The restructuring of the European electricity system

Jacqueline Boucher[1], Jean Dekelver[1] and Yves Smeers[2]

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Introduction

The idea of an internal European electricity market dates back to 1988. First, namely in 1990, two Directives were adopted. One dealt with electricity transit (official Journal NR. L313 of November 13, 1990), the second with price transparency (official Journal NR. L185 of July, 17, 1990). The adoption of these Directives did not cause any particular difficulty; they did not really change the market either. In contrast, the Directive on the common rules in electricity, adopted by the Council of Ministers on December 19, 1996 (official Journal NR. L27/20 of January 30, 1997) was really an event. It came after five years of negotiation at the Council of Ministers. Two further years were left to Member States to transpose it into national law. Belgium and Ireland were granted an additional delay of 1 year, whereas Greece was granted an additional 2 years to complete this transposition.

It is obviously too early to say whether this Directive will become effective. It all depends on its implementation by the Member States. It is equally difficult to predict how the European electricity system will evolve in the new regime. This paper does not try to tackle these impossible questions. It simply looks at them from three points of view. The first section provides a brief overview of the diversity of initial situations found in the European electric system. The second section quickly surveys the current state of the transposition of the Directive. The last section discusses a technical question that is likely to emerge with the evolution of the system, namely the interaction between independent systems operators.

The initial conditions matter

It took five years of painful discussions and compromises to move from the first proposals on common rules submitted by the Commission in 1992 to the actual Directive. Some will judge that, during these years, comparatively little effort was devoted to the analysis of competitive electricity systems. The attention was indeed mainly concentrated on finding ways to accommodate different electricity systems in a single piece of legislation. Were the European Commission endowed with strong legislative power, it could have decided a major reform such as in England and Wales in the late eighties. This was not possible. The Commission initiated the process with rather hard proposals, but it is a much weaker text that was eventually passed into law. The diversity of electricity systems and national institutions and the strong relations that often exist between them undoubtedly caused difficulties. This diversity is the main characteristic of the initial conditions.

There are now several studies documenting the European electricity systems. It is not our objective to attempt to repeat them here. Glachand and Finon (1998) have argued that this heterogeneity of the electricity industry only constitutes part of the problem. This dimension should indeed be compounded with the variety of institutions ruling both the member states and their electricity systems. We follow their presentation in this section and characterise the spread of initial conditions in terms of both industry structure and institutional characteristics. The reader is referred to their paper for an in depth analysis of the question.

Systems diversity

European electricity systems differ by ownership. The situation has been extensively documented in several reports and hence only needs to be briefly sketched here. Some systems as in France, Greece, Ireland and Italy are publicly owned. Others are in private hands, most notably England and Wales, Belgium, Spain and partially Germany. Some systems are moving from public to private ownership.

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[1] Corporate Strategy, ELECTRABEL, Brussels, Belgium

[2] CORE, Université Catholique de Louvain, Louvain-la-Neuve, Belgium

Finally, others are owned by regional or local public authorities, for instance the Netherlands, but also a part of Germany. European law is neutral on ownership. Member States have the sole competence to maintain or change ownership.

Systems also differ by vertical and horizontal integration. The French, Greek, Irish and Italian systems are fully integrated. In contrast, electricity is vertically and horizontally de-integrated in England and Wales. In between one finds a whole range of situations that differ by vertical and horizontal integration. The Directive does not impose any divestiture of functions but only requires unbundling of accounts. Again it is up to the Member States to decide.

Antitrust law is the only possible protection at the European level against the abuse of market power by large vertically integrated companies. There is no FERC in Europe. It has been argued for a long time that the application of antitrust law would be limited because of considerations of general economic interest or more simply, by the time taken by the procedure. The scarcity of case law leaves this matter widely open.

European electricity systems also differ by their fuel mix and their size. Both are determinant for ascertaining the potential for market power at the eve of liberalisation. Again, the situation is well known but it is worth to recall its main features. Some systems are quite large notably in France, Germany, Italy and England and Wales. Some of these are fragmented such as in Germany while others are monolithic such as in France and Italy. Most other systems are comparatively small. They may also be fragmented (Austria, Denmark, the Netherlands) or monolithic (Belgium, Greece, Ireland and Portugal). Systems also differ by fuel mix. There are considerable fuel differences between the large systems, such as for instance between France which is mainly nuclear and hydro and Italy which is still largely running on oil and gas. Even if France does not expand its nuclear generation as much as in the past, it still plans to extend the life of its existing plants. Small systems also show quite varied fuel mixes.

Institutional diversity

Restructuring depends on the capability of governments to come up with legislation proposals, to get them through parliaments and possibly also to deal with appeal of these legislations in Courts. Institutions are determinant in this process; they define the means used both to restructure and to guarantee the commitment of public authorities towards the achievement of the objectives of restructuring. Europe is here again a kaleidoscope.

Some European countries have a federal system (Austria, Germany, Belgium) while others are centralised. National governments in Federal States generally have less leverage for restructuring than those of centralised countries which concentrate more power. This is especially so when the electricity system itself is fragmented at the regional level.

Not all governments have equal strength. Some are single party governments like in the UK. They are better fit to pursue (or oppose) restructuring than the more vulnerable and composite coalitions found in Belgium or Italy. The problem is further compounded in Federal States when government composition at the Federal and State level differs.

Restructuring laws need to be passed in Parliaments. These may be more or less controlled by governments. The parliament is under strong supervision in France and the UK. In contrast, it is not unusual to see legislative proposals defeated by the parliament in Germany and the Netherlands. Nevertheless, in the mean time, law has been enforced in Germany.

Last but not least laws can be contested in Courts. This never happened in the UK or The Netherlands but is common in Germany, Spain, Ireland and Italy.

To sum up

In short the electricity systems in the European Community drastically differ by Member States. Governments have different involvements in these systems and their capability to restructure varies considerably. This two dimensional diversity characterises the initial situations. It matters; when initial conditions are too far apart, processes may fail to converge.

A diverse or balkanised market?

Governments, not the European Commission, have the final word as to the content of a European Directive. Ministers in the Council obviously have their initial situations in mind. They know their electricity systems; they also know that they will need to solicit their national institutions to transpose into national law whatever directive is approved at the European level. It is unlikely however that they have a clear cut idea as to what constitutes the ideal restructuring in electricity as the subject is still actively debated today. It is hardly surprising in these conditions to find out that no single reorganisation emerged from the process. In fact, the Directive leaves room for an incredible large number of options. The brief description of the status of the transposition that follows is constructed on the basis of information provided in Eurelectric (1998).

Generation

The directive foresees two different possible systems for new plants, namely licensing and tendering. Each of them can be under the oversight of an independent regulator or of the ministry. Most countries seem to be heading for a license system. But some, most notably France and Italy, plan to maintain tendering in the public supply or franchise markets.

There is no indication that divestiture of generation capacity is foreseen in any country. Given the initial sizes of the companies, this can only result in a overall system affected by considerable market power. In order to survive in this market, the Dutch generators could merge.

Unbundling of accounts or separation of functions

The directive requires to unbundle the accounts of the network activities. It does not go as far as imposing a vertical de-integration of the network. The weaker form, namely unbundling, is retained by most countries (Austria, Germany, France, and Italy). Other countries go beyond that stage and will have separate legal entities operating the network. This is the case for Spain, Denmark, Finland, Sweden and The Netherlands. Belgium does not know yet. The system operator can be the owner of the network or alternatively an operations manager can be designated.

Dispatch

The directive allows for certain priorities in dispatch whether for renewable energy and/or for national sources. Spain will maintain some priority for its domestic coal for some time. Many countries will give priority to the dispatch of renewable or cogeneration energy and a European version of PURPA trying to bring harmonisation between the different approaches is in preparation.

Eligibility

Eligibility is the concept used for opening the market. Eligible customers can act in the market. Non eligible customers cannot. The Directive provides for full eligibility and eligibility by size of customers. It also provides for restriction to eligibility for distribution companies and exception to eligibility for transactions coming from countries that do not grant the same opening of their market (reciprocity clause). Eligibility is total in Finland and Sweden, and will be enforced this year in Germany and England and Wales. It will be restricted to consumers of a certain size in the other Member States. The degree of opening is quite diverse however, as some countries go beyond the minimal levels foreseen by the Directive, while others like France retain this minimal level. Restrictions to eligibility for distribution and resellers can be found in France and Italy. The reciprocity clause is invoked by Germany, Spain and The Netherlands.

Access

Access can be of different forms, namely regulated access, negotiated access, or single buyer. Regulated TPA is the rule in Finland, Sweden, The Netherlands and the UK. Negotiated access is the preferred approach in Germany with the provision that access prices should be non discriminatory and that indicative prices should be published. Negotiated access is also foreseen in Denmark, together with a provision for publication and scrutiny by a specially appointed Committee.

France is taking a remarkable position here, indicating that it will opt for the regulated TPA with published prices. It is understood though that this position is not yet unanimously agreed upon and hence not yet official; Belgium is still hesitating too.

Distribution

Again different organisations of distribution are foreseen. It can be vertically de-integrated from supply. coexistent with independent supply or retain the exclusive rights to supply.

Pool and PX

Legislative proposals say very little about pools and exchanges. Some systems such as Finland and Sweden already operate on an exchange together with Norway (NordPool). It is not a mandatory exchange. In fact, most of the transactions are bilateral and take place outside of the NordPool. Spain introduced an Exchange since January 1. The Dutch also plan to develop an Exchange and have invited companies from neighbouring countries to join. Expansions of DC transmission capacities are planned between Norway and Northern Europe; this is likely to create an interesting development between two exchanges in Northern Europe. The mandatory Pool England and Wales is well known to everybody.

To sum up

Transposition of the Directive is actively taking place throughout member states. Diversity was the rule before. It may be argued that the common rules may not reduce it, on the contrary. There obviously is nothing a priori wrong with diversity. After all , diversity is a very positive characteristic in biological systems. The only condition for this is that a satisfactory equilibrium with this diversity exists. Will this be the case with the European system? The Commission seems to be happy with the transposition process and announces that it will lead to the most liberalised system of the world. In fact, as with the English Pool several years ago and with the reform in California today, we do not really know. What is sure is that several different organisations will need to coexist most likely without any FERC like regulatory oversight, but under the sole supervision of European law. This may require that at least the interfaces between these different systems function correctly. This is the topic that we turn to now.

Getting the interface right

Systems Operators may thus be in charge of quite different systems. Part of their mission will be to insure the same type of reliability level as we know today. Another part of their task will be to provide the conditions that guarantee free trade of electricity between Member States. Both will require that Systems Operators do interact. What will they say when they will start talking to each other, not as representatives of co-operating integrated utilities, but as independent bodies or, worse, as part of competing companies?

Interestingly this question already arises today, albeit in a mild form, with the application of the European Transit Directive. This directive has already been mentioned above. It is one of the two first pieces of legislation passed in the context of the completion of the internal electricity market. Roughly speaking . it deals with wholesale trade of more than one year that involves the network of a third party. It is remarkable to note that the practicalities of the application of this Directive are still under discussion. even though it is now several years old. Specifically a recommendation on the application of the Directive was adopted in April 1998 by the group of representatives of the European utilities (UCPTE). Some implementation details still need to be specified though. These are related to questions that will become more acute in the future with the transposition of the Directive on the common rules in the internal electricity market. It is believed that this type of question is also relevant in the US context.

Problem statement

The following example. depicted in figure 1. will be used in the rest of the discussion. It is due to Chao and Peck (1998). The system comprises two three node networks (respectively (1, 2, 3) and (4, 5, 6)) linked by two interconnection lines ((1-6) and (2-5)). Demand and production are located at these different nodes. The marginal cost and demand curves are indicated on the figure. The impedances of all lines (indicated in parentheses) are equal to 1, except for those of the interconnection lines that are equal to 2. There are thermal limits on the interconnection lines linking the two networks and no other

limit in the rest of the network. Three node examples are commonly used when discussing restructuring issues. This tradition is maintained here.

Suppose that each three node network is controlled by a different ISO and assume that the two ISOs are organised in different ways. The question is to define the interactions between the two ISOs. What information will they need to communicate?

Equilibrium models can be used for looking at these issue. They define information flows that agents may use in their own system in order to balance quantities. Equilibrium models also allow one to study existence questions that have practical interpretations. They also permit to appraise the position of the different participants to the market. Obviously equilibrium models do not solve all questions. They are just a first step. We indeed believe that there will be serious practical difficulties if one cannot even pose the questions in equilibrium terms. In order to simplify the discussion we shall assume that there is no market power. This assumption is unrealistic but useful. Indeed assuming a competitive equilibrium is often the start for the construction of more complex oligopolistic models.

Producers :	Marginal Costs
node1	$10 + 0.05 * q$
node2	$15 + 0.05 * q$
node4	$42.5 + 0.025 * q$
Consumers :	Inverse demand
node3	$37.5 - 0.05 * q$
node5	$75 - 0.1 * q$
node6	$80 - 0.1 * q$

Transmission capacities
line 1-6 : 200 MW
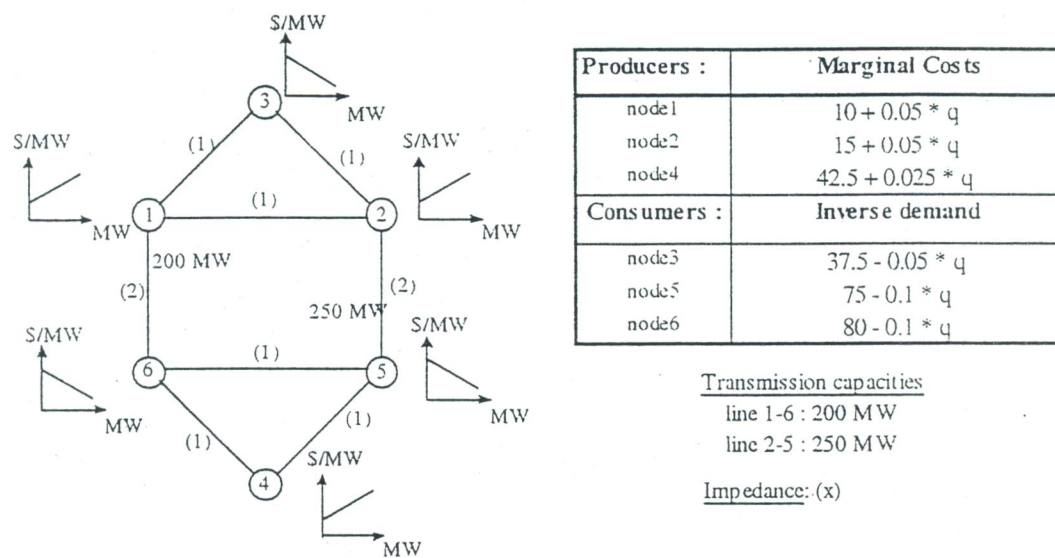line 2-5 : 250 MW

Impedance: (x)

figure 1

Even with those simplifications, one can still consider different alternatives for representing the operations of the ISOs. Two approaches dominate. In the first one, transmission is organised in a nodal way. In the second it is organised on the basis of the utilisation of the electric lines. These two approaches have been elaborated at length in the literature and one cannot even hope to summarise these discussions here. We simply take them as existing paradigms without getting into their promises or problems. It is convenient though to relate these approaches to the two main trends of thought in the US restructuring. One is the centralised model mainly advocated by Hogan et al (1996). The other is the decentralised approach defended by various people on the West Coast, the most extreme example being the approach proposed by Chao and Peck (1996)). We successively discuss how these two approaches can be used to structure the flow of information between ISOs.

The nodal approach

In the nodal spot pricing paradigm generators and consumers submit bids at the different nodes of the zone controlled by the ISO. In the absence of market power these bids follow the marginal cost curves of the generators and the demand curves of the consumers. The ISO then runs a model very similar to an optimal dispatch. It derives nodal prices at which electricity is traded at the different nodes. Differences between nodal prices are the transmission prices. The nodal prices and associated quantities that would be found by a single ISO covering the two three node networks are shown on figure 2.
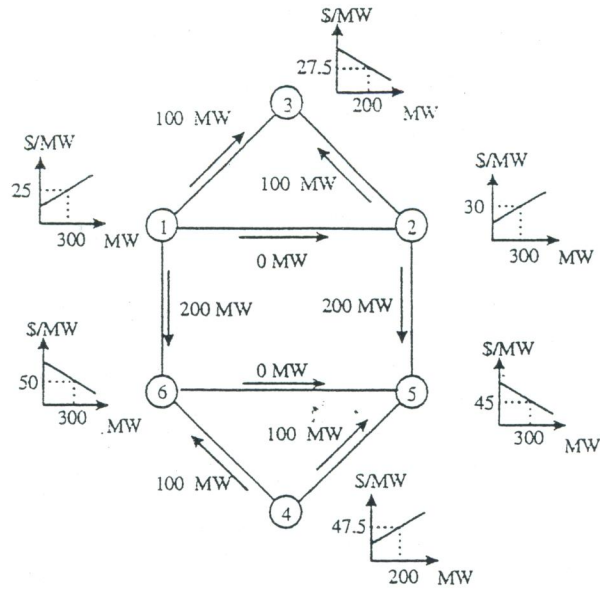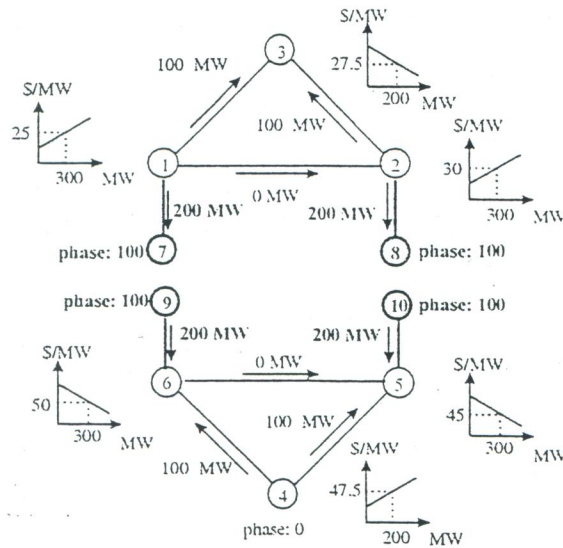
Figure 2

Suppose now that the two three node systems are run by two ISOs operating under the same spot pricing paradigm. We accordingly decompose the above network into two subsystems connected with each other by the interconnection lines (see figure 3). Following an idea of Kim and Baldick (1997), we also introduce additional (fictitious) nodes (7, 8, 9, 10) that we see as junctions between the two systems. What kind of interaction can take place between these ISOs? In particular, can two independent ISOs operating under the same rules reproduce the result of a single ISO operating the full network? This type of decentralisation problem is common in economics. Kim and Baldick (1997) provide an algorithmic view of the problem. We here discuss their idea on the usual DC load flow approximation.

Constraints :

(1) phase(node7) = phase(node9)

(2) phase(node8) = phase(node10)

(3) flow(line 1-7) = flow(line 9-6)

(4) flow(line 2-8) = flow(line 10-5)

Figure 3

A decentralized approach to the optimal power flow problem

Using the decomposition of the network given in figure 3, one can rewrite the DC load flow equation of the full network as a set of two DC load flow equations provided the following variables and equations are added. First, one explicitly introduces the flows in and out of the junction points. Second, one introduces the phases at these nodes. Third, one imposes that the phases and flows at the junction points 7 and 9 are equal, similar equalities holding for the phases and flows at the junction point 8 and 10. Given values for the flows and phases at the junction points each of the ISOs' problems is well defined. Alternatively given prices or penalties associated to the values of these phases and flows at the junction points, the ISOs' problems are also well defined (see Kim and Baldick (1997)). Suppose that the phases and injections found by the ISOs at the junction nodes when they independently solve their problems are equal, then the flows computed by the two ISOs are compatible with the load flow equations of the whole network. They also give the same results as the flows that would have been computed by a single ISO. It thus suffices to impose that the ISOs announce flows and phases at the junction nodes and to find a procedure that insures that they are equal.

Kim and Baldick provide an algorithm for arriving at the adequate values of the phases and flows at the junction points. In this algorithm each ISO announces phase and injection targets at the junctions nodes and pays penalties for deviations. When the two ISOs meet their announces they avoid the penalty. Also, the spot prices found in both networks at the end of the algorithm are identical to those found by a single ISO.

The decentralized approach applied to the interaction of two ISOs operating a nodal system

Kim and Baldick's idea has been proposed to solve an optimal power flow in a decentralised manner. In order to transform it into a general approach for looking at interacting ISOs it is useful to reformulate the question somewhat differently. Consider first the case where the two ISOs each operate their network according to the nodal system, that is by solving an optimal dispatch problem on their system, using the bids that they receive from their producers and consumers. These operations must be feasible for the full network. This means that they need to satisfy Kim and Baldick's phase and injection equalities at the junction nodes. In fact, each ISO must maximise its dispatch function taking into account the way the other ISO operates. This operation is entirely summarised by the phases and injections at the junction points. This is a generalised equilibrium problem, that is one where each agent's action constraints the strategies of the other. The network is at the origin of these constraints. The interesting point of this reformulation is that Kim and Baldick's decentralised optimal dispatch provides one solution of this problem. They may however also be other equilibria. What they are and how they can be achieved is a problem in itself. We do not get into this question here. Our only concern at this stage is that we have an equilibrium (or generalised equilibrium) formulation of two interacting ISOs' problem.

The decentralized approach applied to the interaction of two ISOs operating in different Pool organisations

The equilibrium formulation allows one to move to the case where the two ISOs operate under different rules. The smallest deviation from the preceding situation is the one where we have a full nodal price ISO on one side and an English like ISO on the other side. The first one differentiates prices by location to account for line congestion. The second one aggregates the cost of these congestions and spreads them through an uplift. This situation is clearly of interest for the Nordic Pool where Norway is closer to some nodal vision of the Pool while Sweden is closer to the system that prevails in England and Wales.

We cast this problem in the generalised equilibrium formulation of two interacting ISOs. For network feasibility reasons the phases and injections at the junction nodes must be equal. These constraints need to be introduced whatever the organisational form assumed. One of the ISOs operates according to a nodal price system. It solves a dispatch problem modified to account for phases and injections prices and targets at the junction points. The other ISO's problem is different. It is a fully distributed cost equilibrium problem which can be formulated as follows. This ISO takes the phases and injections prices at the junction points to compute the revenues and/or costs accruing from interactions with the

other ISO. The settlement of these transactions is then added to the other revenues and costs to find the uplift that balances the ISO's accounts. Combining the two ISOs' problems and adding the injections and phase equality constraints at the junction points, one obtains a generalised equilibrium problem where one of the ISO's problem is itself an equilibrium problem.

This is illustrated on figures 4 and 5. On figure 4, the competitive equilibrium problem depicted in figure 3 is seen as the equilibrium problem for a particular uplift of -2.5$/MWh. For this uplift the ISO controlling the network (1, 2, 3) indeed sells electricity to its customers at the marginal production cost (30$/MWh) plus an uplift of -2.5$/MWh. The revenues that it gets from sales to its customers and from the exchanges with the other ISO, together with the payment to its generators at a marginal cost of 30$/MWh leaves this ISO a total revenue of 6500. This can be used to pay for fixed charges. Another equilibrium is shown on figure 5. In this case, the fixed charges that can be covered are equal to 8370,2. A complete evaluation of the fixed costs covered by varying the uplift is given on figure 6. Needless to say for uplifts different from -2.5$/MWh the equilibrium solution is not the competitive equilibrium obtained on figure 3.

Uplift = -2.5 $/MWh
Covered fixed costs : $ 6500
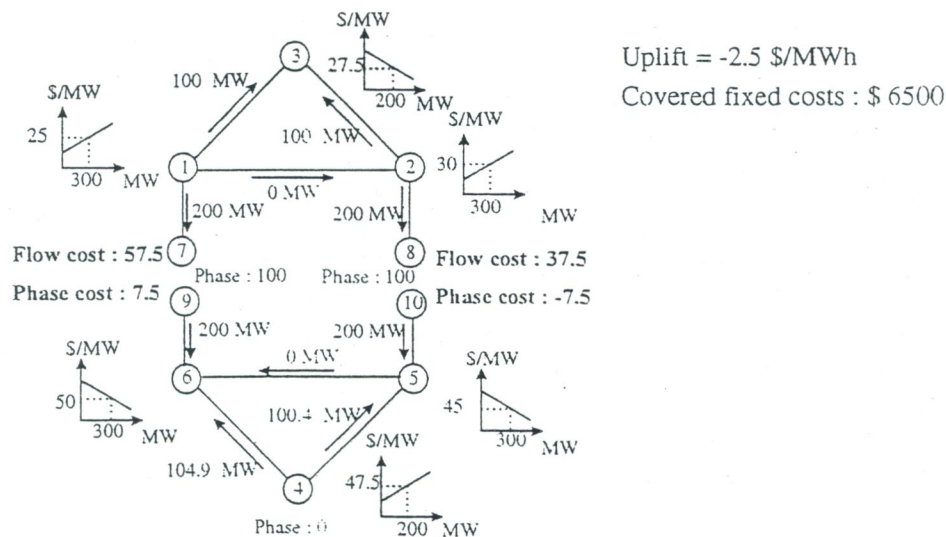
Figure 4

Uplift : 5 $/MWh
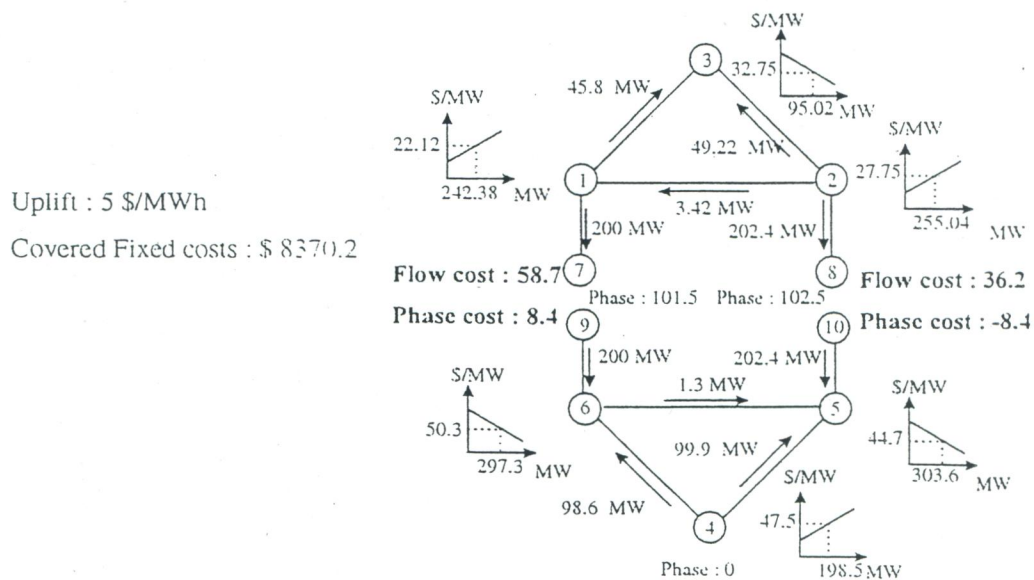Covered Fixed costs : $ 8370.2

Figure 5

This more complex equilibrium problem should not create a real concern. Whatever the exact nature of the equilibrium, the information exchanged by the two ISOs are in terms of phases and injection. Needless to say, it remains to be seen whether an algorithm similar to the one of Kim and Baldick can be devised. This is not an academic question as it relates to the type of information submitted by the two ISOs. Recall that the Kim and Baldick's method proceeds by sending information of phase and injection targets as well as penalties for deviating from these targets. We obviously would like to find a similar algorithm. This task is left for further investigation but it is conjectured that it should not be too difficult.
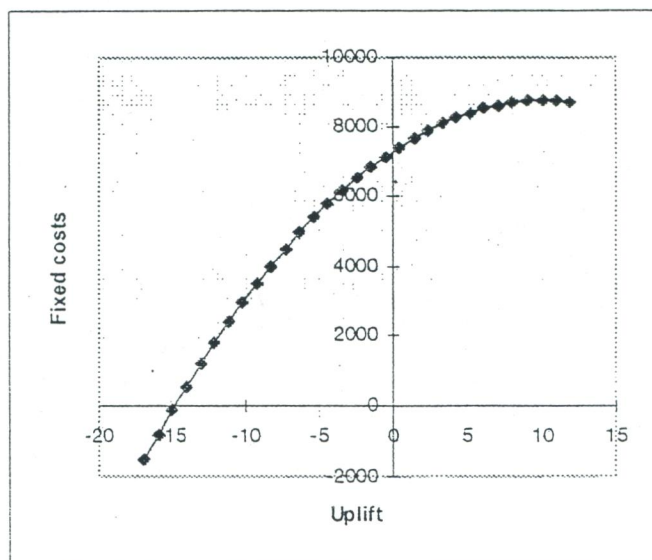

Figure 6

The link based approach

In this approach power marketers buy and sell power at the different nodes of the system. In order to do so they buy transmission services. In the absence of market power the price paid by a consumer is equal to the price paid to the producer plus the transmission price. It is the way this transmission price is computed that constitutes the original aspect of the link based or decentralised approach. Consider a Power Marketer that wants to inject in node 1 and withdraw at node 6. It asks the ISO for the right to utilise the lines. The ISO runs a DC approximation load flow model and answers with the line utilisation levels implied by this transaction. It then aggregates the line utilisation caused by the transactions originating from the different Power Marketers and submits it to the owners of the who fix the price for use. These prices must clear the market: the demand for utilising each line at the equilibrium price is smaller or at most equal to the thermal capacity of the line.

In contrast with the Pool system, the ISO does not run any optimisation model in this case; it simply transforms node to node transportation services into line services and aggregates these services. It is the market that finds the price of the line services and hence plays the role of the optimal dispatch. These prices are shown on figure 7.
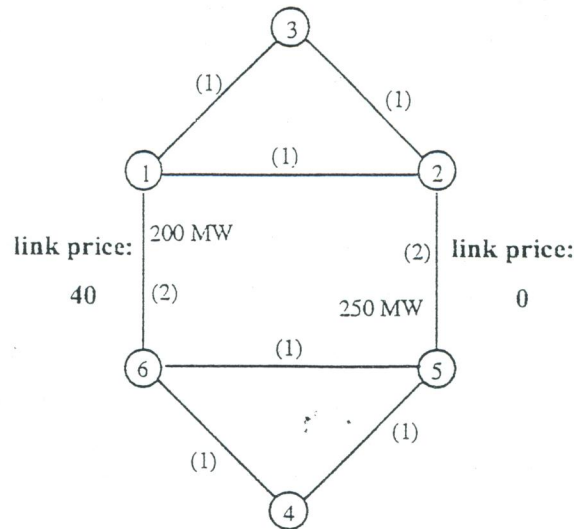
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                    (3)
             (1)          (1)
                   (1)
      (1)                    (2)
link price:  200 MW              link price:
     40  (2)                        0
                 250 MW
               (1)
      (6)                    (5)
             (1)          (1)
                    (4)
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Figure 7

The interaction of two ISOs operating under identical link based systems

Consider first the case of two ISOs operating under the same link based paradigm, namely the one proposed by Chao and Peck. We decompose the above network into two subsystems and assume that each of the connecting lines is owned by one of the ISOs (see figure 8). The question is again to construct the information flows between the ISOs. Chao and Peck's theory immediately answers this question provided we assume that the two ISOs know the entire network. To see this consider Power Marketers requesting cross system transmission services from one ISO. This ISO uses a DC load flow model of the whole network to determine the required utilisation of the lines. The two ISOs exchange information and compute the aggregate utilisation of the lines of the network that they control. They then submit these demands to the owners of the infrastructure who answer with prices. Nothing has changed from Chao and Peck's original model. Having one or two ISOs is here totally transparent. The only requirement is that each ISO knows the whole network.

The procedure is not only totally transparent with respect to the number of ISOs; it also immediately leads to a formulation in terms of an equilibrium problem. Indeed, in this approach, Power Marketers maximise their profit taking into account the price of energy at the seller's and buyer's node as well as the price for utilising the lines. The owners of the infrastructure also maximise the profit accruing from their assets. This equilibrium formulation immediately paves the way towards extensions to the case of different organisations of the ISOs.

The interaction of two ISOs operating under different link based systems

Consider now the case where the ISOs operate under different rules. As argued by Chao and Peck their link based method can be seen as a spot price version of the traditional MW.Km pricing favoured by many utilities. In this interpretation the price of using a line is computed as the distributed cost of that line. Specifically the unitary cost is equal to the accounting cost of the line divided by the flow.

Chao and Peck's model can be readily reformulated in a fully distributed cost context. Needless to say proving the existence of an equilibrium, let alone its uniqueness, is probably difficult, if not impossible. This is not only a mathematical question but also a practical issue. Fully distributed cost equilibrium problems may not have solution, which may have dramatic practical consequences. Neglect this problem for the time being. The mix of FDC and competitive link based method can be stated as follows. Assume as before that each Power Marketer goes to an ISO to request cross system transmission services. Each ISO determines the implied utilisation of the lines. The ISOs exchange information and come up with aggregate utilisation of the lines of their network that they submit to the owners of the infrastructure. The ISO operating under the FDC rule will be responded with FDC based prices. The other ISO will receive competitive prices.

Both types of line prices will be used to compute transmission prices. The equilibrium will thus result from a mix of competitive and accounting line prices.

It is important to note that the information flow between the ISOs is identical to the one assumed by Chao and Peck in their procedure. The ISOs only need to compute and exchange the utilisation of the lines implied by each transaction. It was assumed that both ISOs know the whole network. It is conjectured that weaker assumptions can be made at the cost of exchanging more information between the ISOs.
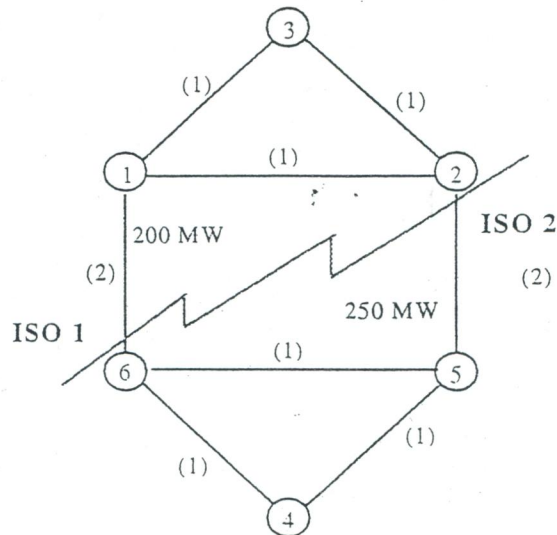

Figure 8

Figure 8 illustrates the application of this principle when the ISO controlling network 1-2-3 prices line 1-6 at fully distributed cost, and the ISO controlling network 4-5-6 auctions the line 2-5. No other line cost is incurred. The graphic of figure 10 depicts the revenue collected from line 1-6 by varying the price of the line. It can be seen that no equilibrium exists if the accounting cost of this line exceeds 8000. In other words, there is no equilibrium that allows one to recover this level of network cost. Figures 9 and 11 show similar results when the ISO controlling the network 1-2-3 prices line 2-5 at fully distributed cost while the ISO controlling the network 4-5-6, auctions line 1-6. Again, the graph shows the accounting cost that can be covered by varying the price charged for line 2-5. There is no equilibrium when the accounting cost of the line exceeds 6796.
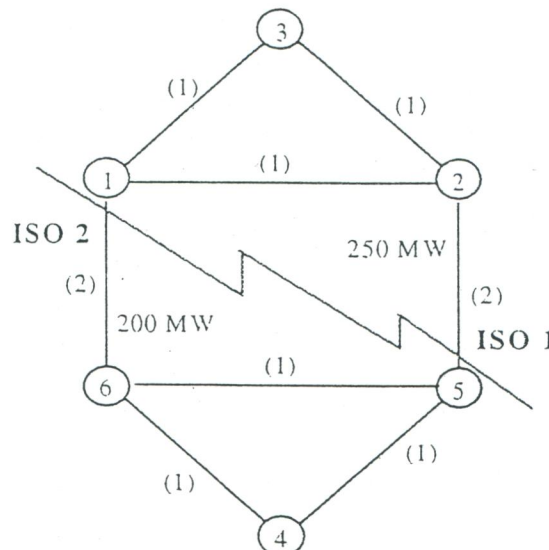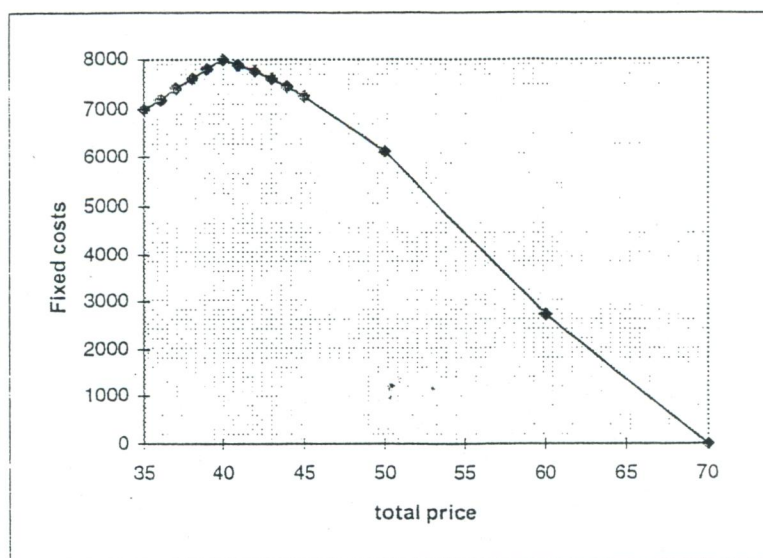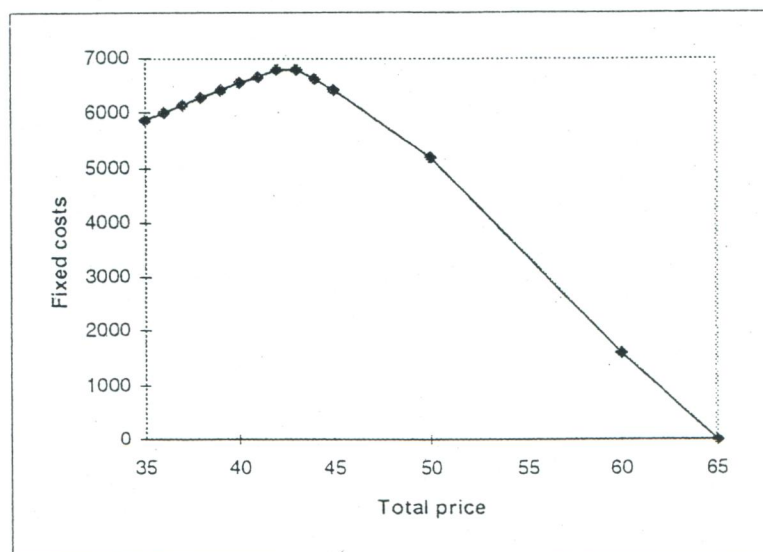

Figure 9

Figure 10

Figure 11

Conclusion

Restructuring of electricity system is underway in different places of the world. Diversity is the rule whether by purpose or by necessity. This also applies to Europe. It is probably too early to come up with an exact picture of how the system will develop but it is certain that it will be heterogeneous. This raises the problem of how the different network operators will co-ordinate their operations. It is argued that the current knowledge on system operations allows one to devise reasonable procedures for structuring the flow of information between ISOs organised according to different paradigms.

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