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# OWNERSHIP UNBUNDLING IN ELECTRICITY MARKETS - A SOCIAL COST BENEFIT ANALYSIS OF THE GERMAN TSO'S

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## 1 Introduction

On September 19, 2007 the European Commission presented the draft for the 3rd Energy Liberalisation Package. The draft followed the sector inquiry of early 2007, which concluded that competition in the European energy sector is developing too slowly, and it is clear from the draft that the key objective of the the new Directive is to stimulate competition. Among other things, the Directive proposes further unbundling of the networks from the competitive

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businesses. More precisely, within different options, full ownership unbundling of the transmission system operators in electricity and gas is proposed.[2] This paper presents a comprehensive *social cost benefit analysis* (SCBA) of ownership unbundling of electricity TSOs in Germany. We restrict the analysis to the German case for two reasons; firstly this seems to be the current focus of the European debate and secondly simply to constrain the calculations and data requirement. The main insights are more general, however, and with due caution, may be carried over to other countries as well.

The SCBA follows the lines set out in Jones, Tandon & Vogelsang (1990), Newbery & Pollitt (1997) and Gulli (2003). This study analyses about 15 effects which are collected in three groups of effects explicitly. First, the "*competition effect*", which captures the arguments that unbundling increases competition. One particularly important aspect is the effect of unbundling on available generation capacity. Second, the "*interconnector effect*", which captures the argument that vertically integrated utilities have insufficient incentives to invest in interconnector capacity in order to hold off competition from abroad (the "strategic investment withholding" argument). Third, the "*cost effect*", for which we distinguish three subgroups. In particular, the potential loss of vertical synergies may be important.

The key step in the analysis is to define the competitive concept. We use the concept of the *residual supply index* (RSI) linked to the Lerner Index. The parameters we need for applying this concept were estimated for Germany for 2006 in a study by London Economics (2007) for the European Commission. The so-defined competitive concept captures a critical notion for electricity markets: the "capacity-demand ratio". The concept concentrates on relative scarcity, which can be artificially created by so-called *pivotal firms*, as the main determinant on the spot market.

Apart from our base case, which is formulated relatively "unbundling-friendly", we distinguish six alternative scenarios. The counterfactual business-as-usual case (BAU) is defined as the current state of legal and management unbundling. Thus importantly, the study concentrates only the marginal step from legal unbundling to full ownership unbundling. The study focuses on the scenarios varying four main assumptions:

1) low generation capacity (base case) versus high generation capacity,

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[2] The other option is a so-called "deep ISO" and a third option called "the third way" which basically is a stricter form of legal unbundling. The current state of the debate in Brussels is a Council agreement that all three options are feasible, which means in practical terms that everything will stay as it is. However, as this is not the topic of the papers, the reader may be referred to Balmert at.al. (2008) for a detailed analysis of "deep ISOs".

2) low versus high vertical synergy losses
3) varying the assumption that unbundling does or does not accelerate new generation investment (the “capacity effect”)
4) varying the assumption that unbundling does or does not accelerate new interconnector investment (the “interconnector effect”).

For the four assumptions above, the base case assumes low generation capacity and low synergy losses, and both a generation investment acceleration effect and an interconnector investment acceleration effect.

The key results are the following.

- For the base-case, the net weighted discounted social-cost-benefit effect (weighted-ΔSCB) is likely to be positive, but small. The moderate magnitude is at least partly due to the fact that we focus only on the marginal step from legal unbundling to ownership unbundling.
- The relative weighing for consumers versus producers/shareholders is critical. For the base case, the slightly positive net effect on social welfare relies on the higher weighing of consumer interests. In the base case, producers lose ever so slightly more than consumers gain.
- The interconnector effect is surprisingly and perhaps disappointingly small. We should note, however, that the interconnector effect has the strongest uncertainty around the assumptions.
- Applying the RSI concept, a particularly important point is the effect of total available generation capacity relative to demand. In times of capacity scarcity prices tend to be high and therefore the effects of unbundling tend by amplified. This is relevant because Germany may actually enter a period of low capacity. If, by comparison, we assume adequate capacity, the competition effect gets small, whereas costs of unbundling remain. The overall weighted effect of a high-capacity scenario is still likely to be positive but small.
- The effect of the capacity acceleration (the capacity effect) for CS and PS in isolation is potentially substantial; this holds especially for the low-capacity case.
- Only for the high-cost scenario we find a slightly negative weighted net effect; the costs of unbundling are critical. Since we analyse the marginal step from legal to ownership unbundling, this study tends to assume relatively modest costs. However, should the cost be high, then the net effects can quickly become negative.

In total, the SCBA in this study suggests that for most scenarios the weighted net effect is likely to be positive, but small as compared to the size of the sector. We conclude that arguments other than strict static economic efficiency will have to decide the debate.

The paper is organized as follows. Section 2 explains the competitive concept and derives underlying theory of the *residual supply index*. Section 3 discusses the assumptions of the approach. This long section is broken down into three parts following the classification into 1) the competition effect, 2) the interconnector effect and 3) the cost effect. Section 4 discusses the results and section 5 concludes.

## 2 The competitive concept – Residual Supply Index

The idea of unbundling is twofold. On the one hand, unbundling should improve competition by restoring the level playing field among competitors. On the other hand, unbundling should improve the incentives for more investment in interconnector capacity. This in turn serves three goals. It improves competition, it improves supply security and it strengthens the development of the internal European energy market. Overall, the promotion of competition is a key argument. Therefore, in a SCBA the underlying competitive concept is central.

This study relies on the concept of the *residual supply index* (RSI) to capture a number of effects on competition. The concept was developed in California following the investigations into whether the crisis around 2000 was triggered by an abuse of market power (cf. CAISO, 2004); the notion is that generators may have the incentives to withhold capacity strategically in order to create scarcity and thereby drive up prices. The RSI captures the idea that capacity scarcity (relative to demand) reduces competitive pressure, while excess capacity is likely to promote competition. The theoretical background in industrial economics of this capacity constraint argument relies in particular on Kreps & Scheinkman (1983), Dixit (1980) and was argued forcefully for electricity spot-markets by Green & Newbery (1992) and Newbery (1998).

The Residual Supply Index for firm $i$, $RSI_i$ , is defined as follows:

$$RSI_{i,t,s} = \frac{\sum_{all\ j} Q_{j,t} - TUC_{i,t}}{Load_{t,s}} \qquad (1)$$

Where $Q_{,j,t}$ is generation capacity of firm $i$ in year $t$, $TUC_{i,t}$ is total uncommitted capacity (i.e. capacity, which is not covered by long-term contracts) of firm $i$. $Load_{t,s}$ is peak load in year $t$ in load period $s$. We distinguish 8 different load periods $s$ within the year $t$.

Key to the competitive effects is relating the so-defined RSI to the Lerner Index as follows:

$$LI_{i,t,s} = f_i(RSI_{i,t,s}) \tag{2}$$

Where, $LI_{t,s} = \frac{P_{t,s} - MC_{t,s}}{P_{t,s}}$. The $RSI_i$ is defined for each individual firm, but the main important relation is the $LI$ for the *largest* single supplier (in terms of $TUC_i$).

An extensive study by London Economics (2007) for the European Commission (DG COMP) estimates the LI-RSI relations for four different countries (Germany, Spain, Netherlands and Great Britain) and for a variety of specifications. From this study we use the parameter estimates for the *squared* specification for the *price-cost mark-up*.[3]

$$\frac{P - MC(Q)}{MC(Q)} = \beta_{1,i} + \beta_{2,i} RSI_i + \beta_{3,i} RSI^2 \tag{3}$$

Before doing so, we first derive the underlying theoretical rationale. The concept can be seen to capture the notion of *conjectural variations* known from industrial economics. To illustrate conjectural variations, we follow the formulation of Cowling & Waterson (1976). First, we derive the Lerner index using the standard approach with conjectural variation. Assume for ease of notation, N symmetrical firms. Profit for firm $i$ is:

$$\pi_i = P \cdot Q_i - C(Q_i) - F_i \tag{4}$$

Where, $P = P(Q) = P(Q_1, Q_2, ..., Q_N)$. The FOC gives:

$$\frac{\partial \pi_i}{\partial Q_i} = P + Q_i \frac{\partial P}{\partial Q} \frac{dQ}{dQ_i} - MC(Q_i) = 0 \tag{5}$$

Where $\frac{dQ}{dQ_i} = 1 + \frac{d\sum_{j \neq i} Q_j}{dQ_i} = 1 + \lambda_i$. In this, $\lambda_i$ is the parameter for conjectural variation (CV), characterizing the intensity of competition in the market.

[3] Note that we do not use the Lerner Index, because the statistical goodness of fit in the London Economics study is far better for the PCMU.

Summing for all firms N, dividing by P and denoting $\lambda = \frac{\sum_{all\ i} Q_i \lambda_i}{\sum_{all\ i} Q_i}$, then yields the "CV approach":

$$\frac{P - MC(Q)}{P} = \frac{1+\lambda}{N\varepsilon} = \frac{1+\lambda}{\varepsilon_{RD}} \tag{6}$$

Where $\varepsilon$ is positively defined elasticity of demand and $\varepsilon_{RD}$ is (positively) defined elasticity of residual demand. Evidently, in symmetry, $\lambda_i = \lambda$, for all *i*. We use *MC(Q)* as the system marginal costs, in contrast to individual marginal cost. Whereas this is theoretically restrictive and would require more justification, for electric power markets it is highly realistic. Moreover, in symmetry it does not make a difference. The conjectural variation parameter λ makes an explicit assumption about the competitive intensity in the market, as it establishes the reaction of firms to the actions of other firms. In particular, we say that the market outcome is:

- Bertrand if $\lambda = -1$
- Cournot if $\lambda = 0$
- Collusion (monopoly outcome) if $\lambda = N-1$

Using these parameter values, the relation with the familiar Lerner Index is evident.

Now we establish the analogy with the RSI approach. To capture the spirit of the model, which is the effect of capacity excess and shortages, we use capacities rather than output. Residual demand for firm *i* is:

$$RD_i = D - \sum_{j \neq i} Q_j - LTC_i \tag{7}$$

Where *D* is market demand and $LTC_i$ is the amount capacity covered by long term contracts for firm *i*. Rewriting gives:

$$RD_i = D - \sum_{all\ j} Q_j + (Q_i - LTC_i) \tag{8}$$

Note that, $Q_i - LTC_i = TUC_i$. It follows that:

$$RD_i = D(1 - RSI_i) \tag{9}$$

If, as asserted, we write $\lambda_i$ as a function of $RSI_i$ (next to other factors not specified here), we find:[4]

[4] Strictly speaking, we should make a distinction between capacity and output here; simplifying, we assume immediately that output is equal to capacity for all firms $j \neq i$.

$$\frac{P - MC(Q)}{P} = \frac{(1 + \lambda_i(RSI_i)) \cdot (1 - RSI_i)}{\varepsilon} \tag{10}$$

The key idea is that the type or the intensity of competition (conjectural variation) changes with relative capacity availability. Now assume a linear negative relation:[5]

$$\lambda_i(RSI_i) = (\gamma_i - 1) - \mu_i RSI_i \text{, with } \gamma_i, \mu_i \geq 0 \tag{11}$$

Substituting into (10) and writing out gives the quadratic specification:

$$\frac{P - MC(Q)}{P} = \varphi_{1,i} + \varphi_{2,i} RSI_i + \varphi_{3,i} RSI^2 \tag{12}$$

where,

$$\varphi_{1,i} = \frac{\gamma_i}{\varepsilon} \geq 0, \quad \varphi_{2,i} = -\frac{\gamma_i + \mu_i}{\varepsilon} \leq 0, \quad \varphi_{3,i} = \frac{\mu_i}{\varepsilon} \geq 0 \tag{13}$$

Taken together, this establishes different types of effects of unbundling. First, competition within the market may change directly. This affects $\lambda_i$ in the CV-approach and similarly the $\varphi_i$'s in the RSI-approach. Secondly, unbundling can ease market entry, increase total capacity and thereby affect *RSI*. In the CV-approach, the effects are exogenous, whereas in the RSI-approach, the effects are endogenous via $RSI_i$ and via $\lambda_i(RSI_i)$. Thus, new entry increases *RSI* so lowering *LI*, and decreasing $\lambda$ and thus *LI*.

The equations in (11) to (13) deserve some attention. First, by conjectural variation $-1 \leq \lambda_i \leq$ N-1, and from this it might be argued that: $\gamma_i = N + \mu_i$. Assuming $RSI_i = 1$, we would expect that $\lambda_i$ might go to N-1 (the collusive outcome in the CV approach); notably, however, the relation only holds for pivotal firms; i.e. those which, acting alone, may bring total capacity below demand; all others drop out. Paradoxically therefore, for a country with many small firms, N may be actually be small, as the probability of pivotal firms is small. Moreover, if $RSI_i$ is relatively high, say 2, we would find $\gamma_i = N - \mu_i - 1$ ; if $N = \mu_i$, we would find $\lambda_i =$ -1 (the Bertrand outcome in the CV approach). Therefore, we assert the following to hold approximately:

$$\gamma_i = N + \mu_i \text{, and}$$

$$N = \mu_i \text{, where } N \text{ is the number of pivotal firms.}$$

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[5] In fact, for a complete and consistent specification, this relation should be specified endogenously. The theory is inconclusive about the relation between conjectural variations and capacity availability (which also underlies our simplification in footnote 4). A promising approach, however, is the concept of supply function equilibria under capacity constraints (Klemperer & Meyer, 1989 and more specifically Newbery, 1998). Under this concept the type of competition is changed endogenously by the capacity constraints.

It is, however, not straightforward to determine the "number" of pivotal firms as this changes with fluctuating load. At night there may be no pivotal firms, while in peak times several firms might be pivotal. Secondly, note that as the number of pivotal firms N goes to zero, we would expect the market to be more competitive which, ceteris paribus, results in parameter values closer to zero. More generally, stronger competition implies parameter values closer to zero. Thirdly, note that with $\varphi_1$, $\varphi_3 > 0$ and $\varphi_2 < 0$ and the relations above that: $\varphi_2 = -(\varphi_1 + \varphi_3)$.

The numbers in London Economics (2007) specified for the price-cost mark-up (PCMU), hold surprisingly well. The PCMU-RSI is:

$$\frac{P - MC(Q)}{MC(Q)} = \beta_{1,i} + \beta_{2,i} RSI_i + \beta_{3,i} RSI^2 \tag{14}$$

Straightforward rewriting gives:

$$\frac{P - MC(Q)}{P} = (\beta_{1,i} + \beta_{2,i} RSI_i + \beta_{3,i} RSI^2) \cdot \frac{MC(Q)}{P} \tag{15}$$

And thus $\beta_{k,i} \frac{MC(Q)}{P} = \varphi_{k,i}$, for each $k$ = 1,..,3 and all $i$. In other words, in the statistical estimates of the parameter values $\varphi$ and $\beta$ for each firm are transformed with a constant roughly ranging between 0.5 and 1.

Table 1 below summarizes results from the LE-study for different firms (coded in original) and four different countries.

| Country | Firm | β1 – const. | β2 | β3 - sq. | s.e.- β1 | s.e.- β2 | s.e.- β3 | R2 |
|---|---|---|---|---|---|---|---|---|
| DE | 0436-S-DE | 7,879008 | -10,843200 | 3,586526 | 0,310 | 0,530 | 0,230 | 0,162 |
| DE | 0569-S-DE | 6,665326 | -7,811026 | 2,170243 | 0,300 | 0,450 | 0,170 | 0,150 |
| DE | 1338-S-DE | 5,705663 | -8,119380 | 2,686736 | 0,350 | 0,670 | 0,320 | 0,114 |
| DE | 1681-S-DE | 5,941010 | -6,681421 | 1,757341 | 0,290 | 0,420 | 0,160 | 0,150 |
| ES | 0577-S-ES | 3,825810 | -4,866206 | 1,440906 | 0,060 | 0,090 | 0,040 | 0,393 |
| ES | 0875-S-ES | 4,745113 | -6,554793 | 2,152538 | 0,070 | 0,110 | 0,050 | 0,401 |
| NL | 0511-S-NL | 4,649714 | -5,989611 | 1,765735 | 0,140 | 0,210 | 0,080 | 0,128 |
| NL | 0712-S-NL | 4,546965 | -6,362027 | 2,036108 | 0,150 | 0,250 | 0,100 | 0,120 |
| GB | 0242-S-GB | 4,053944 | -4,462942 | 1,158067 | 0,130 | 0,170 | 0,050 | 0,230 |
| GB | 0453-S-GB | 4,481927 | -5,149696 | 1,404872 | 0,130 | 0,180 | 0,060 | 0,242 |
| GB | 1340-S-GB | 2,197158 | -2,023862 | 0,409721 | 0,063 | 0,080 | 0,028 | 0,219 |
| GB | 1477-S-GB | 4,004359 | -4,641921 | 1,272108 | 0,130 | 0,177 | 0,060 | 0,222 |

*Table 1: Parameter values for the squared PCMU-RSI relation for different firms in different countries.*
*Source: London Economics (2007)*

From these estimates we note the following. The data seem to confirm the theory surprisingly well. Although the London Economics study has been criticized on several accounts (cf.

Ockenfels, 2007 and NERA, 2007) and indeed for example the estimates for the Lerner index seem to be very poor, the estimates for the PCMU seem to be entirely reasonable. The parameters have the expected signs without exception. Moreover, $\varphi_2 = -(\varphi_1 + \varphi_3)$ and thus $\beta_2 = -(\beta_1 + \beta_3)$ seems to hold quite accurately. Very roughly also, the magnitude of the parameter values seems to be plausible. London Economics (2007) finds either 1 or sometimes 2 pivotal firms in Germany, varying, depending on definition, between 24% and 68% of the time.[6] Using the assertions made above, if we assume for the German case that 2 firms could be pivotal 50% of the time, and thus that N = 0.5*2 = 1 and thus $\mu = 1$ and assume $\varepsilon = 0.5$, and a *P/MC*-ratio of 1.5, we would find that $\beta_1 = 6$, $\beta_2 = -9$, $\beta_3 = 3$. For the case of Great Britain, no firm was found to be pivotal at any point in time and as expected we find low parameter values. Lastly, the $R^2$ values are reasonable. In our study below, we use the parameter values for the German company 0436-S-DE.

Although the RSI-approach is elegant and powerful, it is not without drawbacks. We note two major drawbacks, potentially affecting the outcome of this study. First, the RSI-approach focuses on scarce capacity, or in reverse terms, lack of excess capacity. In addition, the concept strongly relies on the pivotal firm; i.e. a firm is called pivotal if the *RSI* for this firm is less than one, in which case this firm alone could lower total available capacity on the market below peak load. The RSI-approach covers the more mainstream competitive concepts without pivotal firms only indirectly. Thus, effects not related to available capacity or pivotal firms are implicit in the parameters. This also concerns part of the unbundling effects. Second, the RSI-approach focuses strongly on the spot market. In particular, the influence of the pivotal firm is captured with “total uncommitted capacity” (TUC), which is capacity which is not covered by long-term contracts and therefore available to the spot market. Yet, a large part of the market is determined by bilateral long-term contracts. We have to assume, which is fairly usual, that the correlation between prices on the spot market and prices of long-term contracts is sufficiently strong. In other words, we assume that the spot prices are signals for the long term contracts.

Overall thus we have two channels through the PCMU-RSI equation for the competition effects of unbundling. First, the collection of effects which affect the *RSI* (which in turn affects the equation directly and via the parameters). Second, the indirect effects which affect the parameter values directly. We describe the assumptions and effects in more detail in

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[6] For Spain 2 firms were pivotal each about 25% of the time. For the Netherlands, 3 firms qualify ranging from 5%, to 10% to 30% of the time. Notably around 2005, the Netherlands were short in capacity.

section 3, but illustrate the asserted effects of unbundling via the mechanism of the PCMU-RSI, with the following four effects:

- A stronger competitive intensity implies that the $\beta$'s go to zero,
- More efficient use of constrained interconnectors implies that $\Sigma Q$ increases and $\beta$'s go to zero,
- Accelerated generation investment means that $\Sigma Q$ increases,
- Stronger competitive pressure decreases MC.

# 3 The assumptions on the effects of ownership unbundling

This section discusses and explains the effects and arguments that entered the SCBA analysis. For good discussions on the pros and cons of ownership unbundling, the reader may be referred to De Noooij and Baarsma (2008), CPB (2005), Pollitt (2007) and Growitsch et.al. (2008). The study examines quantitatively about 15 effects which we group along three lines:

- The competition effect
- The interconnector effect
- The cost effect

Strictly speaking the interconnector effect is simultaneously part of the competition effect and the cost effect and not a group on its own. But as the effect is central and deserves detailed discussion, separate treatment seems justified.

## 3.1 Base assumptions

The study distinguishes 8 (i.e. $2^3$) different load periods following three different criteria: 1) day/night, 2) week ("Midweek")/weekend ("Endweek") and 3) winter/summer. Two periods are the relevant load periods: DMW (day – midweek - winter) and DMS (day – midweek - summer). As day-time has been defined as 08:00am – 20:00pm and summer and winter are both 6 months, each of these periods has a time-weight of 22%. The effects of unbundling on competition and thereby prices occur particularly in these two peak periods and thus during somewhat less than 50% of all time.

The marginal system costs, following the merit order, depend on the system load and thus on the load period. For the relevant periods, we assume that only hard coal or gas is marginal. We assume that in DMW, gas is price setting 64%, and in DMS 18% of the time. This is a conservative estimate of the use of gas. Assuming a CO2-price of 25€/tCO2, we calculate MC-gas of €46.1/MWh and MC-coal of €36.4/MWh. The weighted averages for the load periods then are $MC_{DMW}$ : €42.6/MWh and for $MC_{DMS}$ : €38.1/MWh.[7] For load values the study relies on data from UCTE: For average load, we assume $L_{DMW}$ = 75.5 GW and $L_{DMS}$ = 68.1 GW.

Estimating total capacity in the system is not without problems. Simply summing gross capacity of the power plants would result in total capacity of 122 GW, which overestimates useful capacity. More meaningful is the registered available capacity at the spot market EEX in Leipzig, plus an additional component for wind (which is not registered at EEX), from which we assume available capacity to be 82 GW. We do not have data on TUC, because this requires data on the coverage of contract coverage. Instead we assume that relative TUC is the same as the ratio of EEX-trade over total available capacity, which gives about 12%; if we assume that the largest supplier is RWE with 34.5 GW, TUC would be about 4.2 GW. Note that this is small compared to total available capacity. Changes of TUC will have negligible effects only.

The calculations are made from 2008 to 2030, which is 22 years. However, we assume that any effects of unbundling, are felt no sooner than 2010. Before 2010, unbundling, if it should enter into force at all, will simply have not started yet. Even 2010 may be considered optimistic, but on the other hand, the debate about unbundling on a European level has been going for quite some time now and thus some anticipatory behaviour may be expected. Consequently, we simply assume that effects start at 2010.

Demand growth is assumed to be zero. This perhaps surprising assumption is actually realistic. First, the link between GDP growth and energy use is broken. Second, population growth is low (if not negative). Third, the German government has an ambitious programme to promote energy efficiency. Zero growth in electricity demand may even be an overestimate; following Eikmeier et.al. (2007) for northern Germany, a decrease in electricity demand is also possible. We make no assumptions on technological effects. Nor do we assume major changes in fuel prices or availability. In other words, we assume that there will be no merit-order switch and the merit-order of 2008 simply stays valid. These simplifications are rigid but the effects of the rigidities on the SCBA are likely to be small.

The discount factor in this study is 7%, though we test sensitivity with alternative discount factors of 5.5% and 12%. Demand is assumed to be perfectly inelastic. This is a quite usual assumption (cf. e.g. Newbery & Pollitt, 1997; Nooij & Baarsma, 2008). The required

[7] Although the current 2008 prices are considerably higher, these numbers were relevant in 2005/6, for which the PCMU-RSI parameter values were estimated. As our SCBA is only interested in price *changes*, the absolute values are only of secondary importance.

additional calculations if demand elasticity is not zero are substantial. Furthermore, since the literature suggests that more realistic estimates of demand elasticity are small, we can trust that the effects on the deadweight loss are small as well.

We use a sharing parameter to weigh consumer- versus shareholder-interests. Following convention (cf. e.g. Vickers & Yarrow, 1988, p. 93), define social welfare, SW:

$$SW = CS + \alpha \cdot PS \text{ , with } 0 \le \alpha \le 1,$$

where *CS* is consumer surplus, *PS* is producer surplus and *α* is the sharing parameter. The sharing parameter is critical. The reader may be reminded that the normal textbook case of social welfare applies equal weighing; i.e. *α* = 1. This in turn implies that, with inelastic demand, a mere price change has an effect on income distribution but not on social welfare. On the other hand, the European Commission places considerable value on consumer interest (somewhat neglecting social welfare) and tends to favour a low *α*. Following Newbery & Pollitt (1997) we apply *α* < 1, for two reasons. First, *α* < 1 means that price decreases do have an effect on social welfare, which thereby compensates for underestimation of the effects on the deadweight loss by assuming inelastic demand. For linear demand, the change of the deadweight loss (per hour) can be roughly expressed as: $\Delta DWL = \frac{1}{2} \cdot \varepsilon \cdot \frac{Q}{P} \cdot \Delta P^2$ , where $\varepsilon$ is price elasticity of demand and *Q* is load per hour in MW. Checking the numbers presented below with a back-of-the-envelope calculation, and using $\varepsilon$ = -0.5, suggests that the numbers are comparable in size, although price elastic *ΔDWL* appears to be somewhat smaller than net SCB weighted with *α* = 0.8. Hence, if anything, the weighing seems to overcompensate the assumption of inelastic demand. Secondly, the justification for using a weighing factor is the notion that shareholders are richer than consumers and hence marginal value of the additional euro is higher for consumers. Yet, are shareholders richer than consumers? Obviously this depends on who the shareholders are. The German energy sector is in mixed ownership; substantial parts of the energy firms are state-owned (i.e. by tax payers), whereas, for the remainder, we find institutional investors (like investment banks, pension funds and insurance companies) and public float. For our base case, we apply *α* = 0.8 and compare in the sensitivity analysis with *α* = 0.5.

We have excluded the following issues from our analysis.

External effects, in particular, effects on the environment, employment and the macro-economy. In these cases, we do not know in which direction the effects theoretically go on balance. By and large, we would assume that if the effect of unbundling is to create a more competitive sector, that the effect on the environment is ambiguous, on employment negative and on the macro-economy positive. But, even if we did know the theoretical effects, we do not know the magnitude of the effects. Therefore, we restrict the SCBA to a partial analysis and exclude these external effects.

Privatisation. Underlying the debate on unbundling of the distribution network operators (DNOs) in the Netherlands was a debate on privatisation. The local governments, being the owners of the DNOs, strongly favoured selling the DNOs, which in other words would have meant privatisation. The central government in The Hague, however, is opposed to privatising the networks, while promoting private ownership of the commercial businesses. This debate inevitably leads to ownership unbundling. It is thus no surprise that part of the debate (e.g. CPB, 2005, and De Nooij & Baarsma, 2008) addresses the pro's and con's of privatisation. Privatisation does not concern the case of the German TSOs. For those parts of the sector in public hands, there is no discussion of privatisation of power networks.[8]

An additional consideration is the asset value of the firms – "sum of separate parts". The European Commission argues that unbundling will at least not lead to a reduction in the value of the sum of different parts as compared to the value of the integrated firm. This debate does not contribute to the social cost and benefit of unbundling but is important for income transfers. If unbundling leads to a devaluation of the firms, the current owners will issue damage claims, which might be quite expensive to settle and, more importantly, may be deemed as expropriation of private assets which possibly violates the constitution. Therefore, the European Commission goes into pains to argue that unbundling does not lead to a loss of the firm's asset value. The evidence we know of seems to argue into this direction (cf. eg. Sequoia, 2005). Presumably, in the somewhat longer run, the total effect of unbundling on the value of separate parts is near zero. If anything, then the effect may be slightly positive, reflecting investors' preference to split different risks. Because the effect seems to be small, and because the debate does not really fit in a SCBA, we exclude this issue, without denying its relevance.

[8] If anything, there is some debate as to whether or not to hand over the transmission networks to a state-owned enterprise should ownership unbundling occur.

## 3.2 The competition effect ("A")

The debate so far discusses a variety of different effects which potentially have a positive impact on the intensity of competition. This study attempts to capture a wide set of effects. However, as we discuss further below, only a few really make a difference.

### A.1) Direct effects

Direct effects on competitive pressure are captured by changes of the $\beta$'s in the PCMU-RSI equation.

An important direct effect which is often mentioned is the reduction of cross-subsidies. The argument is that provided regulation is imperfect, an integrated firm has an incentive to shift costs administratively from the competitive business to the regulated network. In doing so, the firm can inflate the regulatory cost base of the network and so aim to increase the level of allowed network charges. At the same time, the cost base for the competitive business is lowered, distorting the level playing field among different competitors.[9] Vertical ownership unbundling would remove the incentive to shift costs and would thereby achieve two goals: a reduction of regulated network charges and thereby end-user charges because costs are shifted back to the competitive business, and a restoration of the level playing field. An indirect effect is that regulation would be more cost-effective.

There are three critical points in this line of argument. First, it relies critically on some medium level of regulatory imperfection. If there is no regulation at all, cross-subsidies achieve nothing (cf. eg. Posner, 1976), and if regulation is perfect, cross-subsidies would be detected. The argument only works for imperfect regulation. Although this is an entirely reasonable assumption, experience suggests that strong regulators backed-up by strong law can actually be quite effective (Jamasb & Pollitt, 2005; quoted in De Nooij & Baarsma, 2007).[10]

Second, cross-subsidies are not easy to achieve in practice. Normally, cross-subsidies involve fundamental issues on allocation of (common) costs. If these questions are settled by regulation, all else is simply book-keeping and deliberate cost-shifting is actually not that obvious. Yet, settling these questions may be time-consuming, may involve legal issues and may be different for different players.

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[9] This latter effect may be a by-product though as the rational profit maximizing integrated firm will use the real cost (and not the administratively deflated cost) as the decision criterion at the competitive stage.

[10] Somewhat surprising against the background of the Dutch debate, a study by the Dutch regulator DTe (2007) seems to suggest that legal unbundling functions quite well.

Third, the effectiveness of cross-subsidies depends on the type of regulation. Inflating the cost base to get higher allowed charges only works in a cost-pass-through regulatory system. In a system with benchmarking-based, price-cap regulation, inflating the cost base only means that efficiency catch-up factor will be higher. It depends on regulatory details whether it is profitable, but we can conclude that in a pure price-based regulation, cross-subsidies are not effective.

Besides the cross-subsidy argument, we note three more direct effects within the competition effect. First, unbundling could improve congestion management and thus make better use of existing scarce interconnector capacity. It is well-known that availability of interconnector capacity relies on dispatch, which is controlled by the TSOs. More efficient use of the interconnectors could increase competitive pressure from the other side of the interconnector. Hence, unbundling would improve the use of the interconnectors and thereby increase competitive pressure. The argument may hold on paper but the effect seems to be small in practice. The price effect is to strengthen competition through improved use of congested interconnector capacity; this involves three small steps of which the product is very small. Moreover, at the moment, there is a strong European initiative towards the development of regional markets and market coupling, which would result in improved congestion management irrespective of unbundling.

Secondly, ownership unbundling removes the incentive for third-party discrimination (or, non-price discrimination). An integrated firm with a sufficiently strongly regulated network department has incentives for non-price discrimination (Brunekreeft, 2003 and Mandy, 2001). Unbundling removes these incentives. Whereas the argument holds forcefully on paper, it is not as obvious in practice and indeed sometimes industry observers voice exactly this point. The German competition commission reported in 2001 that it accomplished substantial reduction of the potential for non-price discrimination with a wide set of rules (Bundeskartellamt, 2001). Indeed, looking in detail at TSO level, taking numerous legal constraints into account, it is not obvious how non-price discrimination works in practice. Two mechanisms are often mentioned. On the one hand, competitors can be discriminated against by delaying their connection to the network. The government addressed this issue with a new ordinance which specifies obligations, duties and steps in network connection of power plants. On the other, TSO are sometimes said to abuse their position in the market for ancillary services. It is beyond the scope of this paper to go into detail, and we just note that the European Commission  is looking into the issue.

Third, following the second argument above, unbundling may ease the entry of third-party generators. If unbundling restores the level playing field, we would expect to see more third-party entry. This works in three different ways. First, more third-party entry means (unless fully offset by less investment of incumbents) higher total capacity. Second, third-party entry reduces, ceteris paribus, the dominance of the pivotal firm. Third, a larger number of third parties will affect the competitive intensity in the market. The last effect is the effect on $\beta$. This argument relies critically on two perspectives. On the one hand, the perception of investors about the restoration of the level playing field as compared to other investment decision criteria (price development). On the other hand, the scope for third-party investment depends on how much the incumbent will invest; the projections of plans suggest that the latter is substantial.

Following the relations between the parameters as set out in section 2, we assume that the parameters $\beta_1$, $\beta_2$, and $\beta_3$, change with the same factor. The direct effects of the changes of the $\beta$'s are formulated as follows:

$$\beta_\tau = \beta_0 \cdot (1 - \kappa_\tau) \tag{16}$$

The factor $\kappa_\tau$ is the cumulative change at time τ = t-T and T = 2009, and $\kappa_0 = 0$. Define as follows:

$$\kappa_\tau = \kappa_{\tau-1} + \eta \cdot (1-\gamma)^{(\tau-1)} \tag{17}$$

which solves as:

$$\kappa_\tau = \eta \cdot \frac{1-(1-\gamma)^{(\tau+1)}}{\gamma}. \tag{18}$$

Where $\eta$ is the initial change and $\gamma$ is a convergence parameter ($\gamma > 0$), which we assume 0.10%. By 2030 there is an absolute sustained change of the $\beta$'s as compared to 2010, but by 2030 they do not change anymore.

For the total changes of the $\beta$'s, we make the following assumption. Table 1 suggests a systematic difference between Germany on one hand and Spain, Netherlands and Great Britain on the other. Apart from a number of institutional differences, we note that the only country that does not have ownership unbundling is Germany. An appealing assumption would thus be to allow the German $\beta$'s to change to the approximate level of the other three. Therefore, we set the initial change $\eta$ at 5%, which with a convergence parameter $\gamma$ = 0.10% gives a cumulative change of the $\beta$'s of about 45%. In section 2, we argued that the parameters in the PCMU-RSI equation are determined through two channels: The RSI on the one hand and other direct effects on the other hand. Following this line of argument, we split up the “β-effect” 50/50 in these two channels. The RSI-effect following additional capacity will be discussed as the capacity effect under A.3). The effect of the direct effects as in this section thus also is 50% of the above expression. The distinction of the two channels is important as they may not take place simultaneously. If the A1-effect takes place we attribute 50% and if the A3-effect takes place we attribute the other 50% of the *β*-changes; if both take place, the *β*-changes are 100%.

We summarize the parameter values in table 2 The parameter values in the right column, where both channels take place at the same time, seems reasonably close to the parameter values for ES and NL in table 1. Note, however, that this is a very strong assumption as it attributes the differences in parameter values between the countries in table 1 entirely to ownership unbundling.

| | 2008 | 2030 (at 50%) | 2030 (at 100%) |
|---|---|---|---|
| $\beta_1$ | 7.8790 | 6.1248 | 4.3706 |
| $\beta_2$ | -10.8432 | -8.4290 | -6.0148 |
| $\beta_3$ | 3.5865 | 2.7880 | 1.9895 |

*Table 2: Assumed changes in the β's.*

**A.2) Cost-effect resulting from competition effect (lower MC)**

If unbundling increases competition, we would expect that stronger competitive pressure leads to stronger pressure to reduce costs. The direct effect is to lower the marginal costs. We know examples of these phenomena for market reform in general. Note that this effect aims at the generation side and not at the network side. Two effects are mentioned quite often (cf. also Newbery & Pollitt, 1997). Reform may trigger investment by alternatively technologies. In the UK, reform was followed by the “dash for gas”, i.e. a wave of new entry with high efficiency gas-fuelled CCGT. Reform pressure improved efficiency rates of power plants and thereby reduced marginal costs.

With due reservation we can try to relate the argument to the case in point. For this study we focus on the potential effect of the additional step from legal unbundling to ownership unbundling. Therefore, other reform effects, like privatisation and the removal of formal entry barriers are not relevant. Furthermore, the study should focus only on the effect of the additional step. In Germany, two significant events have already triggered a productivity increase: first, reunification of east and west in 1990 implied modernisation of the electricity sector and second, liberalisation of the market starting in 1998. The productivity improvements since 1990 have been very substantial (cf. Brunekreeft & Keller, 2000; Hense & Stronzik, 2005) and it is unlikely that the additional steps to ownership unbundling can precipitate such significant gains. Events like the "dash for gas" are unlikely to happen. If anything, we would have to expect that uncertainty around the CO2-emission trading scheme and environmental policy in general would reduce productivity.

In all, the approach is as follows. We consider the implementation of unbundling as a structural break, much in the line of for instance the implementation of incentive regulation for the networks. Following this argument, we use the notion of the so-called "stretch factor" to represent the structural break. In the context of calculating the general X-factor for the regulation of network charges, the stretch factor has been estimated for the USA at an average of 0.56% (cf. in particular Kaufman, 2004. Dec.). We reduce marginal costs in the PCMU by approximately one-third of this estimate, because as mentioned above a substantial part of the potential productivity increase may already have been achieved and because the effect of the additional step towards full ownership unbundling is only one effect among many. Furthermore, we apply the same growth rule as for the $\beta$'s.

$$MC_\tau = MC_0 \cdot (1 - \rho_\tau) \tag{19}$$

The factor $\rho_\tau$ is the cumulative change at time τ = t-T and T = 2009, $\rho_0 = 0$. Define as follows:

$$\rho_\tau = \rho_{\tau-1} + SF \cdot (1-\sigma)^{(\tau-1)} \tag{20}$$

Which solves as:

$$\rho_\tau = SF \cdot \frac{1-(1-\sigma)^{(\tau+1)}}{\sigma}. \tag{21}$$

SF is the initial stretch factor, which we assume at 0.2%; σ is a convergence parameter, which we assume 0.18%, and again T is the year 2009. These parameter values secure a convergence of a cumulative change MC of about 1%. Hence, at 2030, the MC's are sustainably 1% lower.

### A.3) Indirect effects: the capacity effect

The most important driver turns out to be the effect on capacity. This concerns both interconnector capacity and generation capacity. As can readily be seen in equations in section 2, the effect runs through the changes in available capacity and thereby the RSI and thereby the Lerner Index or PCMU. As these effects affect competitiveness indirectly via available capacity, we regard these as indirect effects. Note that the competition effect would typically be beneficial; we deal with the cost-side of higher CAPEX associated with additional capacity (the flip side of the same coin) in section 3.4. The effect on interconnector capacity plays a crucial role in the debate, we shift this discussion to section 3.3, and concentrate here on the generation capacity effect.

The effect of additional generation capacity is potentially substantial due to the non-linear relation between price and capacity in the PCMU-RSI relation. This is of course the idea of the concept in the first place. If capacity gets scarce and demand is short term inelastic, prices soar, whereas in times of excess capacity prices will be reasonably close to marginal costs. This implies that if the market is in the range of a relative high RSI, any competition effects of unbundling are almost by definition going to be small; in contrast, if capacity on the market is scarce and the RSI relative small (close to 1), any competition effects of unbundling will be amplified if expressed in absolute price changes and effects will be large. Yet, this is exactly what the model captures.

As the model relies on the competitive concept of the RSI, it is conceptually unsurprising that available capacity is the main driver of the analysis. The power of the argument lies in the fact that Germany, for unrelated reasons, seems to move towards relative scarcity. Studies by for instance BDEW (2007) and DENA (2008) suggest that there will be inadequate capacity as from 2014, and suggest two key reasons First, the nuclear phase-out law mandates the phasing out of nuclear generation by 2021 and thus more nuclear power plants will need to be decommissioned in the near future. Secondly, many existing power plants are aging and require replacement. There are many plans for new build but construction has commenced on only few of these  Currently, the bulk of new capacity comes from two sources. Off-shore wind which is under construction, but due to constraints on the transmission network it is unclear how much the capacity can contribute to closing the gap. Further, gas or coal plants (possibly large scale CHP) are planned, but face strong public opposition and face difficulty gaining the necessary building permissions.

Our approach is the following. We rely on data from especially BDEW, but also company data to estimate decommissioning of existing plants and plans for new construction. Beyond about 2018, we have reliable information about decommissioning but not about new plants; from that moment on, we simply assume that decommissioned capacity will be replaced. The latter assumption stabilizes the capacity margin at an endogenous level after which it does not change anymore. This artificial, yet not unrealistic assumption avoids capacity dropping below demand, which would obviously be problematic.

We assume a capacity effect of unbundling, which means that investment is *accelerated*. We do not assume that unbundling triggers *more* capacity. We assume that the "capacity acceleration effect" only applies to new plant, whereas unbundling would have no effect on decommissioning. However, with the capacity acceleration effect investment is accelerated and thereby, although aggregately the capacity effect does not trigger more capacity, at any point in time (snapshot view) from 2010 there is more capacity (than in BAU), until the effects runs out. This means that the acceleration effect alleviates the capacity gap. In the normal case, we assume that the acceleration is one year, which appears to be "unbundling-friendly". Because this assumption is critical, we have constructed alternative scenarios around this assumption in order to examine the effects more carefully.

We assume that the effect applies symmetrically to incumbents and third parties. For third parties the argument is obvious; vertically integrated network operators would have incentives to hold off new competition and would have the possibility to do so through the network. The argument holds strongly on paper, but it may be questioned how strong this still is in practice; above we already mentioned that discrimination is far from obvious and has already been successfully countered. For incumbent firms the effect of accelerated investment is less obvious. We would expects incumbents to be reluctant to invest in additional capacity as this might decrease prices. However, if unbundling gives third parties better opportunity to invest, then it would be better for incumbent parties to invest themselves instead of hoping to withhold or deter investment. We note in passing that this is not anticompetitive behaviour but rather an expression of stronger competition.

If the capacity gap is small then the capacity acceleration effect will be small, while if the capacity gap is severe, the acceleration effect is strong. This effect turns out to be important. Therefore we distinguish two scenarios (see section 4): first, a "low-capacity" case (which uses the data as explained), and secondly, a "high-capacity" case which makes the alternative assumption that it could be possible to postpone decommissioning of existing plant by five years.

The capacity acceleration effect affects RSI and thereby enters the calculation in two ways. Directly into the PCMU-RSI equation, and indirectly through the parameters: $\lambda_i(RSI_i)$. The precise specification of the latter was described in the section of the direct effects A.1) above (eqs. 16-18). The effect of capacity acceleration on $\lambda_i(RSI_i)$ sets the other 50% of the changes on the $\beta$'s.

### 3.3 The interconnector effect ("B.1")

The biggest problem arising from the assumptions is the effect of the interconnectors. We assume a starting level of interconnector capacity of 20 GW and equal as import and export. The precise starting level of the interconnector capacity is unimportant; in the SCBA calculations only the *changes* of the *differences* in imports and exports matter are germaine, in turn, only the unbundling effect on the changes matters.

The interconnector effect captures the notion that vertically integrated utilities would have inadequate incentives to invest in interconnector capacity. This is one of the more important arguments for the European Commission because more interconnector capacity is expected to increase network reliability,[11] cross-border competition and strengthen the internal European market. We call the argument “strategic investment withholding”. The argument is straightforward. Assume a load pocket with network constraints from “the outside world”. Assume further a local vertically integrated utility with (local) monopoly power in the load pocket. Building a larger line to the outside increases import capacity into the load pocket and would allow third parties to supply the load pocket and would thus intensify competition for the local supplier. Therefore, in order to protect the position in generation, the integrated TSO will have inadequate incentives to build the lines. In contrast, an unbundled TSO does not have an incentive to protect a local generation monopoly and will therefore invest more or faster in lines.

The argument is convincing, but has limits. First, vertically integrated utilities may be long or short in generation as compared to their retail liability. If own production is short as compared to retail, then on aggregate the firm may have an interest to increase interconnector capacity to broaden the options to purchase power. Secondly, integrated utilities with excess capacity and low variable costs will want to export their power and therefore need interconnector capacity. Thirdly, interconnector capacity can lead to more imports or to more exports; if the interconnector capacity is used predominantly for more exports, we find that competition actually decreases locally. Globally, competition is likely to increase, but in an area considered in isolation competition may actually decrease. This seems to be particularly important for the German case. Lastly, even if the strategic investment withholding argument may hold in principle, in practice there are of course other investment limitations. In Germany as in other countries, the acquisition of permissions to build new lines is a large burden, and the siting of lines problematic. At the moment it is barely possible to build new lines, though the government is about to implement a law introducing accelerated procedures for the granting of permits for essential infrastructure.

[11] We should point out that this is not necessarily the case, as expanded interconnector capacity also changes power flows and facilitates increased trade; hence, the pressure on the network might increase rather than decrease.

The assumptions for the analysis face quite severe problems. First, it is problematic to make a distinction between interconnector capacity and internal network upgrading. Second, how should we determine the volume of new interconnector capacity which needs to be built? Third, how does new interconnector capacity impact production and trade, power flows, and imports and exports? This is far from trivial and differs from hour to hour. Finally, what exactly is the effect of unbundling on investment in new interconnectors? To the best of our knowledge there is no convincing empirical evidence to guide us in answering these questions. For now, we have to rely on assumptions.[12]

As a first step we try to identify how much interconnector capacity will be built. We rely on CESI et.al. (2005), which is a study for the European Commission on Transeuropean networks (TEN-E). Table 3 below depicts part of table 4.30 in CESI et.al (2005, p. 94).

| Cross-border connections | | | Scenarios | | | | | |
|---|---|---|---|---|---|---|---|---|
| Country A | Country B | TEN-E | S1 baseline | S1 baseline | S3 high RES | S3 high RES | S5 I & G optim. | S5 I & G optim. |
| | | | 2005-2013 | 2014-2023 | 2005-2013 | 2014-2023 | 2005-2013 | 2014-2023 |
| Austria | Germany | EL8 | 0 | 0 | 0 | 1200 | 1700 | 2600 |
| Czech Rep. | Germany | EL8 | 0 | 0 | 0 | 1300 | 400 | 1400 |
| Germany | Netherlands | EL1 | 0 | 0 | 100 | 2600 | 0 | 0 |
| Germany | France | EL1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Germany | Denmark | EL7 | 0 | 0 | 1200 | 4100 | 400 | 800 |
| Germany | Poland | EL8 | 0 | 0 | 0 | 1900 | 0 | 0 |
| Switzerland | Germany | | 0 | 0 | 0 | 1900 | 0 | 0 |
| Luxembourg | Germany | EL1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | Sum | 0 | 0 | 1300 | 13000 | 2500 | 4800 |

*Table 3: New interconnector capacity*
*Source: CESI et.al (2005, p. 94)*

The study uses a variety of electricity market models in a wide set of scenarios to estimate new construction of European interconnector capacity along the TEN-E priority routes for the period 2004-2023, split up in two separate periods. For our SCBA, we have selected the interconnectors at the German borders. We depict three CESI?? scenarios: 1) the base case which is their business as usual, and assumes that interconnector capacity follows exogenous

[12] By means of an electricity market model we hope to gain more accurate insights on the effects of the interconnector effect. This work is in progress.

generation investment, 2) high RES, which assumes a high share of renewables, and 3) baseline plus optimized generation, which in contrast to the baseline assumes that generation and interconnector capacity is simultaneously optimised across borders. We note that in the baseline scenario, no new interconnector capacity will be built.[13] In such a scenario, unbundling would have no effect whatsoever on interconnector capacity. The more relevant scenario is high-RES; this assumes investment in off-shore wind, which indeed is currently under construction in the north of Germany. As pointed out in a variety of studies (eg. DENA, 2008), the transmission network in Germany cannot handle the planned volume of off-shore wind energy and expansion would be required. Off-shore wind energy coming on land in the north would spread to the Netherlands, Denmark and Poland, necessitating additional interconnector capacity. Presumably, we should expect that in periods with low wind the direction of the power flow may be reversed. This explains the big picture, but we hasten to add that details matter. Of course, the real power flows depend strongly on new generation capacity elsewhere (for example in the Netherlands) and on relative prices (gas and coal). We use the high RES scenario in our SCBA as an indicator of how much new interconnector capacity to expect.

The next step is to make an assumption of the effect of unbundling on investment in new interconnector capacity. In the absence of any empirical evidence, we simply have to make a bold assumption. As with the generation capacity effect, we assume that unbundling *accelerates* the investment by one year, rather than assuming that there will be more investment. The underlying rationale is that the European Commission claims that integrated utilities delay the investments, and therefore by reversing the argument, unbundling would accelerate the investment. Whereas results in the SCBA turn out to be sensitive to the acceleration in the generation capacity effects, this is not the case for the interconnector effect; hence, where the acceleration is one or two years or less than one year does not matter all that much.

New interconnector capacity enters the model through the RSI. There are two ways which are roughly the same. Imports effectively increase available capacity because it adds foreign capacity; by the same argument, exports decrease inland available capacity because part of the available capacity goes abroad. Technically, we can make the changes through load rather than capacity. I.e. imports effectively decrease demand and thereby increase RSI. Exports, by contrast, increase inland demand and thereby decrease RSI. In the RSI approach,

[13] As a side remark, the scenario (not shown here) with soaring gas and oil prices also gives the result without additional interconnector capacity.

imports increase and exports decrease competitiveness. If additional imports and exports roughly balance, nothing happens. This is by and large the case for Germany. There is an additional effect, however. Suppose substantial Europe-wide new interconnector capacity such that no congestion would occur. Clearly this would increase competitiveness on the European market overall, irrespective of the RSI. We capture this effect of stronger competition irrespective of RSI with a change of $\beta$'s towards zero in the PCMU-RSI equation; this has been explained in section 3.2 (A1). Table 3 indicates imports and exports; for the years within the two periods, we spread the investment evenly over the years.

## 3.4 The cost effect ("C")

### C.1) Organisation cost: „Economies of scope“

A potentially big effect is the cost of reorganization and loss of synergies. After all, it had long been assumed that a vertically integrated sector would be the most efficient way to organize an electricity system, until Joskow and Schmalensee (1983) painted a more refined picture. Yet, it seems commonly acknowledged that in splitting the sector at least some vertical synergies get lost; the question is what are they and how large are they. In the following examination, we need to distinguish carefully between a split of generation and retail, which is not considered here, from a split of the transmission network from commercial activities, which is.

In this subsection, we first focus on the firm internal cost of organisation; we deal with external cost of organisation in the subsequent sections. External cost would, for instance, be a mismatch of investment. The borderline between internal and external is not sharp though. The data is thin; unfortunately and rather surprisingly we have not been able to trace any management study trying to estimate the organisation costs of ownership unbundling for the German TSOs. Instead we use studies that have been prepared during the debate on ownership unbundling of the Dutch distribution network operators around 2004 and 2005 and extrapolate these for the German case of TSOs. This is admittedly inaccurate but it seems to be the best around. Following these studies we distinguish between one-off cost of restructuring and permanent loss of synergies.

#### C.1.1. One-off costs of restructuring

For the SCBA we assume that the one-off costs of restructuring are €100 million and are incurred immediately at the moment of unbundling. Whereas this may look high at first sight, it is almost negligible compared to a total annual cost in the sector of about €50 billion. Hence, €100 million is a conservative estimate which does not affect the outcome.

To compare, PWC (2006) estimates the one-off costs of the DNOs in New Zealand at about NZ$30 million restructuring costs (~€15 million) and NZ$140 million contracting costs. If we focus on the former only, this corresponds to about 3.5% of the annual distribution revenues. This seems high. For the Netherlands, Deloitte (2005) estimates the one-off restructuring cost of DNO ownership unbundling between € 70 million and €100 million. The main cost drivers in this study are the adjustment of ICT-systems and the transfer, re-contracting and re-administration of staff. However, Deloitte also points out that a significant part of the costs are attributable to the step towards a fat-DNO, reflecting a strong form of legal unbundling. This is followed by De Nooij and Baarsma (2008), who assume that the one–off costs for the step between a fat-DNO and ownership unbundling is €20 million. We follow this approach and simply extrapolate for the German TSOs where far-reaching functional unbundling is already implemented. As the German market is approximately 5 times larger than the Dutch market, we assume that the one-off restructuring cost is €100 million. It should be noted again that the results are non-sensitive to this variable.

#### C.1.2. Permanent loss of synergies

Organisational costs with a potentially substantial impact on social welfare are the losses of vertical synergies, first because they can be high and second because they are permanent. Because sensitivity of this variable is high we distinguish two scenarios:

1) “Base case”: a low-cost scenario with annual loss of synergies of  €50 million,
2) “High cost case”: a high-cost scenario with annual loss of synergies of €250 million.

Note that, compared to the total size of the sector these numbers are actually both small; €50m corresponds to 0.1% of total costs of the sector.

For the base case we use a bottom-up approach, in which we try to calculate the sum of separate cost-drivers. An example illustrates. In case of full ownership unbundling of TSOs, volatility in the costs and revenues of ancillary services cannot be hedged against own production and can only be passed through with delay; this uncertainty translates into higher risk and therefore into higher cost of capital.[14] As the cash-flow associated with ancillary services is very substantial, this can be a serious effect. Deloitte (2005) studies the lost synergies of DNO unbundling in detail and examines the synergies of some 26 cost drivers

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[14] It is worth noting that S&P recently put one of the Dutch utilities (Nuon) on credit watch in expectation of unbundling.

allocated in five groups: general management, human resources, ICT, finance and support. Importantly, Deloitte distinguishes cost levels per driver and estimates the extent of synergies per driver. Calculated this way, Deloitte identifies in particular ICT as a high-cost element with substantial synergies for practically all cost drivers, in particular ICT products and services. In support, we find customer care, billing and facilities as high cost drivers with high synergies. Lastly, in general management, strategy and asset- and risk-management are high cost with high synergies. Deloitte calculates the total recurrent cost of DNO unbundling in the Netherlands between a staggering €350 million and €450 million per year. This is very high. Deloitte notes that a substantial part of these costs can be attributed to the step towards a fat-DNO, whereas the step from a fat-DNO to full ownership unbundling is far smaller. De Nooij and Baarsma (2008) follow the Deloitte study, and estimate the annual permanent loss of synergies of Dutch DNO ownership unbundling (as the marginal step from a fat-DNO) at €20 million. We follow this approach and extrapolate for the German market, but divide by 2 to account for the effect of billing which is substantial at DNO level but not at TSO level. Therefore, in our low-cost base case, we assume annual permanent loss of synergies to be €50 million.

For the high-case scenario, we use a top-down approach, which uses econometric studies on vertical economies of scope. There are many such studies, but hardly ever do they measure ownership unbundling of the networks alone. Meyer (2008) provides a useful survey and identifies Kwoka, Ozturk and Pollitt (2007) and Arocena (2008) as studies that do actually estimate the cost or efficiency associated with ownership unbundling of the networks. A top-down approach suggests that an increase of as much as 5% of total sectoral costs could possibly be expected. This is very substantial. We apply this 5%-rule, but take only 10% of this to account for the marginal step from a functional unbundling to full ownership unbundling. The 10% is rough estimate from the Dutch studies citied above. This gives a total effect of 0.5% of total costs. For the German case, 0.05 * 0.1 * €50 billion makes €250 million per year.

We remark that even the high-cost scenario may be conservative and the assumptions made to come to this number are “unbundling friendly” and rely specifically on the notion that the current state is already very far-reaching unbundling such that further costs cannot be very high. We also remark that the results of the SCBA are sensitive to the permanent cost of reorganisation.

### C.2) Production costs

This section deals with the effects of unbundling on the cost of producing electricity. Although the borderline is blurred, we do distinguish this from the cost effect as in subsection A2, where we discussed the effect unbundling on *competition* which in turn increases the pressure on production costs. Here we deal briefly with two other effects on production costs. First, the effect on production costs of more interconnector capacity. Second, the effect on production costs of better TSO cooperation.

#### C.2.1. Production cost changes resulting from interconnector capacity

We have explained above following the "strategic-investment-withholding" argument, that unbundling may lead to stronger incentives to invest in interconnector capacity. In our SCBA, we assume that unbundling would accelerate interconnector investment, meaning that at any point in time there is more (or at least the same) interconnector capacity than there otherwise would be. More interconnector capacity will have effects on trading and power flows, both physical and contractual. With intensified trade, we would expect effects on inland production costs. This is the effect we try to capture here. The difficulty is that in order to make an assessment, it is important to have an idea of new interconnector capacity and how this will work out on a detailed basis. As pointed above, for this one needs an electricity market model. This is in preparation and until then we make a conservative assumption. The results in the SCBA are not sensitive to this assumption, because the total effect depends only on the additional interconnector capacity as a result of unbundling, which as pointed out above is minimal. Therefore, the cost effect is small.

Because the SCBA focuses on the effects within Germany, we necessarily fail to capture effects outside Germany; obviously, however, as cross-border trade necessarily affects at least two systems, this is a restriction which should be kept in mind.

In total, our working assumption is that additional interconnector capacity used for imports leads to a shift away from inland production with expensive gas but towards relatively cheap (imported) coal generated power, thereby saving production costs. This implicitly makes the "large world market" assumption, as is usual in international economics; it assumes that the outside world is big enough not to be affected. We thus assume that the savings in production costs are $(MC_{GAS} - MC_{COAL})*\Delta I_{IMPORTS}$. Furthermore, for our SCBA we ignore the inland cost effect of exports-dominated additional interconnector capacity to "compensate" for the fact that the gains of the trade that fall abroad are not taken into account in our calculation. These assumptions are inaccurate but as mentioned the total effect will be small and the results not sensitive to these assumptions.

### C.2.2. Better horizontal SO-coordination

Unbundling is claimed to increase the potential for cross-border TSO cooperation and therefore will make better use of scarce interconnector capacity. Basically, the argument is similar to the argument of strategic investment withholding. Capacity of an existing interconnector is not fixed, but must accomodate loop flows which depend on overall dispatch. Hence, a TSO can affect the available interconnector capacity within ranges. If TSOs cooperate closely, and collectively optimize dispatch, they can virtually increase the capacity of the interconnectors. If properly incentivised, an unbundled TSO will do so, whereas an integrated TSO will consider the effects on its own generation market. As a aside, whether an unbundled TSO will indeed do so depends a great deal on the regulatory system. In particular, a TSO should not profit from congestion. In contrast, a properly incentivised TSO should make profits from resolving congestion. Summing up, the argument is that unbundling leads to better TSO cooperation and thereby increases interconnector capacity and thereby increases competition and cross-border trade and thereby reduces production costs. The last part of the argument is the same as above in C.2.1.

As in C.2.1., we expect the quantitative effect to be small. The most important argument is that stronger TSO cooperation is already promoted independent of unbundling. The EU commission is strongly pushing the formation of regional markets with far-reaching market coupling and requiring strong TSO cooperation and improved use of scarce interconnector capacity. Further improvement from ownership unbundling in addition to market coupling will be modest. A second argument is that if there is adequate interconnector capacity, the need for coordinated TSO congestion management gets less. The two effects of more interconnector capacity on the one hand and better use of the existing interconnectors on the other cancel one another out to some extent. Lastly, the effects include several steps and are of second or third order and therefore expected to be small.

To be sure, adequate TSO cooperation is crucial and beyond doubt. The question, however, concerns the effect of unbundling on improved TSO cooperation. We make the assumption that the argument that unbundling implies improved TSO coordination leads to a cost saving of 0.01% of total generation costs per year. Considering the reservation made above, this is still quite substantial, but will not make the decisive difference.

**C.3) Investment costs**

The major effect on the cost side of unbundling comes with the investment costs of generation assets. Above we assumed that an effect of unbundling could be that it accelerates the investment in generation and interconnector capacity (the capacity acceleration effect). The argument here is straightforward. Apart form the competitive advantages this would bring, it does have higher capital costs as the downside. Capacity needs to be paid for and in particular for the generation assets this turns out to be substantial. The same applies for capital cost of interconnectors, which however is of a far smaller magnitude. A second effect of investment costs is more subtle, but far more interesting. Unbundling causes coordination of investment of the network and power plants to be flawed. As a rule this will cause additional capital costs. We deal with one case in more detail.

**C.3.1. Higher capacity: CAPEX**

As we explained in section A.3 and 3.3, we assume that unbundling can have a positive effect on investment. We assume for the base case scenario that unbundling can accelerate investment in power plants and new interconnector capacity by one year. We do not assume that unbundling triggers more investment; but of course by mechanism of the acceleration of the investment, we do observe higher capacity at each point in time (until no chances occur anymore, after which capacity is the same in different scenarios). The higher capacity at each point in time causes additional capital costs, which is a cost in the SCBA.

For both the interconnectors and the power plants we use annualized investment costs.[15] The annualized investment costs for power plants we assume at €55,000 per MWyr, which is an unweighted average for new coal and new gas. We make this calculation using and comparing assumptions from a number of sources. The €55,000/MWyr seems to be somewhat on the high side of a range but entirely reasonable. For the interconnector capacity we assume annualized investment costs of €5,000 per MWyr. Although we use our own calculations, the underlying numbers were drawn particularly from CESI et.al. (2005, pp. 94 ff)). It should be noted that an indicator like CAPEX per MW for interconnector capacity is problematic because the costs depend strongly on the specific project and thereby especially the type of line, location and the length of the line. It would not be an exaggeration to say that each line is different and has different costs. Yet as an indication €5,000 per MWyr seems appropriate.

[15] The alternative would be to use CAPEX at the moment the investment is done. This would be justifiable as well but makes the annual SCB very volatile and difficult to interpret.

Checking the results in the SCBA, we find that the additional investment costs of the power plants are critical, whereas the additional costs of the interconnector do not make that much difference. The costs of the interconnectors are not especially high, and more importantly, the additional interconnector capacity and thereby the unbundling effect is relatively small. Nevertheless, even if the additional investment costs of accelerated interconnector capacity is small as compared to the overall SCB, it may be high compared the isolated benefits of the new interconnectors. As we will discuss further below in section 4, the effect of the investment costs of additional power plants can quite easily offset the advantages of additional capacity. The main message is that unbundling may have a positive effect on new investment, which in turn has positive effects on competition, but the additional capacity comes at a cost.

### C.3.2. Loss of coordinated investment

A problematic consequence of unbundling that has received only very limited attention in the literature is the reduction of coordination of investment.[16] As the network connects the different parts of a large technical system, investments in power plants (small and large) and the network are highly interrelated. Unbundling changes internal firm coordination into external market coordination. The coordination problem is well illustrated by the following quote from New Zealand (Bertram, 2005, p. 33): "Since 2002 a rush by large incumbent generators to build windfarms is raising a raft of difficult coordination problems, since the location of favourable sites for windfarms, and of the hydro generation assets that will be used to back-up wind generators, does not always coincide with the existing grid infrastructure, presenting the grid's operator and the new regulator with investment and coordination requirements not foreseen even a few years ago."

Importantly, the coordination problem is not merely an informational problem, which can be solved by some kind of improved information exchange, but is also an incentive problem. On the one hand, market players may withhold strategically important information on investment decisions, while on the other hand, even with perfect information, nothing actually guarantees that the uncoordinated investments are optimal. The coordination problem can be split into at least the following three problems. First, a "locational problem", which relates to the question of *where* the power plants should be built. Second, a "timing problem", which relates to the question of *when* the network should be expanded. This is particularly

[16] Some work in this direction can be found in Brunekreeft & Ehlers (2006) and more theoretical work in Cremer et.al. (2006).

difficult as bringing new network infrastructure online requires more time than that required to build and commission new power plants. This means that in case of doubt the network should be expanded under a "veil of ignorance", almost certainly leading to an oversized network. Third, a "technology problem", which means that depending on network and location it may be individually rational to invest in for instance a coal plant, whereas overall it would be optimal to invest in gas-fuelled plant somewhere else.

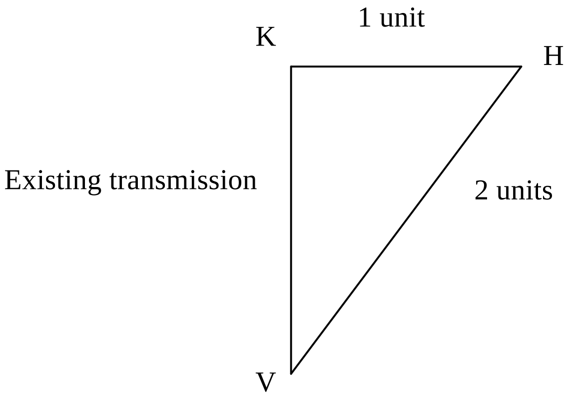


*Figure 1: Coordination problem in network upgrading*
*Source: Baldick & Kahn (1993, p. 373)*

While noting that the investment coordination problem is a fruitful and urgent field for further theoretical research, for this SCBA we concentrate on the locational problem only. To illustrate this problem, we follow Baldick & Kahn (1993). Consider figure 1. K and H are generation nodes and V is a load node. The line between K and V already exists, but possibly should be upgraded, whereas the other lines still need to be constructed. If the generation capacity of K or H or both is expanded, the network needs to be upgraded. Baldick & Kahn distinguish two options. First, the 'radial connections', which is a direct connection between generator and load (K-V and H-V), and second, 'network connection', which implies building the line H-K, such that the connection between H and V is in fact the combination H-K-V. Network expansion takes a longer route (than H-V) but can be cheaper, for instance, due to economies of scale in the K-V expansion, as Baldick & Kahn (1993, p. 374) assume.

Baldick & Kahn calculate that the optimal transmission investment depends on how generation capacity expansion is divided over the two generators (at K and H). Radial connection tends to be optimal if either of the generators takes over most of the additional generator capacity. If, on the other hand, the additional capacity were divided more or less evenly between the two generators, network connection would be optimal. In more concrete terms, if a new power plant is built at H but not at K, the network expansion should be a radial line H-V. If alternatively, new generation capacity is built at both H and K, the line H-K should be built and the line K-V be upgraded. The coordination problem arises with new investment at H, while it is unknown what will happen at K.[17]

To the best of our knowledge, there are no empirical studies to give an indication of the real cost of the coordination problem. Instead, we rely on assumptions. These assumptions are admittedly heroic, but we note that the overall SCB results are not sensitive to the assumptions. The quantitative effects seem to be relatively small. The reason is straightforward; the monetary cost of building new HV lines is relatively moderate and thus the cost of overbuilding the network are moderate as well.

To get an idea of the costs of the investment coordination problem, we examine the case of the German HV network. As pointed out above, at the moment much of the planned new generation capacity is in the North near the coast; to handle this, the HV network must be expanded, with at least 1100 km (cf. DENA, 2008). The main driver is off-shore wind, but the problem is exacerbated by new coal power plant in the vicinity of the coast to save on transportation cost of the coal (and possibly at a later date close to carbon storage facilities). The critical point is that new generation investment is not incentivised to take account of network effects. Hence, analytically, there is a positive probability that part of the network expansion is unnecessary. We note in passing that whereas unbundling or in fact liberalisation in general can create a shift towards external, market coordination that the challenging task is to find a market mechanism to address the coordination. For instance, appropriately designed locational network pricing would adequately signal the investment needs (cf. Brunekreeft, Neuhoff, & Newbery, 2005).

We assume that the costs of 1100 km HV network is about € 1.1 billion, which is about € 84 million annualized investment costs. We assume further that the probability of building the expansion unnecessarily is 10%. This assumption lacks any relation to underlying empirical study and intuitively a probability of making a mistake of 10% seems high. Yet, the meaning of this calculation is to highlight the coordination problem in the first place and to gain an impression of the magnitude of the problem. The numbers above are not decisive: 10% of € 84 million is a small number in comparison to other effects and changing the magnitude of the assumptions will not make a big difference.

[17] Note that if we know the investment plans at K (whilst not at H), there is no real problem.

## 4 Discussion of results

As explained intuitively above the results are critically sensitive to some of our assumptions, while other assumptions do not make that much difference. We have constructed in total seven scenarios derived from varying four different assumptions. The scenarios are listed in table 4.

| Assumption on: | Base Case: | Cases and scenarios | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D** | **E** | **F** | **G** |
| Cost | Low | **Base case** | **base case** | **base case** | **base case** | **High cost** | **High cost** | **base case** |
| Capacity | Low | **Base case** | **base case** | **High cap** | **high cap.** | **base case** | **High cap.** | **base case** |
| Capacity acceleration effect | With | **Base case** | **without Cap-effect** | **base case** | **without Cap-effect** | **base case** | **without Cap-effect** | **base case** |
| Intercon-nectoreffect | With | **Base case** | **base case** | **base case** | **Base case** | **base case** | **Base case** | **w/o I-effect** |

*Table 4: Overview of scenarios*

The four assumptions are the following:

- For the permanent loss of synergies (C.1.2), we distinguish a low-cost case with €50 million per year (A, B, C, D and G) and a high-cost case with €250 million per year (E & F). We use the low-cost case in our base case.
- As explained in section 3.2, total available capacity is crucial to the results. Therefore, we distinguish a low-capacity case in our base case (A, B, E, G), assuming the projections known at the moment, from a hypothetical high-capacity case (C, D, F). For the latter, we simply assume that planned decommissioned capacity will remain on the system for five more years. Thereby, in each period total available capacity will be higher by postponed decommissioning.
- Following the importance of total available capacity, we distinguish the base case, in which the generation capacity acceleration effect (cf. A.3) does take place (A, C, E, G) from an alternative scenario where we assume that the generation capacity acceleration effect does not take place (B, D, F).
- Similar to the generation acceleration effect, we include in the base case the assumption of interconnector acceleration effect (B.1) and compare with an alternative scenario where we assume that the interconnector acceleration effect does not take place (G).

The scenarios A to G in table 4 are constructed around these four assumptions. Scenario A is our base case, which is somewhat “unbundling friendly” overall. A & B differ from C & D by the assumption under C & D that total available capacity is high. A differs from B, and similarly C differs from D, that in B and D the capacity acceleration effect does not take place. Thus, scenario D combines a high capacity case without the acceleration effect. Although scenario A is our base case, it seems that scenario D may actually be the most likely. Scenarios E & F differ from A & B as they assume the high-cost scenario. In F in contrast to E we also assume the high-capacity scenario and simultaneously leave out the capacity effect. Lastly, scenario G is equal to A (base case), except that we assume in G that the interconnector acceleration effect does not take place.

## 4.1 Results

The main results are depicted in figures 2 and 3, while the underlying numbers can be found in the appendix. Figure 2 shows the numbers for the weighted difference in social welfare (ΔSCB); a positive number means that that unbundling would improve weighted social welfare. To recall, the weighing factor implies that producer interests weigh 0.8 as compared to 1.0 for consumers. Figure 3 shows "who gains and who loses"; it clarifies the separate effects for consumers and producers, and thus represents the case of equal weighing. The net effect in the case of equal weighing is not that interesting. The numbers in figure 3 are given to illustrate the isolated effects on consumers and producers.

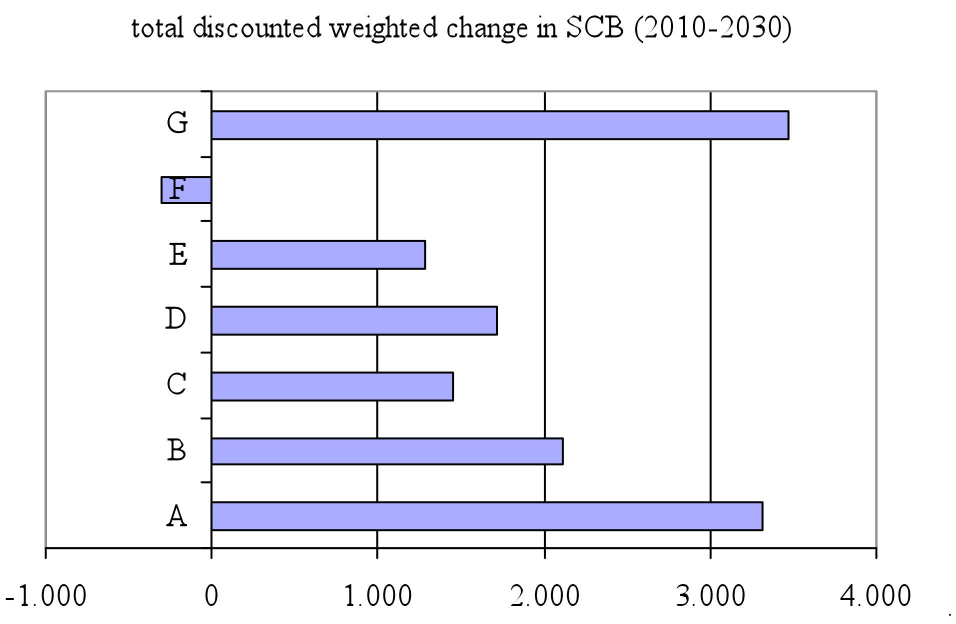


*Figure 2: The overall weighted net effect on social welfare (ΔSCB); million €.*

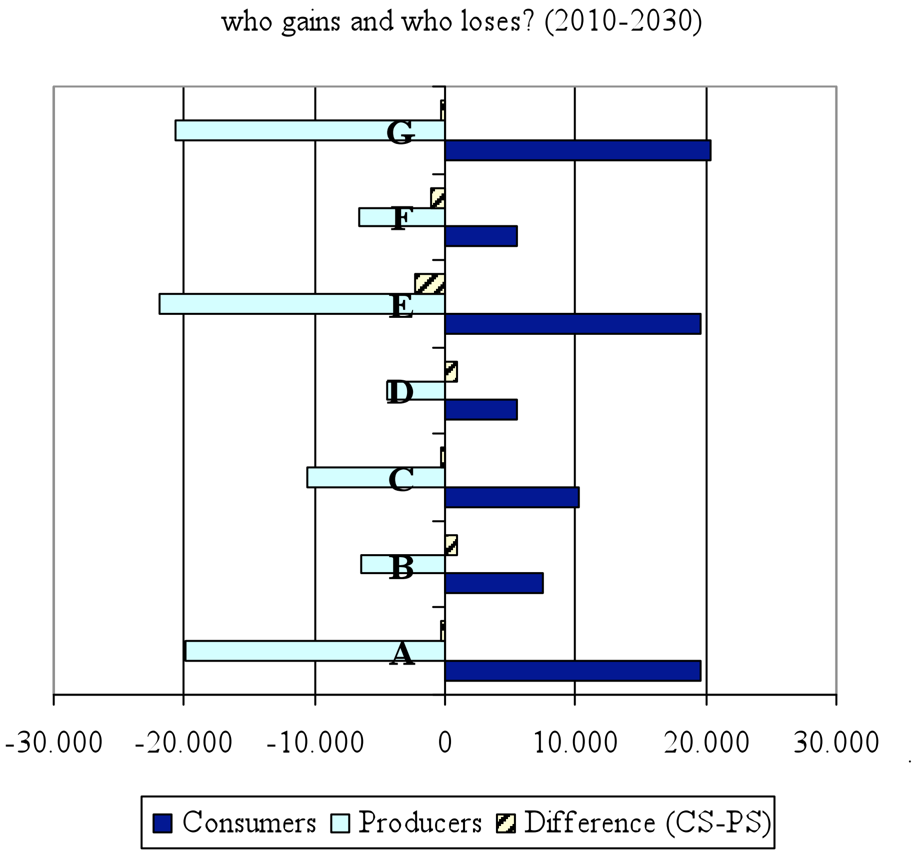


*Figure 3: Who gains and who loses?; (in million €).*

The big picture is the comparison between likely scenarios A and D. In the base-case scenario A, the discounted sum of ΔSCB for 2010 to 2030 is about €3.3 billion, which, after annualizing with a 7% discount factor, is €313 million per year, or in still other terms, is about €3.68 per person per year. For the likely alternative case D, we find that the total weighted net effect is about €1.7 billion, which corresponds to €162 million per year, or about €1.91 per person per year. Compared to total costs of the electricity sector in Germany of about €50 billion per year, we conclude that the weighted effect of unbundling is likely to be positive, but small in absolute terms. The costs of the last step of unbundling are small but so are the benefits.

In the base case scenario A, consumers gain and producers lose slightly less than €20 billion over the entire period. Strikingly though the producers lose marginally more than the consumers gain, making the equal-weighted ΔSCB slightly negative. If only the effect for consumers is considered, (disregarding the effect on producers), the effect starts to become substantial, but still unspectacular (annualized about €1.8 billion per year, which amounts to about €22 per person per year). We find that for the likely alternative scenario D, the numbers decrease very rapidly. First note that the equal-weight net effect becomes positive; this is because of avoided CAPEX of investment not made, as the capacity acceleration effect does not take place by assumption. More importantly, note how the stand-alone benefits to consumers decrease (compared to A) to around €5.4 billion, which corresponds to about €514 million annualised, which in turn is about €6 per person per year.

As mentioned above, the most significant effects are the available capacity and the generation capacity acceleration effects. First comparing scenarios A and B we find that the capacity acceleration effect on ΔSCB is modest in the low-capacity scenario. At the same time, the effects on CS and PS are substantial. What happens is the following. In the low-capacity scenario (A and B) corresponds to relative scarcity and thus to a relatively low RSI. In the PCMU-RSI approach, prices thus tend to be relatively high and consequently any effects of unbundling tend to be amplified. The capacity acceleration effect results in more capacity at any point in time and thus brings down prices (thereby CS goes up and PS goes down), but at the costs of higher CAPEX. If we assume alternatively in scenario B that the capacity acceleration effect does not take place, we find that prices do not fall so much as a consequence of unbundling and of course CAPEX is lower. The effect on the stand-alone values of CS and PS is large. The effect on the net weighted ΔSCB is small and non-systematic.[18] For our base case in A we can thus conclude that by and large the additional CAPEX of accelerated capacity offsets the weighted efficiency effect of lower prices. In other words, getting more competition by having more capacity turns out to be quite expensive.

As a next step we compare scenarios A and C, stepping from the low-capacity to the high-capacity case. We observe that weighted discounted cumulative ΔSCB in scenario C is still positive, but drops by some €1.9 billion to about €1.4 billion. Similarly, the effects for CS and PS decrease substantially. The reason is straightforward. The main driver of the competition effect is the residual supply index. If the market is already fairly competitive, as in the high-capacity scenarios, any competitive effects of unbundling must be small much by definition. Comparing scenarios C and D we can study the capacity acceleration effect in the high capacity case. We observe that ΔSCB is significantly higher in D than in C, implying that in the high-capacity case the effect of capacity acceleration is negative. The obvious reason is that with high capacity the competition effect will be small while the additional

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[18] I.e. whether the net effect of B compared to A is positive or negative seems to be arbitrary. We should note that the results are sensitive to the combination of low capacity and a capacity effect. Hypothetically trying out situations with very low capacity suggests that the price lowering effect of capacity acceleration may dominate the effect of additional CAPEX.

capacity nevertheless causes additional CAPEX. Therefore, not having a capacity acceleration effect would hardly cost anything while it would save on CAPEX.

We should remark that scenario C is not entirely realistic as compared to scenario D though. Case C assumes that the unbundling effect of accelerated new build of power plants takes place irrespective of the relative capacity situation. This is of course not plausible. We would expect that investors reduce their investment activity faced with adequate capacity and thus we would expect the acceleration effect to slow down as well and therefore case D is the more realistic. Whether we face scenario A or D depends on the likelihood of the capacity shortage. The causes of the threatening capacity shortage are threefold. First, the nuclear phase-out implemented by government in 2002, decommissions stepwise some 21 GW of nuclear power to 2021. No new nuclear power plants are planned. Secondly, there is substantial new investment in coal and gas in the planning process. However, recent experience suggests that many projects may be dropped, because investors face strong local opposition. Thirdly, the government relies strongly on renewables and energy efficiency to achieve their climate goals; whereas the goals are valid in themselves and surely the potential of renewables and energy efficiency in the future is high, according to various analyses, in the short term, capacity shortage may result. Yet, political awareness of capacity shortage is increasing and subsequent policy changes may be expected.

Next we examine the effect of organizational cost in particular the permanent cost of the loss of synergies. Somewhat surprising, but no doubt by coincidence, the difference between a positive and a negative net effect on weighted social welfare rests on the difference between the low-cost scenario (base case) and the high-cost scenario F (scenario F combines high costs, high capacity and no capacity acceleration effect). As can be seen in figure 2, the weighted ΔSCB in scenarios F is negative. Comparing CS for scenarios A and E, we see that by mechanism, the high-costs scenario has no effect on consumers, but does have an effect on producer surplus. Technically this is because the price effects are all related to marginal costs, whereas the organization costs are treated as fixed costs which (in the short run) do not affect prices. The scenario suggests that the net results of unbundling rather critically depend on the loss of synergies. In a different context and studying different aspects, this was also the result of the debate in the Netherlands. We should note moreover, that our study applies moderate estimates of the organization costs (permanent loss of synergies) even for the high-costs case. The results are sensitive to these costs, because the net effects in social welfare are moderate themselves. Hence, even moderate changes in the organization costs can make a difference between a positive and negative ΔSCB.

The difference between E and F is rather strong if we compare weighted ΔSCB and the plain difference CS and PS. Scenario F is the high-cost follow up of scenario D, where we have already shown that because no capacity effects occur, various numbers are significantly lower than in A. It is therefore not surprising that F yields low numbers. The value of scenario F is the fact that it is the only scenario where the net weighted ΔSCB is negative.

Scenario G studies the interconnector effect. As the difference between A and G is about €160 million, which suggests that the effect is positive but surprisingly small, for a number of reasons. First, the studies we used for the SCBA seem to suggest that despite congestion, new construction of interconnector capacity at least at the German borders is modest. Only with substantial new build of off-shore wind, new interconnector capacity will be needed. We do note, however, that these studies concentrate on the TEN-E priority lines, whereas there is considerable transmission network expansion within the system, but with cross-border effects. Secondly, the competition effect of new interconnector capacity is indirect. The effect runs through the capacity effect in the RSI. More problematic is that in the RSI, imports and exports are dealt with differently. As explained in the text, in a context where capacity is the main competitive driver, interconnector capacity which increases imports increases competition, but interconnector capacity which is used for exports actually decreases competition. If additional imports and exports balance, the net effect would be zero. In our case, the net effect is not zero but small.[19] Nevertheless, testing sensitivity by excluding exports effects, suggests that the import effect alone is not substantial either. It should be realized that even if the theoretical arguments support the idea that unbundled network operators will enhance interconnector investment, the quantitative effect may be moderate. Moreover, although this was not explicitly modelled, even if the incentives should be correct, it will still be problematic to invest in high-voltage overland transmission lines because of siting procedures. Nevertheless, we do support the idea that interconnector capacity is important.

[19] We have explained above that we compensate for other effects on competition of the interconnector capacity by making an adjustment in $\beta$.

## 4.2 Sensitivity and restrictions

An overall sensitivity analysis suggests that only few effects would actually make a difference. We check the sensitivity by comparing the base-case results and isolating each of the tested effects. In most cases this implies the alternative assumption that the effect does not take place (a binary test). For the CS-PS weighing factor, the discount factor, and the change in MC, we tested alternative numbers (a gradual test). We loosely assume that results are sensitive if the overall isolated effect is larger that € 1 billion. The numbers are given in the appendix.

In the binary test, we observe that the results are only sensitive to the assumption on the change in the $\beta$'s and MC. The effect of the change in MC (SF = 0.1 instead of 0.2) is more or less linear and is potentially quite substantial. Whether this is a relevant effect depends on the efficiency of the sector. As mentioned, and this is likely for many countries by now, the sector in Germany has experienced an impressive productivity increase and it is likely that the stretch has become thin.

To test sensitivity of the $\beta$'s, we assume that only the direct effects takes place and this only 50% of the changes actually take place. We find that the net weighted ΔSCB very significantly drops.[20] We recall that the assumed changes of the $\beta$'s have been constructed to fit the differences between observed parameter values between Germany on the one hand and Spain, Netherlands and the UK on the other hand. Whereas this is not entirely unreasonable, we do call for some reservation. First, the comparison of 1 versus 3 other countries does stand econometric scrutiny. Second, in doing so, we implicitly contribute the entire difference in parameter values to unbundling, which seems to be a strong assumption.

The discount factor is not particularly influential. We tested for 12% and 5.5% as alternative values. Whereas the changes assuming a 12% discount factor are substantial, for the more likely case of 5.5% the changes of the results are unspectacular. The primary reason for this is that investment costs have been annualized, whereas the one-off costs which of course should not be annualized are small. However, even if the investment costs were not annualized, the discount factor would not make the decisive difference as the investments themselves are spread over time. Hence, by and large, both costs and benefits tend to be spread over the time period in a more or less balanced way and thus we would expect a relatively low influence of the discount factor.

[20] This does not hold if we assume that only the capacity effect alter the $\beta$'s. In that case, the changes are far less, because of the induced capacity changes.

As we pointed out above, the weighing factor $\alpha$ is critical. If we change the weighing factor from our base-case assumption with $\alpha = 0.8$, to the alternative assumption that $\alpha = 0.5$ (hence, consumer interests are weighted twice as strongly as shareholders' interests), the net weighted effect on ΔSCB increases with a factor 2.5 to about €8.7 billion.[21] From a pure economic efficiency perspective only a weighing factor close to one would be optimal. However, we recall that because we assumed inelastic demand, a weighing factor of 1 would define away a lot of the net benefits. From a practical socio-political point of view, a subjective weighing fact substantially less than one seems important. We leave this subjective decision to be decided by politics and use $\alpha = 0.8$ for our base case.

The numerical results are context-specific and are not easily transferred to other countries, or other times. The main insights can of course be transferred to other countries but regarding the order of magnitude of the effects, we should bear in mind that these numbers are for Germany and rely on data from around 2006. Three points seem to be particularly important. Firstly, the estimates of the $\beta$'s underlying the PCMU-RSI equation are for Germany. Other countries have different parameter values. Secondly, a driver of the quantitative results is a looming capacity shortage as from around 2014. This seems to be typical for the German situation and is driven by the nuclear phase-out and decommissioning of old coal plant, whereas replacement turns out to be extremely difficult. Lastly, expectations around new build of interconnector capacity and its effects on imports and exports differ strongly between countries. For Germany, the interconnector effect seems to be small, but this may not hold for all countries, and not for Europe as a whole. On the other hand, many other effects hold more generally. In particular, we expect the organization costs (permanent loss of synergies) to be proportionally similar for various countries.

A main shortcoming of a static social cost benefit analysis is that it does not include dynamic effects. Of course, the study does include a number of years, but it does not (or only barely) make assumptions on changes in technology, firm strategies and possibly even demand-side responses. For instance, unbundling may have an effect on R&D activities. Also we would expect that network development, interconnector capacity and horizontal TSO cooperation will affect the choice of technology, size and location of power plants. Furthermore,

[21] Cf. eg. Newbery & Pollitt (1997). In their main analysis, Newbery & Pollitt (1997) assume no price effects in which case weighing is irrelevant. In their section V(v) they do consider price effects and assume for comparison a weighing factor of 0.975 for consumers and 0.5 for shareholders (with government having 1).

unbundling could have an impact on the development of load management, both in the management of the network and purely on the demand-side. Lastly, as unbundling would create specialized and focused network owners and management on the one hand and generators on the other hand, which are quite different managerial fields, we would expect that the various segments in the value chain to start developing in different directions. M&A activities should be expected to develop differently in an unbundled scenario than in an integrated scenario, leading to a different world. We should note though that in all these, we neither have a firm idea in which direction these changes go, nor whether the effects are good or bad. In the study in this paper we refrained from making rather speculative assumption on dynamic effects and constrained our attention to the static effects.

## 5 Concluding remarks

This paper presents a social cost benefit analysis (SCBA) of ownership unbundling of the electricity transmission system operators (TSO) in Germany. It thereby contributes to the ongoing debate on ownership unbundling as it is promoted by the European Commission. The current formal state of the debate in Brussels is that each member state shall be allowed an option out of three possibilities including ownership unbundling. We concentrate on the electricity transmission system operators in Germany for practical reasons and because these are the focus of the debate anyhow. Whereas the numerical effects cannot readily be transferred to other countries or Europe as a whole, the main insights hold more generally.

The primary aim of the study is to try find out which effects are quantitatively important and which are not. The ultimate answer of the study, the weighted net change of social welfare, is not that important, as this is merely the sum of the assumptions. The key contribution of the study is to allow a more substantiated discussion of the main arguments in the unbundling debate.

The important step in the analysis is to define the competitive concept. We rely on the so-called Residual Supply Index (RSI), linked to the Price-Cost-Mark-Up. For the parameter values we rely on estimates made by London Economics (2007) for the European Commission. The strength of the Residual Supply Index is its emphasis on available capacity relative to demand; prices tend to rise sharply with relative capacity scarcity. Moreover, the RSI concept covers the possibility of so-called pivotal firms to influence this. A pivotal firm can reduce available capacity on the market below market demand and thereby create artificial scarcity.

The study examines the effect of ownership unbundling on weighted social welfare as compared to business as usual, which is the current state of functional, legal unbundling. It should thus be realized that the step to be studied is small. In total the study examines about 15 effects. We group these effects in three classes:

- First, the "*competition effect*", which captures the arguments that unbundling increases competition. One particularly important aspect is the effect of unbundling on available generation capacity.
- Second, the "*interconnector effect*", which captures the argument that vertically integrated utilities have insufficient incentives to invest in interconnector capacity in order to hold off competition from abroad (the "strategic investment withholding" argument).
- Third, the "*cost effect*", for which we distinguish three separate effects. In particular, the potential loss of vertical synergies may be important and the fact that new capacity of power plants and interconnectors causes additional capital costs.

The main results are as follows:

- For the base-case the net weighted, discounted change of social-cost-benefit effect (weighted-ΔSCB) is likely to be positive, but small. Importantly the costs are assumed to be relatively small, because we concentrate on the marginal step from legal and management unbundling (BAU) to full ownership unbundling). This marginal step is small.
- Much depends on the relative weights for consumers versus producers/shareholders. In the base case, the consumers gain quite substantially, but producers/shareholders lose. Following the typical relatively strong weighing of consumer interests by the European Commission, the stand alone benefits for consumers in the case base are quite substantial, although still unspectacular. At the same time, however, in the base case, producers lose slightly more than consumers gain; hence, with equal weighing the net-ΔSCB is negative.
- The study assumes that unbundling can have an *accelerating* effect on investment in power plants and interconnector capacity, which by mechanism works out as additional capacity in the relevant periods. Additional capacity strengthens competition, but on the other hand, causes additional cost of capital.
- Available capacity and the effects of unbundling on capacity make all the difference. Our base case scenario A follows the projections that Germany enters a period of low capacity

and we assume that unbundling can have a capacity acceleration effect (i.e. investment would become available quicker). If, by alternative comparison (scenario D), we assume adequate capacity, and consequently assume that the capacity acceleration effect would not take place (basically because investment need will be small in the face of adequate capacity), the effects get small. The overall weighted net effect (and the stand alone effects) of a high-capacity scenario without the capacity acceleration effect, is still likely to be positive, but is small. The likelihood of a low-capacity scenario is decreasing as political awareness of the potential problem grows rapidly.

- The effect of the permanent loss of synergies ('loss of vertical economies of scope') is surprisingly small but nevertheless critical for the direction of the outcome. Our low-cost base-case assumes €50 million per year, whereas the high-cost scenario assumes €250 million per year. As total annual production costs in Germany are about €50 billion, even the high-cost case is moderate. The likely outcome of the net-ΔSCB of the high-cost case is at least in one case negative, but also moderate in magnitude.
- For a number of reasons, the interconnector effect is surprisingly and perhaps disappointingly small. First, there are indications that despite congestion the need for additional interconnector capacity is not that big. Secondly, the competition effect of new interconnector capacity is indirect. Thirdly, the magnitude of the effect of unbundling on new interconnector capacity may be moderate.

In total, the SCBA in this study suggests that the weighted net effect on social welfare is likely to be positive, but small. The relatively small effect has an important consequence. Arguments other than strict economic static efficiency will have to decide the debate.

## References


Arocena, P., 2008, "Cost and quality gains from diversification and vertical integration in the electricity: A DEA Approach. *Energy Economics*, 30:39–58.

Baldick, R., Kahn, E., 1993, 'Network costs and the regulation of wholesale competition in electric power', *Journal of Regulatory Economics* Vol. 5, 367-384.

Balmert, D., Brunekreeft, G. und Gabriel, J., 2008, „Independent System Operators – die Investitionsfrage", forthcoming: *Schriftenreihe der Deutschen Verkehrswissenschaftlichen Gesellschaft: Entbündelung in Netzindustrien: Chancen und Risiken, Reihe B, Berlin, 2008, S. 73-98.* Also UNECOM Discussionpaper 2008-04 (www.unecom.de).

BDEW, 2007, *Ausblick:Rollt die Kraftwerkswelle wirklich an?*, Presentation Chrsitian Bantle (BDEW) in Düsseldorf, September 2007.

Bertram, G., 2005, 'Restructuring of the New Zealand electricity sector 1984-2005' forthcoming in: Sioshansi, F.P. & Pfaffenberger, W. (eds.), '*International experience in restructured electricity markets: What works, what does not and why?*', Elsevier Science.

Brunekreeft, G., Neuhoff, K. & Newbery, D.N., 2005, ‘Electricity transmission: An overview of the current debate’, *Utilities Policy*, Vol. 13, No. 2, pp. 73-93.

Brunekreeft, G. & Ehlers, E., 2006, ‘Ownership unbundling of electricity distribution networks and distributed generation’, *Competition and Regulation in Network Industries*, Vol. 1, No.1, pp. 63-86.

Brunekreeft, G. & Keller, K., 2000, ‘The electricity supply industry in Germany; Market power or power of the market?’, *Utilities Policy*, Vol. 9, No. 1, pp. 15-29.

Brunekreeft, G., 2003, *Regulation and Competition Policy in the Electricity Market; Economic Analysis and German Experience*, Nomos, Baden-Baden (Univ.Habil., University of Freiburg).

Bundeskartellamt, 2001, *Bericht der Arbeitsgruppe Netznutzung Strom der Kartellbehörden des Bundes und der Länder*, 19 April 2001, Bundeskartellamt, Bonn.

CAISO, 2004, Transmission Economic Assessment Methodology (TEAM), June 2004.

CESI et.al., 2005, “TEN-Energy Invest”, Study prepared for European Commission DG TREN, October 2005.

Cowling K. & Waterson M., 1976, “Price-cost margins and market structure,” *Economica*, Vol. 43, pp. 267-274.

CPB, 2005, ’Vertical separation of the energy-distribution industry, An assessment of several options for unbundling’, CPB Document 84, Den Haag.

Cremer, H., Crémer, J., De Donder, P., 2006, ‘Legal vs. Ownership unbundling in network industries’, Centre for Economic Policy Research, *Discussion paper series*, 5767.

De Nooij, M. & Baarsma, B., 2007, „An Ex Ante Welfare Analysis of the Unbundling of the Distribution and Supply Companies in the Dutch Electricity Sector”, *SEO Discussion Paper 52 & UNECOM DP* 2008-02.

Deloitte, 2005, „Reorganisatiekosten Splitsing Energiebedrijven“, April 2005, Deloitte Amstelveen.

DENA, 2008, *Kurzanalyse der Kraftwerks- und Netzplanung in Deutschland 2020*, Berlin March 2008.

Dixit, A.,1980, “The role of investment in entry-deterrence”, *Economic Journal*, Vol. 90, pp. 95-106.

DTe, 2007, *Onderzoeksrapport inzake publiek en onafhankelijk netbeheer*, Rapportnr. 102680/23; June 2007, Dte/NMa, The Hague,

Eikmeier, B., Jahn, K., Bode, S. & Groscurth, H.-M., 2007, „Entwiclung der Energieversorgung in Norddeutschland, *report* Bremer Energie Institut, July 2007.

Green, R.J. & Newbery, D.M., 1992, ‘Competition in the British electricity spot market’, *Journal of Political Economy*, Vol. 100, No. 5, pp. 929-953.

Growitsch, Chr., Müller, G. & Stronzik, M., 2008, „Ownership unbundling in der Gaswirtschaft – Theoretische Grundlagen und empirische Evidenz, WIK discussion paper No. 308, May 2008.

Gulli, F., 2003, ‘Distributed generation versus centralised supply – A social cost-benefit analysis’, *Cambridge working papers in economics* 0336.

Hense, A, & Stronzik, M., 2005, “Produktivitätsentwicklung der deutschen Strom- und Gasnetzbetreiber; Untersuchungsmethodik und empirische Ergebnisse”, WIK *Diskussionbeiträge* Nr. 268, Sept. 2005

Jamasb, T. & Pollitt, M., 2005, “Electricity market reform in the European Union; Review of progress towards liberalization and integration”, *Energy Journal*, April, pp. 11-42.

Jones, L.P., Tandon, P. & Vogelsang, I., 1990, ‘*Selling public enterprises: A cost-benefit methodology*’, Cambridge, Mass: MIT Press.

Joskow, P.L., Schmalensee, R., 1983, ‘Markets for power : an analysis of electric utility deregulation’, Cambridge, Mass: MIT Press.

Kaufman, L., et. al., 2004, TFP research for Victoria's power distribution industry, Pacific Economics Group report, December 2004.
Klemperer, P.D. & Meyer, M.A., 1989, "Supply function equilibria in oligopoly under uncertainty," *Econometrica*, Vol. 57, No. 2, pp. 1243-1277.
Kreps, D.M. & Scheinkman, J.A., 1983, "Quantity precommitment and Bertrand competition yield Cournot outcomes", *Bell Journal of Economics*, Vol. 14, No. 2, pp. 326-337.
Kwoka, J. E., Ozturk, S., and Pollitt, M., 2007,."Divestiture, Vertical Integration, and Efficiency: An Exploratory Analysis of Electric Power Distribution.", unpublished mimeo.
London Economics, 2007, "Structure and performance of six European wholesale electricity markets in 2003, 2004 and 2005", *Study for the European Commission* DG COMP, Feb. 2007.
Mandy, D.M., 2000, 'Killing the goose that may have laid the golden egg: Only the data know whether sabotage pays', *Journal of Regulatory Economics*, Vol. 17, No. 2, pp. 157-172.
Meyer, R., 2008, "Vertical Economies and the Costs of Separating Electricity Supply – A Review of Theoretical and Empirical Literature", *mimeo*, Jacobs University Bremen
Nera, 2007, Structure and performance in Europe: A review of the report by DG Comp", *NERA Energy Regulation Insights*, April 2007.
Newbery, D.M., & Pollitt, M.G., 1997, 'The restructuring and privatisation of the CEGB – Was it worth it?', *Journal of Industrial Economics*, Vol. 45, No. 3., 269-303
Newbery, D.M., 1998, 'Competition, contracts and entry in the electricity spot market', *Rand Journal of Economics*, Vol. 29, No. 4, pp. 726-749.
Ockenfels, A., 2007, „Marktmachtmessung im deutschen Strommarkt in Theorie und Praxis – Kritische Anmerkungen zur London Economics-Studie", *Energiewirtschaftliche Tagesfragen*, 09-2007.
Pollitt, M., 2007, The arguments for and against ownership unbundling of energy transmission networks, EPRG 0714, Cambridge.
Posner, R.A., 1976, *Antitrust law; An economic perspective*, University of Chicago Press, Chicago.
PWC, 2006, *An economic analysis of the ownership unbundling of electricity distribution in New Zealand*, PriceWaterhouseCoopers, March 2006.
Sequoia, 2005, "Valuation and financing of unbundled energy companies", *presentation* at CIEP seminar, February 2005, Clingendael Institute, The Hague.
Vickers J. & Yarrow, G., 1988 (1997, 7th ed.), *Privatization: An economic analysis*, MIT Press, Cambridge, Mass..

# Appendix

| Variable / Assumption | Value |
|---|---|
| Discount factor | 7% |
| Weighing factor, α | 0.8 |
| Annualized costs for generation capacity | € 55,000 / MW |
| Annualized costs for interconnector capacity | € 5,000 / MW |
| Starting available G-cap | 82,000 MW |
| Share of largest supplier | 28% |
| TUC share of total capacity | 12% |
| starting value $\beta_1$ | 7.879008 |
| starting value $\beta_2$ | -10.8432 |
| starting value $\beta_3$ | 3.586526 |
| η | 5.0% |
| γ | 0.1 |
| SF | 0.2% |
| σ | 0.18 |

*Table 5: Overview of base assumptions*

| | |
|---|---|
| D | Daytime (08:00 am - 20:00 pm) |
| N | Nighttime (20:00 pm - 24:00 pm) and (00:00 am - 08:00 am) |
| M | Midweek (Monday - Friday) |
| E | Endweek (Saturday and Sunday) |
| S | Summer |
| W | Winter |

*Table 6: Description of periods*

| | | | Share in price setting | | | |
|---|---|---|---|---|---|---|
| Period | hourly weights | Avg. Load (GW) | lignite | coal | gas | weighted MC |
| DMW | 0,22 | 75,51 | | 0,36 | 0,64 | 42,6 |
| DMS | 0,22 | 68,14 | | 0,82 | 0,18 | 38,1 |
| DEW | 0,09 | 52,86 | | 1 | | 36,4 |
| DES | 0,09 | 47,70 | | 1 | | 36,4 |
| NMW | 0,13 | 60,11 | | 1 | | 36,4 |
| NMS | 0,13 | 51,48 | | 1 | | 36,4 |
| NEW | 0,05 | 42,08 | 1 | | | 31,4 |
| NES | 0,05 | 36,04 | 1 | | | 31,4 |

*Table 7: Table with key data for different periods*

| relevant Gen-unit | electrical efficiency | fuel price 2007 EUR/MWh (th) | CO2 emission rate | CO2 price (€ tCO2) | fuel cost €/MWh (el) |
|---|---|---|---|---|---|
| lignite | 0,43 | 3,60 | 0,92 | 25 | 31,4 |
| coal | 0,45 | 7,93 | 0,75 | 25 | 36,4 |
| gas | 0,57 | 21,32 | 0,35 | 25 | 46,1 |

*Table 8: Key data for generation units*

| Year | New I-cap. Import | New I-cap. Export | New pivotal plant | Decommission of plants - pivotal | New non-pivotal G.-Cap. | Decommission of non-pivotal G-cap |
|---|---|---|---|---|---|---|
| | [MW] | [MW] | [MW] | [MW] | [MW] | [MW] |
| 2008 | 0 | 0 | 270 | -222 | 3652 | -563 |
| 2009 | 0 | 260 | 850 | -1511 | 327 | -3833 |
| 2010 | 0 | 260 | 2100 | -943 | 4421 | -2391 |
| 2011 | 0 | 260 | 0 | -1544 | 6548 | -3915 |
| 2012 | 0 | 260 | 3200 | -1187 | 10855 | -3010 |
| 2013 | 0 | 260 | 0 | -943 | 748 | -2391 |
| 2014 | 440 | 860 | 450 | -1303 | 2050 | -3305 |
| 2015 | 440 | 860 | 0 | -943 | 1250 | -2391 |
| 2016 | 440 | 860 | 0 | -1651 | 600 | -4187 |
| 2017 | 440 | 860 | 600 | -943 | 420 | -2391 |
| 2018 | 440 | 860 | 0 | 0 | 420 | 0 |
| 2019 | 440 | 860 | 0 | 0 | 420 | 0 |
| 2020 | 440 | 860 | 0 | 0 | 420 | 0 |
| 2021 | 440 | 860 | 0 | 0 | 420 | 0 |
| 2022 | 440 | 860 | 0 | 0 | 420 | 0 |
| 2023 | 440 | 860 | 0 | 0 | 420 | 0 |
| 2024 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2025 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2026 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2027 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2028 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2029 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2030 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 9: Assumed changes in capacity (generation (G) and interconnectors (I))*

| Assumption on: | Base Case: | Cases and scenarios | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D** | **E** | **F** | **G** |
| Cost | Low | **base case** | **base case** | **base case** | **base case** | **high cost** | **high cost** | **base case** |
| Capacity | Low | **base case** | **base case** | **high cap** | **high cap.** | **base case** | **high cap.** | **base case** |
| Capacity acceleration effect | With | **base case** | **without cap-effect** | **base case** | **without cap-effect** | **base case** | **without cap-effect** | **base case** |
| Intercon-nectoreffect | With | **base case** | **base case** | **base case** | **base case** | **base case** | **Base case** | **w/o I-effect** |
| weighted SCB overall | | 3.314 | 2.117 | 1.450 | 1.720 | 1.288 | -305 | 3.474 |
| consumers alone | | 19.604 | 7.429 | 10.285 | 5.447 | 19.604 | 5.447 | 20.401 |
| producers alone | | -19.895 | -6.481 | -10.576 | -4.499 | -21.920 | -6.525 | -20.690 |

*Table 10: Overall weighted net effect on social welfare (ΔSCB) and CS and PS; discounted sum for 2010-2030; in million €.*

| **Isolated effects on weighted SCB of the other drivers set against the base case** | **A** | **A without effect** | **Difference** |
|---|---|---|---|
| new I-cap. Import | 3314 | 3141 | 173 |
| new I-cap Export | 3314 | 3645 | -331 |
| new pivotal G-cap | 3314 | 2798 | 515 |
| new TP G-cap | 3314 | 2824 | 490 |
| delta MC (Stretch-Faktor) | 3314 | 1684 | 1629 |
| delta Beta (RSI) 50% - direct effect only | 3314 | 771 | 2543 |
| One-off costs | 3314 | 3401 | -87 |
| permanent loss of synergy | 3314 | 3820 | -506 |
| TSO coordination | 3314 | 3283 | 30 |
| locational problem | 3314 | 3385 | -71 |

| **Sensitivity** | Alternative assumption | **A** | **A with akternative assumption** | **Difference** |
|---|---|---|---|---|
| PS weights | 0,5 | 3314 | 8720 | -5406 |
| discount factor | 12% | 3314 | 1739 | 1575 |
| discount factor | 5,5% | 3314 | 4071 | -758 |
| low delta MC | 0,1 | 3314 | 2499 | 815 |

*Table 11: Sensitivity analysis (in million €)*