that Italy is the only big country in the EU besides Poland without nuclear power. Together with the other past energy policy decisions this has resulted in the highest electricity wholesale prices in the EU. This is true in spite of Italy being one of the rare countries which took important structural measures to reduce the dominant position of the incumbent generation company. The consequence of these high prices is that all electricity transported to Italy is very profitable. The volume of the electricity trade with Italy is so high that the transmission lines to Italy are permanently congested and the flows are felt in the whole Central European transmission system.

The TSO Terna has ENEL, the incumbent generation company, as a minority shareholder. The transmission network in Italy is weak and there are many bottlenecks inside the Italian system. This has lead to splitting the country into six price zones. Increasing import capacity is an important political target for the government. Several attempts have been made to reserve part of the imported electricity to industrial consumers in order to avoid them paying the high Italian price. Part of this policy has been to promote merchant lines, in particular with Switzerland. Terna also has several projects to build more import capacity. However, building new lines in the alpine area is difficult and as imports are already at a high level, there are serious system security concerns linked to capacity increase.

Italian high prices have attracted plenty of new generation investments mainly based on gas. The pressure on imports has become a bit smaller, in short periods Italy has even been exporting, which was unthinkable in the past. It is likely that to reduce prices, further generation investments in Italy are necessary as there is no transmission technology in sight that could allow to solve the problem of high prices by only increasing imports.

In summary, the Italian TSO Terna has pursued a consumer welfare oriented policy and has tried to operate efficiently the relatively weak transmission grid.

5.12.7. Malta

Malta has only a distribution network. A cable to Italy is planned.

5.12.8. Switzerland

According to the analysis in this study, in the past Switzerland has been able to increase consumer welfare. One has to be careful with this result, as Switzerland is an extreme transit country and only a simultaneous analysis of all changes in cross-border capacity at the Swiss borders, which is not done in this study, would give a more reliable result.

The Swiss transmission grid is still owned by generation companies. Now the assets are transferred to the TSO Swissgrid, but the generation companies remain the owners of the TSO.

Switzerland has increased import capacities from commercially interesting import directions, which would normally lower prices and reduce benefits for the Swiss generating companies. This unexpected behaviour could be explained by the fact that the Swiss market is not open and the prices for final consumers are to a large extent regulated but exports can be made at prices of the neighbouring markets. Thus imports are mainly done by the generation companies themselves for reselling the electricity abroad for increased profits. The Swiss Federal Energy Agency reported that the difference between the income from exports and the costs for imports was 2115 million SFR (about 1600 million Euros) in 2008.[198] Additionally, the increase of import capacity from France is all used for the

[198] Swiss Federal Office of Energy, electricity statistics 2008, 2009

long-term contracts between EdF and Swiss Companies for free under priority reservation, thus profiting again directly Swiss generation companies.

Switzerland has a strong dilemma regarding its relation with the EU electricity market. Switzerland has been allowed to fully participate in the EU electricity market and Swiss companies are among the most active traders in Europe. Swiss traders were early to profit from trading opportunities and they are still making big profits from the contracts made in the past. In contrast, access to the Swiss market is only very limited for non-Swiss companies which makes it difficult for them to trade inside and around Switzerland. Additionally most of the profitable import and export transmission capacity is retained by the Swiss generation and supply companies, a practise which is not allowed in the EU. Consequently the value of potential congestion rents is collected by the Swiss generation and supply companies and increases their profits, instead of being collected by Swissgrid which would use congestion rents for investments. Thus Swiss consumers are losing as they have to pay a higher transmission tariff than what they would pay if all potential congestions rents were received by Swissgrid.

Swiss generation companies are allowed to trade freely in Europe. Further integration of Switzerland to the European electricity market is hardly possible without an agreement between the EU and Switzerland.[199] If the Swiss took a longer term view, they might conclude, like Norway has already done, that a deeper integration in the EU market gives the best value for the Swiss hydro power. An agreement would also give a more stable investment environment for energy investments in Switzerland.[200]

To sum up, the Swiss TSO Swissgrid and its predecessors have followed carefully the owners' interests. It remains to be seen how unbundling and other planned changes affect its behaviour in the future.

5.13. Other third countries

Russia, Ukraine, Morocco and the non-EU South East European countries including Turkey are trading electricity with the EU Member States. The level of trade and reciprocity in market access depends on the country. Some of these third countries have an electricity deficit, some of them are

[199] EC, Oettinger speech, 2011

[200] EC, Barbaso speech, 2010; Swiss Federal Office of Energy, Leuenberg speech, 2010

keen to sell electricity to the EU. There has been some increase in these cross-border flows, in particular imports from Ukraine developed in the observation period 2000 – 2010. The motivation for trade varies depending on the country, in some cases the income from the electricity sold is the most important, and in other cases security of supply or political influence through interconnection are the driving factors.

5.14. Summary of the TSOs' behaviour

The results of the analysis based on social welfare calculations and empirical knowledge of the TSOs' behaviour are summarised in Table 8. The table summarises the national and company interest factors identified in this study for all EU countries except Malta and Cyprus, and for Norway and Switzerland. The factors in the table are divided into two parts, negative and positive factors. Negative factors are illegal or harmful practises from the point of view of European transmission investments, for example if they unduly try to transfer social welfare benefits from one Member State to another. Positive factors are practises which are favourable to transmission investments such as ways to redistribute social welfare inside a Member State in order to get acceptance for these investments.

From Table 8 one can see that regulated prices are still a very common practise, even for industrial consumers. Regulated prices do not only disturb prices in the market but they are also an indication of lack of motivation of the Member State for establishing a functioning electricity market in their own country. One could argue that such a country is not interested in investing in interconnectors or at least the criteria for deciding on investing in interconnectors might not be the same as for those countries who believe in functioning electricity markets.

Regarding the positive factors, investing in wind power is becoming more and more important to justify interconnector building. Denmark, Spain and Germany need to export in the peak production periods, otherwise wind power would be difficult to integrate into the system. The basic reason for interconnector investments, namely increasing social welfare, applies to most European countries. For importing countries this factor is evident. For exporting countries often a factor that mitigates the negative effects of redistribution of social welfare from consumers to producers is the public ownership of generation companies. This helps in many countries accepting additional welfare benefits for producers as public ownership allows using various methods to circulate these benefits back to citizens.

Another important factor on the positive side is the possibility for the TSO to increase congestion rents. This possibility is quite common as many borders are far from price convergence. The aim to achieve price convergence with the neighbouring country is also among these positive factors, even if it means that congestion rents are reduced. The cases where this applies are very important for the development of the single electricity market. Potential price convergence areas are Central Europe, the Nordic countries and the Iberian peninsula.

The possibility to redistribute social welfare through taxes and levies shall also be considered as a positive factor. This applies in particular for Germany and Denmark which collect funds for supporting renewables from grid tariffs and for Norway and Switzerland which collect taxes and concession revenues for public bodies. Industrial policy could promote investments in the grid in countries which have companies producing equipment for transmission systems, in particular in Germany, Sweden and France.

Regarding negative factors, an important one is causing loop-flows to neighbouring countries. Where this is possible, in particular in Germany and France, it reduces the motivation of the TSO for investing in the grid as the system can be operated by partly using the grid of the neighbours. Analogically, the countries which suffer from loop-flows such as the Czech Republic, Poland, Slovakia, Belgium, the Netherlands and Austria, are not keen to develop their grid if it is mainly used by the neighbour. A similar negative factor appears when the TSO has a possibility to hoard commercial capacity at the most wanted border, usually possible for big countries with several interconnections.

Both import and export limitations are common practises regarding interconnections. These limitations can be used for influencing prices in a country, but often they are used for managing internal bottlenecks in the grid. The motivation for increasing interconnection capacity is small if this increase aggravates internal bottlenecks and makes their congestion management more difficult.

Regulating wholesale prices, prices for industry and prices for households, still common practises in many countries, distort the price signals for generation investments, usually also making building interconnectors less attractive. Lack of generation investments is sometimes compensated by export fees or export limitations in tight supply situations. Examples of this type of measures can be found in Bulgaria, Romania, Slovakia, Spain, Poland and Greece.

A special case regarding price regulation is France which is introducing a two price system. Even if the measure as such shall be considered negative, it can boost interconnector investments as the wholesale price is decoupled from the end user price in France. In this way export revenues can be increased without influencing too much the price for French consumers.

Table 8 Summary table of the factors that influence transmission investments based on the analysis in this study.

How the national or company interests appear?	Discussed in Chapter	APG (AT)	ELIA (BE)	NEK (BG)	CEPS (CZ)	Energinet.dk (DK)	Elering (EE)	Fingrid (FI)	EdF-RTE (FR)	German TSOs (DE)	HTSO (GR)	Mavir (HU)	Eirgrid (IE)	Terna (IT)	Augstprieguma Tikls (LV)	Lietuvos Energija (LT)	Sogedel (LU)	Tennet (NL)	Statnett (NO)	PSE-Operator (PL)	REN (PT)	Transelectrica (RO)	SEPS (SK)	ELES (SI)	REE (ES)	SVK (SE)	National Grid (UK)	Swissgrid (CH)
Positive factors																												
Mitigating variability of wind power	2.7					x				x			x					x			x				x		x	
Possibility for major congestion rent increase	3.3	x				x			x	x				x					x	x				x		x	x	x
Possibility for major consumer welfare increase	3.4				x					x	x	x	x	x				x			x		x		x		x	x
Possibility for major producer welfare increase	3.4	x		x	x			x	x										x	x		x	x			x		x
Price convergence	3.13	x	x		x		x	x	x	x		x			x	x	x	x			x		x		x	x		x
Redistribution of social welfare through taxes and levies	4.4					x				x									x									x
Generation welfare to the local public owners	5.9	x		x	(x)	x	x	(x)	x	(x)	x	x	x	(x)	x	x			x	(x)	x	x		x		(x)		(x)
Industrial policy	5.9					x			x	x																x		
Negative factors																												
Causing loop flows to neighbouring countries	4.2								x	x																		
Suffering from extra physical flows	4.2	x	x		x													x		x			x	x				x
Hoarding of commercial capacity	4.2	x							x	x				x														
TSO limits unduly imports	4.3	x								x	x																	
TSO limits unduly exports	4.3			x						x	x									x						x		
Regulation of wholesale price	4.5								x				x			x												
Regulated prices for industry	4.5			x		x	x		x					x							x	x						x
Regulated prices for households	4.5			x		x	x		x		x	x	x		x	x				x	x	x	x		x			x
Cross-border fees	4.5			x																		x	x					
Use of security of supply clauses to restrict exports	4.6										x									x					x			
Redistribution of social welfare through a two price system	5.9								x																			x
Passivity in building interconnectors	5.9	x		x						x	x									x		x				x	x	

Finally the table identifies countries which have been passive regarding interconnector investments for various reasons even if there would have been a high potential for welfare benefits. For Austria, in addition to the loop flows discussed above, acceptance of new transmission infrastructure has been particularly difficult. German TSOs have been passive in particular regarding investments for increasing imports which would lower prices in Germany. The Swedish TSO has been passive regarding investments in increasing exports which would increase prices in Sweden. The UK TSO has had legal restrictions in investing in interconnectors. For Bulgaria and Romania it is quite difficult to understand the reason for the passive behaviour regarding interconnector investments.

6. CONCLUSIONS

6.1. Evaluation of the methodology used in this study

The methodology used in this study consists of an analytical and an empirical part. The analytical part, for which a method is developed in this study, uses current congestion rents and interconnection capacity as the basis to analyse how much welfare gains could ideally be achieved by building interconnectors. Year 2008 is used as the reference year because there is a full set of data available for that year and it was almost unaffected by the economic crisis, contrary to year 2009, another possible candidate for the reference year. There are differences in prices and cross-border trade patterns from year to year, for example year 2010 was very dry in Scandinavia and there was much more South-North flows in the interconnectors than in the past. Thus the results are specific for the reference year. However, the variations between years do not dramatically change the overall results obtained in this study even if they might influence the results at some interconnections.

After calculating how much welfare the past and planned interconnection capacity increase has generated and could potentially generate in the future, a behavioural pattern for each TSO is developed. The pattern is based on analysing which potentially profitable projects have been promoted and which have not. This pattern is then compared with what would be the assumed behaviour of the TSO according to the company and national interests. To validate the results from this analysis, empirical knowledge on real interconnector projects is used. It is studied whether the actual behaviour of the TSOs regarding investments is equal to the assumed behaviour according to the national and company interests or whether the success or failure of the TSO to invest is better explained through other factors.

The methodology has provided some interesting findings. It provides a good combination of analytical results and their validation through empirical knowledge. The analysis is based on real data and not on scenarios. This is at the same time the strength and the weakness of the methodology. Investment decisions on interconnectors need to be based on their future profitability which requires the use of scenarios. Developing a scenario for the future system would, however, require significant further assumptions which could introduce additionally arbitrary elements in the analysis. This is why the situation in 2008 is used as the base case for the analytical part of this study.

The quantitative analysis of welfare gains in this study is only used as an indicator to reveal and compare TSOs' behaviour. The results should not be used as such for the profitability calculation of any interconnector as the analysis is not designed for that purpose. Using standard investment costs for interconnection capacity is one important simplification which reduces the usability of the results regarding profitability. However, in spite of these limitations, the results give an indication which interconnectors have the highest potential for welfare gains and how these gains are distributed. The results also serve as a model for the information that needs to be made available to stakeholders in the context of a public consultation on an interconnector project. Be it a single interconnector case or a regional or European plan, decision makers and stakeholders need to understand the effects of new interconnectors on the market and on the welfare distribution.

One strong assumption in the analysis is the use of the price load correlations in spot markets as a proxy for supply curves. Using these correlations, the calculation answers the question what had been the change in market results if interconnection capacity would have suddenly been increased in 2008. It is clear that the supply curve reflecting long term elasticity is different. For constructing long term supply curves it is necessary to make assumptions on what kind of generation capacity will be constructed or withdrawn if the supply and demand balance in the countries involved changes due to a new interconnector. It is also clear that no national system has enough spare generation capacity necessary to supply the electricity to fill several thousands of megawatts of additional interconnection capacity, which was in some cases necessary for reaching the full or the optimal price convergence point. In this sense the results of calculation for these cases are unrealistic. For these reasons it is necessary to emphasise the indicator nature of the calculated values.

The analytical method used in this study is less well adapted for countries with a high share of transit flows because in this study each interconnection is analysed separately. For transit countries it is important to analyse the development of all interconnections in an integrated manner including the increase both in import and export capacity. In spite of this, even for transit countries the results give a good insight of the past and potential future welfare gains when properly interpreted.

For countries in which significant loop flows decrease cross-border capacities, such as Poland and the Czech Republic, one should be careful in drawing conclusions from the welfare calculations in this study. For these countries calculating welfare border by border does not properly take into account the effect of loop flows, thus regional models should be used instead.

6.2. Results regarding the research objective

The study has provided strong evidence that national and company interests have influence on cross-border transmission investments. The findings indicate that national and company interests have contributed to serious underinvestment in the European transmission network from the overall social welfare point of view. The study has identified an overall annual social welfare potential of around one billion Euros when increasing interconnector capacity between regions, from which potential only about two thirds is addressed in the first ENTSO-E ten year network development plan.

The study has shown that the EU Member States have very different possibilities to benefit from interconnector investments. In high price countries lowering the price through increased imports is an obvious target for the government. For example in Italy, the Netherlands and Portugal interconnectors have been built with this target in mind. Other targets have been pursued as well, for example Finland and Belgium have achieved a high level of price convergence with the neighbouring countries through building interconnectors. The welfare effect of increased competition achieved through price convergence can potentially be far more important than the social welfare benefits from price arbitrage. This welfare effect is, however, not analysed in this study as it would require a completely different approach.

The study has revealed the beauty contest nature of interconnector investments. In particular in countries with several borders, prioritisation of developing interconnectors probably is necessary for reasons such as limited resources of the TSO and limited capacity of the country to absorb more imports or exports. For this prioritisation maximising the TSO or national benefits seems to be one important criterion.

The study has investigated how vertically integrated TSOs behave with respect to their owners' interests. Vertically integrated TSOs, often situated in exporting countries, prioritise investments which increase income for their owner through a higher market price in their home country and through improved export possibilities. Profitable interconnectors in import directions are sometimes not developed at all, such as in the case of the German TSOs in the past or in the case of the French TSO regarding planned investments.

The behavioural pattern is less clear for the majority of the TSOs which are publicly owned or with a mixed public/private ownership and can be considered as semi-independent because the state owns also generation assets. Among these TSOs the behaviour varies considerably from generation welfare oriented, such as the in Czech Republic and Norway, to consumer welfare oriented such as in Belgium, Sweden, Poland and Slovakia. The study discusses in the empirical part reasons which could explain these differences, for example plans to expand nuclear generation capacity, importance of increasing competition or reducing prices, or as in the case of Poland capacity reductions because of loop flows from neighbouring countries.

Independent TSOs without interests in generation business, often situated in importing countries such as Italy, the Netherlands and Portugal, align their behaviour to the national interests in order to lower electricity prices and increase competition by increasing import capacity. Interconnector projects have been successfully finalised and there are more projects planned for the future. An exception of this behaviour is the UK TSO which has been passive regarding interconnector building in spite of the high potential for welfare gains, probably because of the legal restrictions to finance interconnectors from tariffs.

The assumption of the TSO behaviour is validated by analysing how TSOs have developed interconnectors in meaningful directions,[201] depending on the type of ownership of the TSO on each side of the border. The analyses uses simple assumptions that (i) a vertically integrated TSO prefers to increase capacity only to export direction, (ii) an independent TSO is positive both to export of import capacity increase and (iii) a semi-independent TSO with an indirect link to generation business acts neutrally. The results indicate that TSO ownership has had a strong influence on the choice of interconnectors which have been developed in the past and which are planned to be developed in the future, see Figure 43. Further unbundling of vertically integrated TSOs already seems to have influenced the planned interconnector projects in such a way that a higher share of the overall social welfare potential will be addressed in the future compared to the past. A good example is the interconnector project between Germany and Norway.

201 Meaningful direction in this study is the predominant direction of commercial flows in 2008.

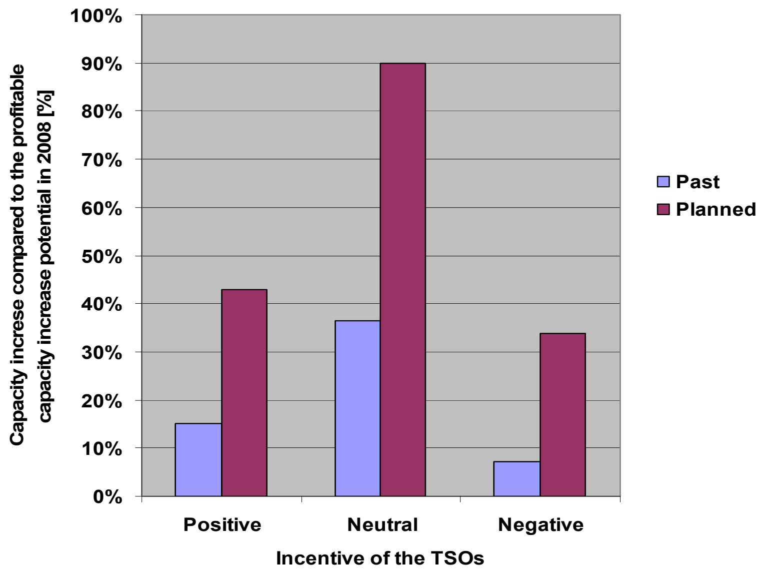

Figure 43 Influence of the ownership of the TSO on the past and planned interconnector investments.[202]

The study has demonstrated that there is an important dimension of welfare distribution between the two countries involved in an interconnector project due to the change in the market outcome in both countries. The effects depend on several parameters such as on the price elasticity and on the variability of market price in the markets to be connected. The effect can be very different on each side of the border, for example the increase of the absolute welfare for one country can be much higher than for the other. The study also has demonstrated that there is an important dimension of internal welfare distribution within the two countries involved. This is due to the transfer of welfare between producers and consumers. For this reason at least part of the benefits are often redistributed back from the winners to the losers inside each country. A two price system in France, taxes and a relatively high share of grid costs paid by generators in Norway and maintaining price regulation for the end user prices in several Member States are examples of this welfare redistribution. Redistribution of welfare seems to be commonly used to get political acceptance for major interconnector investments.

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202 The motivation of the TSO to build interconnection capacity is (i) positive from the less independent TSO to a more independent TSO, (ii) neutral between two semi-independent TSOs or from an independent TSO to a semi-independent TSO and (iii) negative to the direction of a vertically integrated TSO. The calculation is presented in Chapter 5.3.

Even if the study has demonstrated that company interests are important regarding the selection of interconnector projects, the study has also indicated that company interests might not always be the determining factor for the success of transmission investments. There are many cases in which there is a clear company interest on both sides to invest but the project is not successful. This could be due to the difficulty to get local acceptance for the project. This may be a far more serious obstacle to interconnector investments than company interests. Thus projects may not be finalised independently of whether the TSOs had the motivation for trying hard or not.

Our findings indicate that there are a number of factors that potentially influence the motivation of TSO for investing. Among these factors security of supply considerations tend to promote investments. Uncertainty regarding many assumptions needed for profitability calculation can stop or delay investments, as also uncertainty regarding the development of the project, for example whether the project gets a permit or not. A serious distortion of investment signals is caused by the difference between commercial and physical flows, inherent to electricity networks. This issue is aggravated by the fact that large countries can make discretionary decisions on cross-border capacities and can influence flows through dispatching decisions while small countries have fewer possibilities for this. Without any global agreement on this issue, usually referred as loop flows, there is a risk that the European transmission network will be developed using partial optimisation leading to important welfare losses. A worrying example of the consequences of this phenomenon is the uncoordinated investment in phase shifter transformers and the uncoordinated operation of these transformers. Several disputes are ongoing on how to share the commercial capacity for example at the borders of Italy or in the Central Eastern Europe region.

The influence of company and national interests in transmission investments could become more aggravated in the future. The need to build transmission capacity for integrating wind power is huge and the projects will be increasingly expensive. Price arbitrage between regions then becomes one determinant among several others. Cross-border flows will not be marginal exchanges between two countries but they will spread all over Europe from wind production areas to consumption areas. More countries feel the effect of variable loop flows which are originating from distant locations such as from the North Sea. Wind power will thus have a strong market integration effect as the whole Europe needs to be motivated for being part of the system. The way the social welfare benefits and costs are distributed between countries will become even more important. In addition to the common co-ordinated transmission infrastructure plan for the whole Europe, the governments, regulators and TSOs need to agree to the implied costs and price effects of the plan, otherwise the new network simply will not be built.

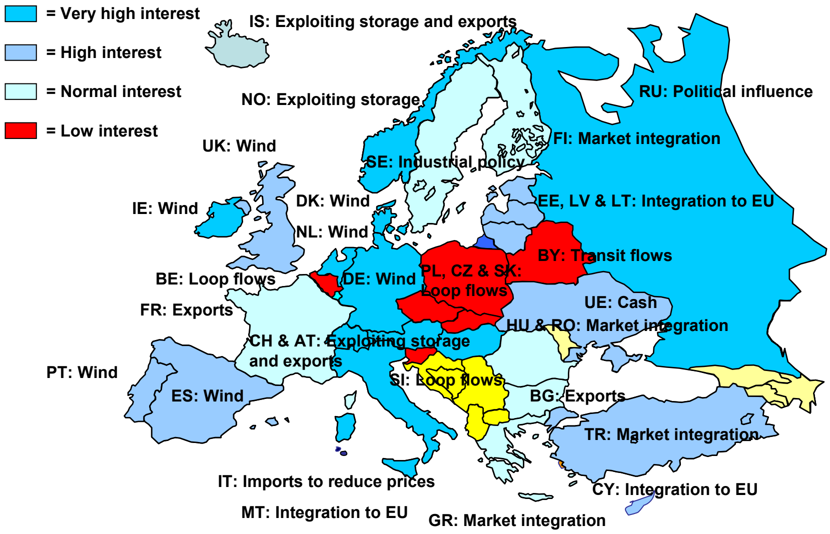

Figure 44 Overall motivation of the European countries for investing in the electricity transmission infrastructure in the time period 2020 – 2030.

An overall picture of the motivation of each European country for building transmission infrastructure based on the findings of this study is presented in Figure 44. Countries are divided into four categories depending on their level of motivation for investing in the European grid. The main reason for each country for the motivation or lack of motivation is indicated in the figure.

6.3. Other findings and proposals based on this study

The study has estimated that the annual congestion cost in the European electricity market is more than two billion Euros based on analysing the congestion between regions using 2008 as the reference year. This estimation is based on a method with some heroic assumptions, the main purpose of the method being to analyse TSOs' behaviour regarding transmission investments. However, the results are also interesting for welfare calculation as the method allows estimating welfare potential of interconnectors for countries without transparent market price data.

The results indicate that there is a lot of potential to increase social welfare benefits by building interconnectors. This is in particular true for interconnectors from Central Europe to the regions at the perimeter, namely to Italy, the Iberian peninsula, the UK, and the Nordic countries. This study estimates that connecting these regions as planned in the ENTSO-E ten year plan will increase the annual social welfare by about 700 million euros. The optimum annual social welfare increase which amounts almost to one billion euros would require more than a two times higher capacity increase compared to what is planned in the ENTSO-E ten year plan.

As the cost of interconnectors from Central Europe to the perimeter regions is high, an average absolute price difference of about 5 €/MWh is needed at the optimal investment level if only the price arbitrage benefits are taken into account. This means that no full market integration between Central Europe and these other regions will be achieved. However, inside Central Europe, including both the Western and Eastern parts of Central Europe, a high level of price convergence is achievable and is already the case today to a large extent. Spreading of market coupling will further improve price convergence. However, the increasing volatile wind production will oppose this trend by causing in high wind periods big price differences inside the Central European region. In order to provide efficient locational signals in the more volatile market, price and bidding zones need to be redesigned with the underlying network and the scarcity signals in mind. This study contributes to the discussion by presenting a subjective view on how to split Europe into 45 bidding zones and into five price index areas.

The study shows that it is possible to develop objective criteria for interconnector investments. Social welfare benefits from price arbitrage should be one criterion but several other criteria should be used as well including price convergence, security of supply and competition benefits. These other criteria can be included with a reasonable accuracy in the social welfare calculation.

The study shows that uncertainty linked to infrastructure investments is increasing. The need for transmission investments depends to a large extent on how much and which type of generation capacity is built and where it is located. Most of the new generation capacity in the European electricity system will be subsidised renewable capacity. The way these subsidies are attributed varies considerably across Europe. These differences together with the inherent uncertainty linked to political decisions create uncertainty for interconnector investment decisions.

The study has only shortly discussed merchant investments presenting the difficulties to have merchant investments in the same network as regulated investments. EU's current legislation assumes that most interconnectors will be built by the regulated TSOs. However, in some countries there is a risk that the regulated TSO will not proceed with the necessary projects because of rapidly increasing investment needs, limited human resources of the TSO, limited capability of the TSO to finance projects with debt and equity, and finally because of a distorted incentive structure. Thus it might be necessary to reopen the discussion on the need for merchant investments.

The study discusses the close relation between transmission and generation investments and suggests that the ten year network development plan prepared by ENTSO-E should promote optimal location of generation. This plan should be consistent with the market design including optimisation of the price and bidding zones. TSOs should define and publish a realistic target for transmission capacity between price and bidding zones, taking into account the generation and load scenarios of the Member States. The aim should be to set the target at the level of the best estimate of the optimal capacity.

The study discusses how distribution of welfare between countries and between TSOs can be addressed by developing financing and cost and revenue distribution schemes which aim at a better distribution of the project costs and welfare benefits. This is possible for example when deciding on the value of commercial capacity, on sharing of project costs and on sharing of congestion rents. Currently each TSO covers the costs in its own territory and congestion rents are shared fifty-fifty which does not necessarily make investments equally desirable for both sides. In the future when the European transmission system needs to be developed in a more global manner, a more sophisticated system should be developed to finance projects that are important from the European perspective and cannot be attributed only to one or two single countries.[203]

A European transmission financing system should first address the current flaws in the cost and benefit sharing, such as the cases of unfair distribution of commercial capacity and congestion rents identified in this study. Transparency of network income, costs and investments should also considerably improve. Network development plans should include, besides

203 The infrastructure package of the European Commission proposes that such a mechanism should be developed. EC, infrastructure package, 2010

investment costs, a calculation of social welfare benefits and how they are distributed. This helps to address the issue of sharing the costs and benefits.

The study discusses how to implement in practise the cost and benefit readjustment of transmission investments. For example the investment can be paid or the congestion rent can be shared proportionally to the benefits. One of the problems is that there is currently no mechanism in any Member State how the tariff system can take into account investments in another country.

Investments can be decided in a global package designed to make all parties satisfied when summing up the costs and benefits for each party. This type of a package has already been successful for example in Northern Europe. Investments can also be promoted by a fund in which all countries would contribute for example through a European levy in the transmission tariffs or through a portion from the congestion rents.[204]

This study presents the basic elements for the design of a two-tier European transmission financing system. This system consists of an ex-ante part for sharing the investment costs and benefits and an ex-post part for the continuous distribution of costs and benefits during the lifetime of the investment.

6.4. Recommendations for further work

This study has not depleted the topic of influence of national and company interests on transmission investments. It would be interesting to know to what extent the recently decided unbundling requirements will improve the situation regarding investments. The results of such a study would give an indication whether further steps are needed and whether unbundling also should be pursued in distribution networks. Another topic of interest is how efficient unbundling is when the state owns both the TSO and a generation company. Even if the ownership is formally separated, there is a risk that at the government level decisions are not taken in an independent manner.

Data on interconnector usage reveals interconnectors which are not used efficiently. One should study to what extent TSOs unduly reduce cross-border capacity to manage their internal congestion problems. The usually modest sums used for redispatching give an indication that limiting cross-border capacity is a widely used practise.

The social welfare calculations of this study have been made using a simple model with strong assumptions using 2008 as the reference year.

[204] Proposal made by the Czech Government in the context of the discussion on ITC mechanism in 2009.

The same calculations could be made using network modelling and load and generation scenarios for the future time periods. It would be interesting to calculate the social welfare for a combination of projects, at least per region.

This study gives indications that there are several transmission projects that would benefit from reattribution of costs and benefits in order to motivate all TSOs involved to do their share of the investment. However, further work should be done to identify the individual projects suitable for this kind of reattribution and to estimate the efficiency of reattribution.

Transparency of network data is still an area which requires further work. Even if this study only uses rather elementary data, we have not been able to find coherent and complete datasets for the analysis, even if there has been an enormous progress in the past years regarding the availability of relevant network data. ENTSO-E should make a further effort to publish a complete set of relevant data in an easily accessible form. Redispatching costs is one example of missing data which would be important for understanding congestion in the European transmission network.

The ENTSO-E ten year network development plan needs to include generation scenarios. The ten year plan should also include a social welfare calculation, not only for price arbitrage, but also estimations of security of supply and competition effects of investments. The plan should have a global view of Europe with the aim to find an optimal combination of investments and to define binding target values for cross-border capacity.

Further research should address the competition benefits of interconnectors, in particular for regions with high price convergence. It is possible that the competition benefits of increasing interconnection capacity for these regions are far higher than the price arbitrage benefits. One should also address the potential threat for increased market power through interconnectors. Academic literature of these topics exists and calculations have been made for some regions, but they do not cover well the whole of Europe.

Optimal price zones for Europe should be studied. There is research in this area and the Central Western Europe regulators have decided to launch a study on this issue for their region. Also nodal pricing should be kept on the research agenda in Europe, in particular as Russia applies it already and Poland is planning to do so.

Local opposition is the biggest obstacle to overhead high voltage line investments. This topic is not well covered by academic studies. Literature exists on this topic for transport infrastructure such as roads and railways. More studies should be made how local opposition can be overcome for example through more efficient compensations schemes for people living close to transmission lines and through improving the planning process.

It should be studied whether the new institutions put in place in the recent European legislation, namely ENTSO-E and the ACER, are sufficiently equipped for addressing the challenge of European transmission investments. It is possible that the new investment challenges partly driven by technology opportunities require increasing the powers of these new institutions regarding investment decisions.

Building the future European grid needs strong co-operation between Member States. National interests will not disappear, it is clear that governments need to take care of their citizens' interests. For this reason the European co-operation should be organised in such a way that national interests are properly taken into account in transmission investment decisions. Every participant should be equally thrilled when building the future transmission grid for Europe. This did not quite succeed when the monks made experiments with their grid in Paris in 1746.

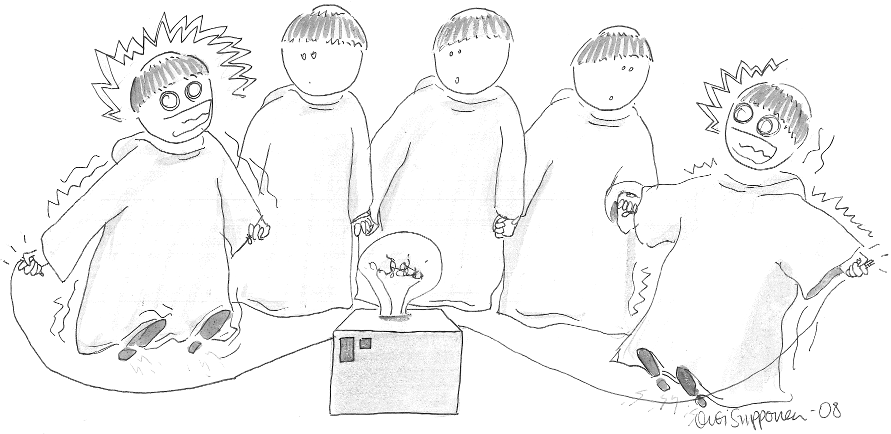

Figure 45: *Supergrid experiment in Paris in 1746.*[205]

205 Lindell, history of electricity, 1994. Nollet made an experiment in Paris in 1746 in which 200 monks were connected with metal wires to a 1.5 km chain. An electric discharge was connected to both ends of the chain which made the monks scream. However, all monks did not feel the thrill. This has been explained to be due to wet sandals causing an earth fault.

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Appendix 1

Description of the method used in this study to analyse past, planned and optimal interconnector investments

The method used in this study to calculate the social welfare effects of the past, planned and optimal interconnector investments uses as parameters (i) supply curves with the slope equal to the slope of the linear regression line of correlation between spot price and load in 2008 (2009) for each country, see Figure 1, (ii) cross-border capacities and commercial flows between countries in 2008 and (iii) congestion rents collected from each border in 2008.

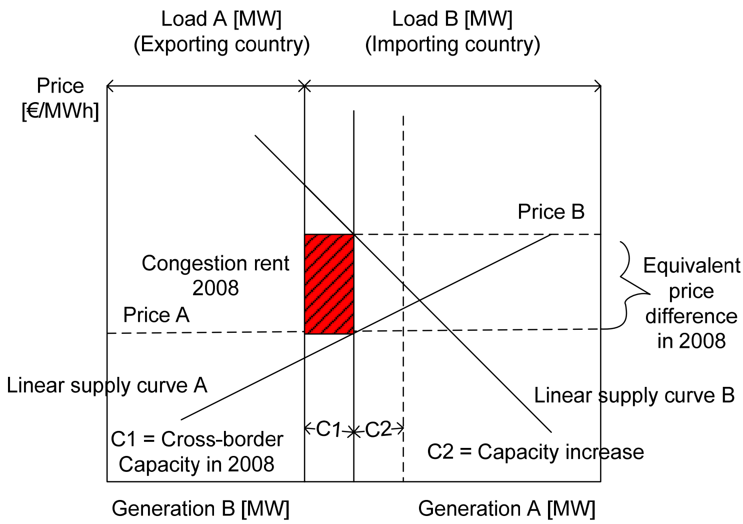

Figure 1 Illustration of the method used in this study.

Firstly an equivalent price difference between two countries is calculated by dividing the congestion rents in 2008 by the corresponding cross-border flows. The effects of increasing the interconnection capacity are then calculated by assuming that the additional interconnection capacity is fully used until the price convergence point.

The slopes of the linear regression lines of correlation between spot price and load in 2008 (2009 and 2010) for each country, the congestion rents, commercial flows and cross-border capacities in 2008 as well as the past, planned and optimal increase of the interconnector capacity including their welfare effects are in Tables 1 – 5 of this appendix. Welfare calculation results for each country are shown in Tables 6 - 8 of this appendix.

The model uses 2008 as the reference year. The effects of the past, planned and optimal investments are calculated using this reference year as the base case. Regarding past investments the results answer thus the question: if everything else remains as it was in 2008, what was the welfare effect of a single investment in the past? Similarly regarding planned investments the results answer the question: what will be the welfare effect of each planned investment in the future if only one interconnector is built, everything else remaining as in 2008. Regarding the optimal investments the approach is the same as for the planned investments. First the optimal capacity is determined using the model, after that the corresponding welfare effects are calculated.

The benefit of using congestion rents for calculating the price difference between countries is that it allows analysing also interconnectors which do not have spot prices on both sides of the interconnector.

In the calculations the cost of an AC interconnection is assumed to be 10.000€/a/MW and the cost of a DC interconnector 50.000M€/a/MW, based on the author's estimation for reasonable average costs relying on data on existing investment projects.

The data for 2008 is presented in Tables 1 – 2. Some missing data is replaced by estimated values, the reasons are explained in the tables and in Endnote 2 of this appendix.

The following formulas have been used in the calculation.

Equivalent price difference in 2008,

$$P_{eq\,i} = CR_i \,/\, CF_i, \qquad (1)$$

where CR_i = congestion rent in 2008 at interconnector i and CF_i is the sum of net nominated flows over the interconnector in 2008.

Additional flow due to capacity increase,

$$CF_{add\,i} = C_{add\,i} * 8760h, \qquad (2)$$

where C_{add} i is the capacity added.

Absolute increase in producer welfare,

$$PW_i = CF_{add\,i} * C_{add\,i} * p_a \,/\, 2, \qquad (3)$$

where p_a is the slope of the supply curve in Country a.

Absolute increase in consumer welfare,

$$CW_i = CF_{add\,i} * C_{add\,i} * p_b / 2, \qquad (4)$$

where p_b is the slope of the supply curve in Country b.

Shift from congestion rent to producer welfare,

$$SCRP\ i = Cadd\ i * pa / Peq\ i * CR\ i. \qquad (5)$$

Shift from congestion rent to consumer welfare,

$$SCRC\ i = Cadd\ i * pb / Peq\ i * CR\ i. \qquad (6)$$

Change in congestion rent,

$$CR_{add} = CR_i - SCRP - SCRC + (P_{eq\,i} - C_{add\,i} * (p_a + p_b)) * C_{add\,i}. \qquad (7)$$

Shift from consumer welfare to producer welfare in Country a,

$$SCP_i = C_{add\,i} * p_a * L_a, \qquad (8)$$

where L_a is the load in Country a.

Shift from producer welfare to consumer welfare in Country b,

$$SPC_i = C_{add\,i} * p_b * (L_b - CF_i) - CW_i, \qquad (9)$$

where L_b is the load in Country b.

An equivalent price difference is calculated from the realised flows and not from the theoretically feasible flows which would be the other alternative. Most interconnectors with significant price difference between price zones which they are connecting have utilisation ratios of around 70 %. There are several reasons why the utilisation is not higher. First of all, the capacity is not available at all times for example due to maintenance. Secondly, on many interconnectors there are still inefficient methods to allocate capacity such as explicit auctions which reduces the utilisation ratio. Thirdly, as the price difference is in reality volatile and not static as assumed in this method, there are usually periods of price convergence even at interconnectors with a substantial average price difference which means that it is not rationale to use the full capacity in those periods.

On the contrary, the method assumes that the capacity additions are used to their theoretical maximum. An alternative would be to use a standard utilisation ratio lower than 100 % based for example on the average utilisation ratio for all interconnections or an individual utilisation ration based for example on the current utilisation ratio of that interconnector. This would, however, add another strong assumption which would somewhat change the results but would not be significant regarding the conclusions drawn from them.

For each interconnector the capacity for full price convergence and the optimal capacity are calculated.

Capacity needed for full price convergence,

$$C_{conv\,i} = P_{eq\,i} / (p_a + p_b). \qquad (11)$$

The optimal capacity is assumed to be at the level of additional capacity in which the absolute increase in producer and consumer welfare equals to the cost of building new capacity.

Optimal capacity,

$$C_{add\,i\,opt} = (P_{eq\,i} - CO_{int} / 8760h) / (p_a + p_b), \qquad (12)$$

where CO_{int} is the annual cost of the interconnector, for AC 10.000 €/MW and for DC 50.000 €/MW.

It is interesting to note that the remaining price difference at the optimum point is constant, 5.7 €/MWh for DC interconnectors and 1.1 €/MWh for AC interconnectors with these cost assumptions.

Using these formulas the various social welfare components are calculated for the past, planned and optimum investments. The results for each interconnector are shown in Tables 3 - 5 and the overall changes for each country in Table 6 - 8 of this appendix.

Table 1 Load and slope of the supply curve used in the welfare calculations.

Country	Load in 2008 [TWh]	Slope of the supply curve [€/GW]	Year of the spot market data from which the slope of the supply curve is calculated
FI	87	2.8	2009
NO	128.9	1.4	2009
NL	120.2	12.2	2008
DK	36.4	17.0	2009 (average of East and West)
DE	557.2	2.6	2008
SE	144.1	1.3	2009
PL	142.9	9.7	2009
FR	494.5	1.0	2008
BE	89.5	16.0	2008
UK[1]	333	1.3	2010 (part of the year)
ES	270.9	1.6	2008
CH	64.4	12.1	2010 (part of the year)
AT	68.4	9.0	Estimated
CZ	65.1	9.2	2009
SK	27.6	25.0	Estimated
HU	41.3	18.4	2010 (part of the year)
SI	12.7	55.2	Estimated
RO	55.2	14.6	2008
BG	34.5	14.0	Estimated
GR	56.3	14.5	2008
IT	339.5	3.3	2008
PT	52.2	5.6	2009
IE and NI	37	15.6	2010 (part of the year)
EE	8	33.7	2010 (part of the year)
LV	7.6	46.9	Estimated
LT	11.5	14.9	Estimated

Table 2 Interconnection data from 2008 used for welfare calculations. [2]

From country A	To country B	Forward flow in 2008 [TWh]	Return flow in 2008 [TWh]	Capacity in most useful direction in 2008 [MW]	Capacity in return direction in 2008 [MW]	Nominated flow on the theoretical maximum [%]	Congestion rent in 2008 [M€/a]	Price difference from congestion rent [€/MWh]
NO	NL	3.4	0.3	700	700	60%	112.5	30.4
NO	DK	4.8	0.4	750	710	80%	95.3	18.2
DK	DE	9.1	1.4	2050	1500	59%	105.6	10.0
SE	DE	2.5	0.5	600	600	58%	0.0	20.0
SE	DK	6.7	1.8	1980	2240	49%	55.1	6.5
SE	PL	2.1	0.1	600	350	42%	0.0	15.0
DE	NL	14.4	0.1	3925	3450	42%	64.7	4.5
PL	DE	1.3	0.0	1150	1000	13%	21.8	16.8
DE	FR	14.4	1.8	2575	2675	64%	156.3	10.9
FR	BE	9.9	0.9	2950	1650	42%	25.1	2.3
NL	BE	3.7	2.2	2150	2200	32%	33.7	5.7
FR	UK	12.0	0.6	2000	2000	72%	202.2	16.0
FR	ES	3.3	0.6	1300	500	34%	93.4	17.0
FR	CH	18.5	0.1	3100	1850	68%	0.0	8.8
DE	CH	4.0	3.2	1900	4200	43%	67.6	9.4
DE	AT	8.6	0.7	1500	1600	71%	0.0	0.0
CZ	DE	7.6	0.2	2275	750	39%	27.3	3.5
PL	CZ	0.8	0.0	1630	800	6%	12.6	14.8
PL	SK	0.8	0.0	475	525	18%	15.9	20.8
CZ	SK	3.6	0.1	1150	1000	37%	23.1	6.3
SK	HU	6.4	0.0	1000	600	73%	34.1	5.3
CZ	AT	2.5	1.6	250	500	186%	5.4	1.3
AT	HU	1.0	0.2	500	100	29%	32.2	25.7
AT	CH	1.6	0.5	1000	1100	24%	17.1	8.2
AT	SI	3.0	1.1	350	650	132%	41.9	10.3
RO	HU	1.2	0.0	800	600	18%	24.6	19.7
RO	BG	1.4	0.0	625	625	26%	14.1	9.8
BG	GR	3.7	0.0	550	300	77%	37.4	10.0
IT	GR	1.8	0.2	500	500	45%	11.3	5.7
ES	PT	9.3	0.1	1200	1200	90%	64.5	6.8
FR	IT	17.9	0.0	2525	930	81%	299.9	16.7
CH	IT	20.0	0.0	3525	1300	65%	146.5	15.0
AT	IT	1.7	0.0	210	75	90%	30.4	18.3
SI	IT	3.0	0.2	380	140	93%	21.4	6.9
FI	SE	4.2	3.9	1600	2000	58%	1.3	0.2
NO	SE	8.9	2.4	2825	2350	46%	85.1	7.5
NO	DE	0.0	0.0	0	0	NA	0.0	24.4
NO	UK	0.0	0.0	0	0	NA	0.0	30.4
BE	UK	0.0	0.0	0	0	NA	0.0	18.3
UK	IE	0.7	0.2	410	80	24%	0.0	10.0
DK	NL	0.0	0.0	0	0	NA	0.0	14.5
HU	SI	0.0	0.0	0	0	NA	0.0	5.0
NL	UK	0.0	0.0	0	0	NA	0.0	13.7
EE	FI	2.4	0.0	350	350	77%	0.0	5.0
LT	SE	0.0	0.0	0	0	NA	0.0	5.0
LT	PL	0.0	0.0	0	0	NA	0.0	5.0
LV	EE	1.3	0.0	750	750	20%	0.0	0.0
LT	LV	1.0	0.0	1100	900	10%	0.0	0.0
Sum		**224**	**26**	**55210**	**45350**	**Av 46%**	**1979**	**Av 11,2**

Incentive for the TSOs: (green) = Positive (blue) = Neutral (pink) = Negative

Table 3 Past welfare increase due to cross border capacity increase in 2000 – 2010 compared to 2008 welfare.

From country A	To country B	Capacity increase between 2000 - 2010 [MW]	Consumer welfare decrease country A [M€]	Generator welfare increase country A [M€]	Consumer welfare increase country B [M€]	Generator welfare decrease country B [M€]	Congestion rent increase [M€]	Net surplus for country A [M€]	Net surplus for country B [M€]
NO	NL	700	76	77	619	609	113	40	48
NO	DK	-50	-7	-8	-25	-21	-2	-1	-5
DK	DE	350	127	160	297	292	-17	23	-5
SE	DE	140	15	16	118	118	14	4	4
SE	DK	-270	-33	-35	-107	-80	22	9	-16
SE	PL	600	47	48	123	123	33	2	3
DE	NL	200	122	125	124	109	-14	-5	7
PL	DE	-750	-134	-136	-140	-140	-12	-7	-6
DE	FR	1450	1508	1540	515	503	73	61	41
FR	BE	1450	300	305	870	791	-45	-25	50
NL	BE	500	231	241	226	212	-12	1	5
FR	UK	0	0	0	0	0	0	0	0
FR	ES	300	51	51	45	44	15	6	6
FR	CH	700	236	244	373	277	-53	-22	65
DE	CH	1210	301	304	408	377	25	9	38
DE	AT	-250	0	0	0	0	0	0	0
CZ	DE	0	0	0	0	0	0	0	0
PL	CZ	-1085	-65	-65	-28	-27	-5	-3	-3
PL	SK	-320	-82	-82	-41	-39	-8	-5	-6
CZ	SK	780	171	178	197	180	4	5	16
SK	HU	250	125	151	138	120	-29	9	3
CZ	AT	-230	-80	-86	-83	-77	11	0	0
AT	HU	-200	-35	-36	-44	-42	-10	-6	-7
AT	CH	-1210	-57	-59	-72	-69	-1	-3	-3
AT	SI	450	99	106	113	70	-42	-17	19
RO	HU	-1150	-64	-67	-108	-105	-11	-8	-9
RO	BG	-430	-73	-75	-43	-41	-2	-3	-3
BG	GR	400	149	159	252	242	18	17	18
IT	GR	500	252	253	183	180	11	-6	-4
ES	PT	600	233	239	157	136	14	10	25
FR	IT	600	234	241	545	520	43	26	44
CH	IT	660	333	427	479	453	-51	65	-3
AT	IT	0	0	0	0	0	0	0	0
SI	IT	30	20	24	31	31	-3	3	-1
FI	SE	350	49	53	38	36	-5	0	-2
NO	SE	1245	103	110	109	102	28	15	14
NO	DE	0	0	0	0	0	0	0	0
NO	UK	0	0	0	0	0	0	0	0
BE	UK	0	0	0	0	0	0	0	0
UK	IE	0	0	0	0	0	0	0	0
DK	NL	0	0	0	0	0	0	0	0
HU	SI	0	0	0	0	0	0	0	0
NL	UK	0	0	0	0	0	0	0	0
EE	FI	350	73	84	66	65	12	8	-2
LT	SE	0	0	0	0	0	0	0	0
LT	PL	0	0	0	0	0	0	0	0
LV	EE	0	0	0	0	0	0	0	0
LT	LV	0	0	0	0	0	0	0	0
Sum		**7870**	**4228**	**4489**	**5335**	**4948**	**113**	**202**	**328**

Table 4 Welfare increase for capacity increase planned in the ENTSO-E ten year network development plan. [3]

From A	To B	Planned capacity increase in 2011-2025 [MW]	Capacity included in the welfare calculation [MW]	Consumer welfare decrease country A[M€]	Generator welfare increase country A [M€]	Consumer welfare increase country B [M€]	Generator welfare decrease country B [M€]	Congestion rent increase [M€]	Net surplus for country A [M€]	Net surplus for country B [M€]
NO	NL	450	450	81	85	660	629	73	29	56
NO	DK	700	700	126	134	433	334	-35	-27	64
DK	DE	400	400	248	331	579	567	-75	44	-27
SE	DE	0	0	0	0	0	0	0	0	0
SE	DK	0	0	0	0	0	0	0	0	0
SE	PL	0	0	0	0	0	0	0	0	0
DE	NL	1000	302	437	449	442	384	-65	-25	21
PL	DE	0	0	0	0	0	0	0	0	0
DE	FR	250	250	362	372	124	119	7	12	7
FR	BE	300	136	67	69	195	170	-25	-13	11
NL	BE	0	0	0	0	0	0	0	0	0
FR	UK	1000	1000	495	511	433	411	91	38	43
FR	ES	2600	2600	1286	1325	1127	1063	207	78	102
FR	CH	0	0	0	0	0	0	0	0	0
DE	CH	0	0	0	0	0	0	0	0	0
DE	AT	0	0	0	0	0	0	0	0	0
CZ	DE	0	0	0	0	0	0	0	0	0
PL	CZ	0	0	0	0	0	0	0	0	0
PL	SK	200	200	277	280	138	130	19	12	17
CZ	SK	0	0	0	0	0	0	0	0	0
SK	HU	800	123	85	106	94	78	-34	0	-5
CZ	AT	800	72	43	46	44	42	-5	-4	-4
AT	HU	340	340	209	218	258	241	37	25	34
AT	CH	0	0	0	0	0	0	0	0	0
AT	SI	0	0	0	0	0	0	0	0	0
RO	HU	0	0	0	0	0	0	0	0	0
RO	BG	0	0	0	0	0	0	0	0	0
BG	GR	0	0	0	0	0	0	0	0	0
IT	GR	500	322	361	364	263	247	-11	-15	-2
ES	PT	1500	951	412	433	278	206	-65	-19	33
FR	IT	1150	1150	552	579	1288	1201	30	13	73
CH	IT	0	0	0	0	0	0	0	0	0
AT	IT	0	0	0	0	0	0	0	0	0
SI	IT	0	0	0	0	0	0	0	0	0
FI	SE	1550	39	10	10	7	7	-1	-7	-8
NO	SE	375	375	68	75	71	65	10	10	9
NO	DE	1400	1400	253	265	2028	2006	231	92	103
NO	UK	1400	1400	253	265	606	595	327	140	140
BE	UK	1000	1000	1432	1502	433	427	9	50	-15
UK	IE	500	500	216	218	289	265	0	-11	11
DK	NL	700	497	308	326	729	716	0	1	-4
HU	SI	800	68	51	52	47	46	0	-4	-3
NL	UK	1290	958	1405	1455	672	663	0	17	-24
EE	FI	650	137	37	51	33	32	-12	-8	-21
LT	SE	700	309	53	59	58	57	0	-11	-17
LT	PL	1000	203	35	38	282	280	0	-22	-23
LV	EE	250	0	0	0	0	0	0	-1	-1
LT	LV	0	0	0	0	0	0	0	0	0
Sum		**23605**	**15883**	**9162**	**9619**	**11613**	**10982**	**713**	**394**	**569**

Table 5 Welfare increase with optimal capacity increase compared to 2008 welfare.

From country A	To country B	Optimum capacity increase for AC line [MW]	Optimum capacity increase for DC line [MW]	Consumer welfare decrease country A [M€]	Generator welfare increase country A [M€]	Consumer welfare increase country B [M€]	Generator welfare decrease country B [M€]	Congestion rent increase [M€]	Net surplus for country A [M€]	Net surplus for country B [M€]
NO	NL	2154	1818	328	358	2667	2408	0	-16	213
NO	DK	926	677	122	130	419	325	-31	-25	62
DK	DE	454	222	281	378	658	644	-89	50	-32
SE	DE	4835	3665	687	778	5309	5127	139	69	160
SE	DK	291	41	8	8	26	19	-4	-3	3
SE	PL	2933	1967	368	396	963	890	78	17	63
DE	NL	224	0	325	334	329	287	-46	-15	18
PL	DE	1273	901	1764	1849	1844	1821	-8	75	13
DE	FR	2699	1431	3910	4094	1335	1259	-	105	-3
FR	BE	69	0	34	35	99	87	-12	-6	6
NL	BE	161	0	236	249	231	213	-25	0	4
FR	UK	6473	4488	2219	2364	1943	1754	94	80	123
FR	ES	6099	4343	2148	2247	1883	1723	173	78	137
FR	CH	588	239	291	303	458	308	-137	-59	79
DE	CH	628	281	362	368	490	414	-53	-23	46
DE	AT	0	0	0	0	0	0	0	0	0
CZ	DE	201	0	120	136	291	287	-16	7	-5
PL	CZ	724	483	1004	1032	434	407	-4	22	21
PL	SK	567	435	786	804	391	345	-9	10	39
CZ	SK	150	16	90	96	103	87	-17	-3	7
SK	HU	97	0	67	83	74	62	-26	3	-1
CZ	AT	10	0	6	6	6	6	-1	0	0
AT	HU	895	729	551	593	680	595	-22	26	70
AT	CH	335	119	207	217	261	247	-11	3	7
AT	SI	143	0	0	0	0	0	0	0	0
RO	HU	562	424	339	370	571	533	-18	19	27
RO	BG	303	143	244	256	146	134	-9	6	5
BG	GR	313	152	151	173	255	232	-30	6	7
IT	GR	258	1	1	1	1	1	0	0	0
ES	PT	793	158	344	360	232	174	-46	-11	30
FR	IT	3625	2563	1231	1306	2871	2625	-69	-24	148
CH	IT	900	604	470	636	676	631	-156	72	-48
AT	IT	1395	1024	630	687	1147	1126	30	46	10
SI	IT	98	20	14	18	23	22	-3	2	-2
FI	SE	0	0	0	0	0	0	0	0	0
NO	SE	2349	658	424	495	447	381	13	66	61
NO	DE	5815	4673	843	977	6770	6521	234	134	249
NO	UK	10851	9159	1653	2167	3965	3487	458	514	478
BE	UK	995	731	1046	1084	316	313	37	37	3
UK	IE	524	254	110	111	147	139	9	-1	6
DK	NL	458	302	187	193	442	437	15	7	5
HU	SI	52	0	40	40	37	36	1	0	1
NL	UK	879	559	820	837	392	389	28	17	3
EE	FI	106	0	0	0	0	0	0	0	0
LT	SE	238	0	0	0	0	0	0	0	0
LT	PL	157	0	0	0	0	0	0	0	0
LV	EE	0	0	0	0	0	0	0	0	0
LT	LV	0	0	0	0	0	0	0	0	0
Sum		**63600**	**43280**	**24461**	**26570**	**39331**	**36497**	**334**	**1286**	**2011**

[grey box] = Value chosen for the calculations.

Table 6 Summary results for each country of the welfare increase due to the past electricity interconnector investments in 2000 – 2010 compared to the welfare in 2008.

Past 2000 - 2010				
Country	**Consumer welfare increase [M€]**	**Producer welfare increase [M€]**	**TSO revenue increase [M€]**	**Overall welfare increase for the country [M€]**
FI	17	-12	-7	-2
NO	-172	180	45	53
NL	511	-477	22	56
DK	-259	261	0	2
DE	-1657	1699	15	57
SE	117	-110	19	26
PL	404	-405	-11	-13
FR	-307	340	-6	27
BE	1096	-1003	-38	54
UK	0	0	0	0
ES	-188	195	10	16
CH	375	-158	-53	165
AT	-89	88	-24	-25
CZ	-119	119	1	2
SK	31	10	-22	20
HU	-13	27	-26	-13
SI	93	-46	-25	22
RO	137	-142	-6	-11
BG	-192	200	6	14
GR	436	-422	0	14
IT	803	-751	-19	33
PT	157	-136	4	25
IE and NI	0	0	0	0
EE	-73	84	-3	8
LV	0	0	0	0
LT	0	0	0	0
Sum	**1107**	**-459**	**-117**	**530**

Table 7 Summary results for each country of the welfare increase due to the planned electricity interconnector investments in 2011 – 2025 compared to the welfare in 2008.

Planned 2011 - 2025				
Country	**Consumer welfare increase [M€]**	**Producer welfare increase [M€]**	**TSO revenue increase [M€]**	**Overall welfare increase for the country [M€]**
FI	24	-22	-31	-29
NO	-780	823	202	245
NL	426	-274	-62	90
DK	-122	323	-92	109
DE	1809	-1751	6	64
SE	137	-129	-23	-16
PL	5	0	-17	-12
FR	-2276	2365	34	123
BE	-1237	1332	-34	61
UK	1927	-1878	84	133
ES	715	-630	-1	83
CH	0	0	0	0
AT	-165	176	10	21
CZ	-43	46	-7	-4
SK	53	-23	-13	17
HU	301	-267	-8	25
SI	47	-46	-4	-3
RO	0	0	0	0
BG	0	0	0	0
GR	263	-247	-18	-2
IT	928	-837	-32	59
PT	278	-206	-40	33
IE and NI	289	-265	-13	11
EE	-37	51	-23	-10
LV	0	0	-1	-1
LT	-88	97	-43	-34
Sum	**2451**	**-1363**	**-125**	**963**

Table 8 Summary results for each country of the welfare increase due to the optimal electricity interconnector investments compared to the welfare in 2008.

Optimal				
Country	**Consumer welfare increase [M€]**	**Producer welfare increase [M€]**	**TSO revenue increase [M€]**	**Overall welfare increase for the country [M€]**
FI	0	0	0	0
NO	-3370	4128	-84	673
NL	2382	-2046	-83	252
DK	-23	227	-83	121
DE	10275	-9602	-221	452
SE	-616	801	-41	145
PL	-2591	2795	-34	170
FR	-4588	4996	-342	66
BE	-717	783	-20	47
UK	6506	-5834	-67	606
ES	1539	-1363	-49	127
CH	739	-333	-201	204
AT	-1382	1492	-34	76
CZ	218	-169	-25	24
SK	427	-349	-30	48
HU	1286	-1150	-40	96
SI	22	-18	-2	2
RO	-583	626	-18	25
BG	-5	39	-23	11
GR	256	-233	-17	7
IT	4716	-4403	-204	109
PT	232	-174	-27	30
IE and NI	147	-139	-2	6
EE	0	0	0	0
LV	0	0	0	0
LT	0	0	0	0
Sum	**14870**	**-9928**	**-1645**	**3297**

[1] In this study for UK the data for Great Britain is used, Northern Ireland is together with Ireland.

[2] The shaded price difference values are estimated by the author as on these interconnections the congestion rent does not represent the arbitrage value of the capacity or it is not known. This may be due to non market based capacity allocation. CRE, interconnection 2008, 2009.

[3] For planned investments capacity increase is taken into account in the welfare calculations only up to the price convergence point, except for costs which are calculated for the full planned capacity.

APPENDIX 2

Detailed data for Figures 10 and 29

Table 1 Calculations for Figure 10.

Capacity [GW]	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Load A [TWh/a]	200	200	200	200	200	200	200	200	200	200	200
Load B [TWh/a]	100	100	100	100	100	100	100	100	100	100	200
Cost [M€/a]	0	25	50	75	100	125	150	175	200	225	250
Price difference between A and B [€/MWh]	20	18	16	13	11	9	7	4	2	0	0
Flow from A to B [TWh/a]	0	4	9	13	18	22	26	31	35	39	39
Congestion rent [M€/a]	0	78	136	174	193	192	171	130	70	0	0
Additional producer welfare in A [M€/a]	0	2	7	15	26	41	59	80	105	133	133
Additional consumer welfare in B [M€/a]	0	3	13	30	53	82	118	161	210	266	266
Shift from cons. welfare to prod. welfare in A [M€/a]	0	150	300	450	600	750	900	1050	1200	1350	1350
Shift from prod. welfare to cons. welfare in B [M€/a]	0	147	287	420	547	668	782	889	990	1084	1084
Net income for the TSO [M€/a]	0	53	86	99	93	67	21	-45	-130	-225	-250
Net increase in social welfare [M€/a]	0	58	105	143	172	190	198	197	185	174	149
Slope of the supply curve in A [€/GW]	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
Slope of the supply curve in B [€/GW]	3	3	3	3	3	3	3	3	3	3	3
Net benefit A [M€/a]	0	28	49	64	73	74	70	58	40	21	8
Net benefit B [M€/a]	0	30	56	79	99	115	129	139	145	154	141

Table 2 Calculations for Figure 29.[206]

Country	Household price/spot price compared to the European average ratio [%]	Industrial price/spot price compared to the European average ratio [%]	Transmission tariff/spot price compared to the European average ratio [%]	Average spot price in 2008 [€/MWh]
EL	-48%	-26%	-16%	82
FR	-27%	-38%	-65%	69
BG	-34%	-18%	19%	51
EE	-30%	-22%	-55%	54
UK	-22%	-12%	-24%	75
LT	-29%	-4%	88%	54
SI	-21%	-10%	-25%	70
FI	-1%	-17%	-62%	54
PT	-6%	-12%	92%	70
RO	-21%	6%	35%	51
LV	-19%	8%	0%	54
IT	-5%	3%	21%	87
CZ	-11%	14%	7%	64
PL	-5%	9%	53%	56
IE	2%	2%	41%	75
NL	9%	3%	-59%	70
HU	-6%	21%	-36%	70
AT	19%	0%	-20%	66
SE	33%	-12%	-68%	51
ES	8%	14%	-12%	64
SK	-8%	31%	103%	70
BE	22%	1%	-54%	71
LU	18%	15%	0%	66
DE	44%	13%	-14%	66
NO	54%	24%	-52%	42
DK	87%	7%	109%	57
European average ratio	**2.42 = 0%**	**1.53 = 0%**	**0.12 = 0%**	

= Estimated

206 Source for household and industrial prices is Eurostat 2009 2nd semester prices. Source for transmission tariffs: ETSO, transmission tariffs 2008, 2009. Source for spot prices is Power exchanges. Some markets do not have spot prices or the spot market data is not available. Equivalent prices are estimated by the author.

Matti Supponen's study on national and company interests in the European electricity transmission networks is topical because of the increasing investment challenge due to development of wind power. National and company interests indeed seem to influence investment decisions and may be a reason for underinvestment in the sector. The analysis is based on calculating social welfare effects of price arbitrage between electricity markets, the results are validated through case studies. Concrete proposals are made how to mitigate the adverse effects of national and company interests. The study covers the whole Europe and the findings are amply illustrated with graphs and tables. Drawings by Matti's daughter Outi give a touch of humour to this serious subject.

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