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Cross-border electricity interconnections for a well-functioning EU Internal Electricity Market

Alex Jacottet

Introduction

Historically the European electricity network has developed largely on the basis of self-sufficient national systems. Transmission interconnections between the various national systems have been designed largely to promote security of supply – in an emergency, they enable a system with a shortage in generation to import power from a system with a surplus. In recent decades however, cross-border interconnections have taken on a wider role because of two important challenges. The first has been the move within Europe to liberalize the electricity sector and create an Internal Electricity Market (IEM) by 2014, in order to promote competition, trade, and an increase in overall welfare (and ultimately, it is hoped, lower electricity prices). A shortage of interconnection capacity creates barriers to trade between Member States. The European Commission (EC) has therefore been taking steps to promote investment in new cross-border interconnections, most recently through the so-called Third Energy Package in 2009.[1] However, although interconnections may improve overall welfare, they also create winners and losers, and the process still has some way to go. The second challenge is the massive expansion in renewable energy sources which will take place under the 20/20/20 agreement.[2] A number of these renewable projects will involve the creation of new international electricity transmission capacity and will require extensive coordination

[1] For more information, see: http://ec.europa.eu/energy/gas_electricity/legislation/legislation_en.htm
[2] This refers to the Commission's planned 20% reduction in carbon emissions by the year 2020.

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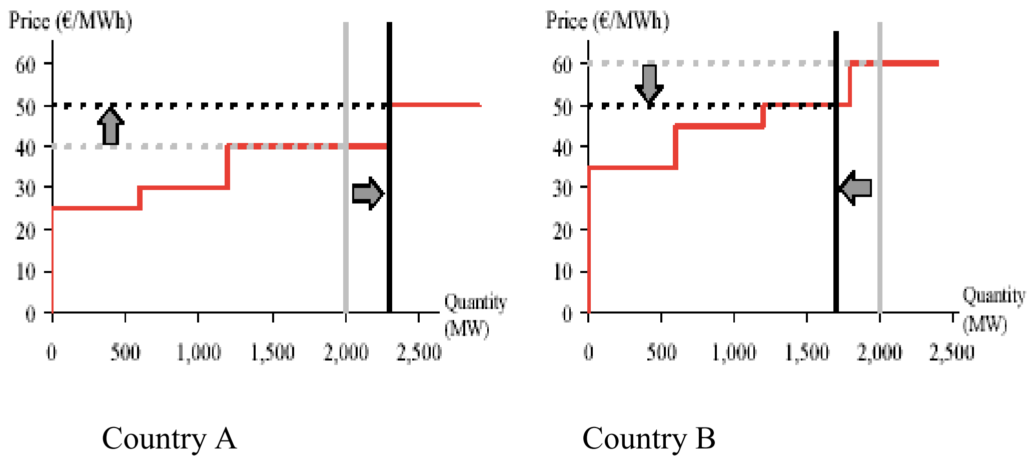
between different national systems if they are to develop to their full potential. This paper looks at how these new challenges are being addressed, what problems are being encountered, and what the future might hold.

Costs and benefits of interconnections.

The costs and benefits of cross-border interconnections are broadly similar to those of international trade in general. In principle, there should be an overall gain to welfare, as shown in Figure 1.

Figure 1



Source: Frontier Economics (2004).

Figure 1 shows the effect of trade between two countries (A and B) with differing marginal costs of generation, and illustrates the effect of unconstrained dispatch between the countries. Demand is 2000 MW in each country and is perfectly inelastic in this example. Initially electricity is sold at the marginal cost of €40/MWh in country A, and €60/MWh in country B. Once trade is facilitated by an interconnector (of at least 300 MW capacity), country A exports to country B, as it produces more cheaply. However, as country A's generators now need to produce more, its marginal cost rises from €40/MWh to €50/MWh. Country B's generators face competition from country A's generators, and so less is generated in country B, which means it now produces at a lower marginal cost of €50/MWh. In this case, prices have equalized in the two countries. If we assume consumer surplus to be the area between €60/MWh and price in both countries, we can see that while country B has had an increase in

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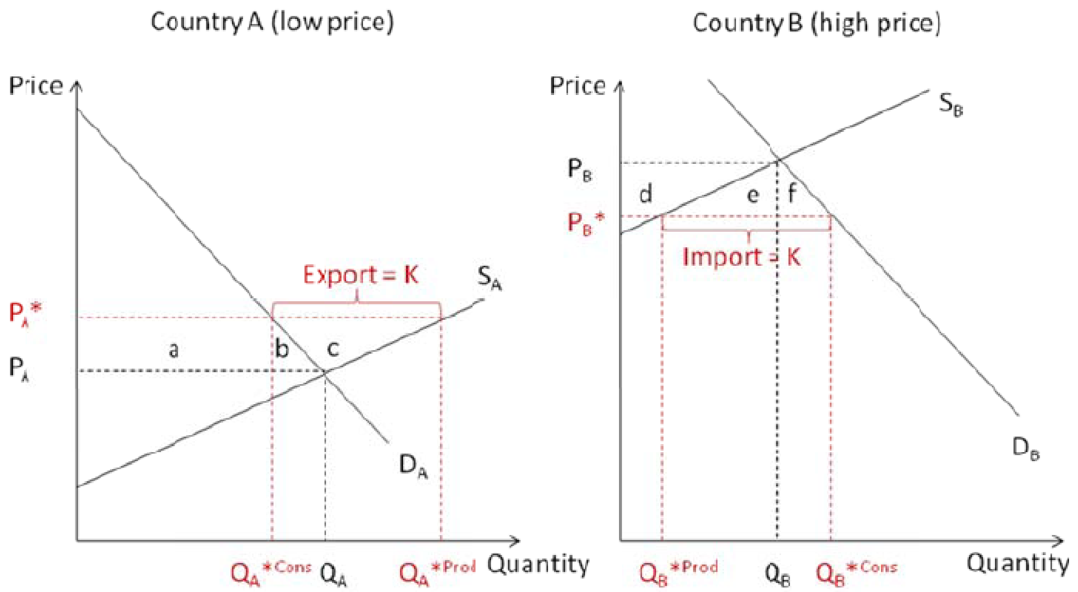
consumer surplus, country A, the exporting country, has had a loss of consumer surplus. The opposite is true of producer surplus. This example illustrates that even if there is overall welfare improvement, there is also welfare redistribution between the consumers of the two countries, as well as between the producers of the two countries. This highlights the reason why individual Member States may be for or against increased levels of interconnection, while the EC, as a central body, is in a freer position to advocate trade.

Figure 2



Source: Kapff and Pelkmans (2010) in turn adapted from Turvey (2006).

Figure 2 illustrates how trade can increase overall welfare. It shows supply and demand for electricity in two countries. Price at equilibrium before trade is lower in country A, at P_A, than price in country B at P_B. Country A has more efficient, lower cost production of electricity. In this example, a cross-border electricity interconnector is built with capacity K. Country A exports quantity K of electricity to country B. Price then falls to P_B^* in country B. Due to increased production in country A, the marginal cost of generation rises, and so the price of electricity for consumers in country A will rise to P_A^*. In country A there is a loss of consumer surplus of a + b but an increase in producer surplus of a + b + c; c is a net welfare gain for country A. In country B there is a loss of producer surplus of d, but a gain in consumer surplus of d + e + f; there is thus a net welfare gain of e + f for country B. So

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although a, b, and d are redistributed surpluses between consumers and producers, there is a net welfare gain from trade of c + e + f for the two countries seen as a whole.

This is one of the reasons why the European Commission is keen to see greater investment in interconnection within the EU. It sees the potential for net welfare gains for the EU as a whole. Individual Member States, however, may be more or less keen to see this in practice. In particular, national regulatory authorities (NRAs) generally have duties to protect the interests of consumers within their respective countries, and may not be keen to see consumer prices rise (if they are a low cost country). An example might be trade between France and Germany. France is usually a lower marginal cost system than Germany because of its surplus of nuclear plant; as France exports to Germany, the marginal generation price increases in France and French consumers pay more. The winners are consumers in Germany, French producers, and the interconnector provider (who gains rents of ($P_B^* - P_A^*$) × K. This has understandably led to some discontent among French consumers, who see themselves as subsidizing German consumers, and there has been considerable political opposition to the extension of trade.

Although interconnection can increase producer surplus, and create rents for interconnector owners, overall consumer surplus (total for all countries) can also rise, but this depends on the balance between the increase in consumer surplus in the importing countries, where prices will fall, and the fall in surplus in exporting countries, where prices will rise. Beyond that, an interconnector will provide other positive externalities – such as reducing generators' market power, and providing for greater security of supply. These externalities cannot be captured by an interconnector investor, and are thus not included in its own cost–benefit analysis at the planning stage. Thus, to some degree, interconnectors can be considered a public good, with the risk that private investors will underinvest relative to the social welfare optimal position, as public benefits are not included in the company's cost–benefit analysis. Along with the difference in interests between different groups and different Member States, this creates a case for regulation and incentives to bring about the missing links.

EU policy measures to date

The evidence suggests that in Europe there is, in practice, a lack both of interconnectors and of the right incentives for national transmission system operators (TSOs) to invest in new

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capacity. Interconnection pricing in Europe is generally based on congestion rents; the very fact that these still exist is itself evidence that there is a sub-optimal provision of interconnection. There are also wider policy reasons to promote interconnections – the EC argues that interconnectors provide three main benefits: i) increased security of supply, ii) increased competition in generation and supply, and iii) better connections for new renewable/sustainable power. Indeed, interconnections are central to the EU's objective of creating a properly functioning Internal Electricity Market by 2014. As one study has pointed out 'A physically interconnected Europe-wide electricity grid is a *sine qua non* for a genuine IEM'.[3] (This may mean in practice that the target is not met – it can take years or even decades from the stage of a feasibility study to the completed interconnector, so the present sub-optimal level of interconnection capacity will not be corrected overnight.)

Against this background, the EC has been trying to promote interconnections; for instance back in 2002 a rather arbitrary target – that all Member States should aim to have at least 10 per cent of their production serviceable by interconnectors – was set. This is indeed the case in most core Member States (though not in islands like the UK or virtual islands such as Iberia). However, in principle it still leaves 90 per cent of production available only for the domestic market – a level of openness to trade very far below that of most other production sectors.

One problem has been the incentives faced by regulated investors – the Transmission System Operators (TSOs). These are natural monopolies, subject to National Regulatory Authorities (NRAs) who impose price controls on electricity transmission, giving it a guaranteed rate of return. The duties of the NRAs do not normally extend to consumers in other countries, so the position of cross-border interconnections has often been unclear under this system; furthermore, for international transmission, regulation comes from more than one NRA, each with its own different rules. NRAs have not always had incentives to coordinate their positions and encourage interconnections, given the risk of creating losers as well as winners through increases in the level of trade.

[3] Kapff and Pelkmans (2010).

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Merchant Investors

Developments in relation to regulation are considered later in this paper, but against the background sketched out above, the EC has particularly sought to encourage private investors to invest in new interconnection capacity, starting with Regulation 1228/2003/EC, which allows exemptions from the requirement of Third Party Access (TPA). This enables a private (merchant) investor to keep the excess rents arising from an interconnection, thus creating strong incentives for such investments (whereas regulated TSOs must either plough excess rents into new or existing interconnector investments, or return the rents to grid users by reducing tariffs). Under Article 7 of the Regulation, a merchant investor may be granted exemptions if the following conditions are satisfied:

(a) the investment must enhance competition in electricity supply;

(b) the level of risk attached to the investment is such that the investment would not take place unless an exemption is granted;

(c) the interconnector must be owned by a natural or legal person which is separate, at least in terms of its legal form, from the system operators in whose systems that interconnector will be built;

(d) charges are levied on users of that interconnector;

(e) since the partial market opening referred to in Article 19 of Directive 96/92/EC, no part of the capital or operating costs of the interconnector has been recovered from any component of charges made for the use of transmission or distribution systems linked by the interconnector;

(f) the exemption is not to the detriment of competition or the effective functioning of the internal electricity market, or the efficient functioning of the regulated system to which the interconnector is linked.[4]

Merchant investors may therefore be better incentivized than regulated TSOs to build new interconnectors, because they can take more of the benefit from the investment. They also face less regulatory uncertainty if they are granted an exemption (or regulatory holiday)

[4] Source: Regulation (EC) No 1228/2003.

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under the terms of Regulation 1228/2003/EC. Regulated TSO investments suffer from the additional uncertainty that regulated rates of return might change in the future. This is particularly the case for interconnectors, as more than one regulator is involved.

However, there are disadvantages in relying on merchant investors from a social welfare point of view; the basis for their profits is the ability to take advantage of spot price differentials, and this may lead to sub-optimal provision of capacity (that is, as explained below, because the greater the difference in electricity price between two countries, the greater the rent obtained by the interconnection provider, so there are no incentives to expand capacity up to the point where prices are equalized). As transmission capacity is subject to economies of scale, the building of an interconnector may well have the effect of foreclosing the market to new entrants. In other words, in a situation where a large interconnector would provide maximal social benefit, an interconnector of restricted size (as provided by a merchant investor) would reduce the economies of scale available from incremental capacity, making it unprofitable for another investor to complete the job with a second competing interconnector. In this context, a regulated investment would be preferable if it were to provide greater capacity. The regulated investor is less concerned with spot price differentials, as rents above the regulated tariff cannot (legally) be taken as profits. So in the short term, merchant investors may supply more interconnection capacity because of their ability to exploit congestion rents, while in the long term they have an interest in disintegrated markets.

Prior to 2005, some bilaterally agreed charging mechanisms used a fixed price per KWh, a so-called postage stamp tariff, for the use of an interconnector. The EC decided to abolish this in 2005, and to harmonize charging mechanisms across Europe. The result is that the more congested the interconnector, the more rent can be extracted. If sufficient cross-border capacity were made available, there would be price convergence between the two countries due to trade, and no arbitrage opportunities would exist. Merchant investors recover their costs solely through congestion charges, whereas TSO investors recover their costs through regulated transport tariffs. Once a TSO has persuaded the regulator that new interconnector capacity is socially beneficial, its investment costs will be included in its regulated asset base. Because of this, the regulated TSO's Weighted Average Cost of Capital will be lower than

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that for a merchant investor (it has a relatively more guaranteed revenue stream). Under Article 6(6) of Electricity Regulation 1228/2003/EC, the TSO can auction capacity during times of congestion, but revenues must be used i) to guarantee availability of capacity, ii) to maintain or invest in new interconnection capacity, or iii) as income taken into account by NRAs and used to reduce network tariffs. The incentive to reduce network tariffs might encourage regulated investors to maximize congestion rents, and so make the TSO act like a merchant investor by restricting capacity.

Unbundling

Further complications may arise from the present, arguably half-finished, state of structural reforms in the European electricity sector. One of the key themes of the EC's Third Energy Package is *ownership* unbundling of TSOs from generation and supply sectors.

Many Member States have settled for legal unbundling whereby, although a TSO may be managed independently of the energy group, it is still owned by the same parent company. France is a particular example of this, where its TSO is still owned by the parent company, EDF, itself still predominantly state-owned. It is arguable that legal unbundling creates conflicts, and that full ownership unbundling would give independent TSOs greater incentives to invest in cross-border electricity interconnections, as the competition it generates in generation and supply sectors in its home country does not affect the TSO's holding company itself. It should be noted that all merchant investments so far in the EU, for example Estlink and BritNed, are financed by holding companies that also own TSOs. The investors are legally unbundled from the TSOs but have common ownership. This means that although the TSO is unbundled to the extent that it is managed independently of other sectors, the TSO is still owned by the same parent company that also owns generation capacity, and in some cases also distribution and supply companies.

Regulation

Another potential barrier to cross-border interconnection is the fact that regulation of electricity transmission is still the responsibility of national regulators. Various steps have been taken to encourage a more consistent approach to regulation across the EU, and in 2011 a new European agency – the Agency for the Cooperation of Energy Regulators (ACER) –

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was established to deal with Europe's pressing demands for an ever more closely integrated energy market. ACER took over the work of ERGEG (the European Regulators' Group for Electricity and Gas) which was an advisory group to the European Commission on internal energy market issues in Europe.

One of ACER's tasks is to help coordinate agreements between Member States for the construction of new electricity interconnectors. However, the agency's powers are limited; it may only coordinate, with respect to interconnectors, where bilateral agreement is not working. Given the lack of incentives to invest in new cross-border capacity, it is arguable that a bigger role could be forged for ACER as a more centralized planning body, or at least as a more effective provider of legal and financial support to TSO coordinators and planners.. As one commentator has suggested 'There is an urgent need to reinforce governance on a European level in order to get projects going'.[5] Unfortunately, of course, this runs up against the principle of subsidiarity, with issues of regulation mainly taking place at the national level, and most decisions on cross-border investment being negotiated bilaterally. There are circumstances in which the EC can intervene – for example with merchant investments, the EC, as a centralized body, has to approve any exemptions granted by the concerned Member States. But for a potential investor, having to deal with at least two National Regulatory Authorities (NRAs) (and the possibility of the involvement of ACER and the EC), adds to the complexity and regulatory uncertainty of any investment decision.

Interactions Between Cross-Border Interconnections and National Systems

Electricity flows according to physical laws, not commercial contracts, so the building of a cross-border interconnector can have various effects on national transmission systems, including third party systems, some positive, but more often negative. One particular issue in this context is **inter-TSO compensation** (ITC). At present there is no formal method of financial compensation for flows of electricity caused by neighbours on third-countries' transmission networks. As electricity flows through the path of least resistance, often it will flow from one country's generator, through a third country's transmission network, and then back to the generating country's load centre or to another destination country. The costs of such loop flows are difficult to calculate, but one study has concluded that there is currently

[5] Nies (2009).

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no 'physical or economic meaning'[6] to the sums allocated. At the moment these are governed by a voluntary code, but ENTSO-E[7] is working on a formal mechanism, which may potentially lead to major changes. The current pot in the EU for ITC is €100m, but the actual cost has been put at billions of euros.[8]

Other forms of interaction between cross-border interconnections and national systems can also create problems. For instance, congestion in national markets can be exacerbated by new imports from interconnectors; on the other hand, it is also possible that congestion can be pushed to the border by national TSOs dealing with internal congestion. For interconnectors to fulfil their potential as welfare increasers, investment in transmission lines within national boundaries is therefore often also necessary. A particular example is Germany, where changes in the national mix of generation, as well as new interconnections, are creating the need for new deep transmission investment. Germany is to decommission its entire nuclear sector (mainly in the south of the country) and will be connecting a significant amount of new wind power (mainly in the north). This will require massive transmission investment in cables from the north to major load centres in the south.

Future Challenges

Interconnections are particularly useful when two countries have diverging characteristics, and this will be increasingly the case as the massive planned expansion in renewable sources takes place across Europe. Renewable generation has to be sited where the resource is available (which will not coincide straightforwardly with national boundaries) and each country will have a different degree of renewables potential. There is therefore considerable new scope for synergies between different systems as the penetration of renewables increases, requiring the expansion of cross-border transmission capacity. One example is the recent completion (in 2008) after years of planning of a 700 MW interconnector between the Netherlands and Norway (NorNed). Norway, due to its geography, has plenty of renewable hydropower, which is cheap for generation during times of peak demand. The Netherlands has plenty of thermal power plants which are useful for base load. In that respect, Norway can supply hydropower to the Netherlands in peak times, and the Netherlands can supply

[6] Stoilov, Dimitrov, and François (2011).
[7] ENTSO-E is an association of European TSOs which deals with issues of cooperation between TSOs of all Member States in the EU.
[8] Source: Ofgem.

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cheap energy to Norway for base load. Thermal energy can also be used to pump water back into reservoirs in Norway for use at peak times, allowing the complementarity between the two systems to be exploited effectively. This type of complementary system – of connecting renewables together with interconnectors – will play an increasing role in the years to come.

However, there will also be much wider coordination and investment issues involving cross-border interconnections. For instance, the connection of new renewable sources of power, such as solar power from North Africa (the so-called Desertec project), will involve huge investments and new regulation to integrate potentially meshed networks with interconnectors between many countries. Wind power from the North Sea may pose more immediate challenges. There is a new project, the North Seas Countries Offshore Grid Initiative (NSCOGI), which aims to connect ten countries with a huge network of wind farms and interconnectors. These countries are: Belgium, Denmark, France, Germany, Ireland, Luxembourg, Netherlands, Norway, Sweden, and the UK. This initiative was proposed in the Second Strategic Energy Review in November 2008. A memorandum of understanding was signed by the ten countries on 3 December 2010.

North Sea and Baltic wind capacity is expected to reach 40 GW by 2020 and 126 GW by 2030.[9] The expected cost to 2030 is €84–86bn. It is envisaged that initially wind farms will be connected directly to shore with limited use of interconnectors. However, a fully meshed design, involving wind farms connected to interconnectors covering several countries, is planned for the future. There are two possible designs for the network – the Direct Design and the Split Design. In the Direct Design, interconnectors are first built 'to promote unconstrained trade between countries and electricity markets'.[10] Once trade is unconstrained, tee-in, hub-to-hub, and meshed grids are added to connect the new wind farms. (A tee-in is where a wind farm is connected to an existing interconnector, and electricity flows from the wind farm are made available to one or more of the interconnected countries. A hub is where a number of wind farms are connected to a central point. These hubs can then be connected to each other in a so-called hub-to-hub network. Finally these hub-to-hub connections can either be connected directly to shore, or teed-in to an interconnector. This reduces infrastructure

[9] De Decker and Kreutzkamp (2011).
[10] De Decker and Kreutzkamp (2011).

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costs (relative to the cost of connecting each wind farm directly to shore). In the Split Design, the grid is planned *around* the new wind farms. The Split Design is estimated as costing slightly less than the Direct Design, at €84bn as opposed to €86bn. It is estimated, by the group Offshore Grid, that hub connections for clusters of wind farms could save €14bn up to 2030.)

Of course advance planning is needed for hub-to-hub connections because of the enormous coordination problems involved. Not all wind farms will be built at the same time, and so there is always the risk of over investment in the hub, which could create a stranded asset if other wind farms are not built as planned. This is a risk that has to be taken into account, and could add to the already enormous cost and complexity of the planning process before a fully meshed North Sea grid can be built, especially given the number of independent stakeholders involved – not just ten countries (for the NSCOGI), but also numerous private generation and transmission companies. On top of the many private investors comes regulation from ten NRAs, as well as the EC and ACER as regulatory coordinator. ENTSO-E will also coordinate, as representative of the European TSOs. Other stakeholders include nature conservationists, fishermen, and others whose interests would be in ensuring a less disruptive (but also potentially more expensive) network.

As well as the benefits of introducing carbon neutral generation, and the promotion of competition through the meshed grid, the massive investment in wind power in the North Sea would provide significant security of supply advantages. The meshed grid would improve connection between the ten participating countries of the NSCOGI, providing potential backup supplies to the involved countries. The estimated generation capacity of 126 GW, by 2030, would reduce dependency on gas. Another potential advantage is that the interconnection cables would be able to bypass transmission bottlenecks in participating countries, thus alleviating domestic congestion. (However, it is worth noting that the headline capacity of 126 GW, is a maximum. Given that levels of wind are variable, the farms will not always produce this level of power, meaning that significant levels of backup generation will still be needed to cope with times of low wind generation.)

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The teeing-in of wind farms or hubs to an interconnector can also affect the operation of that interconnector and the trade through it, as capacity used by the teed-in wind farm can no longer be used for international electricity exchange. This may reduce the opportunities for international trade and arbitrage. There can therefore be a trade-off between renewable energy supplies (plus associated reduced infrastructure costs) and international trade. Tee-ins are therefore more beneficial when price differences between countries are low.

Market Coupling

One significant new development being encouraged by the EC, which will have implications for cross-border interconnections, is the so-called 'market coupling' which has started to take place in some parts of Europe. Market coupling involves two or more countries coordinating their power exchanges, in such a way as to remove the need for explicit auctions for cross-border capacity. Instead, the integrated power exchanges make cross-border capacity implicitly available, up to the maximum physical limit, in a process known as implicit auctioning. If sufficient physical capacity is available, prices are equalized where import demand meets export supply at equilibrium and there are no longer any price differences between the countries involved.

This market coupling has been going on in the Nordic countries under Nordpool combining the electricity markets of five countries: Denmark, Estonia, Finland, Norway, and Sweden. Another area of pentalateral market coupling takes place between Belgium, France, Germany, Luxembourg, and the Netherlands. Subject to the availability of sufficient cross-border capacity, electricity prices will tend to converge between participating countries. It is hoped by the EC that market coupling could eventually encompass the whole of the EU. Increased levels of interconnection between the ten countries of the NSCOGI could also help pave the way for extended coverage of market coupling.

Although market coupling will increase overall welfare in the coupled zone (as discussed in relation to Figure 2), there will again be some winners and losers. There may also be unintended consequences within national markets. For instance, David Newbery has noted a potential anomaly in the UK arising from the proposed Electricity Market Reforms. These reforms will create new fixed price contracts for low carbon sources based around contracts for difference (CfDs) between a contract price and a market reference price. Within the UK

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there are at present transmission constraints between Scotland (which has a surplus of generating capacity) and England and these constraints are likely to increase, given the huge potential for renewables in Scotland (and the opposition to building new transmission lines across the border hills between the two countries). Newbery (2012) highlights the implication that that the Third Energy Package 'is likely to require Britain to couple with Europe and adopt price zones that may lead to different prices in England and Scotland'.

A Final Thought

Anomalies such as these may bring into question whether the present basis of pricing for interconnection capacity, on the basis of congestion costs (in other words, the difference in electricity price between two interconnected countries is reflected in the rent gained by the interconnection provider) is the best method from a social welfare point of view. This may not in the longer term be the best form of charging mechanism. An alternative might be that the congestion charge could be replaced by a postage stamp tariff, whereby a fixed charge is applied for cross-border transmission per KWh. Then instead of giving interconnection providers the benefit of the arbitrage, this would go to electricity consumers and producers instead. The level of the postage stamp tariff could be set to make investment in interconnectors profitable at the same time as limiting price differentials felt between countries. But there are obvious regulatory issues arising from such a proposal, given the various problems noted above; such tariffs might ultimately have to be set by some sort of transnational regulatory system, a sort of European equivalent of the US Federal Energy Regulatory Commission (FERC), and Europe is undoubtedly not yet ready for such a step.

Conclusion

- The European Commission has been keen to promote investment in cross-border electricity interconnection capacity with the aim of creating a properly functioning Internal Electricity Market by 2014.
- Due to the current lack of interconnection capacity it is unlikely that such a functioning IEM will be achieved by 2014, indeed there is a risk that it might never happen.
- It is also clear that although merchant interconnectors can provide some help in the short term, they have an intrinsic interest in keeping markets partially separated, and

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so are not necessarily useful in the long term, particularly if price harmonization is on the agenda.

- Electricity price convergence between countries creates winners and losers, as surpluses are exchanged between consumers and producers and between Member States. Overall, there is a net welfare gain, but this situation can create different incentives for European central bodies on the one hand, aiming at overall (EU wide) welfare gains, and individual Member States, on the other, where NRAs will only take account of the interests of their own consumers.
- If the EC is really keen to see EU-wide market coupling, it may need to give greater coordinating powers to ACER, and perhaps clarify and harmonize rates of return allowed to TSOs in order to reduce the investment risk and guarantee a rate of return.
- EU-wide market coupling will go some way towards resolving the problems but will still involve winners and losers. The political difficulties of extending interconnections will remain.
- Ultimately, a Europe-wide regulatory system might be able to deal with these issues, but this is not a prospect for the foreseeable future.

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