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THE COMPETITION LAW & ECONOMICS OF ELECTRICITY MARKET REGULATION

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The competition law & economics of electricity market regulation

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Abstract: *Price correlations are used to delineate the geographic market in two recent Danish electricity cases. They indicate that power generators hold temporally transitory and irregularly intermittent dominant positions. Calculation of the Lerner index reveals that they abused this position. The Danish Competition Authority decided to settle this case by agreement for reasons explained. We finally indicate how economics may be used pro-actively to achieve a better market design.*

1. Introduction

The electricity markets in the Scandinavian region have gone a fair distance towards liberalisation. In Denmark, the Electricity Supply Act of 2 June 1999 (with later amendments of 1999 and 2000) led to the introduction of competition between power generators and has rendered regulation of the power market through competition legislation feasible and necessary. Inspired by a recent Danish case, we argue below that economics can assist the legal analysis of competition in electricity markets. We first show how economic analysis can contribute to delineation of the relevant geographical market. Second, we explain how to reveal a dominant position. Finally, we will take the issue one step further and ague that the intervention by the competition authority sometimes proves *second best*. At times the competition issue can be solved by a change in design of the market. For example, it is possible to change the market forces that determine price and quantity in the market and you can change the market mechanism.

The Danish Competition Authority's recently investigated the behaviour on the electricity spot markets in 2000 and 2001 of the two major Danish power generators, Elsam (West Denmark) and

E2 (East Denmark). At its meeting on 26 March 2002, the Competition Council took a decision[1] that is breaking new ground in several ways: First because, to an unprecedented extent, it applied economic methods to delineate the geographic market and to reveal abuse of domination. Second, because the Competition Council entered a settlement with the companies following a so-called negotiation procedure which had previously been used in merger cases alone. The settlement binds Elsam and E2 to follow specific pricing policies during periods in which they could dominate the market and to operate as market makers, thereby making the markets for wholesale electricity thicker, i.e. more liquid.

2. Economic market delineation

At the end of 2001, Elkraft System, the transmission system operator (TSO) responsible for the wholesale electricity market in Eastern Denmark initiated an investigation into price peaks that were observed intermittantly. The basic question was whether the peaks could be explained as normal fluctuations in a competitive market or whether it should be seen a consequence of abuse of a dominant position. Figure 1 shows the price peaks by reporting the spot price of electricity in Eastern Denmark relative to the similar price in Sweden.

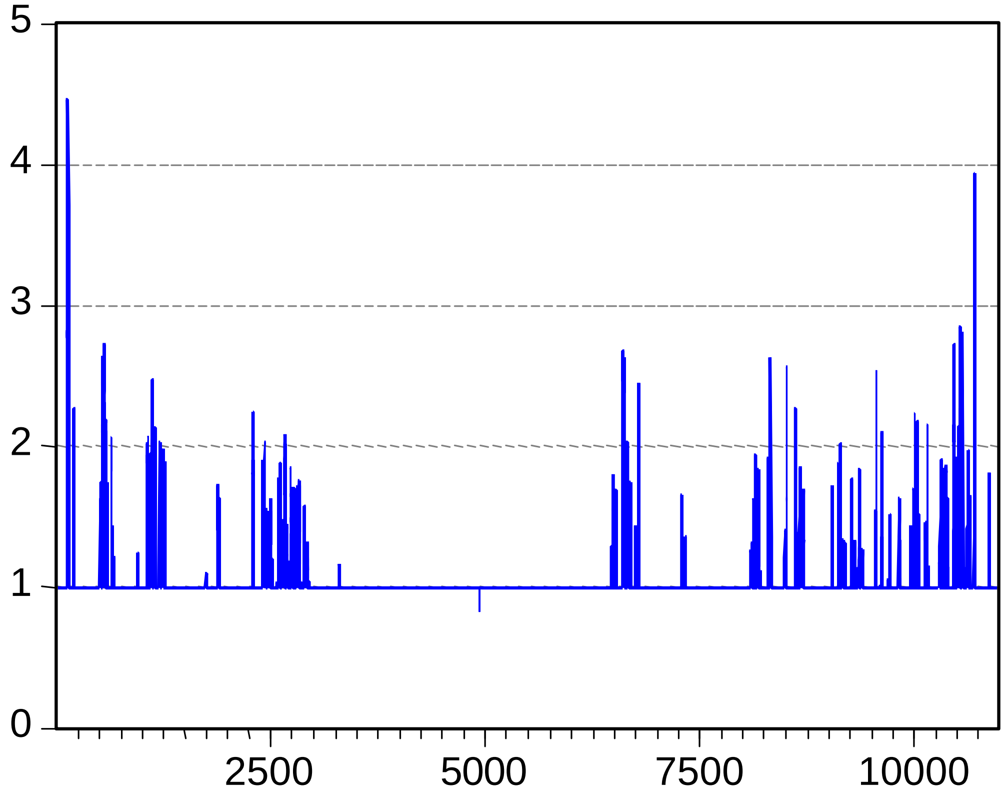

Figure 1: Price peaks in Eastern Denmark

[1] Danish Competition Authority (2003) *Analysis of Elsam A/S and Energi E2 A/S' behaviour on the electricity spot markets in 2000 and 2001*. Combined cases 3/1120-0100-0776 and 3/1120-0204-0089/Energi 2/lsu. The decision (in Danish) is found at www.ks.dk/konkuromr/afg/2003/26-03/Elsam-lsu.htm.

Figure 1 is based on hourly data from the Nordic electricity exchange, Nord Pool. Electricity is traded hour by hour on Nord Pool as regards Scandinavian electricity and on the electricity stock exchange in Leipzig (now EEX) as regards German electricity. There are 24 x 365 hours p.a. or 8760 annual observations. Our sample starts in October 2000 when Eastern Denmark started trading on Nord Pool and ends on the last hour of trading in 2001. Thus we have approximately 11,000 observations.

The wholesale electricity market in Eastern Denmark is connected to the German market via the Kontek interconnection and to the Swedish market via the Øresund interconnection. The market in Eastern Denmark is not directly connected to the market in Western Denmark. The two interconnections are bottlenecks for the power flow between Eastern Denmark and Germany and Sweden respectively. They have limited capacity and when this limit is reached, market integration breaks down and the law of one price does not hold. The market in Western Denmark is connected to Norway, Sweden and Germany in the same way. The import capacity into each of the Danish markets is equal to approximately half the production capacity in each market.[2]

In order to determine the extent of the relevant geographical market, we investigate how closely the different market shares are connected and whether this depends on if the interconnections are open or closed.[3] When Eastern Denmark and Sweden are connected and there is spare capacity on the Øresund connection, the spot prices for these two areas on the electricity exchange, Nord Pool, will by definition be the same. The “law of one price” applies. But how does it look when the Øresund connection is closed, i.e. when its capacity is fully utilised? This can be illustrated by calculating correlation coefficients i.e. numbers between 0 and 1 which indicate the degree of co-variation between prices in different submarkets.

The economic analysis benefits from the large amount of data available in the electricity markets which aids the application of modern econometric methods. To ensure that the calculations of the correlation coefficients are at all relevant, you first have to ensure that the time series is stationary. This means, that the prices do not have a (common) tendency to increase or decrease.[4] The prices in Eastern Denmark, Sweden and Germany are all stationary during the period in question (October 2000 to December 2002).

Subsequently, you have to ensure that a high degree of co-variation is not due to factors which are not directly related to whether the markets are integrated or not. It is easy to imagine that the weather in Sweden, Eastern Denmark and northern Germany often causes electricity consumption to be either high or low at the same times. Furthermore, night time falls at approximately the same time in the three countries. Evening hours typically have low consumption. Such common factors have to be eliminated using econometric techniques before you can get a true picture of the degree of market integration. The result is called a partial correlation coefficient. In the following, the

[2] See Danish Competition Authority (2003, table 1) for the precise figures.

[3] For details on the methodology, consult Copenhagen Economics (2002a) *Relevant markets in the Nordic area*, main report for Nordel’s project on “Market power on the Nordic power market” (subproject 1); available at www.nordel.org.

[4] If the time series are not stationary, you have to apply more advanced methods such as co-integration analysis. See Copenhagen Economics (2002c) *The internal market and the relevant geographical market – the impact of the completion of the Single Market Programme on the definition of the geographical market for consumer products*, report for DG Enterprise, EU Commission, Bruxelles; http://europa.eu.int/comm/enterprise/library/lib-competition/doc/marketdef_final_report.pdf.

correlation coefficients have been stripped of common factors which are not relevant to the market integration.

When the Øresund connection is open, the correlation coefficient is 1 per definition, corresponding to full integration of the Danish and Swedish markets. When the Øresund connection is closed, the partial correlation coefficient between Danish and Swedish prices falls to 0.55. At the same time the correlation between Danish and German prices increases from 0.17 to 0.34. This means that the German market becomes a little more integrated with the Danish when the connection to Sweden is disconnected.[5] However, in all cases, the Danish-German correlation is low.

As a basis for comparison, benchmark correlations can be calculated using spot markets which are by guarantee not integrated with the market in Eastern Denmark. We calculated partial correlation coefficients between prices in Eastern Denmark and prices at the Spanish spot market in Madrid and the Dutch spot market in Amsterdam. Partial correlation coefficients were found to between 0.11 and 0.36. In this light, prices in Leipzig clearly have a low covariation with prices in Eastern Denmark. We thus conclude that Germany is not a part of the same relevant market as Eastern Denmark, independently of whether the Kontek or the Øresund interconnections are open or closed.[6]

When the Øresund interconnection is open, Eastern Denmark and Sweden are without doubt part of the same relevant market. On the other hand, we cautiously conclude that Eastern Denmark can constitute an independent market when the interconnection is closed. It was closed during six percent of the hours in the period October 2000 to December 2001. You cannot make a more firm conclusion in this correlation analysis because there is no objective target for how low the correlation should be in order to view the markets as independent. Obviously, the "law of one price" does not apply when the Øresund connection is closed, and a hypothetical monopolist could increase the prices without losing customers.[7] For this reason, the conclusion is that Eastern Demark does constitute an independent relevant market when the Øresund connection is closed.

The Danish Competition Authority[8] has carried out a similar analysis of whether Western Denmark can be viewed as being part of the same geographical market as Southern Norway, Sweden and Germany respectively. The conclusion is the same as for Eastern Denmark. Western Denmark is never a part of the same market as Germany (partial correlation in the 0.15 – 0.28 interval), is always part of the same market as southern Norway and Sweden when the interconnections, Skagerrak and KontiScan respectively, are open, but is not when the interconnections are closed (correlations between 0.15 and 0.34).

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[5] The reason is probably that Danish production technologies are based on fossil fuels like the German technologies. The Swedish production technologies are to a much larger extent based on hydro and nuclear power. Thus when the Danish and Swedish markets are integrated the price experienced in East Denmark are to a larger degree "out of sync" with German prices than when the interconnection is lost.

[6] If the prices are independent, the correlation coefficient is 0. If the prices are distributed normally, we could also conclude that from a correlation coefficient of 0, that the prices (the markets) and independent. See Alexander M. Mood, Franklin A. Graybill & Duane C. Boes (1974) *Introduction to the Theory of Statistics*, 3rd edition, Singapore: McGraw-Hill, ch. IV. However, the electricity prices do not entirely follow a normal distribution.

[7] The market is thus fulfilling the demands for the SSNIP-test which is used in the US and increasingly in the EU. SSNIP = *Small but Significant Non-transitory Increase of Price*.

[8] Danish Competition Authority, *op.cit.*, table 3.

Therefore, the main conclusion is, that the two Danish markets for whole sale electricity are never part of the same relevant market as Germany, is always a part of the same market as Sweden and southern Norway when the respective interconnections are open, but is probably not when they are closed.

3. Economic methods for determining abuse of dominance

During periods where the relevant markets are broader than Eastern Denmark and Western Denmark respectively, the two Danish electricity producers, Elsam and E2, do not have a dominant position. They have a relatively small share of the relevant market, and they can (probably) not to an appreciable extent behave independently of their competitors, customers and ultimately of consumers by increasing prices.

On the contrary, when the relevant markets are limited to Eastern Denmark and Western Denmark, respectively, these electricity producers have a very significant market share in their respective markets. At the same time they can to a large extent behave independently of competitors, customers and ultimately of consumers, so they possess a dominant position as defined by the European Court of Justice (ECJ).

The economic analysis of whether a company is charging unreasonably high prices is based on the Lerner index, *L*, which indicates by how many percent the price exceeds the marginal costs of producing electricity at any given time:

$$L = \frac{P - MC}{P}$$

The Lerner index forms a natural economic basis for the analysis since it is an often-used measure of market power. Furthermore it conforms with the standard of proof in abuse cases of excessive prices as expounded by the ECJ in the Banana-case (at 251):[9]

> ”This excess could, *inter alia,* be determined objectively if it were possible for it to be calculated by making a comparison between the selling price of the product in question and its cost of production, which would disclose the amount of the profit margin; however, the Commission has not done this since it has not analysed UBC’s costs structure.”

The Lerner index is such an estimation of the size of the profit margins. In a perfectly competitive market, the prices would equal the marginal costs so the Lerner-index would be 0. The prices are known from Nord Pool, so to calculate the Lerner index we “just” need to calculate the marginal costs. The production methods of the electricity sector have been well documented from an engineering point of view and it is possible to calculate the marginal costs through technical knowledge and observation of of input-prices. This method has been applied to diagnose market power in the UK and in California.[10]

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[9] *United Brands Company* v. *Commission*, *Case 27/76*, [1978] ECR 207, [1978] 1 CMLR 429.

[10] See e.g. Borenstein, Severin; James Bushnell & Frank Wolak (2000) “Diagnosing Market Power in California’s Deregulated Wholesale Electricity Market,” *POWER* PWP-064, University of California Energy Institute; and C. Wolfram (1999) “Measuring Duopoly Power in the British Electricity Spot Market,” *American Economic Review* 89(4): 805-826. For an overview of the relevant economic literature, see Copenhagen Economics (2002b, ch. 6) *Use and abuse*

Step by step the procedure is:

1. Calculate the theoretical supply curve for the potential marginal power plants by calculating the actual capacity of each plant and its marginal costs.
2. Calculate the residual demands which the plants have to meet.
3. Make hourly readings of the marginal costs where residual demand and supply intersect.

Conservatively, the actual capacity can be estimated to be the 80 percen quantile of actual production. This means that the capacity for a plant is estimated so actual production is below capacity during 80 percent of the hours. This is conservative in the sense that it increases the marginal costs compared with the situation where the nominal capacity (which is higher) is used for the calculation. This makes it easier for the company to justify increased prices, and therefore more difficult to prove abuse.

Each plant's marginal costs can be calculated according to the following formula:

$$MC = ep + c + t\,,$$

where e is the (inverse of the) plant-specific average efficiency rate, p is the cost of the relevant fuel at the time, c is other variable operating or maintenance costs (including start-up costs, handling of fuel, ashes and cinders), and t plant- or fuel-specific taxes. The electricity efficiency rate shows how much fuel is needed to produce one additional unit of electricity (1 MWh) at this plant. If e is multiplied with the price of fuel, p, the result is the direct fuel costs. To this you add the start-up costs of a plant, and other variable operating costs. Precisely how you do this can be debated, and this has been the subject of conflicting views in the cases regarding Elsam and E2. The method is most convincing when you make a conservative estimate of the cost, i.e. make sure that if you err it will tend to bias MC upwards. That way it is more difficult to prove abuse by excessive prices, and the companies will benefit from the doubt regarding the costs.

The most significant point at which our and the Danish Competition Authority's analyses can be improved regards the decision to start-up and shut-down plants. By rights, the companies have stated that you do not start-up a plant for one single hour. This would not be cost effective due to the large start-up costs. In the same way, a plant is not shut down merely because it is not cost effective for just one single hour. Such decisions can be viewed as investments under uncertainty and well developed theories about real options[11] can be used to value the price of start-up. It would then possible to estimate whether the simple method which has been used so far, can be said to overestimate or underestimate the actual costs.

When the capacity and marginal costs of each plant have been found, the theoretical supply curve can be calculated by assuming that the most cost effective plants are used first. Typically, in Eastern Denmark it would be the Svanemølle plant and the H. C. Ørsted plant that are never shut down, apart from e.g. for planned maintenance. The least cost effective plants will be put in use last. Typically, this would be a plant such as the Kyndbyværk on Eastern Zealand. This way, a stepwise increasing marginal cost curve appears for a given electricity producer, cf. figure 2.

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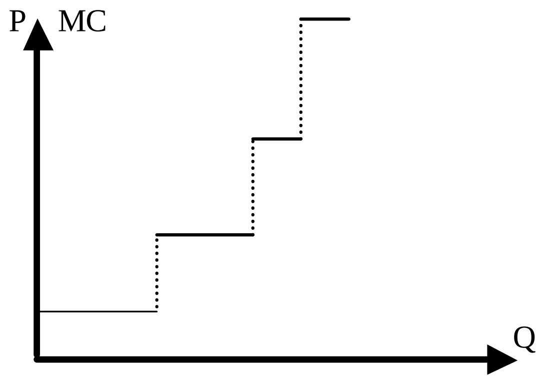
of market power in the Nordic power market, main report for Nordel's project on "Market power on the Nordic power market" (subproject 3); available at www.nordel.org.

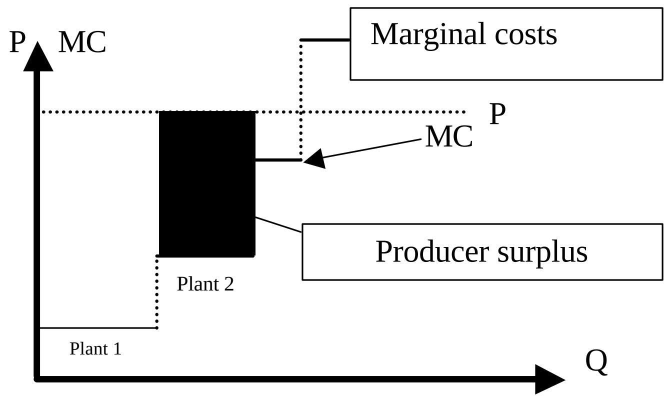
[11] See Dixit, Avinash K. & Robert S. Pindyck (1994) *Investment under uncertainty*, Princeton University Press.

Figure 2: The marginal cost curve: The supply curve for a competitive producer



If the company is small and trades on an integrated market, the price is taken for given. In this case, the price is fixed competitively on Nord Pool.

Figure 3: Equilibrium for a competitive company.

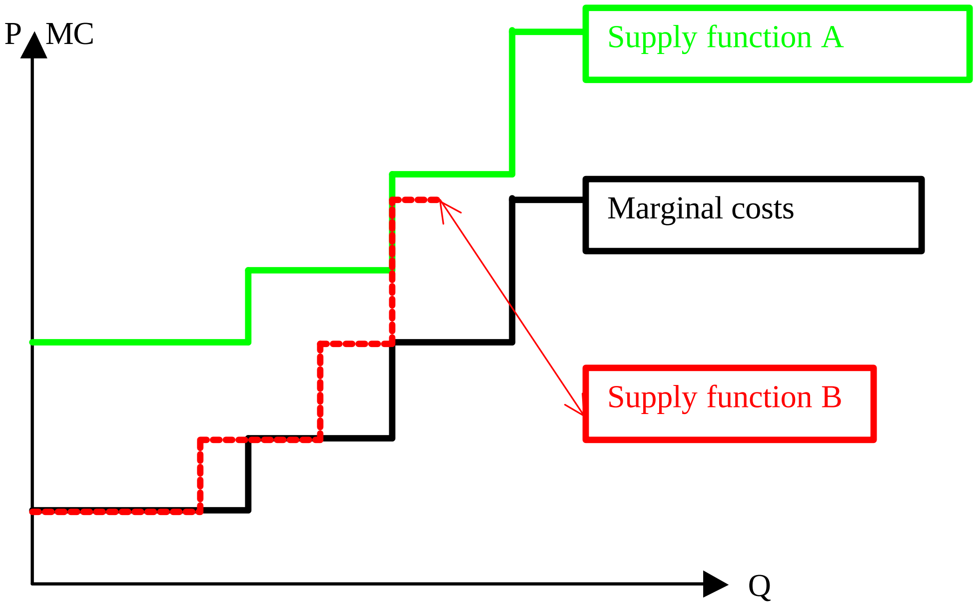


The Lerner-index for the hour in question can therefore be calculated according to the formula $L = (P - MC)/P$, as indicated above. It is worth noting that the Lerner-index for a given hour can become negative if the marginal costs are overestimated. This can easily be the case if conservative estimates are applied to let the company benefit from the doubt. Furthermore, we note that the gross profit (or the producer surplus) for the company is positive even if the company does not make a profit on the ”marginal plant,” i.e. the plant that is started up last. The electricity producer gets his surplus from the so-called infra marginal plants. In figure 2 these are plants 1 and 2.

The most important application of the above in a competition law analysis of abuse, is that it allows the calculation of the Lerner-index in a situation with competition. This may then be used as a benchmark for comparison to investigate whether the behaviour changes significantly when the company has a dominant position.

An electricity producer can abuse his dominant position in two ways. Firstly, the marginal costs can be exaggerated for each plant (cf. the supply function A in figure 3), and secondly, he can artificially limit the capacity for each plant (cf. the supply function B in figure 3). A combination of the two methods can of course also be applied. The supply functions are what generators submit to the power exchange, Nord Pool. For a competitive company, the supply function concurs with the marginal cost curve. Both types of abuse has the effect that the price is fixed artificially above the actual production price, and therefore, it is a question of unreasonably high prices.

Figure 4: Supply functions



In principle, it is possible to make a direct comparison of the electricity producers' supply function submitted to Nord Pool with the marginal cost curve for the hour in question. For this to work, Nord Pool or the company has to release the supply function. In practice, this method has not been applied.

A solution that requires less information relies on calculation of the Lerner-index in situations where the company has a dominant position. Subsequently, it can be tested whether it is markedly higher than in the situations where the market is integrated and the company is forced to set price competitively. Here the application of the Lerner-index needs to identify the marginal plant. For this purpose it is necessary to determine how much demand the company has had during a given period, the residual demand.

	Residual demand
=	Total electricity consumption on the market in question for the hour in question
minus	Electricity production by independent wind mills
minus	Electricity production by independent, de-central power plants
minus	Net import from Scandinavia
minus	Net import from Germany
plus	Automatic reserve capacity

When the residual demand has been determined, the marginal plant and thereby the marginal costs can be determined. To do this you need to know which plants have been shut down for a given hour, but such data will typically be known by the Transmission Systems Operator (TSO). This now enables the Lerner-index to be calculated for the situation with dominance.

We[12] calculated the Lerner-index for Eastern Denmark during the period October 2002 to December 2001. During the 630 hours when the firm, E2, held a dominant position, the index was on average 0.43; during the 10,336 hours when it did not possess a dominant position, *L* was on average equal to 0.04, close to the competitive benchmark of 0. In practice, this means that the prices were on average 75% higher than the marginal costs during periods of dominance. This is probably enough to establish that excessively high prices were in place. (During periods without dominant position, prices were 4% higher than the marginal costs).

The Danish Competition Authority has in similar fashion calculated the Lerner-index for Western Denmark[13], and also finds significant differences between the values of the index during periods with dominance and those without. For 2001, the calculations are very similar to those for Eastern Denmark. For 2000, the Lerner-index is however negative both for periods with and for periods without a dominant position. This could be an indication of problems with the calibration of the marginal cost curve for this year.

The conclusion is that the companies change their behaviour and increase the profit margins significantly during periods with dominance. The calculated Lerner-index solidly supports that the companies have charged unreasonably high prices during periods with a dominant position.

In the transition from economics to jurisprudence, this conclusion faces two challenges:

1. The abuse is not continuous or uninterrupted during the sample period, but is temporally transitory and irregularly intermittent.[14]
2. It has not yet happened in EU practice that a company has been charged with setting unreasonably high prices.[15]

These issues, and the fact that first-time abuse from before 1st July 2002 cannot be punished by fine, probably caused the Danish Competition Council be reluctant in taking a tough decision. Instead, the case was settled by an agreement according to which

- in the future, the electricity producers commit to following a particular policy for submission of supply functions to Nord Pool,
- and, before 1st July 2003, they have to begin to operate as market makers, i.e. they promise always to give notice of prices at which they will buy and sell. This will make the market more liquid.

The Danish Competition Authority[16] estimates that these undertakings will create a significant improvement of the markets. By giving relatively lenient terms, the Competition Authority is in

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[12] Since our report contains confidential information, all figures reported in this article are copied from the Danish Competition Authority, 2003, *op.cit.*, in this case from Table 10.
[13] Danish Competition Authority, 2003, *op.cit.*, Table 7.
[14] The Norwegian competition authorities have accepted time-dependent geographic markets in a recent merger case.
[15] The British Director-General of Fair Trading has recently fined a pharmaceutical company for both excessive and predatory pricing under the new UK Competition Act 1998. See Stephen Kon and Sarah Turnbull (2003) "Pricing and the Dominant Firm: Implications of the Competition Commission Appeal Tribunal's Judgment in the *Napp* Case," *European Competition Law Review* 24(2): 70-86.
[16] *Op.cit.*, point 21.

sync with the European Commission in so far as the EU Commission in a number of cases have adopted a lenient approach to the electricity markets, than is common practice for other markets.[17]

4. Economic analysis to remedy market power

In the previous sections we have outlined how economic analysis can be applied re-actively to establish the extent of a relevant market for electricity and to determine whether prices have been excessive or not. In addition, economics can be applied pro-actively to determine how to reduce incentives for exercising market power or equivalently, for abusing a dominant position. The incentives to exercise market power can be changed by eliminating or reducing the importance of the bottlenecks which cause the dominant position to exist, by reducing the significance of existing bottlenecks, or by changing the rules that govern interaction between the system operator and the electricity producer. In sum, economic analysis can be used to create a better design of the markets.

In the short term, the easy solution for the problem created by limited capacity on interconnections, is to increase capacity on the transmission lines. It could be on the Øresund connection to Sweden or the KONTEK connection to Germany. Another possibility is to build a new connection. For instance, in Denmark this could be a line connecting Eastern and Western Denmark, which makes Elsam and E2 direct competitors. Again, you have consider the advantages and disadvantages of a new connection.

Increased transmission capacity, whether due to increased capacity of the existing connection or construction of new lines, is however, an expensive solution. Therefore, a cost benefit analysis is necessary to determine whether it is viable to increase capacity and in the affirmative which possibility is the cheapest and the best. In such an analysis, benefits will include the possibilities for reduction of the number of hours during which the companies can achieve dominant positions.

A less dramatic strategy which can be carried out in a shorter timeframe, could be to go through the mechanisms which are used to allocate transmission rights for the bottlenecks for the different market participants. Should a type of auction be used as happens today on e.g. the Kontek connection between Eastern Denmark and Germany? How should such an auction be set up in order to give the best allocation? How does this effect the possibility for exercising market power? Does this allow a potentially dominant company to create its own dominant position by buying the rights for transmission? Or would it be more efficient to introduce a price area model as known from the Øresund connection?

Finally, one might challenge the legality of the Swedish practice of reducing capacity on the Øresund interconnection to reduce demand from Eastern Denmark in situations with capacity problems internally in Sweden which stops power flowing from the North where it is produced to the South where it is consumed. It seems that such a practice cannot be consistent with the principle of free movement of goods, and this could very well be a case for the EU Commission.

[17] For an overview of what is common practice in the EU, the Nordic region and other selected countries, see Copenhagen Economics, 2002b, *op.cit.*, ch. 3. See also Jonathan Faull & Ali Nikpay (1999) *The EC Law of Competition*, Oxford University Press, ch. 10.