Structure and Performance of Six European Wholesale Electricity Markets in 2003, 2004 and 2005

Part II

Presented to DG Comp 26th February 2007

Prepared by London Economics in association with Global Energy Decisions

February 2007

Structure and Performance of Six European Wholesale Electricity Markets in 2003, 2004 and 2005

Part II – Results for Germany and Spain

Presented to DG Comp 26th February 2007

DG Comp

Prepared by London Economics in association with Global Energy Decisions

February 2007

Contents

Page

Tables & Figures

Page

Tables & Figures

Page

Tables & Figures

Page

Tables & Figures

Page

Tables & Figures

Page

Tables & Figures

Page

Tables & Figures

Page

Tables & Figures

Page

Tables & Figures

Page

Tables & Figures

Page

6 Germany

6.1 Introduction to the German Electricity Market

This chapter contains our analysis of the competitive situation of the wholesale electricity market in Germany. In the chapter we report on a host of quantitative indicators, most of which are based on primary data, which have been collected for this purpose by DG Competition. Our data covers all significant operators active in the market over the period 2003-2005.

We start with a general introduction to the market, followed by a detailed analysis of market structure and observed outcomes. In the following sections, we analyse in detail the relationship between structure and outcomes, and extend our investigation to the determinants of observed wholesale prices, and potential evidence of strategies designed to manipulate the wholesale price.

6.1.1 Load Duration Curve

The load duration curve of the German electricity market is an ordered ranking of the electricity demanded in each hour of each year. The load is presented in descending order for each year allowing the reader to quickly determine the amount of hours in each year that demand in Germany (DE) is above the scale on the vertical axis. From Figure 6.1, one can see that peak demand levels have increased slightly over time but in general the demand for electricity appears to have remained largely unchanged over the period of the study, 2003-2005. Peak demand is slightly greater than 70GWh in 2005, with demand in the majority of hours greater than 40GWh.

Importantly, this load presented in the load duration curves represents the constructed load, described in the methodology chapter of this report as the sum of generation over all units in each hour. The hourly load included within this report is not that reported by the TSOs (E.ON Netz, EnBW Transportnetze, RWE Transportnetz Strom, and Vattenfall Europe Transmission (VET)). This approach was adopted so that the results of both the modelling and analysis are accurate and consistently reflect the market for which data is available. Given the quality and quantity of data collected by DG Competition as part of the Sector Inquiry, it means that only small companies with small non-peaking (price setting) units are not contained in our analysis. However to include the demand for electricity potentially served by these units, contained in the TSO load, and not to include them in the formal modelling and analysis would have created an over utilisation of the capacity in the market, represented by all other companies and units. As previously discussed in the methodology chapter, this approach also accounts for flows over the interconnectors with neighbouring countries.

Figure 6.1: Load Duration Curve - Germany

Source: LE

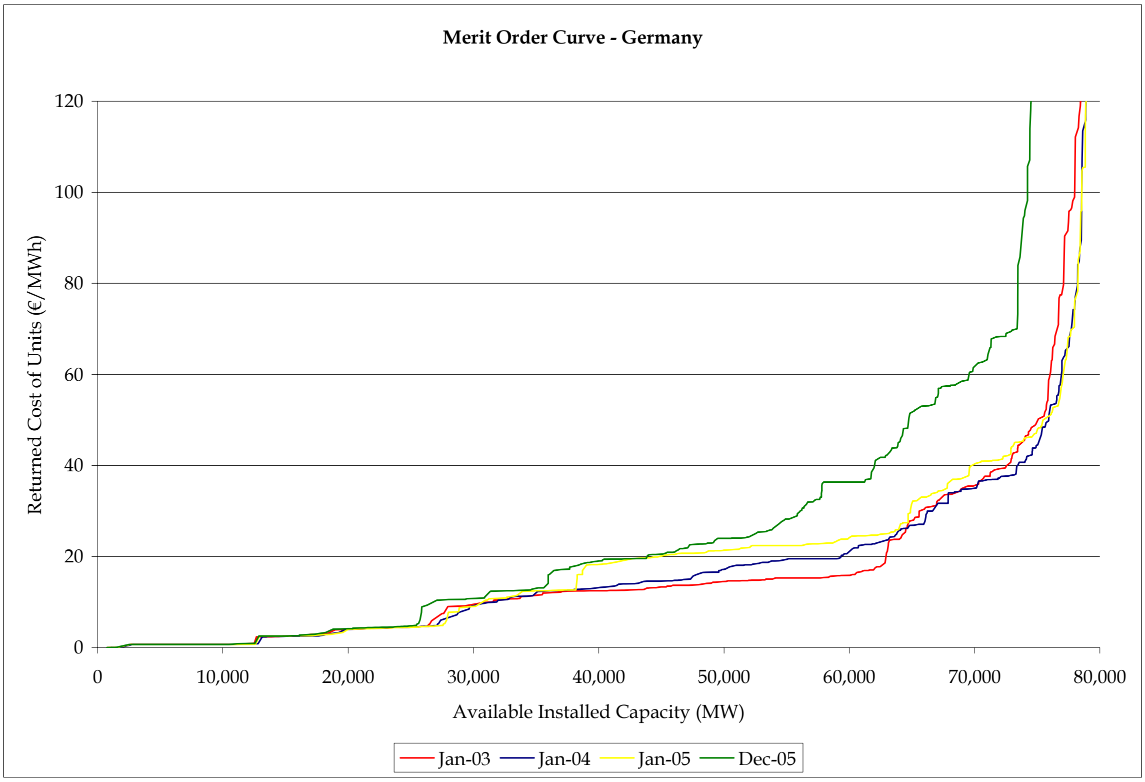
6.1.2 Merit Order Curve

The merit curve is an ascending ordering of the available installed capacity in the system, based on the marginal cost of generation (€/MWh) for each unit on the system. The merit curve can shift based on availability, fuel prices, etc, and thus is specific to a time period or an average. In this instance the merit curve was calculated by taking a monthly average of each unit's available installed capacity and the marginal cost of the unit, calculated using the fuel prices and efficiencies returned by each of the companies for each of their units. These costs are then sorted in ascending order and the corresponding average available capacities aggregated over the market.

The December 2005 merit curve is the only curve of the four to exhibit a marked difference is shape from the three January curves. There are two fundamental elements contributing to this. Firstly increasing fuel costs, particularly for natural gas, have shifted the curve upwards, a trend that was already noticeable in January of the same year and secondly a reduction in the availability of mid-merit installed capacity has meant that the curve begins to increase, the marginal cost of electricity becomes more expensive, at a lower absolute level of capacity. This reduction in available installed capacity is largely due to the unavailability of units on average in this month due to outages and planned maintenance events and not because this capacity was retired during the period of 2005.

Importantly, these merit curves do not capture the impact of the ETS scheme in 2005 and the inclusion of the economic cost of carbon to the generation costs of these units. This issue is addressed subsequently.

Figure 6.2: Merit Order Curve (excl. Carbon) - Germany

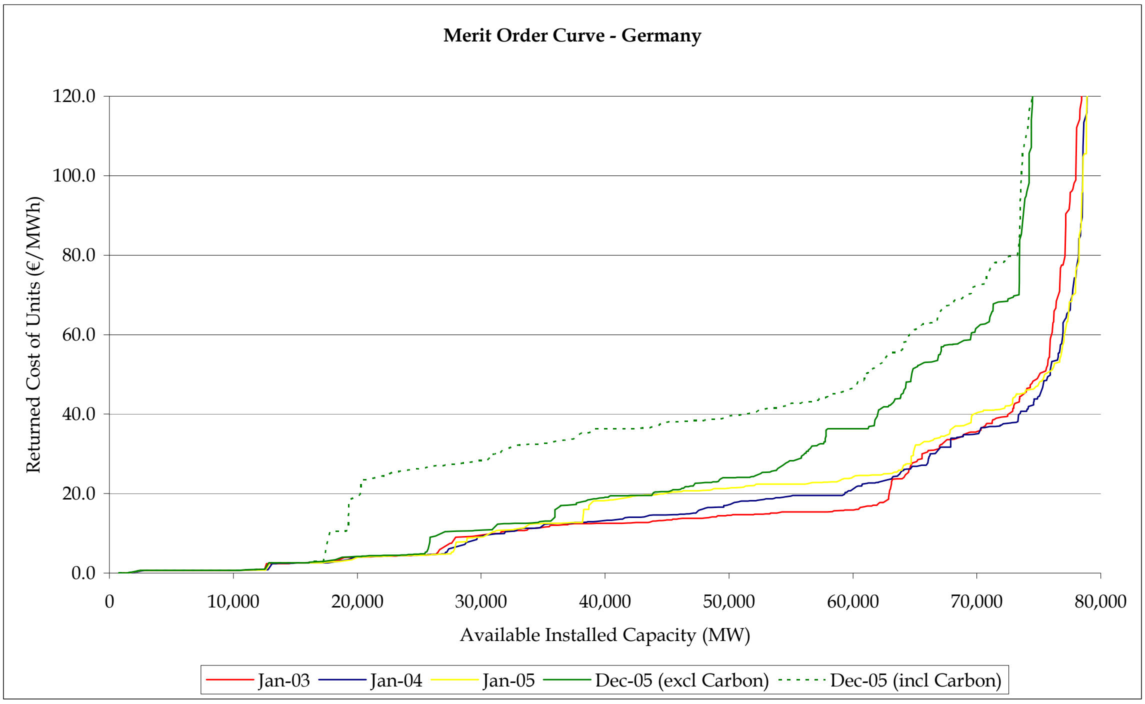


Source:

Merit Order Curve, including the average cost of carbon in December 2005 for all units emitting carbon.

In order to fully assess the impact on the merit order curve of the introduction of the ETS in 2005, the merit order curve for Belgium in December 2005 has been adjusted to include the unit specific €/MWh economic cost of carbon for all generation units liable under this scheme. As one can see from Figure 6.3 nuclear capacity in Germany remains unaffected by the introduction of the ETS as does the generation capacity with zero fuel costs such as wind. However, as one moves to the position on the merit curve where one would expect to see the conventional thermal units located, beginning with coal and moving to gas as one moves further to the right, the impact of the inclusion of the full economic cost of carbon on these units is apparent. It is important for one to note at this point that the inclusion of the full economic cost of carbon has the potential to change the ordering of the units on the merit curve such that one should not consider the difference between the two December 2005 merit curves to represent the full economic cost of carbon for a particular unit but rather for a particular megawatt, not necessarily one located at that point on the merit curve in the absence of the cost of carbon. The implication of this is that one cannot simply estimate the cost of carbon for the system based on the cost of carbon for the marginal unit as the marginal unit may potentially be different between the carbon and no-carbon case. This is similarly the case for all of the merit curves presented here for different periods, the ordering of the units is potentially different in each period due largely to changes in fuel costs.

Figure 6.3: Merit Order Curve (incl. Carbon) - Germany

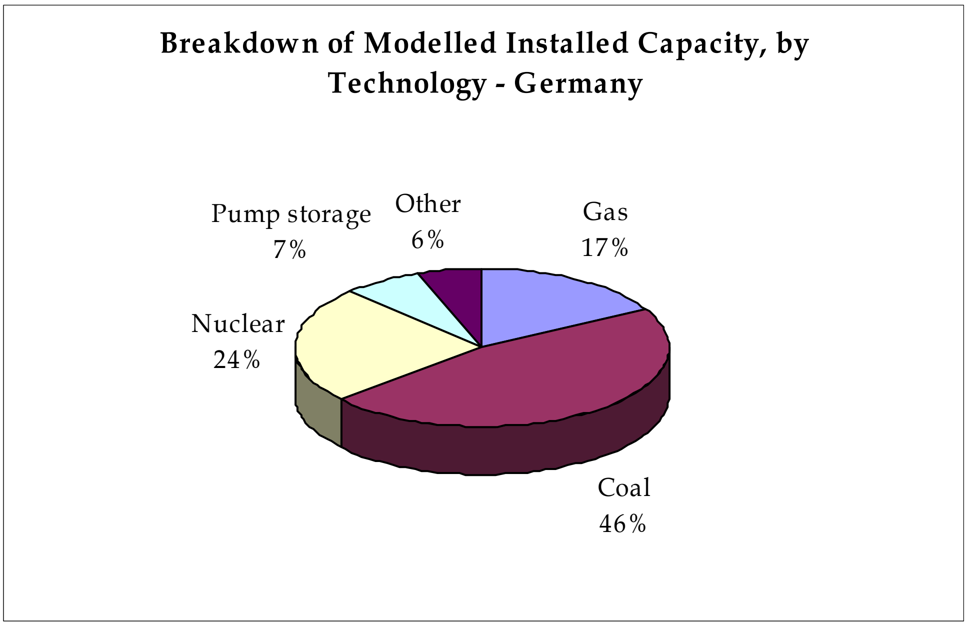


Source: LE

The introduction of an effective cost for CO_2 emissions, introduced by the ETS, can be seen to have a notable impact on the per unit cost of CO_2 emitting generation capacity. The effect is most striking for cheap, thermodynamically inefficient, coal units who in the absence of the ETS were capable of generating electricity for almost the same cost as nuclear units, which are located on the left of the merit curve and of course are not liable under the ETS. The very large initial impact of including the full economic cost of carbon in the merit curve begins to moderate as one moves to the right of the curve, particularly after 55,000MW. Greater thermal efficiency and relatively cleaner natural gas fired technology all contribute to narrow the difference to approximately one third of the impact observed at 20,000

If one considers the breakdown of installed capacity by technology, presented in the following figure, one immediately sees the basis for such a large carbon cost impact, both in terms of relative size and duration, as almost half of the installed capacity in Germany over this period was coal fired[1].

Figure 6.4: Breakdown of Installed Capacity, by Technology - Germany



Source: LE

[1] The proportion of coal in the German market represents the share of both coal and lignite. Throughout the remainder of this report, we shall ignore this distinction and simply refer to the category as coal.

6.2 Structural Indicators

Traditional structural indicators have been calculated based on a number of different measures of market share for the German electricity market. These indicators can change with availability and market conditions, so *CR(n)* and HHI indicators have been calculated, on an hourly basis, for all companies included in the study. Three different measures of market share (capacity) (generation) have been used to calculate these indicators. A brief overview of these measures is presented here but for a more detailed description one should review the relevant section of the methodology chapter.

Available Installed Capacity (AIC) – The Available Installed Capacity of each company is equal to the sum of maximum operating capacity reported for each unit in the company's portfolio (taking account of warm weather deration and outages). The impact of warm weather derations on the normal operating capacity of units was included as part of DG Competition's data request to companies under the auspices of the Sector Inquiry. Data on outages was similarly returned by the companies and these were seen to take two particular forms: full outages and partial outages. A full outage is recorded where a company reports an outage and the hourly generation in that hour is zero. This unit is regarded to be out of operation and therefore not available in that hour. Companies have also reported partial outages which arise when the period of a reported outage does not correspond with a zero electrical production. In this case we have taken the available capacity to be the maximum hourly generation figure reported by the company, for the specific unit, over the period for which a partial outage has been identified. Further discussion of this as well as a formal exposition of the approach taken is contained in the methodology chapter of this report.

Available Capacity (AC) – Available Capacity is a measure calculated primarily for the purposes of the electricity specific structural indicators, however it is still interesting to assess the results of the traditional measures based on AC both in relation to the other measures of capacity and as an assessment of the HHI approach in general vis-à-vis the more specific measures calculated further on in this chapter. As has previously been stated in the methodology chapter, available capacity is equal to available installed capacity less capacity committed to upward system balancing (reserve) requirements and plus the net purchasing position of companies via long-term contracts.

Total Generation – Both the *CR(n)* and HHI indicators have been calculated using the hourly net electrical generation figures reported by the companies for the full three year period 2003-2005 (26,304 hours). The hourly generation of each company is simply the arithmetic sum of generation over all units in the company's portfolio in each hour. If one was to aggregate this over each company, it would be equivalent to the load. Therefore, concentration measures based on total generation reflect the market shares of companies over the load of the system.

In Merit/Economic Capacity - *CR(n)* and HHI indicators have been calculated using the concept of in merit/economic capacity. A station is in merit if its running cost is less than the system marginal cost. This requires the estimation of an hourly system marginal cost and information on the hourly marginal cost of generation for each of the units in a company's portfolio. If the hourly marginal cost of generation of a particular unit is below, or equal to, the system marginal cost, the available generation capacity (as calculated above) is included in the company's available capacity for that hour. Units which report a marginal cost of generation above that of the system marginal cost are excluded. The system marginal cost used for this was the maximum unit cost of any unit reported running on the system in that hour.

CR(n)

The Concentration Ratio (*CR(n)*) of the *n* largest companies in the market is comprised of the sum of the relevant capacity measures (C) of the *n* largest companies in the market, divided by the total sum of capacity in the market. This measure has been calculated using, Available Installed Capacity, Available Capacity, Total Generation, and, In Merit/Economic Capacity.

HHI

Formula: $$HHI = \sum_{i=1} \left(\frac{C_i}{\sum_i C_i} \right)^2$$ where i = 1, 2, 3,….,N

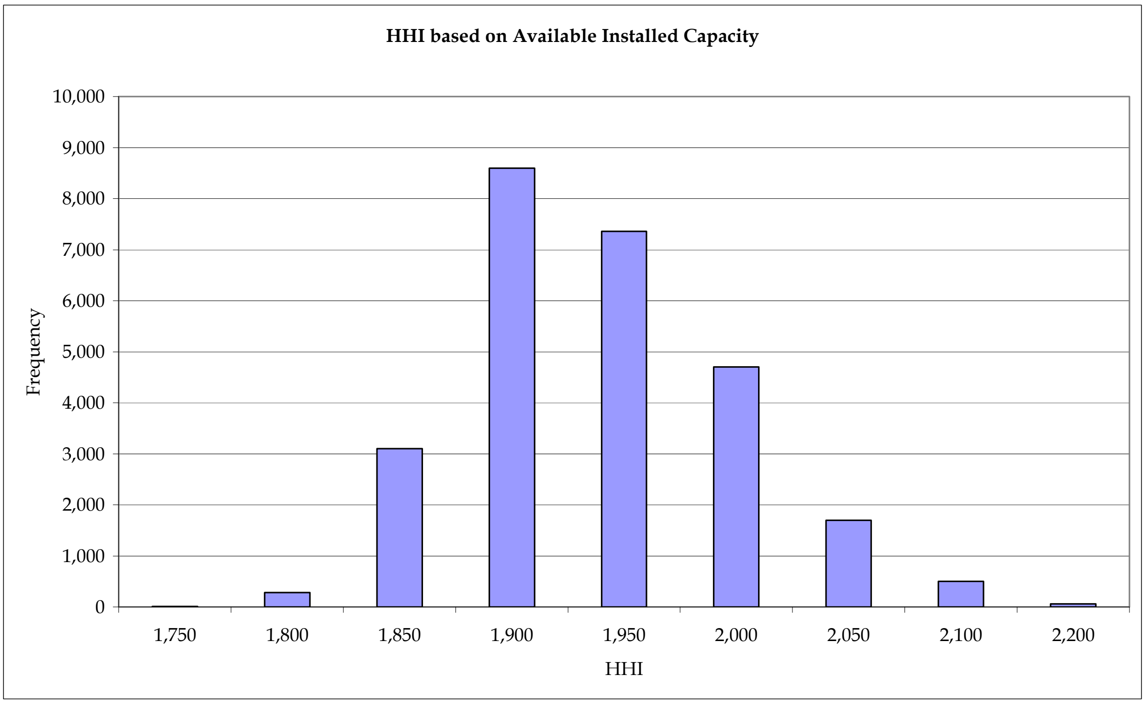
The HHI indicator sums the squares the market shares of all companies in the market, where the market shares of the companies are calculated on an hourly basis using, Available Installed Capacity, Available Capacity, Total Generation, and, In Merit/Economic Capacity. The HHI indicator sums the squares the market shares of all companies in the market, where the market shares of the companies are calculated on an hourly basis using, Available Installed Capacity, Available Capacity, Total Generation, and, In Merit/Economic Capacity. The resulting figures will be assessed vis-à-vis the thresholds for concentration set out by a number of competition authorities, including DG competition, that identify markets with a HHI below 1,000 not to be concentrated, between 1,000 and 1,800 to be moderately concentrated, and above 1,800 to be concentrated. It is important to point out that these thresholds are not the result of rigorous economic analysis but have developed over time as a generally accepted benchmark. These thresholds are therefore not steadfast rules and are adapted in particular situations to accommodate special market conditions.

6.2.1 Results

CR(2) & HHI based on available installed capacity

HHI and *CR(n)* measures have been constructed hourly for the full period of the study. An overall representation of the computed HHI values based on hourly available installed capacity is provided in the following histogram.

Figure 6.5: Histogram of HHI Values based on Available Installed Capacity (2003-2005) - Germany



Source: LE

The distribution of HHI values, based on available installed capacity, presented in the above histogram indicates that the German market is to be considered to be concentrated under this market definition. The distribution is centred around 1,900, with the majority of values in the range 1,850 – 2,050. Interestingly, there are a non-negligible number of observations below the 1,800 threshold indicating a number of periods in the three years where the market may be considered not to be concentrated to an extent that may raise competition concerns, based on this traditional measure of concentration. The summary statistics on CR(2) and HHI based on Available Installed Capacity are presented in Table 6.1. The summary values on the CR(2) measure indicate that over half of the available installed capacity in the market, on average, is owned by the top two companies. This result confirms the preliminary finding of a relatively concentrated market. An analysis of the market power of these large companies is contained within the electricity specific structural measures section of this chapter.

Table 6.1: Summary Statistics of CR(2) & HHI based on Available Installed Capacity - Germany

	Hourly Available Installed Capacity (MW)	CR(2)	HHI
Average	74,313	54.1%	1,914
Maximum	85,228	60.1%	2,158
Minimum	59,893	49.1%	1,734
Standard Deviation	5,152	1.7%	59

Source: LE

As well as the overall representation of the hourly HHI values, a number of pre-selected days have been chosen to assess the existence and prevalence of concentration at different points in weekly and seasonal trends. The pre-selected dates are provided in Table 7.2.

Table 6.2: Pre-Selected Representative Days[2] - Germany		
	Weekday	**Weekend**
January (Winter)	2nd & 4th Wednesday	2nd Sunday
April (Spring)	2nd Wednesday	2nd Sunday
August (Summer)	2nd & 4th Wednesday	2nd Sunday
October (Fall)	2nd Wednesday	2nd Sunday
Source: LE		

Table 7.3 presents the results of the CR(2) and HHI analysis for available installed capacity for these pre-selected dates. One will notice the small degree of variance in both the CR(2) and HHI values over these periods where one can clearly observe weekday and seasonal trends in the demand for electricity. None of the returned HHI values are below the 1,800 threshold, however a number are close to it and the results support the previous finding of concentration based on the values returned over the full period.

[2] The selection of January and August as Winter and Summer respectively is in accordance with the references to these periods contained in the Horizontal Data Request.

Table 6.3: Concentration measures based on Available Installed Capacity - selected days - Germany				
No.	Date	Average Hourly Demand (MWh/h)	CR(2)	HHI
1	08/01/03 (W-2)	62,799	54.5%	1,913
2	12/01/03 (S-2)	52,252	54.4%	1,909
3	22/01/03 (W-4)	58,012	54.4%	1,913
4	09/04/03 (W-2)	58,440	52.9%	1,889
5	13/04/03 (S-2)	46,378	53.2%	1,890
6	10/08/03 (S-2)	40,860	54.7%	1,954
7	13/08/03 (W-2)	49,023	54.8%	1,958
8	27/08/03 (W-4)	50,474	54.2%	1,931
9	08/10/03 (W-2)	55,851	53.9%	1,904
10	12/10/03 (S-2)	45,524	54.9%	1,940
11	11/01/04 (S-2)	47,789	54.2%	1,913
12	14/01/04 (W-2)	56,607	53.7%	1,892
13	28/01/04 (W-4)	62,713	54.4%	1,938
14	11/04/04 (S-2)	44,811	54.0%	1,930
15	14/04/04 (W-2)	56,130	54.9%	1,951
16	08/08/04 (S-2)	38,092	55.0%	1,922
17	11/08/04 (W-2)	48,333	54.2%	1,875
18	25/08/04 (W-4)	48,368	55.9%	1,942
19	06/10/04 (W-2)	56,003	53.5%	1,890
20	10/10/04 (S-2)	44,196	53.4%	1,895
21	09/01/05 (S-2)	44,721	53.7%	1,916
22	12/01/05 (W-2)	57,723	53.7%	1,910
23	26/01/05 (W-4)	64,213	53.6%	1,905
24	10/04/05 (S-2)	48,255	52.5%	1,880
25	13/04/05 (W-2)	57,143	53.0%	1,889
26	10/08/05 (W-2)	43,930	56.6%	1,998
27	14/08/05 (S-2)	38,876	57.3%	2,048
28	24/08/05 (W-4)	49,693	56.8%	1,980
29	09/10/05 (S-2)	44,003	52.0%	1,861
30	12/10/05 (W-2)	52,546	52.0%	1,853

Source: LE.

As well as looking at these pre-selected dates, HHI and CR(2) measures have also been calculated for the peak demand days in each season in each of the three years. In this instance the peak demand days have been selected as the days over which aggregate demand over the 24 hour period was at its highest. The average hourly demand figures are presented in this table along with the concentration measures based on available installed capacity on those days. The results are presented in Table 7.4.

Table 6.4: Concentration measures based on Available Installed Capacity–seasonal peaks - Germany

	Date	Average Hourly Demand (MWh/h)	CR(2)	HHI
Summer	23/06/2005	52,379	55.2%	1,936
	02/06/2004	51,713	57.0%	2,000
	28/08/2003	52,934	54.3%	1,931
Winter	25/02/2005	65,695	54.9%	1,932
	14/12/2004	64,744	54.0%	1,905
	08/01/2003	62,799	54.5%	1,913
Spring	03/03/2005	66,369	53.9%	1,909
	03/03/2004	63,660	54.6%	1,938
	10/04/2003	59,224	53.1%	1,890
Autumn	29/11/2005	62,339	52.0%	1,830
	30/11/2004	63,685	53.6%	1,909
	29/10/2003	62,685	54.1%	1,910

Source: LE.

The returned values for the HHI and CR(2) measures on these peak demand days are consistent with those already found on randomly chosen pre-selected and with the HHI and CR(2) values found for the period as a whole. Therefore one may conclude that based on this market definition, the German electricity market may be considered to be concentrated based on traditional concentration measures.

Available Capacity (allowing for LTCs and Reserves)

In order to assess the impact of long-term contracts and reserve commitments on the HHI and CR(2) measures, these measures have been constructed using Available Capacity. Available capacity differs from available installed capacity as it takes account of each company's long-term contract and upward reserve commitment requirements. Available capacity is the basis for the electricity specific structural measures computed in the following section.

Table 7.5 presents a summary comparison of the results of the HHI and CR(2) measures computed hourly over the full period for Available Capacity and Available Installed Capacity.

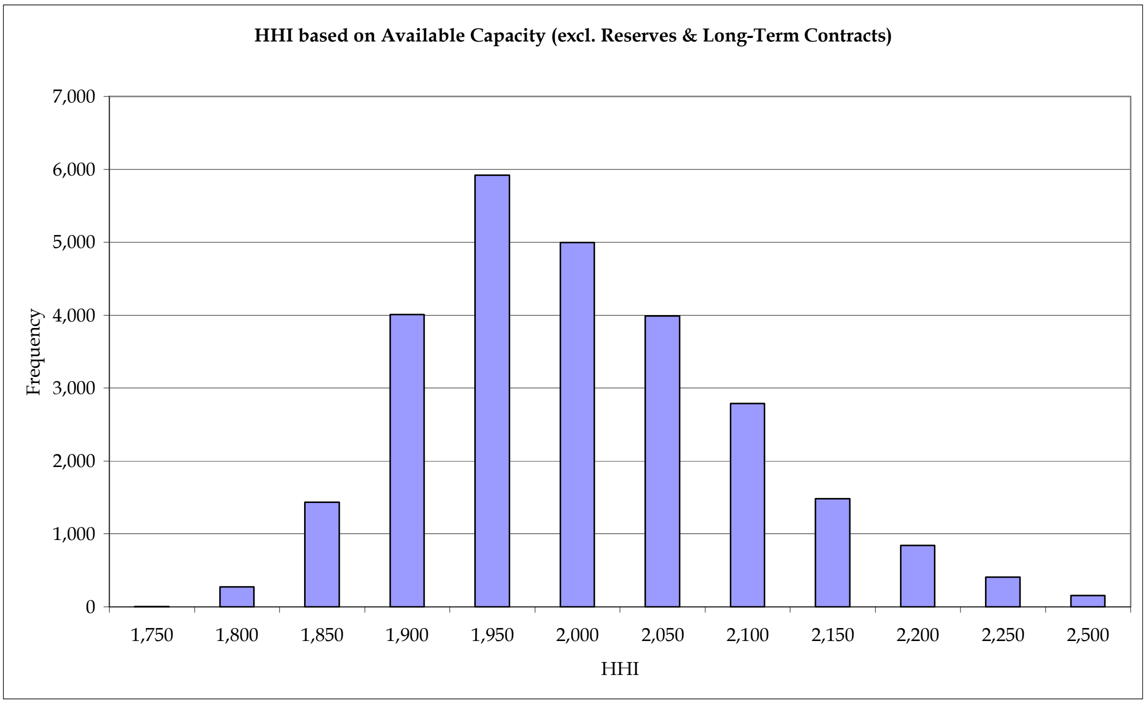
Table 6.5: Comparison of Available Capacity & Available Installed Capacity - Germany

	Available Capacity (MW)		Available Installed Capacity (MW)	
	CR(2)	**HHI**	**CR(2)**	**HHI**
Mean	57.2%	1,977	54.1%	1,914
Max	64.6%	2,403	60.1%	2,158
Min	51.5%	1,734	49.1%	1,734
Standard deviation	2.1%	96	1.7%	59

Source: LE

As one can see from this table and the below histogram of the calculated HHI values, based on available capacity (allowing for LTCs and upward reserve commitments), the results are broadly similar. On average, the market is slightly more concentrated under this market definition with a substantial number of hours returning a higher HHI value than was returned by the previous definition, as is reflected by the distribution in the histogram below.

Figure 6.6: Histogram of HHI Values based on Available Capacity (2003-2005) - Germany



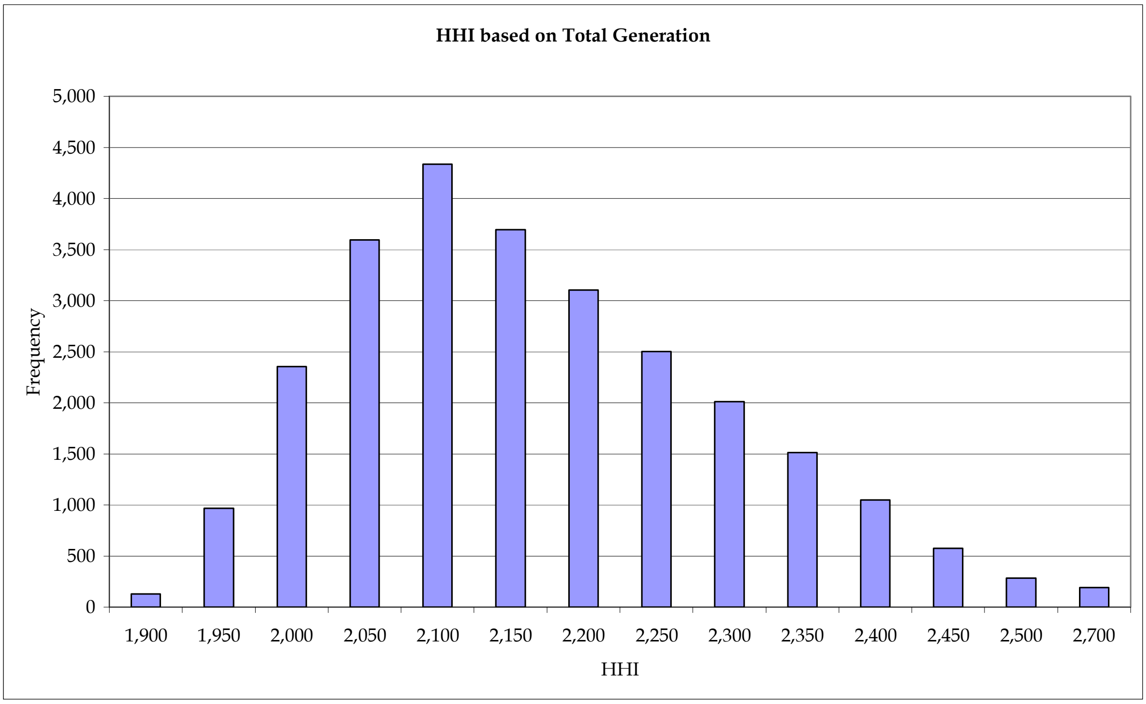
Source: LE

CR(2) & HHI based on Total Generation

An alternative definition often used to assess concentration in electricity markets is to base market share calculations on total generation. This excludes generation capacity in many hours that are available to meet peak demand, but puts greater weight on those generators running baseload, especially in off peak hours. The HHI and CR(2) measures have been re-estimated hourly based on the hourly net electrical production figures of all units contained in the study. This data is also that used to construct the load in Germany for the purpose of this study, as previously discussed.

Figure 6.7 presents a histogram of the frequency of hourly HHI values computed using hourly net generation figures over the period 2003-2005. The shape of the distribution is broadly similar to that presented in relation to the capacity measures previously discussed but under this market definition the market appears to be slightly more concentrated than the results based on the capacity measures would suggest. This distribution is centred around 2,100 with less than 1% of the calculated values found to be below 1,900.

Figure 6.7: Histogram of HHI Values based on Total Generation (2003-2005) - Germany



Source: LE

The summary statistics on the HHI and CR(2) measures, based on total generation, are presented in Table 7.6. Here one can clearly see the moderate increase in concentration, on average, although there are still clearly a small number of values below the 1,800 threshold. Due to the very small number of these observations, they are not displayed in the above histogram. Under this alternate market definition, one still arrives at the same conclusion that the market is concentrated, based on traditional measures of concentration.

Table 6.6: Summary Statistics of CR(2) & HHI based on Total Generation - Germany

	Average Hourly Generation (MWh/h)	CR(2)	HHI
Average	51,873	57.3%	2,143
Maximum	71,541	65.7%	2,665
Minimum	30,945	50.7%	1,795
Standard Deviation	7,801	2.1%	132

Source: LE

For consistency with the previous analysis based on available installed capacity, it has been attempted to control for the possibility that trends in the German electricity market, (seasonally, weekly, daily), may affect the degree of concentration in the market based in this alternate market definition. Table 7.7 presents the HHI and CR(2) measures computed for the pre-selected days previously listed in Table 7.2. These results are largely consistent with the average values returned over the full period and as with the analysis based on the capacity measures, the results do not alter the analysis of the market being concentrated. There is some evidence of greater concentration at weekends within this table but this and other trends shall be investigated using regression analysis later in the chapter.

Table 6.7: Concentration measures based on total generation - selected days- Germany				
No.	**Date**	**Average Hourly Demand (MWh/h)**	**CR(2)**	**HHI**
1	08/01/03 (W-2)	62,799	56.0%	2,025
2	12/01/03 (S-2)	52,252	56.7%	2,202
3	22/01/03 (W-4)	58,012	56.1%	2,046
4	09/04/03 (W-2)	58,440	54.8%	2,014
5	13/04/03 (S-2)	46,378	56.1%	2,170
6	10/08/03 (S-2)	40,860	59.4%	2,309
7	13/08/03 (W-2)	49,023	57.5%	2,142
8	27/08/03 (W-4)	50,474	58.1%	2,115
9	08/10/03 (W-2)	55,851	57.2%	2,081
10	12/10/03 (S-2)	45,524	59.6%	2,297
11	11/01/04 (S-2)	47,789	57.8%	2,270
12	14/01/04 (W-2)	56,607	57.0%	2,090
13	28/01/04 (W-4)	62,713	57.1%	2,082
14	11/04/04 (S-2)	44,811	60.5%	2,361
15	14/04/04 (W-2)	56,130	57.7%	2,116
16	08/08/04 (S-2)	38,092	61.7%	2,390
17	11/08/04 (W-2)	48,333	57.7%	2,087
18	25/08/04 (W-4)	48,368	58.7%	2,128
19	06/10/04 (W-2)	56,003	57.0%	2,134
20	10/10/04 (S-2)	44,196	59.1%	2,287
21	09/01/05 (S-2)	44,721	59.7%	2,410
22	12/01/05 (W-2)	57,723	56.4%	2,121
23	26/01/05 (W-4)	64,213	57.5%	2,099
24	10/04/05 (S-2)	48,255	56.2%	2,183
25	13/04/05 (W-2)	57,143	55.5%	1,997
26	10/08/05 (W-2)	43,930	58.2%	2,201
27	14/08/05 (S-2)	38,876	62.1%	2,456
28	24/08/05 (W-4)	49,693	59.4%	2,151
29	09/10/05 (S-2)	44,003	55.1%	2,199
30	12/10/05 (W-2)	52,546	53.8%	1,998

Source: LE.

Table 6 presents the CR(2) and HHI measures based on total generation for the selected seasonal peaks in demand. As the constructed load is the sum of hourly generation, this table presents, on a daily basis for peak demand days, the degree of concentration at the seasonal high points of the load duration curve. There is no discernable trend in this table leading one to conclude that there is not likely to be a considerable seasonal variation in the degree of concentration in the German electricity market. As with the previous analysis of concentration based on total generation, the HHI values in this table are all in excess of the 1,800 threshold and as with the pre-selected dates the market share of the two largest companies is consistently greater than 50%.

Table 6.8: Concentration measures based on total generation – seasonal peaks - Germany

	Date	Average Hourly Demand (MWh/h)	CR(2)	HHI
Summer	23/06/2005	52,379	59.0%	2,157
	02/06/2004	51,713	58.3%	2,137
	28/08/2003	52,934	56.7%	2,081
Winter	25/02/2005	65,695	57.6%	2,090
	14/12/2004	64,744	57.2%	2,088
	08/01/2003	62,799	56.0%	2,025
Spring	03/03/2005	66,369	56.6%	2,053
	03/03/2004	63,660	57.4%	2,092
	10/04/2003	59,224	55.9%	2,049
Autumn	29/11/2005	62,339	53.3%	1,922
	30/11/2004	63,685	57.4%	2,114
	29/10/2003	62,685	57.0%	2,061

Source: LE.

In order to further investigate the degree of concentration at different intervals in the load duration curve, base, shoulder and peak periods have been identified for a selection of the days already presented as part of the analysis of pre-selected days. The definition of base, shoulder and peak used for this analysis is as follows;

- Base is defined as the hours in the year where in the first two quartiles of the load duration curve;
- Shoulder is defined as the hours in the third quartile of the load duration curve;
- Peak is defined as the hours in the final quartile of the load duration curve.

Table 7.9 presents the HHI and CR(2) values during these periods of the selected days, as well as the order of the top two companies in those hours. The missing values for the shoulder and peak periods in August are due to the failure of this date to return values within the required range. These results do nothing to alter the overall conclusion that the market is concentrated however one should note the order of the two largest companies in the market. On average, the market share of company 0436-S-DE, based in available installed capacity, is the greater than all other companies but consistently over these two days, company 1338-S-DE is the market leader in terms of its market share of total generation at these different intervals of the load duration curve.

Table 6.9: Total Generation – Concentration & Load Duration - Germany				
January 2005		**Company**	**CR(2)**	**HHI**
2nd Wednesday	*Base*	1338&0436	57.9%	2,300
	Shoulder	1338&0436	56.3%	2,150
	Peak	1338&0436	55.8%	2,076
August 2005				
2nd Wednesday	*Base*	1338&0436	58.2%	2,200
	Shoulder	NA	NA	NA
	Peak	NA	NA	NA
Source: LE				

A number of entries appear as NA in this table due to the fact that hours corresponding to the definition of the categories do not exist on these pre-selected days.

CR(2) & HHI based on In Merit/Economic Capacity

In Merit capacity has computed based on the realised costs returned by the companies. In order to compute these costs the heat rate of each unit contained in the analysis, including warm weather de-ratings, was multiplied by the unit specific fuel cost (€/MWh) returned by the companies. A simple stacking model then was used to determine the in merit capacity in each hour. Table 6.10 presents summary statistics on the CR(2) and HHI values computed on an hourly basis.

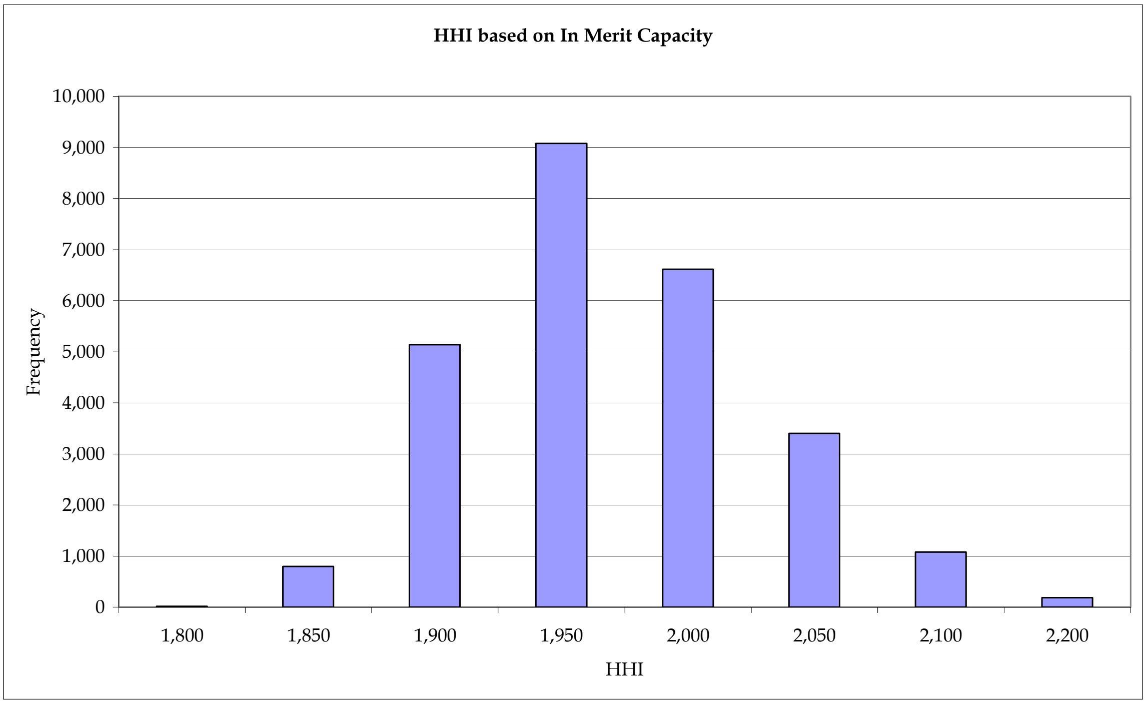
Table 6.10: Summary Statistics of CR(2) & HHI based on In Merit Capacity - Germany

	In Merit Capacity (MW)	CR(2)	HHI
Average	73,901	54.2%	1,945
Maximum	84,856	60.1%	2,177
Minimum	59,397	49.0%	1,775
Standard Deviation	5,139	1.8%	57

Source: LE

The following histogram represents the frequency of HHI values calculated on the basis of in merit capacity. These results are consistent with those previously presented in relation to the available capacity measures and represent no challenge to the conclusions already drawn on in relation to the German electricity market. The market is concentrated and is not notable affected by seasonality or changes in the metric used to measure market share.

Figure 6.8: Histogram of HHI Values based on In-Merit Capacity (2003-2005) - Germany



Source: LE

6.2.2 Interconnector

An assessment of the potential impact of interconnection has been carried out using the indicators of concentration previously presented based on Available Installed Capacity and Total Generation. Importantly, it was possible to extract details of ownership of reserved capacity and interconnector flows, by company, from the data collected by DG Competition as part of the Sector Inquiry and as a result a sensitivity analysis is conducted to put upper and lower bounds on the potential impact of interconnection on the traditional measures concentration. Two scenarios have been considered and represent a sensitivity analysis of the figures calculated in the absence of the interconnector;

1. Atomistic Competition
2. Largest Company Apportionment

1. Atomistic Competition – Under this scenario the companies' hourly market share is not affected. The aggregated impact of the interconnector is included in the denominator of both CR(1) and HHI measures, such that the net impact of the interconnectors is only added to the market. Thus, the atomistic competition scenario reduces the measured concentration by the maximum amount possible due to the interconnector.

2. Largest Company Apportionment – Under this alternative scenario the hourly impact of the interconnectors is apportioned entirely to the largest company in the market (as measured by available installed capacity). This scenario thus represents the largest increase in measured concentration possible due to the allocation of the interconnector.

The two allocation procedures thus form the upper and lower bounds of the measured concentration due to the interconnector allocation. It is important to note at this stage that the potential impact of the interconnector is accounted for differently in these scenarios depending on the basis for the calculation. The hourly net transfer capacity of the interconnectors is used in calculations based on the Available Installed Capacity of the companies in the market, while actual hourly interconnector flows are used in calculations based on Total Generation. This is important due to the potential impact of the interconnector flows on the expectations of upper and lower bounds. These bounds are true in the case of Available Installed Capacity but as one may realise, this will only be the case if the country is, on average, a net importer of electricity. In the event that the country is regarded as an exporter, the expected results from these scenarios may be reversed. For a further discussion and formal exposition of how these interconnector scenarios are calculated, one can revert to the methodology chapter of this report.

Germany has developed approximately 21GW of interconnector capacity (net transfer capacity) with neighbouring countries, Austria, Switzerland, Czech Republic, Denmark, France, Netherlands and Sweden. On average over the period concerned with this study approximately 11.4GW of available net transfer capacity were available on a day-ahead basis, as reported by the four TSOs on an hourly basis. In terms of flows Germany is a net exporter of electricity and on average over the period exported approximately 5.9GWh/h, although this varied substantially between hours. However, in terms of both capacity and flows the average values remain similar in each of the three years.

6.2.3 Results

CR(2) and HHI under 2 Assumptions of Interconnector Capacity Allocation, based on Available Installed Capacity

The two approaches applied to assessing the potential impact of the interconnectors Germany possesses with a large number of its neighbours present an interesting result. Table 6.11 presents summary statistics on these approaches that indicate that Germany's available net transfer capacity could have a significant impact on the determination of concentration in the German electricity market. Under the atomistic approach it can be seen that on average, and overall, the resulting market structure would not be considered to be concentrated in the traditional sense as it would always be below the threshold of 1,800. The result under the largest firm scenario would bring about the opposite result with the market always now seen to breach of the 1,800 threshold.

Although these results are qualitatively interesting, they are largely brought about by the fact that the market was close to the 1,800 threshold in the absence of the interconnectors' impact. The amount of available net transfer capacity of the German interconnectors is relatively small compared to the total amount of available installed capacity in the market and although these extreme scenarios can be seen to have a qualitative impact, the absolute size of the impacts one may consider to be less impressive.

Table 6.11: Summary Statistics Concentration measures based on Available Installed Capacity: Impact of the Interconnector - Germany

	STANDARD (excl. IC based on available installed capacity)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	CR(2)	HHI	CR(2)	HHI	CR(2)	HHI
Average	54.1%	1,914	42.1%	1,160	64.3%	2,603
Max	60.1%	2,158	46.8%	1,351	69.7%	2,947
Min	49.1%	1,734	37.2%	970	59.8%	2,352
Standard Deviation	1.7%	59	1.5%	57	1.7%	102

Source: LE.

As well as the summary statistics, Table 6.12 presents the possible impact of the interconnectors on the peak demand days identified already in this chapter. Qualitatively the results remain unchanged.

Table 6.12: Results of HHI & CR(2) Analysis of the Impact of the Interconnector, based on hourly Available Installed Capacity - Germany

		STANDARD (excl. IC based on available installed capacity)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	Date	CR(2)	HHI	CR(2)	HHI	CR(2)	HHI
Summer	23/06/2005	55.2%	1,936	42.4%	1,143	65.6%	2,601
	02/06/2004	57.0%	2,000	44.0%	1,188	66.9%	2,710
	28/08/2003	54.3%	1,931	43.7%	1,250	63.2%	2,540
Winter	25/02/2005	54.9%	1,932	42.9%	1,179	64.7%	2,576
	14/12/2004	54.0%	1,905	42.2%	1,159	64.1%	2,569
	08/01/2003	54.5%	1,913	41.2%	1,093	65.6%	2,723
Spring	03/03/2005	53.9%	1,909	42.1%	1,163	64.0%	2,549
	03/03/2004	54.6%	1,938	43.3%	1,223	63.9%	2,539
	10/04/2003	53.1%	1,890	43.1%	1,244	62.0%	2,439
Autumn	29/11/2005	52.0%	1,830	41.1%	1,143	62.1%	2,470
	30/11/2004	53.6%	1,909	42.0%	1,171	63.6%	2,552
	29/10/2003	54.1%	1,910	42.4%	1,171	64.1%	2,607

Source: LE.

This first scenario considers the potential impact of the available net transfer capacity of the interconnectors Germany has with its neighbouring countries on the degree of concentration in the German electricity market. However, if one considers the impact interconnectors potentially had, as opposed to the impact they could have had, one might alternatively consider the impact of interconnector flows on the degree of concentration in the market based on total generation. As a net exporter of electricity, the expected impact of the aggregated net interconnector flows on both alternative scenarios is to increase the degree of concentration in the market.

Table 13 presents summary statistics on the degree of concentration based on total generation and interconnector flows under both alterative scenarios.

CR(2) and HHI under 2 Assumptions of Interconnector Flows Allocation, based on Total Generation.

Table 6.13: Summary Statistics Concentration measures based on Total Generation: Impact of the Interconnector - Germany

	STANDARD (excl. IC based on total generation)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	CR(2)	HHI	CR(2)	HHI	CR(2)	HHI
Average	57.3%	2,143	58.1%	2,209	57.6%	2,172
Max	65.7%	2,665	80.0%	4,197	76.8%	3,493
Min	50.7%	1,795	46.9%	1,511	48.8%	1,753
Standard Deviation	2.1%	132	4.6%	357	2.9%	148

Source: LE.

Assessing the peak seasonal days in the German electricity market one also finds the results to be consistent with those in the previous table. Table 6.14 presents the results for the degree of concentration in the market based on total generation and interconnector flows under both alterative scenarios for the peak demand days.

Table 6.14: Results of HHI & CR(2) Analysis of the Impact of the Interconnector, based on hourly Total Generation - Germany							
		STANDARD (excl. IC based total generation)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	Date	CR(2)	HHI	CR(2)	HHI	CR(2)	HHI
Summer	23/06/2005	59.0%	2,157	56.7%	1,991	60.6%	2,210
	02/06/2004	58.3%	2,137	55.5%	1,941	60.3%	2,222
	28/08/2003	56.7%	2,081	56.9%	2,099	56.6%	2,089
Winter	25/02/2005	57.6%	2,090	61.5%	2,387	54.7%	2,039
	14/12/2004	57.2%	2,088	57.2%	2,094	57.1%	2,096
	08/01/2003	56.0%	2,025	54.3%	1,905	57.4%	2,070
Spring	03/03/2005	56.6%	2,053	60.6%	2,355	53.5%	1,997
	03/03/2004	57.4%	2,092	61.2%	2,390	54.5%	2,058
	10/04/2003	55.9%	2,049	55.4%	2,017	56.3%	2,074
Autumn	29/11/2005	53.3%	1,922	53.2%	1,918	53.3%	1,927
	30/11/2004	57.4%	2,114	58.7%	2,218	56.4%	2,102
	29/10/2003	57.0%	2,061	59.4%	2,245	55.1%	2,012

Source: LE.

Accounting for interconnector flows rather than capacity can be seen to have considerably different results in the case of the German market. On average the market can be described as marginally more concentrated under both the atomistic and largest firm scenarios with the overall range of values far greater due the possibility of both positive and negative net flows.

Overall, based on this analysis of concentration in the German market for electricity generation the market is indicative of one that is concentrated, a conclusion that is not altered by demand or seasonal factors. The conclusion is also not sensitive to different market definitions. Available interconnector capacity can be seen to have a potentially positive impact on the degree of concentration in the market but in reality interconnector flows indicate that on average Germany's interconnectors have been used to export electricity thus resulting in what is more likely to be an increase in the degree of concentration.

6.3 Electricity Specific Structural Measures

As discussed previously, electricity markets display many unique characteristics that indicate limits to the usefulness of tradition measures of market structure. We therefore have endeavoured to estimate electricity-specific structural indicators. Both the Residual Supply Index (RSI) and Pivotal Supplier Index (PSI) are calculated using the aggregated Available Capacities of the units in each companies portfolio, unlike the previous available capacity measure, this measure is complimented by adjusting the hourly available capacity figures (as discussed above) for the long-term contract position of the companies and their commitment to provide reserves for upward regulation. The long-term contract position of the companies has been adjusted to reflect any change in the net position of the companies that occurred over the period 2003-2005. This is also true for the quantity of generation committed to meet reserve requirements; this data has been taken from the TSO response to the 2005 Data Request and not from the generators' responses.

6.3.1 RSI

Since much of our further results and regression results are based on the RSI, we repeat the formula for RSI used in the methodology section. It is noteworthy that the RSI is in general specific to a chosen company. The RSI is calculated for each hour (26,304) in accordance with the following formula;

$$RSI_j = \frac{\left(\sum_{i=1}^{N} ac_i - AC_j\right)}{\sum_{i=1}^{N} hourly\_generation_i}$$ where; $i = 1, 2, \ldots, j, \ldots, N$

The companies' total available capacity and generation in each hour is indexed by i. The RSI indicator usually should have the system load as the denominator in this equation, however for the purposes of this study (for reasons outlined elsewhere) the system load has been constructed as the sum of the net hourly electrical production figures reported by all companies. This indicator has been calculated for both the four largest companies in the market in France, rather than the top two as in other countries, because the four largest companies were all of a similar size and market position. The calculation of the capacity of the largest company or chosen company is indicated by Company *j*.

Previous studies that have used this measure have attempted to apply a threshold value to the computed hourly indicator. The threshold states that if the value of the RSI is less than 110% (1.1) for more than 5% of the time, then this is indicative of a market structure that is likely to be open to non competitive behaviour. This threshold test and the threshold itself was developed by the CAISO and as applied indicates potentially troublesome periods as those where the residual supply is less than 110% of the market demand for electricity and whether or not this systematically occurs in more than 5% of the time. The threshold itself is not the result of in-depth economic analysis but rather based on knowledge of market functioning but as such one may consider tailoring the threshold for each country. This was not done as part of this report as it was considered that the 110% threshold would be appropriate to achieving the objectives of this study and would further allow for a consistent comparison across countries.

6.3.2 PSI

The PSI is calculated for each hour (26,304) in accordance with the formulae presented in the methodology section. The PSI is a zero-one indicator of when a company is needed to meet demand.

As with the RSI indicator, the PSI is traditionally calculated using the system load, however for the purposes of this study the system load is replaced by the sum of the hourly generation of the companies included in the study.

A threshold for this indicator has been constructed as part of previous studies and market analysis. The FERC apply a threshold of 20% to this measure, if the value of the measure 1 for more than 20% of the time then this is indicative of a pivotal supplier. As with the threshold applied in relation to the RSI, this threshold is not the result of rigorous economic analysis and as such should be considered to be an indicator of potential market power issues rather than a steadfast rule in relation to overall conclusions that can be drawn from the results.

6.3.3 Results

RSI Results

Table 6.15 presents the results of the threshold test for the RSI calculated on an hourly basis for both the full period and individually for each year. With the threshold set at 110%, the test requires that the value of the RSI be greater than 110% (1.1) for more than 95% of the time for the largest market participant, in order for the market outcome to be deemed competitive. This table presents the results of the threshold test for the four largest generation companies in Germany. If the percentage of hours that the RSI measure is less than 110% is greater than 5% for any of the companies, then the market outcome cannot be considered to be a competitive one. One can see that for two of the companies, 0436-S-DE and 1338-S-DE, the RSI values calculated in relation to them are seen to fall short of the 110% threshold far in excess of 5% of the time. In 2005 each of the four companies can be deemed to be indispensable to meeting demand in the German electricity market, thus indicating a market outcome, similar to the two preceding years, that is not competitive.

Table 6.15: RSI Threshold Analysis - Germany

RSI Result	0436-S-DE	0569-S-DE	1338-S-DE	1681-S-DE
2003-05	12,553	1,217	20,268	1,001
% hrs< 110%	47.7%	4.6%	77.1%	3.8%
2003	4,263	254	6,589	136
% hrs< 110%	48.7%	2.9%	75.2%	1.6%
2004	4,407	291	7,034	169
% hrs< 110%	50.2%	3.3%	80.1%	1.9%
2005	3,883	672	6,645	696
% hrs< 110%	44.3%	7.7%	75.9%	7.9%

Source: LE

Table 6.16 presents summary statistics on the RSI of the two largest companies in the German market. One can see from both these figures, as well as those presented in the previous table, that company 1338-S-DE is, on average, indispensable more frequently and to a greater degree in meeting demand, despite the fact that the company has a smaller portfolio of installed capacity.

Table 6.16: Summary Statistics on RSI - Germany

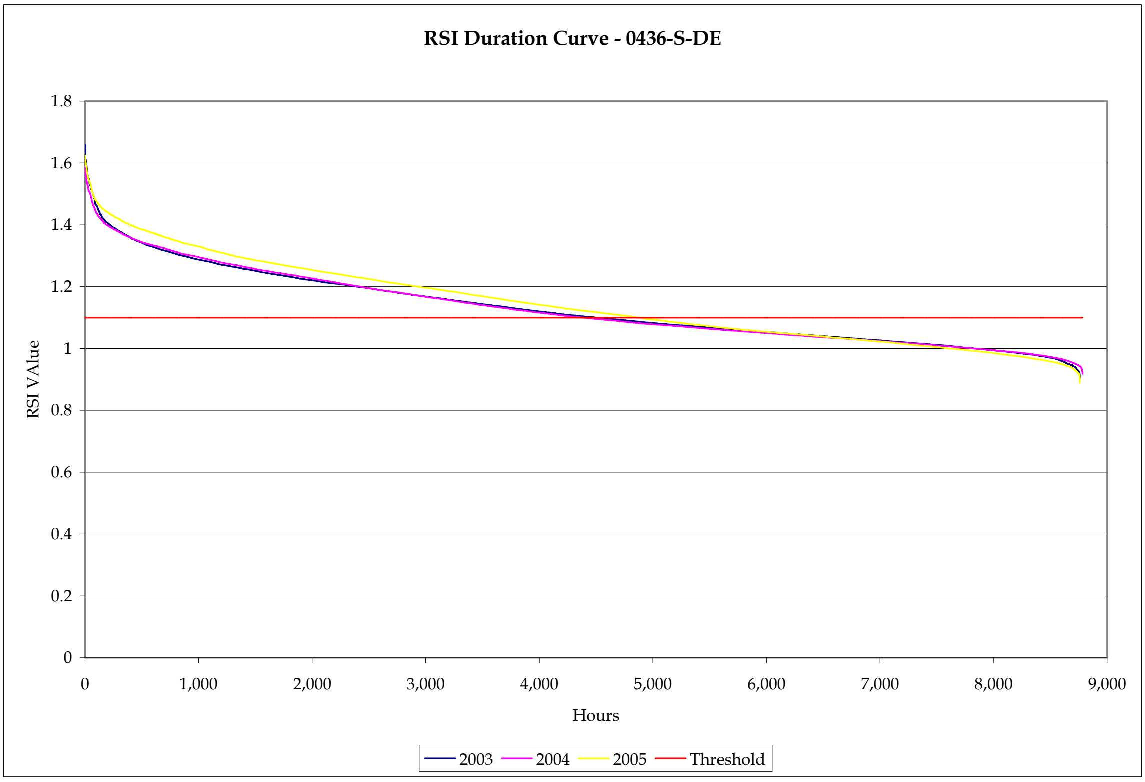
	0436-S-DE				1338-S-DE			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.14	1.13	1.13	1.15	1.02	1.03	1.01	1.02
Min	0.89	0.90	0.92	0.89	0.81	0.84	0.83	0.81
Max	1.66	1.66	1.59	1.62	1.50	1.50	1.40	1.45

Source: LE

RSI Duration Curves

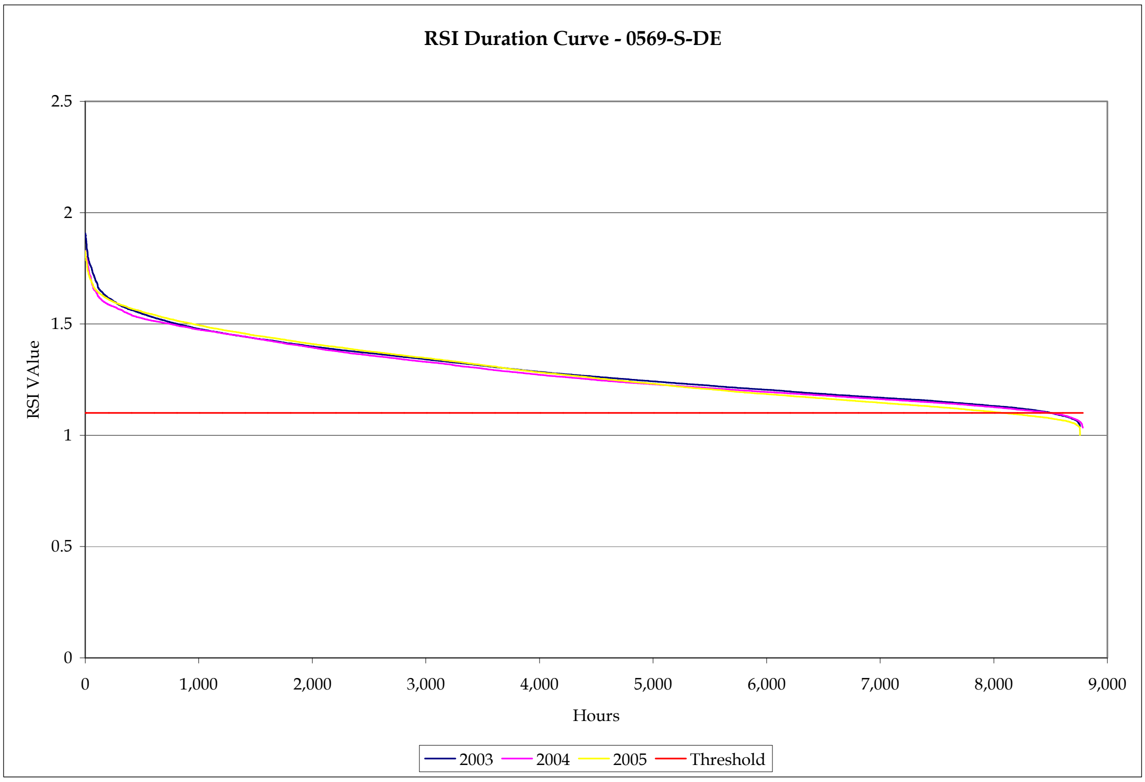
Since the RSI is a continuous measure and calculated hourly, we can also consider an RSI duration curve (a mirror of the cumulative distribution) to show the number of hours that RSI is above a certain value, in particular the threshold value (1.1). The following figures represents the duration curve for the RSIs in Germany, accounting for the market's four largest companies, as summarised in Table 7.15. The 110% threshold is also presented to facilitate understanding.

Figure 6.9: RSI Duration Curve for Company 0436-S-DE



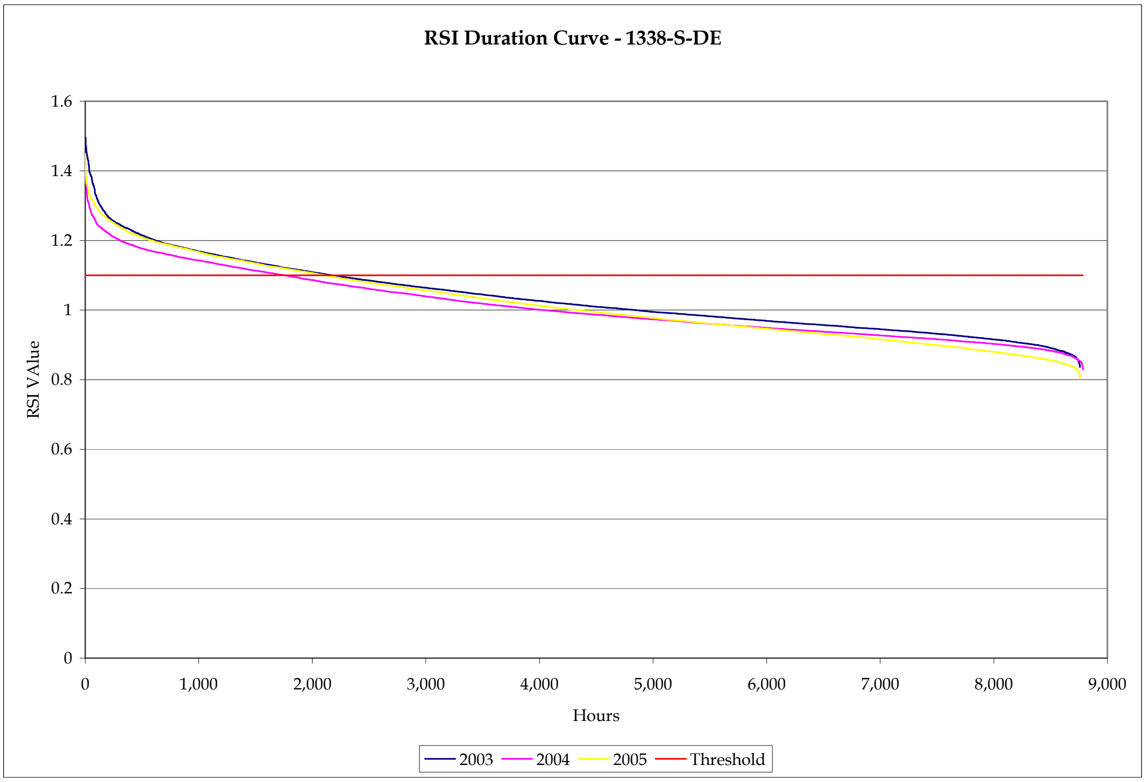
Source: LE

Figure 6.10: RSI Duration Curve for Company 0569-S-DE



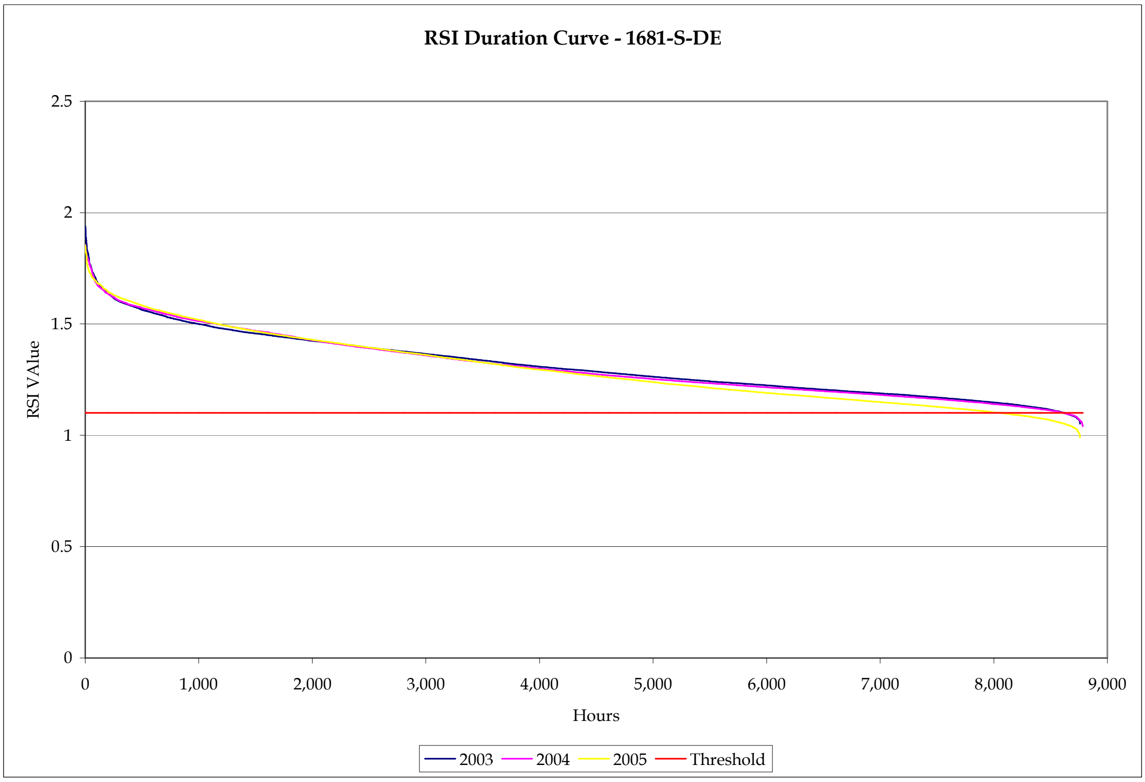
Source: LE

Figure 6.11: RSI Duration Curve for Company 1138-S-DE



Source: LE

Figure 6.12: RSI Duration Curve for Company 1681-S-DE



Source: LE

Alternative RSI Scenarios

As a sensitivity test on the RSI values presented above, the RSI is re-estimated under two alternative scenarios. Firstly, by excluding the long-term contract positions of the companies from the calculation of available capacity, and secondly, by excluding the companies' upward reserve commitments from the same calculation.

Table 7.17 presents the results of the threshold test when long-term contracts have been excluded from the calculation of available capacity, therefore only upward reserve commitments are accounted for. One should be aware that all of these companies commit a substantial amount of capacity to reserves in the German market. This alternative scenario has a marked impact on the frequency with which three of the companies are deemed to be indispensable. In the case of company 1338-S-DE, not accounting for upward reserve commitments reduces the amount of time the company is indispensable, however the effect of this alternative scenario is the opposite for companies 0436-S-DE and, to a greater extent, 1681-S-DE.

Table 6.17: RSI Threshold Analysis - Scenario 1 (accounts for Reserves only) - Germany

RSI Result	0436-S-DE	0569-S-DE	1338-S-DE	1681-S-DE
2003-05	15,435	1,090	14,637	3,976
% hrs< 110%	58.7%	4.1%	55.6%	15.1%
2003	5,240	234	4,453	920
% hrs< 110%	59.8%	2.7%	50.8%	10.5%
2004	5,313	242	5,286	1,102
% hrs< 110%	60.5%	2.8%	60.2%	12.5%
2005	4,882	614	4,898	1,954
% hrs< 110%	55.7%	7.0%	55.9%	22.3%

Source: LE

Table 7.18 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Germany (based on market share of total installed capacity).

Table 6.18: Summary Statistics on RSI - Scenario 1 (accounts for Reserves only) - Germany								
	0436-S-DE				1338-S-DE			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.09	1.09	1.09	1.10	1.10	1.12	1.09	1.10
Min	0.85	0.87	0.89	0.85	0.87	0.90	0.89	0.87
Max	1.60	1.60	1.53	1.56	1.62	1.62	1.50	1.57
Source: LE								

The second sensitivity test on the RSI results obtained previously allow only for long-term contracts to be taken into account in the calculation of available capacity for the purpose of finding the hourly RSI values for each company. Table 7.19 presents the results of the threshold test based on this alternative scenario, this allows one to compare the resulting figures with the original RSI calculations to see the impact of upward reserve commitments on indispensability. As one can see the number of hours these companies are found to be indispensable has increased, on average over the period of the study, all of the companies can now be seen to be indispensable to meeting the load in a sufficient number of hours that one is unable to conclude that the market outcome is competitive.

Table 6.19: RSI Threshold Analysis - Scenario 2 (accounts for LTC only) - Germany				
RSI Result	**0436-S-DE**	**0569-S-DE**	**1338-S-DE**	**1681-S-DE**
2003-05	15,195	2,402	22,566	1,847
% hrs< 110%	57.8%	9.1%	85.8%	7.0%
2003	5,251	539	7,341	349
% hrs< 110%	59.9%	6.2%	83.8%	4.0%
2004	5,261	691	7,825	418
% hrs< 110%	59.9%	7.9%	89.1%	4.8%
2005	4,683	1,172	7,400	1,080
% hrs< 110%	53.5%	13.4%	84.5%	12.3%
Source: LE				

The summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Germany (based on market share of total installed capacity), are presented in Table 7.20.

Table 6.20: Summary Statistics on RSI - Scenario 2 (accounts for LTC only) - Germany

	0436-S-DE				1338-S-DE			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.10	1.09	1.09	1.11	0.98	1.00	0.97	0.98
Min	0.87	0.87	0.89	0.87	0.77	0.81	0.80	0.77
Max	1.60	1.60	1.54	1.57	1.45	1.45	1.35	1.39

Source: LE

6.3.4

6.3.5 PSI Results

The results of the PSI analysis for the four largest generation companies in Germany are presented in Table 7.21. As discussed above the PSI is a (0,1) variable, equal to 1 if the company is deemed to be pivotal to supply in a given hour and zero if not. An established threshold test for this measure is one applied by FERC which considers a market participant to be pivotal, and thus the market outcome not to be competitive, if the PSI for any company is equal to one for more than 20% of the time. Overall the qualitative result of the PSI analysis is similar to that previously found by the RSI analysis, the market outcome is not likely to be competitive. However, unlike with the RSI, only one company (1338-S-DE) can be considered to be in breach of the previously defined threshold of 20% for the quantity of time a company may be deemed to be pivotal to meeting demand.

Table 6.21: PSI Threshold Analysis - Germany

PSI Result	**0436-S-DE**	**0569-S-DE**	**1338-S-DE**	**1681-S-DE**
2003-05	3,037	0	13,091	2
% hrs =1	11.5%	0.0%	49.8%	0.0%
2003	927	0	3,918	0
% hrs =1	10.6%	0.0%	44.7%	0.0%
2004	965	0	4,749	0
% hrs =1	11.0%	0.0%	54.1%	0.0%
2005	1,145	0	4,424	2
% hrs =1	13.1%	0.0%	50.5%	0.0%

Source: LE

Alternative PSI Scenarios

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenarios. Table 7.22 presents the results of the PSI threshold test having excluded long-term contracts from the analysis. This sensitivity test has a considerable impact on the frequency with which company 1338-S-DE is found to be pivotal, thus highlighting the company's dependence on purchased electricity to maintain its pivotal position in the market. Not allowing for the overall negative net purchases of electricity by company 0436-S-DE, one can see that the frequency with which the company can be see to be pivotal to meeting demand increases above the threshold of 20% in all years. Thus company 0436-S-DE could potentially be found to be pivotal, in excess of the threshold, if it balanced its long-term contract position. Although company 1338-S-DE's net short position can be seen to have a large impact on the frequency with which it is found to be pivotal, it remains in breach of the threshold in two of the three years even with a neutral long-term contract position.

Table 6.22: PSI Threshold Analysis - Scenario 1 (accounts for Reserves only) - Germany

PSI Result	0436-S-DE	0569-S-DE	1338-S-DE	1681-S-DE
2003-05	6,789	0	5,206	132
% hrs =1	25.8%	0.0%	19.8%	0.5%
2003	2,147	0	1,116	0
% hrs =1	24.5%	0.0%	12.7%	0.0%
2004	2,263	0	1,924	4
% hrs =1	25.8%	0.0%	21.9%	0.0%
2005	2,379	0	2,166	128
% hrs =1	27.2%	0.0%	24.7%	1.5%

Source: LE

Table 7.23 presents the results of the PSI threshold test - Scenario 2, whereby upward reserve commitments have been excluded from the calculation of available capacity. As with the RSI measure under this same scenario, the extent to which the market relies on, in this case only two of the largest companies, increases relative to the base case. Under this scenario both company 0436-S-DE and 1338-S-DE are in breach of the indicative threshold of 20%.

Table 6.23: PSI Threshold Analysis - Scenario 2 (accounts for LTC only) - Germany

PSI Result	0436-S-DE	0569-S-DE	1338-S-DE	1681-S-DE
2003-05	6,485	2	16,183	19
% hrs =1	24.7%	0.0%	61.5%	0.1%
2003	2,170	0	5,064	0
% hrs =1	24.8%	0.0%	57.8%	0.0%
2004	2,207	0	5,753	0
% hrs =1	25.1%	0.0%	65.5%	0.0%
2005	2,108	2	5,366	19
% hrs =1	24.1%	0.0%	61.3%	0.2%

Source: LE

6.3.6 Interconnector

To account for the potential impact of the interconnectors on the RSI and PSI measures, two sensitivity cases are calculated within this section to address this issue. Given interconnector capacity reservations and flows are not available at the company level it has been necessary to consider two hypothetical situations in order to assess the impact. The two scenarios are briefly described here;

1. The hourly interconnector capacity (IC_c), aggregated over the interconnectors, is added to the total supply of the market and apportioned in accordance with the companies' market shares (as measured by installed capacity) in the market being assessed. The hourly aggregated interconnector flows (IC_f) are added to the load.

2. The hourly interconnector capacity (IC_c) of each interconnector is added to the total supply of the market and the hourly available capacity of each interconnector is apportioned in accordance with the companies' market shares (as measured by installed capacity) in the markets from which electricity can be imported. The hourly aggregated interconnector flows (IC_f) are added to the load.

It is important to note that in all hours the interconnector flows are not necessarily positive values, they will be negative in hours where the market exports more electricity than it imports, therefore necessarily increasing the residual supply relative to the load, holding other factors equal. Given Germany is, on average, an exporter of electricity, one can expect to see this situation in effect in the following results.

The following sections contain the RSI and PSI analysis under the different interconnector scenarios. Under particular scenarios the role of interconnectors can be seen to have a considerable impact on the degree of market power and concentration in the German market.

6.3.7 Results (Interconnector allocated according to domestic market share)

RSI Results

Table 6.24 presents the results of the threshold test for the RSI calculated on an hourly basis for both the full period and individually for each year based on apportionment of interconnector capacity in accordance with domestic market share. The results can be seen to have a considerable impact on the RSI threshold test. Company 1338-S-DE remains indispensable in all years, although the frequency with which this is the case is significantly less. Company 0436-S-DE ceases to be considered indispensable under the threshold test in all years and the remaining two of the four largest companies in Germany do not register a single hour where they are indispensable to meeting demand, under this scenario. Correspondingly, the average values of the RSI can be seen to increase for the country's largest two firms in Table 6.25.

Table 6.24: RSI Threshold Analysis (+IC domestic) - Germany

RSI Result	**0436-S-DE**	**0569-S-DE**	**1338-S-DE**	**1681-S-DE**
2003-05	63	0	1,635	0
% hrs< 110%	0.2%	0.0%	6.2%	0.0%
2003	47	0	455	0
% hrs< 110%	0.5%	0.0%	5.2%	0.0%
2004	8	0	483	0
% hrs< 110%	0.1%	0.0%	5.5%	0.0%
2005	8	0	697	0
% hrs< 110%	0.1%	0.0%	8.0%	0.0%

Source: LE

Table 6.25 presents summary statistics on the RSI.

Table 6.25: Summary Statistics on RSI (+IC domestic) - Germany								
	0436-S-DE				1338-S-DE			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.46	1.45	1.46	1.47	1.34	1.36	1.34	1.34
Min	1.05	1.05	1.09	1.08	0.97	0.99	1.01	0.97
Max	2.59	2.38	2.59	2.56	2.33	2.21	2.33	2.25
Source: LE								

Alternative RSI Scenarios

Table 6.26 presents the results of the threshold test when only long-term contracts are accounted for in the calculation of available capacity, for the purpose of determining the hourly RSI values. Allowing for the potential impact of the interconnector, with apportionment of capacity based on domestic market share, and excluding the effect upward reserve commitments can have on the indispensability of a particular company, one can see that the only company 13838-S-DE is in breach of the indicative 5% threshold. This result still indicates that the resulting market outcome is unlikely to be competitive.

Table 6.26: RSI Threshold Analysis (+IC domestic) - Scenario 2 (accounts for LTC only) - Germany				
RSI Result	**0436-S-DE**	**0569-S-DE**	**1338-S-DE**	**1681-S-DE**
2003-05	376	0	3,025	0
% hrs< 110%	1.4%	0.0%	11.5%	0.0%
2003	218	0	856	0
% hrs< 110%	2.5%	0.0%	9.8%	0.0%
2004	73	0	1,012	0
% hrs< 110%	0.8%	0.0%	11.5%	0.0%
2005	85	0	1,157	0
% hrs< 110%	1.0%	0.0%	13.2%	0.0%
Source: LE				

Table 6.27 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Germany (based on market share of total installed capacity).

Table 6.27: Summary Statistics on RSI (+IC domestic) - Scenario 2 (accounts for LTC only) - Germany

	0436-S-DE				**1338-S-DE**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.42	1.41	1.42	1.43	1.31	1.32	1.30	1.30
Min	1.02	1.02	1.06	1.05	0.94	0.97	0.98	0.94
Max	2.53	2.32	2.53	2.49	2.27	2.16	2.27	2.19
Source:								

PSI Results

The results of the PSI analysis for the large generation companies in Germany are presented in Table 6.28. Based on the 20% threshold test, one could no longer conclude that any of these companies were pivotal to meeting demand. However, it is important to bear in mind the particular circumstances that have brought this result about, the apportionment of significant amounts of interconnector capacity to the companies at the same time as the load is being reduced, on average, due to the real life position of Germany as a net exporter of electricity. Nevertheless, this scenario does point towards the potential impact interconnectors could have on the German electricity market.

Table 6.28: PSI Threshold Analysis (+IC domestic) - Germany

PSI Result	0436-S-DE	0569-S-DE	1338-S-DE	1681-S-DE
2003-05	0	0	22	0
% hrs =1	0.0%	0.0%	0.1%	0.0%
2003	0	0	1	0
% hrs =1	0.0%	0.0%	0.0%	0.0%
2004	0	0	0	0
% hrs =1	0.0%	0.0%	0.0%	0.0%
2005	0	0	21	0
% hrs =1	0.0%	0.0%	0.2%	0.0%

Source: LE

Alternative PSI Scenarios

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenario. Table 6.29 presents the results of the PSI threshold test having included only long-term contracts in the calculation of available installed capacity, thus failing to account for reserve commitments. As with the general PSI calculation, the impact of the interconnectors is considerable in relation to the ability to find any of the large companies pivotal to meeting demand in a significant number of hours.

Table 6.29: PSI Threshold Analysis (+IC domestic) - Scenario 2 (accounts for LTC only) - Germany

PSI Result	0436-S-DE	0569-S-DE	1338-S-DE	1681-S-DE
2003-05	0	0	142	0
% hrs =1	0.0%	0.0%	0.5%	0.0%
2003	0	0	23	0
% hrs =1	0.0%	0.0%	0.3%	0.0%
2004	0	0	9	0
% hrs =1	0.0%	0.0%	0.1%	0.0%
2005	0	0	110	0
% hrs =1	0.0%	0.0%	1.3%	0.0%

Source: LE

6.3.8 Results (Interconnector allocated according to foreign market share)

RSI Results

Table 6.30 presents the results of the threshold test for the RSI calculated on an hourly basis for both the full period and individually for each year based on apportionment of interconnector capacity in accordance with the market share each of the four companies in each of the countries with which Germany has one or more interconnectors. As one can see from the following results that both the increase in available capacity in the market and the reduction, on average, in the demand for electricity brought about by the interconnectors serve to significantly reduce the indispensability of these four companies to a point where one should not consider them to be indispensable/pivotal to meeting demand in the German market.

Table 6.30: RSI Threshold Analysis (+IC foreign) - Germany

RSI Result	0436-S-DE	0569-S-DE	1338-S-DE	1681-S-DE
2003-05	0	0	65	0
% hrs< 110%	0.0%	0.0%	0.2%	0.0%
2003	0	0	21	0
% hrs< 110%	0.0%	0.0%	0.2%	0.0%
2004	0	0	1	0
% hrs< 110%	0.0%	0.0%	0.0%	0.0%
2005	0	0	43	0
% hrs< 110%	0.0%	0.0%	0.5%	0.0%

Source: LE

Table 6.31 presents summary statistics on the RSI.

Table 6.31: Summary Statistics on RSI (+IC foreign) - Germany								
	0436-S-DE				1338-S-DE			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.56	1.56	1.57	1.57	1.46	1.47	1.45	1.45
Min	1.12	1.12	1.18	1.16	1.06	1.06	1.10	1.06
Max	2.79	2.58	2.79	2.75	2.55	2.43	2.55	2.47
Source: LE								

Alternative RSI Scenario

Table 7.17 presents the results of the threshold test under the alternative scenario of not accounting for the upward reserve requirements of the four largest companies in Germany. As with the previous result one can see that the potential impact of the interconnector under this system of apportionment is not diminished by the approach adopted under this scenario. None of the companies in the Germany market can be seen to breach the threshold is a significant number of hours such that one could consider the market outcome not to be indicative of that resulting from a competitive market.

Table 6.32: RSI Threshold Analysis (+IC foreign) - Scenario 2 (accounts for LTC only) - Germany				
RSI Result	**0436-S-DE**	**0569-S-DE**	**1338-S-DE**	**1681-S-DE**
2003-05	3	0	276	0
% hrs< 110%	0.0%	0.0%	1.0%	0.0%
2003	3	0	101	0
% hrs< 110%	0.0%	0.0%	1.2%	0.0%
2004	0	0	18	0
% hrs< 110%	0.0%	0.0%	0.2%	0.0%
2005	0	0	157	0
% hrs< 110%	0.0%	0.0%	1.8%	0.0%
Source: LE				

Table 6.33 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Germany (based on market share of total installed capacity).

Table 6.33: Summary Statistics on RSI (+IC foreign)- Scenario 2 (accounts for LTC only) - Germany

	0436-S-DE				1338-S-DE			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.52	1.51	1.53	1.53	1.42	1.43	1.42	1.41
Min	1.09	1.09	1.15	1.13	1.03	1.03	1.07	1.03
Max	2.73	2.52	2.73	2.68	2.49	2.38	2.49	2.41

Source: LE

PSI Results

The results of the PSI analysis for the large generation companies in Germany are presented in Table 6.34. As discussed above the PSI is a (0,1) variable, equal to 1 if the company is deemed to be pivotal to supply in a given hour and zero if not. An established threshold test for this measure is one applied by FERC which considers a market participant to be pivotal, and thus the market outcome not to be competitive, if the PSI for any company is equal to one for more than twenty percent of the time.

Table 6.34: PSI Threshold Analysis (+IC foreign) - Germany				
PSI Result	**0436-S-DE**	**0569-S-DE**	**1338-S-DE**	**1681-S-DE**
2003-05	0	0	0	0
% hrs =1	0.0%	0.0%	0.0%	0.0%
2003	0	0	0	0
% hrs =1	0.0%	0.0%	0.0%	0.0%
2004	0	0	0	0
% hrs =1	0.0%	0.0%	0.0%	0.0%
2005	0	0	0	0
% hrs =1	0.0%	0.0%	0.0%	0.0%
Source: LE				

Alternative PSI Scenario

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenario. Table 6.35 presents the results of the PSI threshold test having accounted for only long-term contracts in the calculation of available capacity. Interestingly, based on this basis of apportionment of interconnector capacity, none of Germany's four largest companies emerge as being pivotal to meeting demand in a single hour out of the 26,304 contained in the study.

Table 6.35: PSI Threshold Analysis (+IC foreign) - Scenario 2 (accounts for LTC only) - Germany				
PSI Result	**0436-S-DE**	**0569-S-DE**	**1338-S-DE**	**1681-S-DE**
2003-05	0	0	0	0
% hrs =1	0.0%	0.0%	0.0%	0.0%
2003	0	0	0	0
% hrs =1	0.0%	0.0%	0.0%	0.0%
2004	0	0	0	0
% hrs =1	0.0%	0.0%	0.0%	0.0%
2005	0	0	0	0
% hrs =1	0.0%	0.0%	0.0%	0.0%

Source: LE

Overall conclusions

The broad conclusion in relation to this section of the report is that the German electricity market is not structurally conducive to competitive market outcomes. Results of the RSI analysis show that in at least one year all four of the largest four companies in Germany are in breach of the indicative threshold and are indispensable to meeting demand in the market in a significant number of hours. In particular two of the companies have substantial degrees of market power in a large number of hours and these results are consistent across a number of alternative scenarios. However, once one accounts for the potential impact of Germany's interconnectors by using one of two assumptions made in relation to the apportionment of capacity, one can see that the market power of each of the four largest companies in Germany is substantially diminished.

6.4 Contribution to EEX Prices

This analysis assesses the contribution of three factors, (the GED system modelled marginal cost, the estimated costs of carbon and the estimated mark-up) to the load weighted average EEX price. Table 6.36 and Figure 6.13 present the annual contribution of these three factors to the load weighted average EEX price.

Over the course of the three years, one can see that the average cost of generation increased significantly from year to year. This is likely due to a number of factors including increases in fuel costs and a changing portfolio of generation assets. Over this period the load weighted average EEX price does not appear to follow the same pattern, the price remains relatively stable in the first two years and then in 2005 there is a substantial increase, an increase that coincides with the introduction of the ETS in January of that year. As one can see the full economic cost of CO_2 is, on average, equal to €13.86/MWh in Germany, based on a load weighted average of the cost. This additional cost should be added to the system marginal cost to find the true economic cost of generation, on average, in Germany in 2005. Even with this additional cost factored in, on average, the mark-up on electricity improved on the previous year. Our analysis indicates that the mark-up earned in the market, on average, fell from a high of €11.42/MWh in 2003, to €5..36/MWh in 2004, before increasing in the final year to €6.39/MWh. Importantly, one should remember that the CO_2 certificates introduced under the ETS were provided to companies for free in 2005, thus not impacting on their actual accounting cost of generation which one may consider to contribute to the overall mark-up.

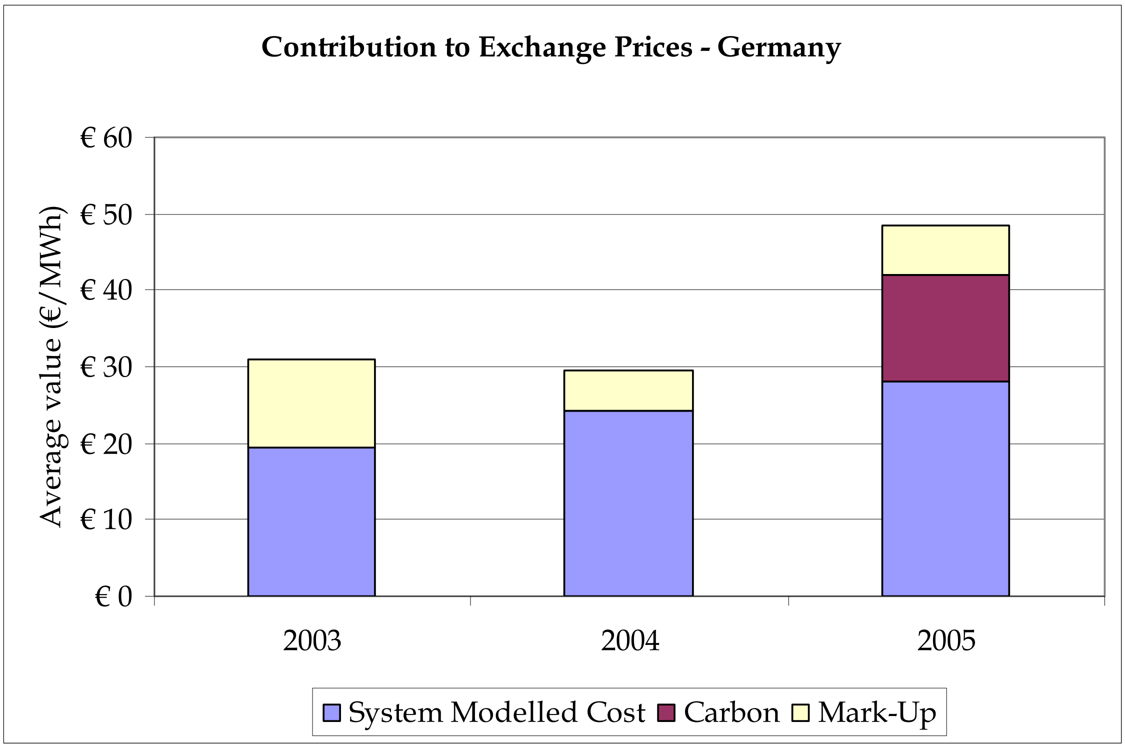
Table 6.36: Contribution of Cost, Carbon and Mark-up to EEX Prices - Germany

	2003	2004	2005
Sys Modelled MC	€ 19.46	€ 24.27	€ 28.17
Carbon	€ 0.00	€ 0.00	€ 13.86
Mark-Up	€ 11.42	€ 5.36	€ 6.39
Total	€ 30.88	€ 29.63	€ 48.42
EEX Price	€ 30.88	€ 29.63	€ 48.42

Note: Based on load weighted average prices and costs
Source: LE

Figure 6.13 provides a graphical representation of the above table. Within each year one can see the load weighted average contributions of each of the three factors to the overall load weighted average EEX price.

Figure 6.13: Contribution to Exchange Prices - Germany



Source: LE

6.5 Outcome Measures

6.5.1 Price-Cost Margin (Lerner Index)

The Price-Cost Margin/Lerner Index (LI) has been calculated hourly based on the System Marginal Cost and the publicly available price of electricity for each hour in the period 2003-2005. The formula for the LI is as follows;

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

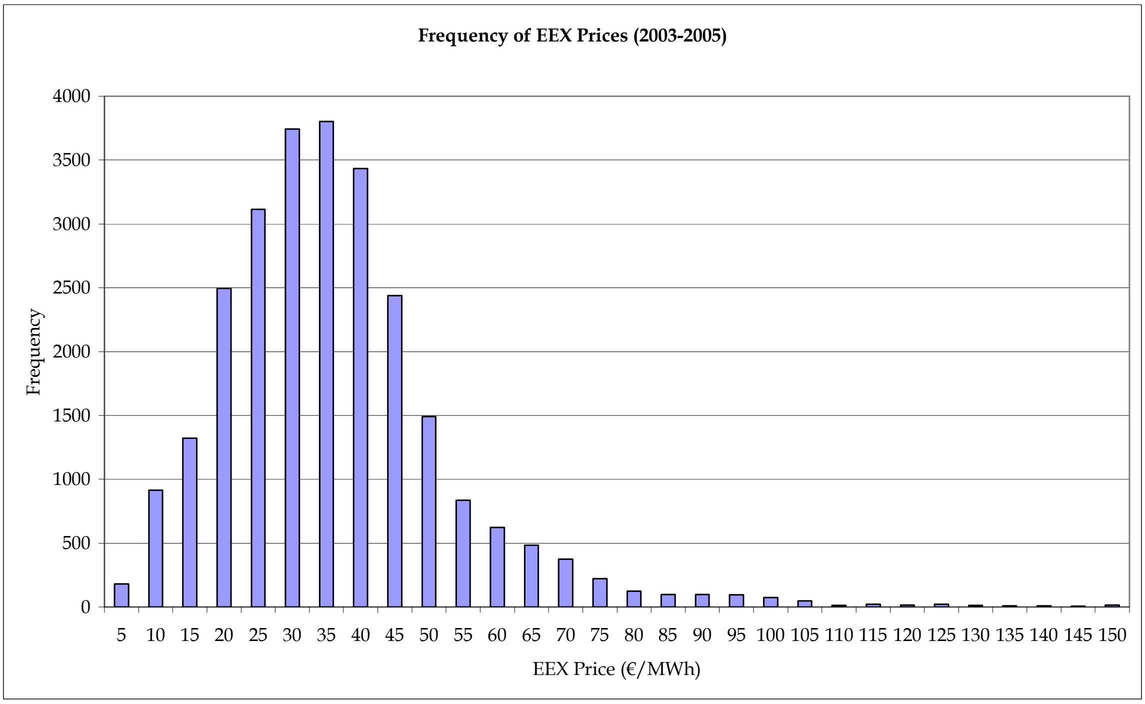
However, the use of a simple average has been rejected in favour of a load weighted average approach. Therefore, a more accurate description of the above equation is to consider each of the variables to be load weighted averages of the relevant period. A more formal exposition of this approach is presented in the methodology chapter of this report.

Two different sets of prices are used for this analysis;

1. The hourly day ahead prices published by the European Energy Exchange (EEX).
2. Platts Assessments Prices – this data set provides a daily base and peak price for the majority of weekdays in the period and a base price for electricity at weekends.

The frequency of hourly prices (€/MWh) on the EEX from January 2003 to December 2005 is presented in the histogram in Figure 6.14.

Figure 6.14: Frequency of EEX Prices (2003-2005) - Germany



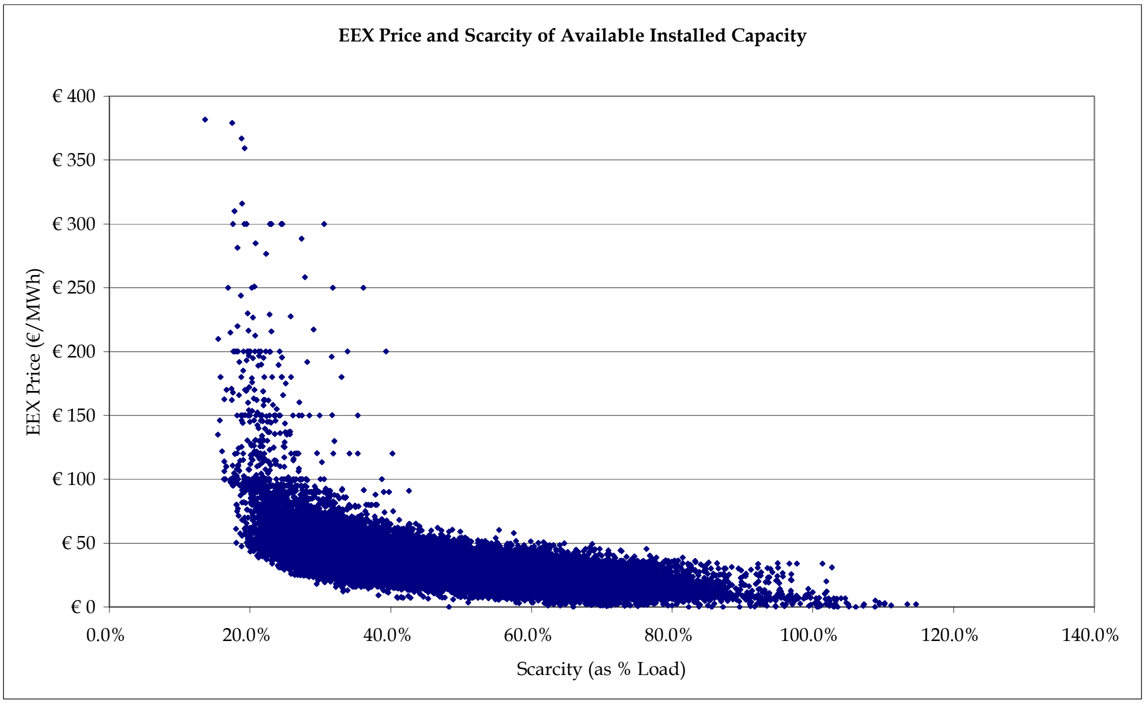
Source: LE

For the EEX price to be considered a relevant price for electricity in Germany it should be seen to reflect changing market dynamics within the German electricity market. Alternatively, the price of electricity on the EEX should reflect the scarcity of available generation capacity in any one hour on the system. The following graph represents the relationship between the hourly price of electricity on the EEX and the scarcity of available generation capacity, expressed as a percentage of the load (sum of generation) in that hour.

The scarcity of available generation capacity in any one hour is computed using the following formula.

$$Scarcity_i = \frac{(ac_i - hourly\_generation_i)}{hourly\_generation_i}$$

Figure 6.15: EEX and Scarcity of Available Generation Capacity - Germany



Source: LE

One can see from this graphic that high EEX prices correspond to times of relative scarcity of generation capacity. The correlation coefficient of the two series over the entire sample period is -0.516.

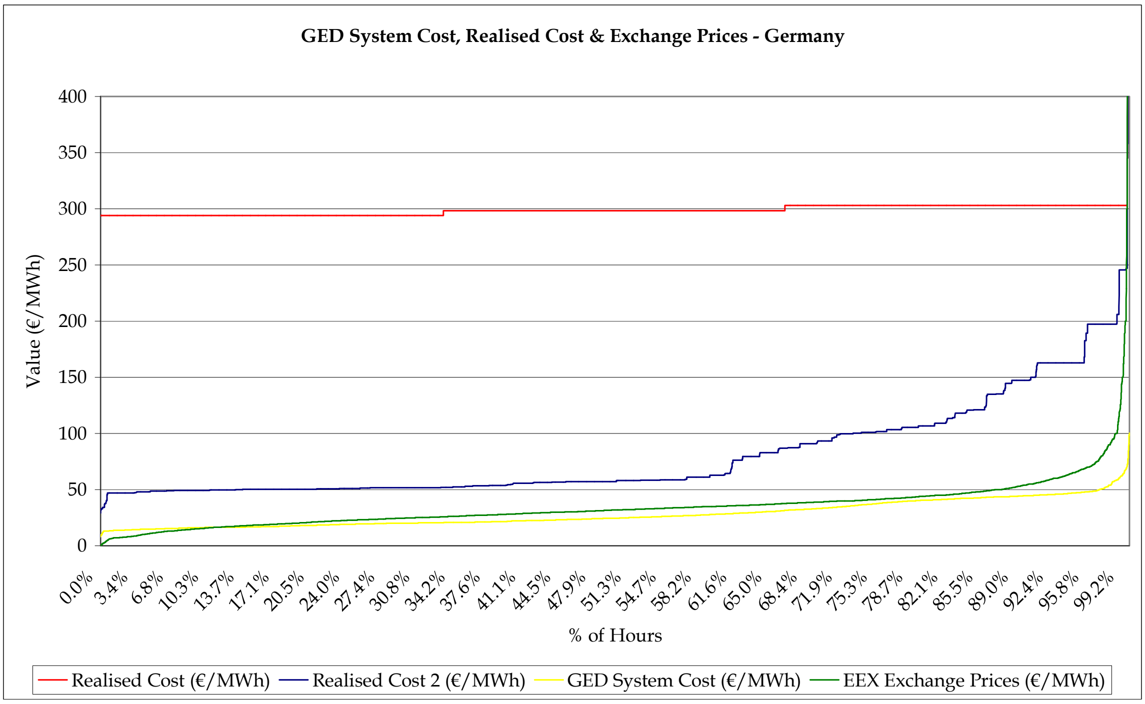
The relationship between these two variables indicates that the EEX price is an appropriate price to use in order to reflect the price of electricity in Germany. However, as indicated above, the Platts assessment price of electricity in Germany shall also be used in calculations of the Lerner Index. This price series provides a base and peak price for electricity on a daily basis on weekdays and a base price for electricity on weekends. As this price is constant for all hours of base and peak in the relevant days, this price may be a more appropriate representation of the price of electricity contracted forward (over periods greater than a day) in Germany, a quantity considerably greater than that traded on a day ahead basis.

The analysis also considers three estimates of cost for the system;

1. The System Cost estimated as part of GED's optimal despatch run.
2. A simple stacking of the returned realised cost of generation (fuel cost) provided for each unit, with the highest cost unit generating in any one hour setting the system marginal cost. This cost only considers the fuel cost of generation.
3. A simple stacking of the returned realised cost excluding units with a generation capacity of less than 25MW, or that are designated must run or CHP (Realised Cost 2).

The relationship between these three series and the exchange price can be seen in Figure 6.16.

Figure 6.16: Comparison of GED System Modelled Cost, Realised Cost and Exchange Prices - Germany



Source: LE

As one can see from this graph, the maximum system realised cost of generation returned by the companies is greater than the system marginal cost estimated by GED's optimal despatch simulation. There are a number of potential reasons for this. Simple stacking models are unable to reflect many market conditions in electricity markets. Unit-specific characteristics may require units to run but not set the price, "must-run" units or units that are run to provide system balancing or reserves may have a cost greater than the system marginal cost but as these units are not being dispatched they do not affect the price. The fact that must run, CHP, and other such units "should" not set the price is common to electricity market marginal cost estimation. This may similarly be the case for some CHP units whose primary function is to provide heat and for whom electricity production is a by-product. These units are not seen as economically relevant price setters because in general they are not representative of capable of providing the next megawatt of energy on the system. Further, in the case of many units, energy is a joint product with other products, and the true marginal cost of energy is economically only the additional cost of production of energy, after the primary product has been produced. Nevertheless, both costs are represented within this analysis.

The Realised Cost 2 curve, also precludes units with capacities of less than 25MW from setting the system marginal cost. These units have been aggregated by companies in their responses' to DG Competition's data request as part of the Sector Inquiry. Both costs and generation output have been aggregated by technology and there is no indication as to whether any of the constituent units are must run. The costs returned by companies are also potentially inclusive of a number of other costs not included in the calculation of the €/MWh fuel cost undertaken on a monthly basis for all other units (those greater than 25MW). Therefore these units have been removed from possibly setting the system cost in the simple stacking model for Realised Cost 2 as it was not possible to determine if only fuel costs were reported and more importantly whether these units were must-run or CHP units, the reason for excluding the other units as part of Realised Cost 2.

One may also notice that there are a number of hours where the GED modelled system cost is greater than the EEX price, thus indicating that there are a number of hours where companies' cost of generation in a competitive environment is in excess of the observed power exchange prices. Part of this can be explained by recourse to reasons similar to those discussed previously in relation to the divergence between the GED modelled cost and the realised costs of units. Power exchange prices can be representative of the residual values of energy on the system and since in reality, electricity that is placed on the grid can often be produced as a joint product with electricity committed to long-term supply contracts, ancillary services, electricity and heat for on-site industrial processes, and general heat production. Additionally, generators might rationally be willing to pay to avoid shutting down and incurring stop and start costs, thus resulting in them effectively dumping electricity on the system. Furthermore, there are technical and operational reasons power plant operators may wish to avoid shutting down and starting on a daily/frequent basis, such as wear and tear on the machine and the increased probability of a forced outage. This result has similarly been found previously in studies of electricity markets in Europe and the US.

Summary statistics on the both the GED MC, Realised Cost and Realised Cost 2 are provided in Table 6.37.

Table 6.37: Comparison of GED System Cost & Realised Cost - Germany					
		Average	**Minimum**	**Maximum**	**St Dev**
2003-2005	*GED System Cost*	€ 28.16	€ 7.99	€ 100.44	€ 11.46
	Realised Cost	€ 299.63	€ 293.98	€ 1,112.64	€ 30.22
	Realised Cost 2	€ 81.89	€ 29.08	€ 1,112.64	€ 57.21
2003	*GED System Cost*	€ 18.99	€ 7.99	€ 47.56	€ 4.74
	Realised Cost	€ 293.98	€ 293.98	€ 293.98	€ 0.00
	Realised Cost 2	€ 57.55	€ 34.23	€ 138.39	€ 13.29
2004	*GED System Cost*	€ 23.83	€ 7.99	€ 50.73	€ 4.49
	Realised Cost	€ 301.89	€ 298.46	€ 1,112.64	€ 51.83
	Realised Cost 2	€ 74.02	€ 32.01	€ 1,112.64	€ 71.06
2005	*GED System Cost*	€ 41.68	€ 13.24	€ 100.44	€ 8.12
	Realised Cost	€ 303.00	€ 303.00	€ 303.00	€ 0.00
	Realised Cost 2	€ 114.13	€ 29.08	€ 246.96	€ 53.79

Source: LE

6.5.2 Results

In the analysis of the EEX price and its suitability as a representative price for electricity on the wholesale market, such that it responds to market conditions, one not only observes a relationship between the observed hourly price and scarcity of available installed capacity but also one can observe substantial variation in the observed hourly price series. In accordance with the general trend, the price is likely to be lower in off-peak hours and rising with scarcity of available capacity, a function of the demand for electricity on the system. Similarly one observes variation in the marginal cost of electricity on the system that reflects the intersection of the demand curve with the merit curve, the higher is demand for electricity, the further to the right you are on the merit curve and the more costly the marginal unit of electricity is.

All of this may be well understood but one must consider the implications of this on the formulation of outcome measures in the electricity sector, where data is available hourly and there is substantial variation in price and cost, driven by demand, within any one particular day. Failure to account for demand conditions leads one to a conclusion on the outcome measures that may not be correct by placing equal weight on the calculated measures for say the peak hour and the lowest demand hour in a particular day. A negative outcome measure in off-peak hours is a very different proposition to that in peak hours as firms may willingly utilise loss making generation capacity in off-peak hours for a number of reasons, including; to avoid turning units off and thus not having to pay large start-up costs, to ensure units are on to meet demand in subsequent hours, or the units may already be on to meet other need such as contract positions, industrial processes or reserve commitments. In peak hours, negative outcome measures are not considered to be a likely outcome and thus merit further attention if they are a systematic occurrence. Therefore, simple averages should be replace by load weighted averages of both the price and cost in order to correctly assess the outcomes produced by the underlying market. This approach is adopted in the remainder of this chapter.

GED Modelled System Cost and EEX Prices

Table 6.38 presents the Lerner Index (LI) values calculated using the load weighted average EEX prices and marginal costs for Germany, the system cost being that was returned by the GED optimal despatch simulation. In this case the full economic cost of carbon has been included in the system marginal cost for 2005.

Table 6.38: Average LI based on GED System Cost & EEX Prices (including carbon) - Germany

	2003-05	2003	2004	2005
Lerner Index	21.2%	37.0%	18.1%	13.2%

Note: Based on load weighted average prices and costs
Source: LE

The figures for the LI indicate that there is likely to be significant opportunities to earn substantial profits in the German electricity market with margins expected to be, on average, as large as 37% for 2003. Although the margin, on average, is declining over the period the figure of 13.2% in 2005 still represents a substantial margin. Figures of this magnitude are not reflective of a market that is functioning efficiently and/or competitively.

Bearing in mind that companies in fact did not pay for their initial carbon emissions rights under the ETS, it is an interesting test to calculate the expected LI value in 2005 for which the cost of carbon in this year is ignored. The results of this calculation are presented in Table 6.39 and one can clearly see that the downward trend previously observed is reversed and the figure for 2005 rises to a high over the 3 years of 41.8%.

Table 6.39: Average LI based on GED System Cost & EEX Prices (excluding carbon) - Germany

	2003-05	2003	2004	2005
Lerner Index	33.9%	37.0%	18.1%	41.8%

Note: Based on load weighted average prices and costs
Source: LE

GED Modelled System Cost and Platts Assessment Prices

Table 6.40 presents the average of the hourly LI calculated using Platts Assessment prices. In order to calculate the hourly LI it has been necessary to impose the daily reported peak and base prices on all hours that correspond to that period; peak is 09:00 – 24:00 and base is 01:00 – 08:00. Overall the general trend previously observed in relation to the LI based on EEX prices (inclusive of carbon) is repeated here however the relative size of the margin has increased both in each year and subsequently over the period as a whole. The estimated load weighted average LI over the three year period is estimated to be 35.2% based on the GED system modelled marginal cost and Platts assessment prices. Importantly, one should recall that this approach may be a closer approximation to the relevant LI in relation to electricity sold by companies through tariffs or contracted agreements, as it is based on a more stable price than that in the observe on the EEX.

Table 6.40: Average LI based on GED System Cost & Platts Assessment Prices (Day-Ahead) - Germany

	2003-05	2003	2004	2005
Lerner Index	35.2%	51.1%	28.5%	25.9%

Note: Based on load weighted average prices and costs
Source: LE

6.5.3 Price Cost Mark-Up

An alternative measure of margin is the price cost mark up. As with the Price-Cost Margin/Lerner Index, the Price-Cost Mark-Up (PCMU) has been calculated based on the GED System Cost and the publicly available price of electricity for each hour in the period 2003-2005. The formula for the PCMU is as follows;

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

As with the Lerner Index, the use of a simple average is rejected in favour of a load weighted average approach. Therefore, a more accurate description of the above equation is to consider each of the variables to be load weighted averages of the relevant period. A more formal exposition of this approach is presented in the methodology chapter of this report.

6.5.4 Results

Price-Cost Mark-Up based on GED Modelled System Cost and EEX Prices

Table 6.41 presents the PCMU values estimated for Germany based on the load weighted average system cost returned by the GED optimal despatch simulation and the EEX price. Over the three year period the estimated PCMU is 27%, indicating a potential mark-up over costs of more than a quarter, on average, over this period. For each year this value ranges considerably from 58.7% in 2003 to 15.2% in 2005. However, as was evident in the LI analysis, once one removes the cost of carbon from the 2005 calculation the PCMU in that year is estimated to be far in excess of the levels observed in the two previous years. This result is further presented in Table 6.42.

Table 6.41: Average PCMU based on GED System Cost & EEX Prices (including carbon) - Germany				
	2003-05	**2003**	**2004**	**2005**
Price-Cost Mark-Up	27.0%	58.7%	22.1%	15.2%
Note: Based on load weighted average prices and costs *Source: LE*				

Table 6.42: Average PCMU based on GED System Cost & EEX Prices (excluding carbon) - Germany				
	2003-05	**2003**	**2004**	**2005**
Price-Cost Mark-Up	51.3%	58.7%	22.1%	71.9%
Note: Based on load weighted average prices and costs *Source: LE*				

Price-Cost Mark-Up based on GED Modelled System Cost and Platts Assessment Prices

An analogous approach to that adopted in relation to the LI has been applied here to test the impact of a more stable price series on the overall outcome of the market. Load annual Price-Cost Mark-Ups have been calculated using load weighted average Platts assessment prices and the GED modelled system marginal cost. Table 7.43 presents the results of this analysis.

Table 6.43: Average PCMU based on GED System Cost & Platts Assessment Prices (Day-Ahead) - Germany				
	2003-05	**2003**	**2004**	**2005**
Price-Cost Mark-Up	54.4%	104.5%	39.8%	34.9%
Note: Based on load weighted average prices and costs *Source: LE*				

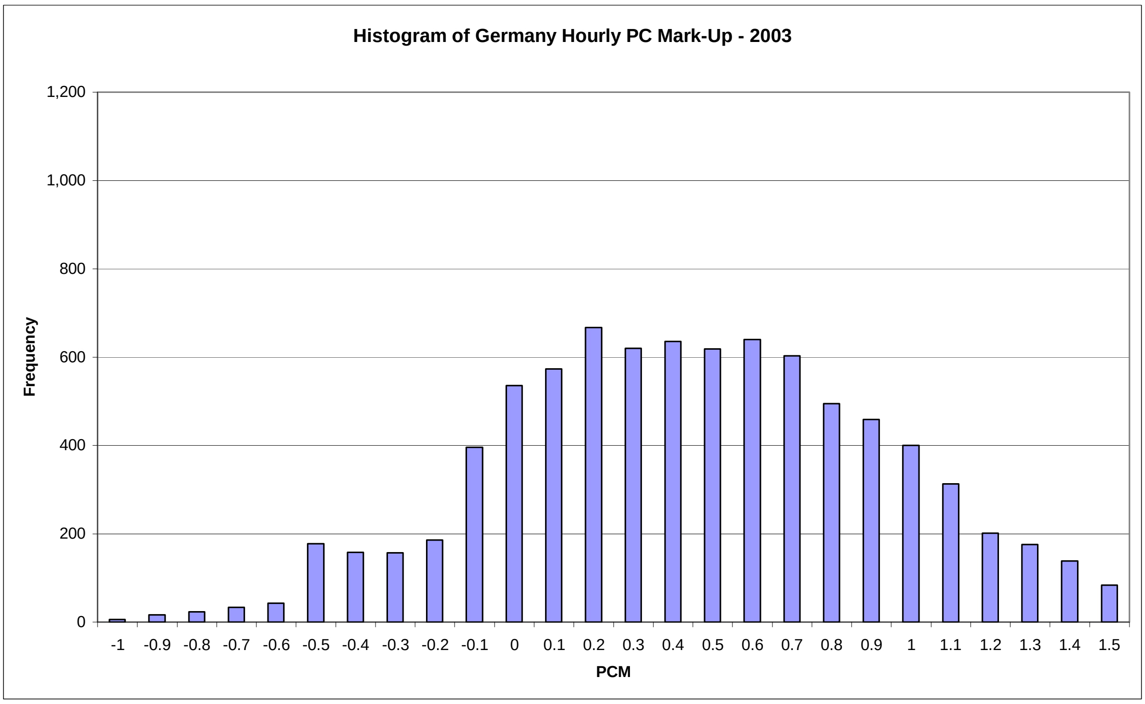
As was the case with the LI, the estimated PCMU under this price scenario is significantly higher than that based on the load weighted average of the EEX price with an average value over the three years of 54.4% and an annual high of 104.5% in 2003.

Overall, the results of this section indicate that considerable profits are likely to be made in the German wholesale electricity market. If these profits are in fact being realised, then one would be most likely to conclude that significant competition was not evident in the German market. Furthermore, if in fact this level of profit is not being realised in the German market, then one must further question the degree of competition in the market as the persistence of cost inefficiencies are likely to be the cause of such a result, relative to that achieved by the optimal despatch modelling of the system. In the presence of significant competition in the wholesale electricity market, one would expect such substantial inefficiencies to be eroded.

6.5.5 Hourly PCMU Histograms

In the figures that follow, we present histograms of the hourly PCMU values in each year. These results are not load weighted and serve to illustrate the frequency with which particular outcomes are realised, irrespective of the demand conditions.

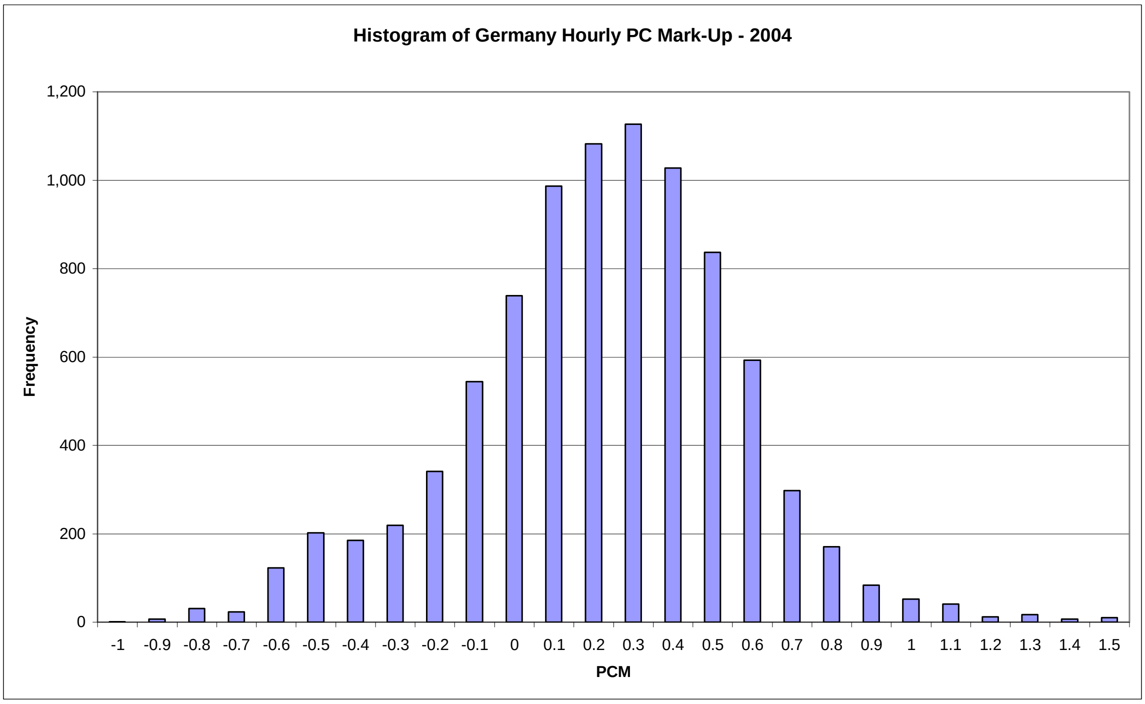
Figure 6.17: Histogram of Germany Hourly Price-Cost Mark-up – 2003 - Germany



Note: N=8,353

Source: LE

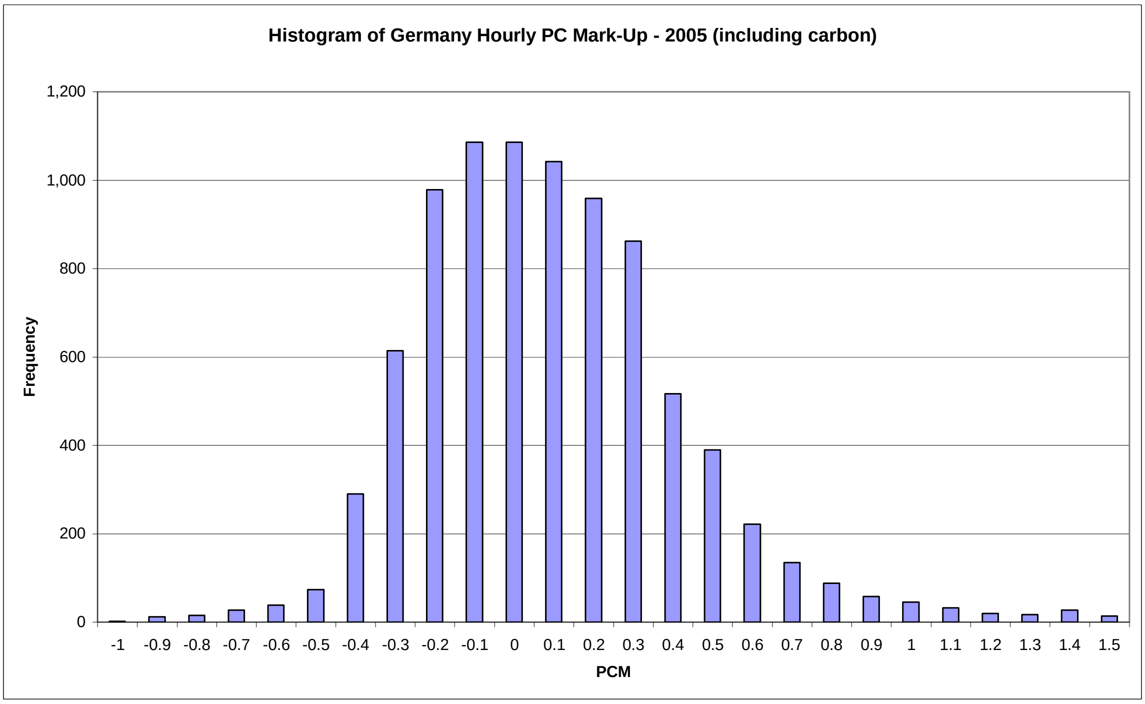
Figure 6.18: Histogram of Germany Hourly Price-Cost Mark-up – 2004 - Germany



Note: N=8,761

Source: LE

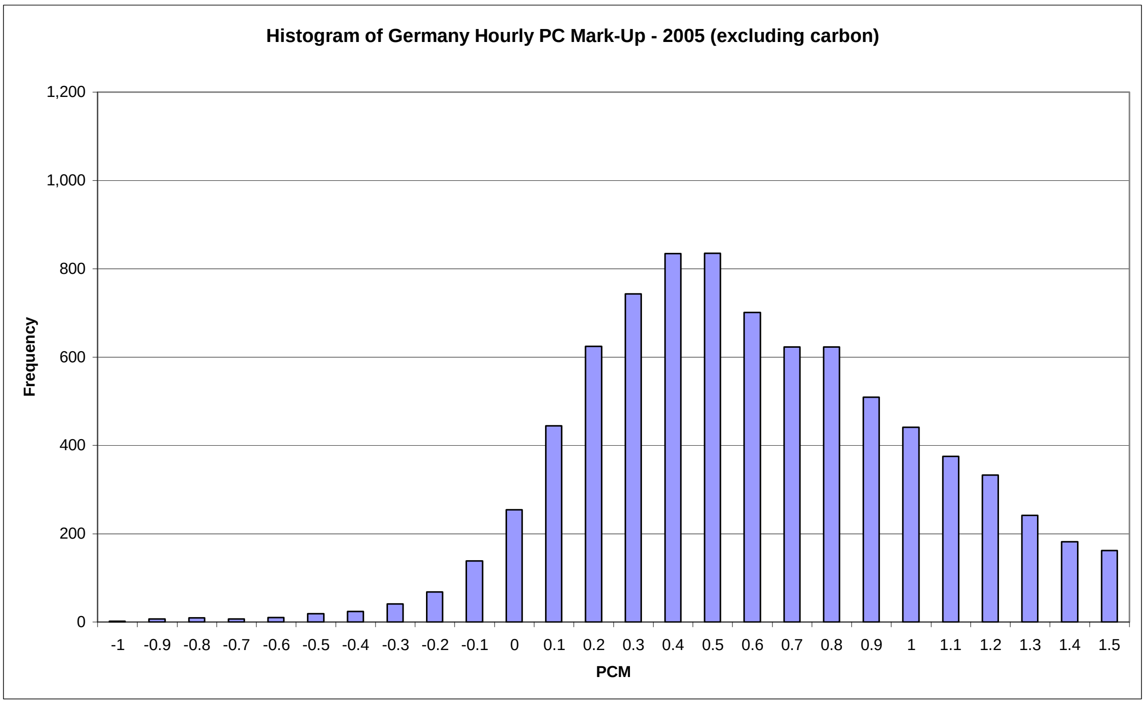
Figure 6.19: Histogram of Germany Hourly Price-Cost Mark-up – 2005 (incl. Carbon) - Germany



Note: N=8,649

Source: LE

Figure 6.20: Histogram of Germany Hourly Price-Cost Mark-up – 2005 (excl. carbon) - Germany



Note: N=8,249

Source: LE

The histograms for 2003 and 2004 illustrate a strong distributional bias towards positive PCMUs, a bias that still persists but is not as evident in 2005 when one includes the full cost of carbon in the calculation of the hourly PCMU. However, if the cost of carbon is excluded from the calculation in 2005, then one is once again presented with a histogram that is strongly skewed towards the positive values in the range.

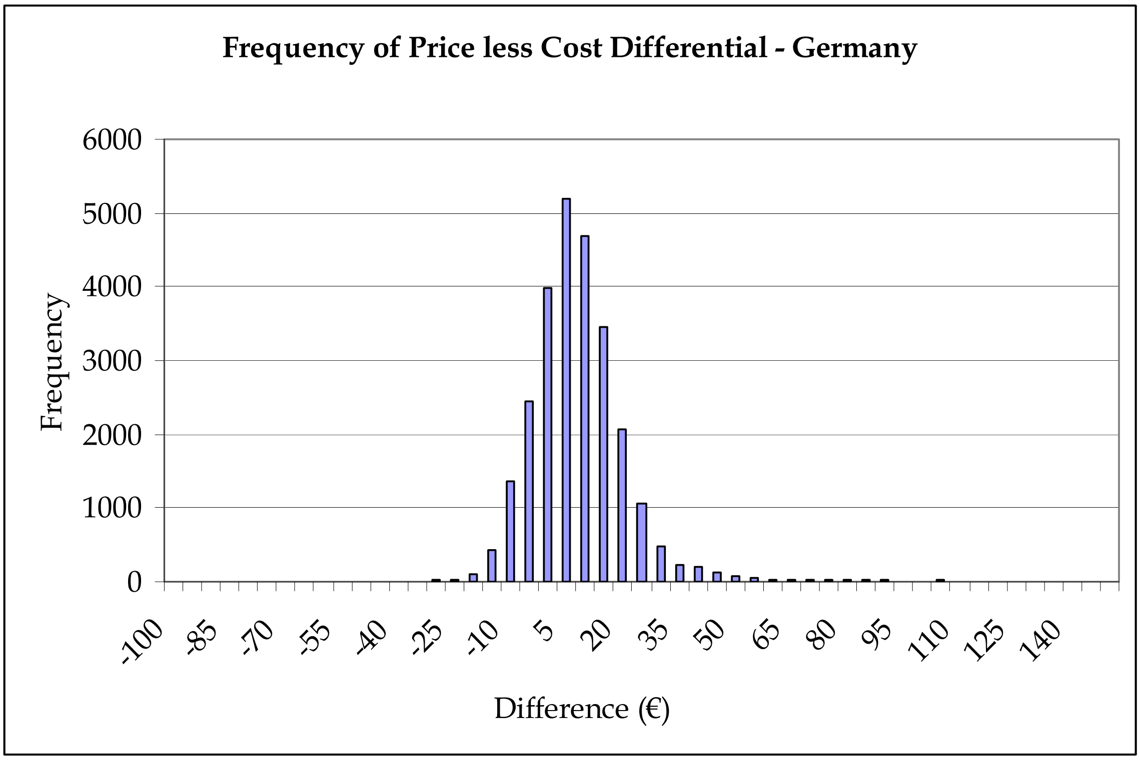
One may note that all of the data points are not represented in the above histograms, this is due partly to a small number of days where price data was not available, however the majority of omitted points are large numbers that appear with relative infrequency to the right of the endpoint on the horizontal axis. By construction, in the presence of non-negative prices, the PCMU is bounded below by -1 and therefore all data points, with the exception of relatively few very large PCMUs are presented in the histograms.

Overall, these results indicate that in the majority of hours the PCMU is positive and that large positive values are more likely to occur than are similar values on the opposite side of the scale. Although this result appears to decline over time, particularly when the cost of carbon is included, it nevertheless holds true and compliments the findings presented previously based on the load weighted averages of the price and cost variables.

6.6 Price Cost Differential

The LI and PCMU values are of considerable interest within the findings of this report, however as they describe the difference between prices and costs relative to either prices or costs, depending on the measure, they are by definition unitless. To present the relationship between price and cost in a more tangible way, a simple histogram of the price minus cost differential in each hour of the three years is presented in the following figure. The figure presents the difference between the hourly EEX price and the System Cost estimated by GED as a result of their optimal despatch simulation. As one can see, the distribution broadly mirrors that already seen in the majority of histograms of the hourly PCMU measures presented previously. The distribution is centred around the €10 point with the majority of remaining points located to the right of this indicating that on average the market provides for a significant return in the German market. One can also see there are relatively few times when the actual difference is negative, such differences occur is less than 10% of hours in the 3 years, indicating that even in off-peak hours the market presents an opportunity for profit to be made.

Figure 6.21: Frequency of Price less Cost Differential - Germany



Source: LE

6.7 Carbon Impact in 2005

In order to quantify the impact of the introduction of the EU ETS scheme, the GED optimal despatch model of 2005 has been compared with a scenario model of that year, within which the cost of carbon is reduced to zero. Not only will this affect the unit costs of emitting stations but it will also alter the optimal system despatch. Table 6.44 presents, for selected months, the modelled difference between the system cost in the model that includes the cost of carbon and the alternative scenario where the cost of carbon has been reduced to zero.

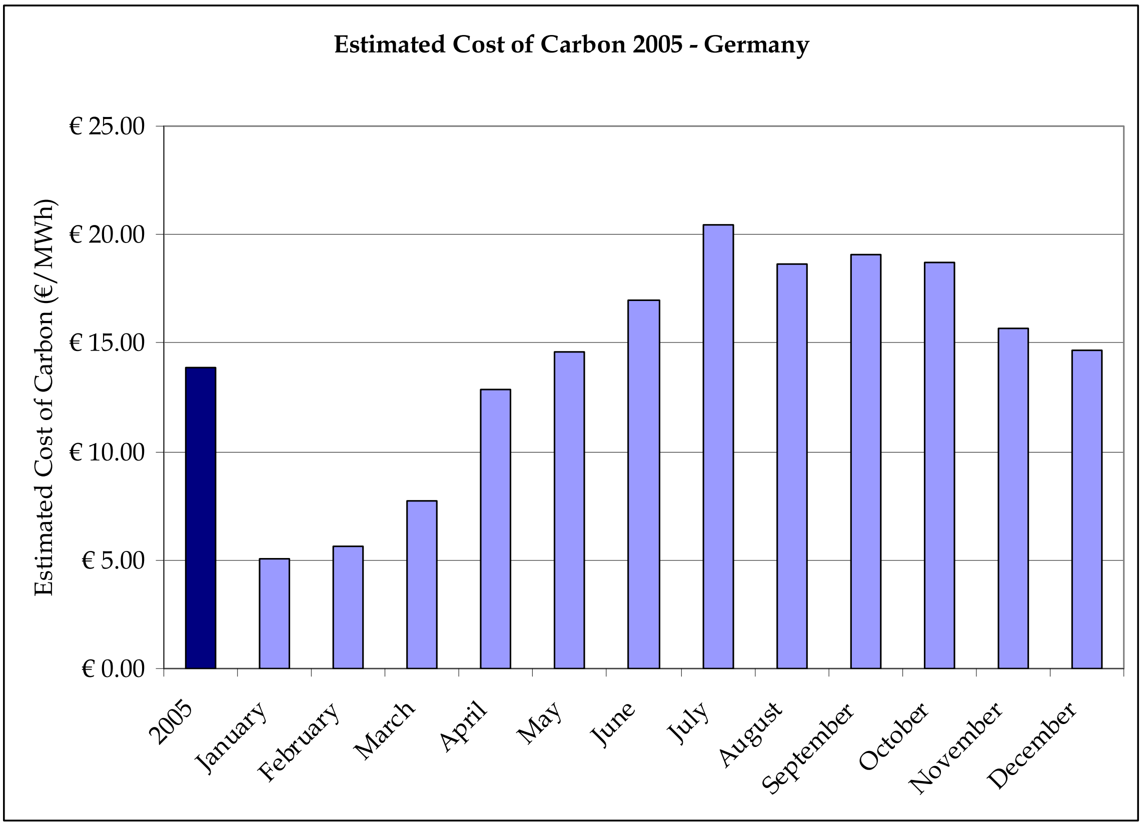
Table 6.44: Summary Statistics on the Modelled Impact of Carbon in 2005 - Germany

	2005	January	April	August	October
Average	€ 13.86	€ 5.08	€ 12.89	€ 18.62	€ 18.74

Note: Based on load weighted average prices and costs
Source: LE

Figure 6.22 presents the evolution of the estimated cost of carbon over the year. As one can see the cost increases consistently over the period January to July after which it stabilises at around €18.50/MWh before declining to closer to €15/MWh in November and December.

Figure 6.22: Estimated Cost of Carbon 2005 – Germany



Source: LE

It is important for one recall at this point the discussion presented in relation to the merit curve both with and without carbon in the introductory section of this chapter. This discussion highlighted the point that one cannot simply estimate the cost of carbon for the system based on the cost of carbon for the marginal unit as the marginal unit may potentially be different between the carbon and no-carbon merit curves as units are not monotonically affected by the ETS and the cost of carbon and in reality the ordering of units on the merit curve is likely to change as a result of including the specific €/MWh cost of carbon, for each unit.

Furthermore, the estimated impact of the introduction of the EU ETS will depend on how much of the value of CO_2 is factored in by operators, however, it has not been possible to discern this information from the data returned by the companies. Therefore, the amounts reported in this study correspond to the maximum possible impact of the ETS, if generators fully factor in the price of the CO_2 certificate in a competitive environment.

6.8 Contribution to Fixed Costs

So far in this assessment of the German electricity market, the outcome measures that have been presented and discussed relate to the market as a whole, however one should realize that regardless of the marginal cost and price setting plant on the system, generation companies normally possess a portfolio of units located at different points on the merit curve. For a large part of the time it is legitimate to consider, although it may be somewhat of a simplification, that if a unit is generating and is not setting the price on the system then this and all other unit, apart from that one setting the price, is operating with costs below the system marginal cost or the price. These units and thus the companies that own them will earn rents or contributions to fixed costs associated with running their plants, which are more efficient than the plants at the margin. Given that this takes place in the real world and is sufficient to ensure continued investment in the electricity market, it is important to consider whether the results of the GED system modelling are consistent with the sustainability of the market, thus allowing for companies to still contribute to fixed costs.

In order to test this, the €/MWh cost of generation returned on a unit by unit basis by all of the companies in the study, calculated as the product of fuel cost by heat rate of the units (including warm weather derations and the full cost of carbon in 2005), is subtracted from the hourly system marginal cost produced by the GED model, which is equivalent to the market price in a perfectly competitive market, and then this hourly figure is multiplied by the hourly optimal unit despatch of each unit, again from the GED modelling of the market. The result of this calculation is summed for each company in each year to give the expected outcome in the market, if the market was to operate optimally.

The results of this assessment are presented in Table 6.45. For the four largest companies identified for the purpose of the electricity specific structural indicators, one can see from this table that the two largest (0436-S-DE and 1338-S-DE) could expect to earn almost €7 billion each in excess of their reported cost over the three years in an optimally dispatched competitive market, an amount one would consider to be sufficient to contribute to fixed costs over this period. Similarly, the second group of large companies (0569-S-DE and 1681-S-DE), these could each expect to have made approximately €3 billion to contribute to their fixed costs over the three-year period. Although the result is positive for the majority of companies and largely for the market as a whole, there are a number of smaller companies that could be expected to suffer under such a competitive scenario, however one can consider a number of alternative revenue streams these companies may be in a position to exploit, thus earning a premium over the market price and thus ensuring a continued return on a operating basis to contribute to fixed costs.

On the basis of these results, particularly for the large companies in the German market, one can conclude that the modelled system marginal costs, used in the calculation of the Lerner Index and Price-Cost Mark-Up, is a suitably high price for electricity to allow companies to contribute to fixed costs and as such ensure continued investment in the future.

Table 6.45: Contribution to Fixed Costs (€'000)- Germany					
Company	**Company ID**	**2003**	**2004**	**2005**	**Total**
C01	**0415-S-DE**	-1,369.9	2,425.2	12,084.2	*13,139.4*
C02	**0436-S-DE**	1,761,631.0	2,094,008.0	3,084,305.0	*6,939,944.0*
C03	**0569-S-DE**	635,197.4	817,859.9	1,358,937.0	*2,811,994.3*
C04	**0804-S-DE**	-56,361.1	-45,770.7	-36,726.0	*-138,857.8*
C05	**0823-S-DE**	3,435.9	3,865.1	-15,377.0	*-8,076.0*
C06	**0995-S-DE**	4,344.8	12,653.1	36,273.2	*53,271.2*
C07	**1069-S-DE**	-4,094.1	-3,574.4	-9,305.7	*-16,974.2*
C08	**1073-S-DE**	12,984.2	16,550.9	12,074.4	*41,609.5*
C09	**1097-S-DE**	7,116.6	17,597.7	7,233.1	*31,947.4*
C10	**1338-S-DE**	1,818,142.0	2,521,370.0	2,782,871.0	*7,122,383.0*
C11	**1382-S-DE**	30,376.4	29,809.3	44,313.7	*104,499.3*
C12	**1487-S-DE**	1,957.1	2,303.0	-529.3	*3,730.9*
C13	**1488-S-DE**	368.9	17.7	13,539.8	*13,926.4*
C14	**1496-S-DE**	10,944.9	17,194.2	6,989.7	*35,128.7*
C15	**1505-S-DE**	-706.1	26,504.8	79,332.9	*105,131.6*
C16	**1520-S-DE**	159,608.5	141,581.4	83,234.7	*384,424.6*
C17	**1681-S-DE**	784,310.1	1,078,262.0	1,227,499.0	*3,090,071.1*
C18	**1711-S-DE**	3,665.3	5,035.3	220.9	*8,921.6*
C19	**1739-S-DE**	2,526.3	3,437.3	6,594.5	*12,558.1*
C20	**2001-S-DE**	-10,744.0	-5,936.7	-23,419.3	*-40,100.1*
C21	**2002-S-DE**	19,180.7	10,993.6	13,902.8	*44,077.1*
C22	**2020-S-DE**	0.0	0.0	0.0	*0.0*
C23	**2022-S-DE**	0.0	0.0	0.0	*0.0*
C24	**2026-S-DE**	0.0	0.0	0.0	*0.0*

Source: LE

The usefulness of this analysis shows a variety of factors. First, it shows that the model estimated competitive prices are not generally so low that companies would not earn an operating profit. The margins estimated could apply to a variety of costs, including investment costs and start-costs, fixed O&M, etc. In general, the figures indicate substantial sums that could be applied to investment, but without more detailed analysis we cannot say with certainty whether firms would have an incentive to invest in new generation plant. Finally, the figures show the extent of portfolio impacts in the electricity generation industry. The contribution to fixed cost estimates below accrue to the largest companies because they own plant that can generate at a marginal cost that is substantially below the marginal cost of the last plant to generate electricity on the system (which will set the price in the simulated competitive market).

It is difficult, however, to say with any great precision how big these contributions to fixed cost are relative to the true economic total cost of capital for utilities in these countries. We note that the estimates of contribution to fixed cost below are, in our opinion, conservative, in that they include the running of plant above the marginal cost that cannot set price (e.g., must-run units, and CHP). There will be added differences still, when one considers the differences between accounting (book values) and economic values[3]. Further, while we consider the figures indicative, one cannot say at what level sufficient incentive to invest exists, without a significant amount of additional detailed study. A whole host of factors will influence the actual size of fixed costs, which are not merely the economic amortisation of the purchase price of the physical capital asset.

[3] In other words, for example, firms may have fully depreciated assets that are still economical. Thus the book value might be zero while the economic value high (a hydro plant would be a good example—as these often have long asset lives).

We note, however, that since our purpose is mainly as a model check, we did perform some calculations merely to give an indicative feel for the size of the fixed costs relative to our estimated contributions to fixed cost. To do this, we constructed a generic new build situation investment cost appraisal and amortisation. This would be consider the cost per MW for new build, so existing build that was built years ago at lower per MW investment cost, or that has been depreciated substantially would need lower payments per annum. To do the new build estimate, we considered estimates of the per MW per year cost of a new 400MW CCGT. The figures are from CER[4] and are figures based on judgement and industry sources. We took the life of the plant to be 15 years, and the weighted average cost of capital to be 6.5%. We then took the investment cost of the plant for greenfield new build to be €250m[5]. The investment cost included all connection costs, financing and financial close, legal, construction etc. We considered the scrape value of the site to be €15m. These figures are based on the recent CER best new entrant paper, and are in line with LE's recent professional experience. We repeated the process with a selected 400MW generic coal project from recent USA DOE data, and converted to Euro using current exchange rates[6]. We then amortized the investment cost over the life of the plant, and divided by the number of MW capacity (400) to get a figure per MW per year.

To create a comparable figure, we summed over companies and years and then divided the total contribution to fixed cost figure by 3 to get the average annual figure. We then divided by the average total installed capacity of each market. Thus we have a per MW per year contribution to fixed cost figure.

---

[4] The Commission for Energy Regulation, Ireland.

[5] As a public source check, the cost of Greenfield CCGT is estimated by CER in its 2006 Best New Entrant pricing example. See http://www.cer.ie/cerdocs/cer05088.pdf. They used a WACC of 6-7% with 70% gearing, a 15 year lifespan and a €259m investment cost. €196m was the estimated cost of the EPC contract. We used 250m as the costs of construction and land in Ireland are likely at the top of the range in the EU.

[6] See http://www.netl.doe.gov/coal/refshelf/ncp.pdf, and www.x-rates.com. There were a range of values on the data table available, but the modal figures seemed to indicate an investment cost of $US 1 million per MW. We took the Colorado tri-state Generation and Transmission Project as indicative.

From Table 6.46, we can see that even taking the generic new build (which we argue should be at the upper end of the investment cost scale), Germany's per MW per year estimated contributions to fixed cost exceed the per unit cost of generic new plant. Alone this result indicates that the profit levels being earned in Germany, on average under a perfectly competitive market scenario, are sufficient to allow for new investment to take place. Considering the market outcomes in Germany over the last three years have not been consistent with the perfectly competitive scenario, one can expect these profits to be even greater in reality. Furthermore, the figures presented indicate the amount needed to amortise brand new plant at each level of the merit curve. In reality, the majority of plant in the German market is already partially or fully amortised, thus reducing the burden on companies' profits to service the replacement cost of the asset. Therefore, even under perfectly competitive conditions and the need to amortise a brand new portfolio of plants, the level of profits being earned by German operators, on average, are consistent with allowing for continued investment in the market. Allowing for the partial and full amortisation of units and the fact that market outcomes are not perfectly competitive serves only to facilitate the ability of companies, on average, to invest in the market.

We note that there will likely be some country-specific details in investment costs, cost of capital, etc, so the "generic" nature of the estimation is a limitation. However, our purpose was to give a broad feel for how big the contribution to fixed cost figures were, rather than a detailed study into investment incentives in Germany. As previously stated, we merely use this as a model check. There may be reasons that investment incentive hurdles are higher or lower.

Table 6.46: Comparison contribution to fixed cost and generic new build - Germany

	€/MW/Year
Generic CCGT 400MW	67,980
Generic Coal 1000MW	61,911
	2003-05 Average
Germany	76,942

Source: LE

Finally it is useful to note that in terms of economics and competition, the mere existence of such operating revenues (or the cost and pricing structure that would generate them) is not necessarily indicative of any particular market failure. Indeed, it is the ability to earn a margin by investing in the latest efficient plant that is expected to provide the incentive to invest for utilities.

6.9 Regression Analysis

In order to investigate the relationship between the above market outcome/market performance measures and the structural indicators previously discussed, we undertook a detailed regression analysis with the objective of testing this link and in the presence of such a link, uncovering the nature of the relationship. In testing this relationship a number of regression models were estimated but in general the approach applied was to develop and explore simple regression models, and then to progress on to more detailed specifications including more explanatory factors, all the time ensuring that the classical linear assumptions were not violated[7].

The Residual Supply Index, as a continuous variable of market structure that was developed specifically for the electricity industry, was used in the regression analysis as a measure of market structure. Previous research has highlighted the problematic nature of using measures such as the HHI as they both exhibit very little variation and have been found to be largely inappropriate for such analysis in the electricity sector. The PSI does present a possible alternative, however given the binary nature of the variable, it being either 1 or 0, its suitability to regression analysis is limited and would represent substantial restrictions on the analysis that are not presented by the RSI. The simple regression model therefore regresses the hourly market outcome measure, either LI or PCMU, on the hourly RSI value of any one company. Ex ante one may expect the sign on the RSI coefficient to be negative if one considers it likely to be the case that the more indispensable a company becomes, the higher their margins are likely to be.

[7] In standard econometric terminology, 'simple' regression refers to regression of the dependent variable on a single independent variable. The standard terminology is to call regression of a dependent variable on more than one explanatory or independent variables 'multiple' regression. We use this standard terminology.

In order to capture the potential for peak and off-peak periods to have different effects, the peak and off-peak RSI values have been separated into different independent variables to allow for the slope of the estimated regression line to differ during these periods. This will allow for potentially different effects on the outcome measure during peak and off-peak periods. A dummy variable has also been created for peak hours. A dummy variable is a zero-one variable that takes a value of one when a particular statement is true and a value of zero when it is not. In this case, during peak hours the dummy variable (dpeak) will adopt a value of 1 during peak hours and zero otherwise. Just as the peak and off-peak RSI variables allow for the estimated regression to have a different slope in these different periods and thus a different overall effect on the outcome measure, the inclusion of a dummy variable allows for the starting point of the regression itself to differ in these separate periods, thus creating effectively two different regression lines, if the dummy variable is statistically significant. This will be particularly important if there is a difference in how the market effectively operates in peak and off-peak periods.

Further to this an interaction term has been constructed that is the product of the RSIs of two companies contained in the study. This measure will capture the degree to which the ability of one firm to exercise market power to influence prices is assisted or impeded by the market power of a competing company. Importantly a measure of scarcity has also been included in a number of regression equations. This variable will capture the degree to which scarcity impacts on outcome measures and will separate out the potential for the RSI value to simply capture this effect from what is designed to reflect, the impact of a particular companies indispensability on the outcome of the market. The scarcity variable is defined as the difference between available installed capacity and load, as a percentage of load in each hour. One would expect such a variable to have a negative sign on its coefficient.

Variables have been included to capture the impact of potential withholding on the outcome measures. These variables have been constructed relative to the whole market and are not specific to any one company, as such one can consider the likely sign of these variables if there is a systematic manner in which coal fired capacity is being withdrawn and replace by gas fired capacity. In the event of such an occurrence, one would expect to observe a negative sign on the coefficient of the coal variable and a positive sign on the coefficient of the gas variable.

In order to allow for the impact of a number of patterns, a number of additional dummy variables have been included to capture the impact of yearly, seasonal, and weekday specific effects[8]. Table 7.47 provides a summary of the variables included in the regression analysis.

Table 6.47: Variables used in the Regression Analysis - Germany

Variable	Description
LI5	Hourly Lerner Index.
PCMup5	Hourly Price-Cost Mark-Up.
RSI_C0X	The hourly RSI value of Company X.
pk_RSI_C0X	The hourly peak time RSI value of Company X.
opk_RSI_C0X	The hourly off-peak time RSI value of Company X.
RSI_C0X_C0Y	Interaction between the RSI values of Company X & Y. Competition/Collusion variable.
Scar	Scarcity variable defined as the difference between available installed capacity and load, as a percentage of load, in each hour
C0_gas	The combined difference between the Actual & Modelled generation profile of gas units owned by Companies X & Y.
C0_coal	The combined difference between the Actual & Modelled generation profile of coal units owned by Companies X & Y.
d2004	Dummy variable for 2004.
d2005	Dummy variable for 2005.
dpeak	Dummy variable for peak hours.
dsummer	Dummy variable for summer months.
dwinter	Dummy variable for winter months.
dwkday	Dummy variable for weekdays.

Furthermore, for ease of understanding when considering the regression output presented subsequently one may wish to refer to the following table that identifies the company's number with the company's identification, used throughout the report.

[8] The dummy for 2003 was dropped from the estimated regression equations to avoid perfect collinearity with the constant. Results therefore are to be viewed relative to the missing year..

Table 6.48: Variables used in the Regression Analysis - Germany	
Company Number	**Company Identification**
C02	0436-S-DE
C03	0569-S-DE
C10	1338-S-DE
C17	1681-S-DE
Source:LE	

6.9.1 Regression Analysis – Part I

In this first section of the regression analysis, a number of simple regression models are presented, these models are further corrected for possible violations of the standard classical regression model assumptions. The first group of regressions separately regress the hourly Lerner Index values on the RSI values of the four largest companies in the German market, each are discussed in turn.

Lerner Index & RSI for 0436-S-DE

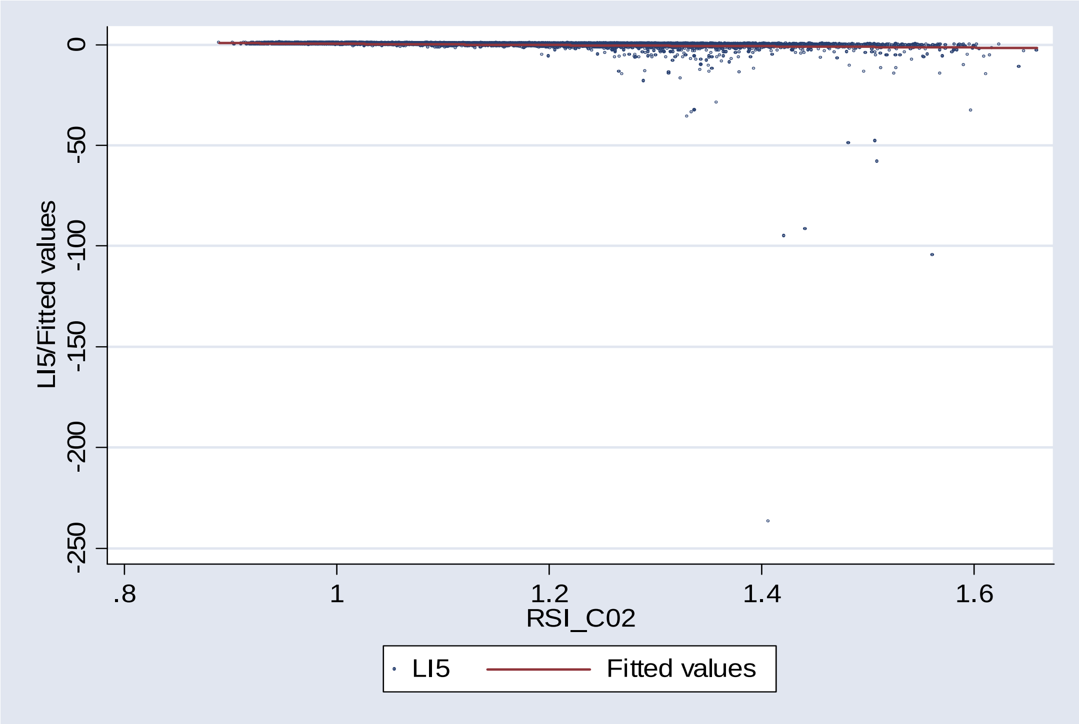
Source	SS	df	MS
Model	4024.09688	1	4024.09688
Residual	105305.802	26245	4.01241388
Total	109329.899	26246	4.16558329

Number of obs	= 26247
F(1, 26245)	= 1002.91
Prob > F	= 0.0000
R-squared	= 0.0368
Adj R-squared	= 0.0368
Root MSE	= 2.0031

LI5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C02	-3.127144	.0987453	-31.67	0.000	-3.32069	-2.933598
_cons	3.556189	.1128552	31.51	0.000	3.334987	3.777391

The result of the first simple regression of the hourly Lerner Index on the RSI values reflecting the indispensability of company 0436-S-DE to serving the previously defined market demand, estimate that the coefficient on the RSI variable is statistically significant and that it is of the expected negative sign, indicating that market power is positively correlated with margins. From the graph of the predicted values of the regression presented here one may notice the likelihood of non-spherical disturbances in the error term of the regression and although this would not bias the result it may affect the statistical inferences we make on the estimated coefficients. In order to investigate this further we present two further regressions, the first with robust standard errors and the second using the Prais-Winston regression to correct for the possibility of first order autoregressive disturbances in the error term.

Figure 6.23: LI Regression on RSI for 0436-S-DE



Source: LE

Regression with Robust Standard Errors 0436-S-DE

To correct for heteroskedasticity, we use the Huber-White sandwich estimator of variance[9] in place of the traditional calculation to ensure that our standard errors are robust.

```
Regression with robust standard errors                Number of obs =   26247
                                                      F(  1, 26245) =  175.10
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.0368
                                                      Root MSE      =  2.0031

------------------------------------------------------------------------------
             |               Robust
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C02 |  -3.127144   .2363228   -13.23   0.000    -3.590349   -2.663938
       _cons |   3.556189   .2564952    13.86   0.000     3.053444    4.058934
```

The result of the regression estimated with robust standard errors indicates that indeed heteroskedasticity was an issue in the first regression. The standard errors of the estimated coefficients have declined thus affecting the estimated t-values, however the estimated coefficients remain unchanged and significant at the 1% level.

Similarly, a correction for serial correlation is possibly needed, since our data have a time series element. Again, the standard errors are biased under serial correlation but the coeffcieint estimates are not. A standard correction is a Prais-Winston estimator. The Prais-Winston regression method fits a linear regression of the LI on the RSI variable that is corrected for first-order serially correlated residuals using the Prais-Winston (1954) transformed regression estimator[10]. The estimator is a Generalised Least Squares (GLS) estimator.

---

[9] See Huber, P. J. 1967. The behavior of maximum likelihood estimates under nonstandard conditions. In *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*. Berkeley, CA: University of California Press, vol. 1, 221–223. Also White, H. 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 48: 817–830.

[10] Prais, S. J. and C. B. Winston. 1954. Trend Estimators and Serial Correlation. *Cowles Commission Discussion PaoerNo. 383*, Chicago.

Prais-Winston Regression method to correct for AR(1) type disturbances 0436-S-DE

```
Prais-Winsten AR(1) regression -- iterated estimates

      Source |       SS       df       MS              Number of obs =   26247
-------------+------------------------------           F(  1, 26245) =  517.05
       Model |  1751.52219     1  1751.52219           Prob > F      =  0.0000
    Residual |   88905.832 26245  3.38753408           R-squared     =  0.0193
-------------+------------------------------           Adj R-squared =  0.0193
       Total |  90657.3542 26246  3.45413984           Root MSE      =  1.8405

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C02 |  -3.390859   .1491446   -22.74   0.000     -3.68319   -3.098527
       _cons |   3.844744   .1705429    22.54   0.000      3.51047    4.179017
-------------+----------------------------------------------------------------
         rho |   .4114618
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    1.033188
Durbin-Watson statistic (transformed) 1.782927
```

Correcting for the likelihood that the original regression was affected by AR(1) type disturbances has not had a qualitative impact on the results preciously estimated. The RSI coefficient is highly significant and of the expected sign. Quantitatively although the coefficients on the RSI variable change slightly, this regression can be seen to predict a very similar result to that of the previous two regressions. One point to note however with this regression, as with each of the regressions so far, the explanatory power of this model is extremely low, 1.9%.

To further investigate the general result that increases in Company 0436-S-DE's indispensability and thus market power positively affect the margin in the market, we introduce an intercept dummy variable (dpeak) and a separate variable for the RSI measures for this company in peak and off-peak hours. This is equivalent to adding a slope dummy to the regression on this variable. From the estimated regression one can see that all of the estimated coefficients are significant and the coefficients on the RSI variables in both peak and off-peak hours are of the expected sign. The estimated coefficient on *dpeak* is not of the expected sign, the negative indicating lower margins in peak times when companies are likely to be more indispensable.

Peak & Off-Peak Analysis 0436-S-DE

Source	SS	df	MS		
Model	4384.25003	3	1461.41668	Number of obs =	26247
Residual	104945.649	26243	3.99899589	F(3, 26243) =	365.45
Total	109329.899	26246	4.16558329	Prob > F =	0.0000
				R-squared =	0.0401
				Adj R-squared =	0.0400
				Root MSE =	1.9997

LI5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dpeak	-1.15812	.2611616	-4.43	0.000	-1.670011	-.6462287
pk_RSI_C02	-2.407744	.1314015	-18.32	0.000	-2.665298	-2.15019
opk_RSI_C02	-3.589801	.1795104	-20.00	0.000	-3.941651	-3.237951
_cons	3.984309	.2166903	18.39	0.000	3.559584	4.409034

A similar set of regressions were estimated based on regressing the hourly PCMU on the RSI of Company 0436-S-DE. Qualitatively the results are very similar, the coefficients are of the expected sign, they are statistically significant and the values of the coefficients indicate similar responses to changes in the RSI variable. The R-squared of this simple regression model is approximately 15.4% indicating a relatively strong degree of explanatory power for a univariate regression of this nature. This is likely to be due the more favourable properties of the PCMU to regression analysis in circumstances where prices can fall to a negligible amount however this proposition has not been exhaustively tested.

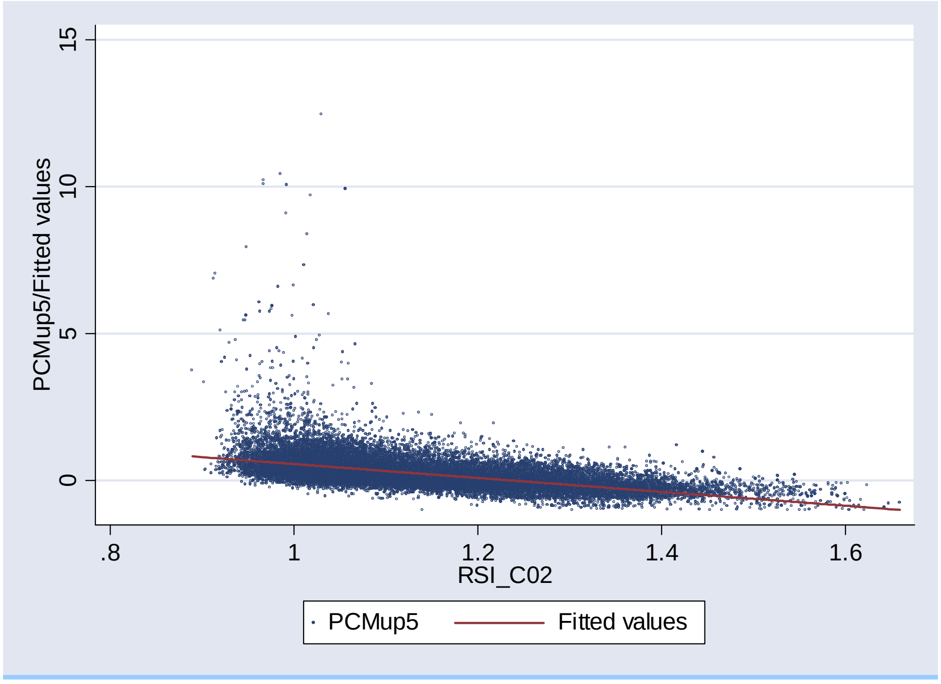
An assessment of the impact of different peak and off-peak effects has similarly been estimated in an analogous regression equation. The estimated coefficients are all statistically significant and of the expected sign, with the estimated coefficients on the peak and off-peak RSI variables indicating a relatively larger impact of market power in peak hours. The R-squared of the regression is 18.9%, once again indicating a reasonable goodness-of-fit for the specified regression.

Price-Cost Mark-Up & RSI for Company 0436-S-DE

```
      Source |       SS       df       MS              Number of obs =   26256
-------------+------------------------------           F(  1, 26254) = 4777.32
       Model |  2304.79645     1  2304.79645           Prob > F      =  0.0000
    Residual |   12666.126 26254  .48244557           R-squared     =  0.1540
-------------+------------------------------           Adj R-squared =  0.1539
       Total |  14970.9225 26255  .570212244           Root MSE      =  .69458

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C02 |  -2.363175   .0341904   -69.12   0.000     -2.43019    -2.29616
       _cons |   2.930428   .0390804    74.98   0.000     2.853828    3.007028
```

Figure 6.24: PCMU Regression on RSI 0436-S-DE



* An extreme outlying observation has been removed from this graph to facilitate a clearer understanding of the relationship.

The scatterplot of the observations indicates that one may want to test for a non-linear relationship between the variables rather than a linear one as estimated in the previous regression. In order to do so a quadratic regression specification has been estimated and the results are presented below. The quadratic term is simply the RSI variable squared and it will allow for the rate of change in the RSI variable to vary from a fixed number, the coefficient on the RSI variable, as one moves along the estimated regression line. Intuitively, this allow for the linear relationship of the simple relationship to include a curve that may better fit the data.

As one can see both RSI variables are statistically significant and of the expected sign with the estimated RSI coefficient predicting a fall in the PCMU as a result of increases in the RSI of company 0436-S-DE. Note however that this decrease is predicted to occur at a decreasing rate the higher the RSI value becomes. Furthermore, this estimated regression equation appears to be a slightly better fit for the data as indicated by the R-squared.

Quadratic Specification – 0436-S-DE

```
      Source |       SS       df       MS              Number of obs =   26256
-------------+------------------------------           F(  2, 26253) = 2538.42
       Model |  2425.95829     2  1212.97914           Prob > F      =  0.0000
    Residual |  12544.9642 26253  .477848786           R-squared     =  0.1620
-------------+------------------------------           Adj R-squared =  0.1620
       Total |  14970.9225 26255  .570212244           Root MSE      =  .69127

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C02 |   -10.8432    .533635   -20.32   0.000    -11.88916   -9.797249
   RSI_C02sq |   3.586526   .2252352    15.92   0.000     3.145053    4.027999
       _cons |   7.879008   .3131971    25.16   0.000     7.265125    8.492892
```

This regression indicates that the likely relationship between the PCMU and RSI of company 0436-S-DE is non-linear but there are a number of other aspects of the relationship that also warrant investigation. The introduction of both slope and intercept dummy variables into the regression equation to attempt to identify differences in the nature of the relationship between the variables during these periods, bring about a result that is broadly consistent with the one found with the LI but which finds the company's indispensability in peak hours to have a greater impact on the market PCMU that it does in off-peak hours, a result one would have expected ex-ante. The coefficients on the RSI variables are of the expected sign and are statistically significant with this simple model capable of explaining 19% of the variation in the PCMU over the three years.

Peak & Off-Peak Analysis 0436-S-DE

```
      Source |       SS       df       MS              Number of obs =   26256
-------------+------------------------------           F(  3, 26252) = 2041.69
       Model |  2832.18487     3  944.061622           Prob > F      =  0.0000
    Residual |  12138.7376 26252  .462392869           R-squared     =  0.1892
-------------+------------------------------           Adj R-squared =  0.1891
       Total |  14970.9225 26255  .570212244           Root MSE      =  .67999

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   1.310182   .0886699    14.78   0.000     1.136384     1.48398
   pk_RSI_C02 |  -2.242939   .0446119   -50.28   0.000    -2.33038   -2.155497
  opk_RSI_C02 |  -1.381165   .0609385   -22.66   0.000    -1.500608   -1.261722
       _cons |   1.575271   .0735687    21.41   0.000     1.431072     1.71947
```

An almost identical approach has been applied to each of the three remaining big four companies in Germany to assess the statistical relationship between their market power (as measured by the RSI) and the market outcome measures (LI and PCMU). Qualitatively all of the regressions return estimated coefficients of the same sign and statistical significance as those found in relation to company 0436-S-DE. A similar test of the impact of non-spherical disturbances on the significance of the estimated coefficients was similarly carried out and the results for each company were once again qualitatively similar to those previously discussed in relation to company 0436-S-DE.

Lerner Index & RSI for Company 0569-S-DE

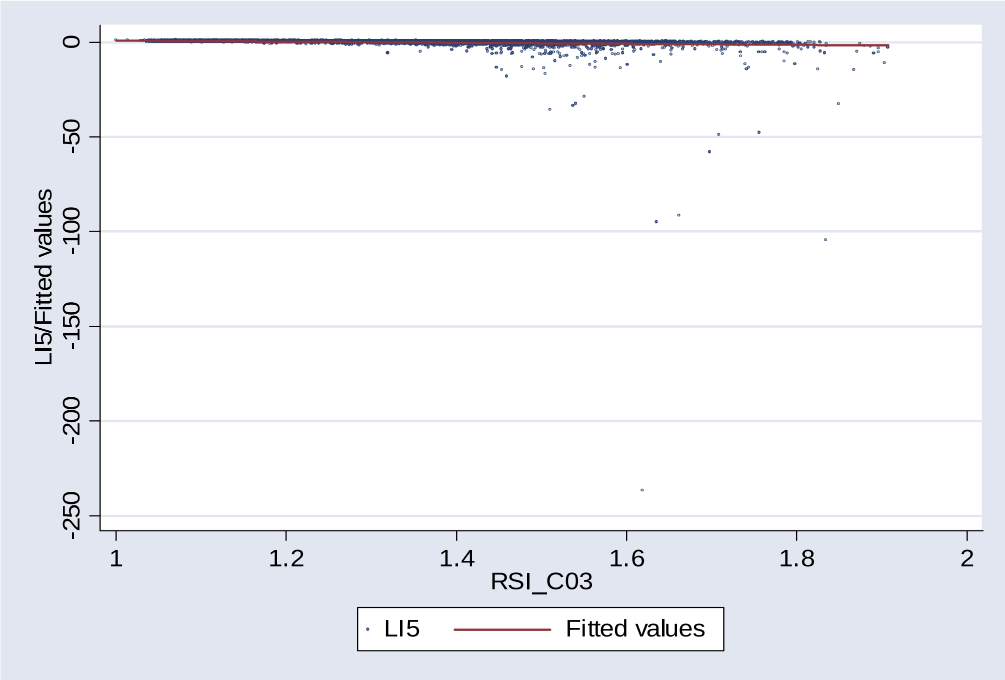
The estimated regression coefficient on the RSI variable relative to company 0569-S-DE is statistically significant at the 1% level. The coefficient predicts that as the company becomes more indispensable to serving load in the market, the observed outcome measure will increase, thus leading to higher profits. Nevertheless, one can see that the goodness-of-fit of the estimated regression is low, as was the case with company 0436-S-DE.

Figure 6.25 presents the predicted regression equation as the red line among the scatter of observations.

```
      Source |       SS       df       MS              Number of obs =   26247
-------------+------------------------------           F(  1, 26245) = 1009.45
       Model |  4049.36928     1  4049.36928           Prob > F      =  0.0000
    Residual |   105280.53 26245  4.01145094           R-squared     =  0.0370
-------------+------------------------------           Adj R-squared =  0.0370
       Total |  109329.899 26246  4.16558329           Root MSE      =  2.0029

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |  -2.731023   .0859572   -31.77   0.000    -2.899504   -2.562542
       _cons |   3.526434   .1115624    31.61   0.000     3.307766    3.745102
```

Figure 6.25: LI Regression on RSI for 0569-S-DE



Source: LE

Peak & Off-Peak Analysis for Company 0569-S-DE

Including both a slope and dummy variables for peak and off-peak hours, one can see from the following estimated regression equation that this distinction is relevant in the underlying data. All of the estimated coefficients are statistically significant and the coefficients on the RSI variables are of the expected sign. The slope dummy is however not of the expected sign with the estimated coefficient on *dpeak* indicating that the LI is predicted to be lower in peak periods.

Source	SS	df	MS
Model	4367.99566	3	1455.99855
Residual	104961.903	26243	3.99961527
Total	109329.899	26246	4.16558329

Number of obs =	26247
F(3, 26243) =	364.03
Prob > F =	0.0000
R-squared =	0.0400
Adj R-squared =	0.0398
Root MSE =	1.9999

LI5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dpeak	-1.214416	.2630998	-4.62	0.000	-1.730106	-.6987259
pk_RSI_C03	-2.108739	.1148784	-18.36	0.000	-2.333907	-1.883572
opk_RSI_C03	-3.174584	.1598254	-19.86	0.000	-3.48785	-2.861317
_cons	4.019929	.2199327	18.28	0.000	3.588849	4.451009

Price-Cost Mark-Up & RSI for Company 0569-S-DE

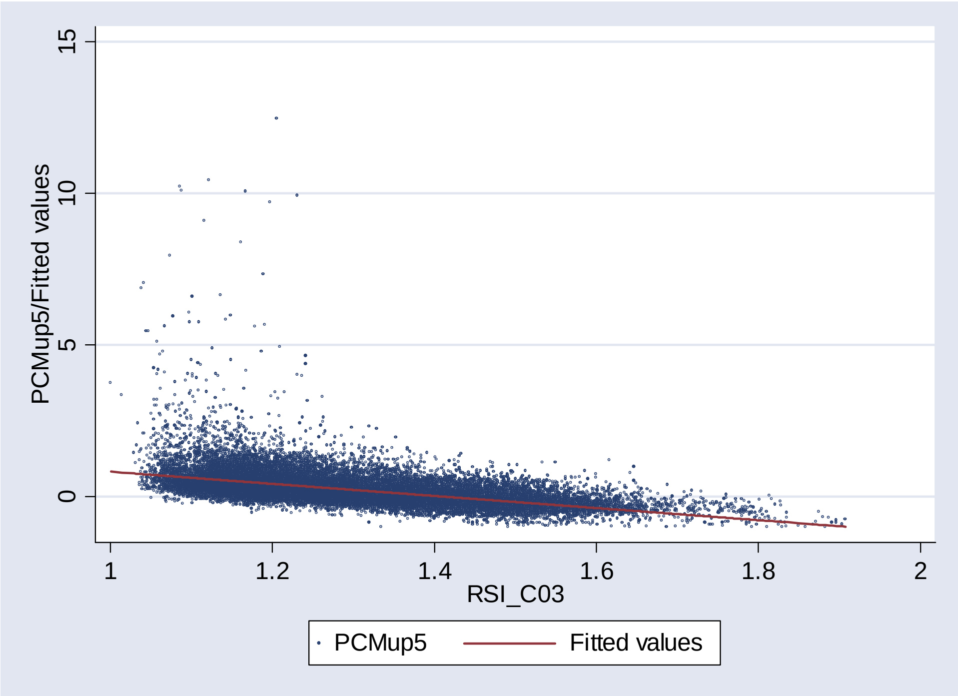
Replacing the LI for the PCMU as the dependent variable in the regression equations yields broadly similar results, however there is a noticeable increase in the goodness-of-fit of the regressions. In the case of the simple regression the reported R-squared is 14.5%.

Figure 6.26 presents a scatterplot of the observations and the predicted regression equation.

```
      Source |       SS       df       MS              Number of obs =   26256
-------------+------------------------------           F(  1, 26254) = 4446.56
       Model |   2168.3333     1   2168.3333           Prob > F      =  0.0000
    Residual |  12802.5892 26254  .487643375           R-squared     =  0.1448
-------------+------------------------------           Adj R-squared =  0.1448
       Total |  14970.9225 26255  .570212244           Root MSE      =  .69831

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |  -1.995121   .0299197   -66.68   0.000    -2.053765   -1.936477
       _cons |    2.81933   .0388372    72.59   0.000     2.743207    2.895453
```

Figure 6.26: PCMU Regression on RSI for 0569-S-DE



* An extreme outlying observation has been removed from this graph to facilitate a clearer understanding of the relationship.

Source: LE

As with the company 0436-S-DE an attempt has been made here to consider the likelihood of the relationship between the variables in the simple regression case being non-linear, for which there is some support based on the preceding graph. The results of the estimated non-linear (quadratic) regression equation indicate that this specification is a marginally better fit for the data and all of the estimated coefficients are statistically significant. The result indicates that as company 0569-DE becomes more indispensable to meeting load the PCMU in the market is predicted to increase and to do so at an increasing rate with indispensability.

Quadratic Specification 0569-S-DE

```
      Source |       SS       df       MS              Number of obs =   26256
-------------+------------------------------           F(  2, 26253) = 2319.30
       Model |  2247.98973     2  1123.99487           Prob > F      =  0.0000
    Residual |  12722.9327 26253  .484627765           R-squared     =  0.1502
-------------+------------------------------           Adj R-squared =  0.1501
       Total |  14970.9225 26255  .570212244           Root MSE      =  .69615

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |  -7.811026   .4546192   -17.18   0.000    -8.702104   -6.919948
   RSI_C03sq |   2.170243   .1692786    12.82   0.000     1.838448    2.502039
       _cons |   6.665326   .3024752    22.04   0.000     6.072458    7.258194
```

Peak & Off-Peak Analysis 0569-S-DE

The inclusion of the slope and intercept dummy variables for peak and off-peak hours are estimated to be statistically significant and of the expected sign under this specification. The estimated coefficients indicate that the PCMU is predicted to be higher in peak hours and that the potential impact of indispensability is greater in peak hours than in off-peak hours, holding all else equal.

```
      Source |       SS       df       MS              Number of obs =   26256
-------------+------------------------------           F(  3, 26252) = 1898.41
       Model |  2668.86301     3  889.621003           Prob > F      =  0.0000
    Residual |  12302.0594 26252  .46861418            R-squared     =  0.1783
-------------+------------------------------           Adj R-squared =  0.1782
       Total |  14970.9225 26255  .570212244           Root MSE      =  .68455

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   1.220909   .0898988    13.58   0.000     1.044703    1.397116
   pk_RSI_C03 |  -1.843869   .0392486   -46.98   0.000    -1.920798   -1.766939
  opk_RSI_C03 |  -1.152511   .0546038   -21.11   0.000    -1.259538   -1.045485
       _cons |   1.494616   .0751489    19.89   0.000      1.34732    1.641912
```

Lerner Index & RSI for Company 1338-S-DE

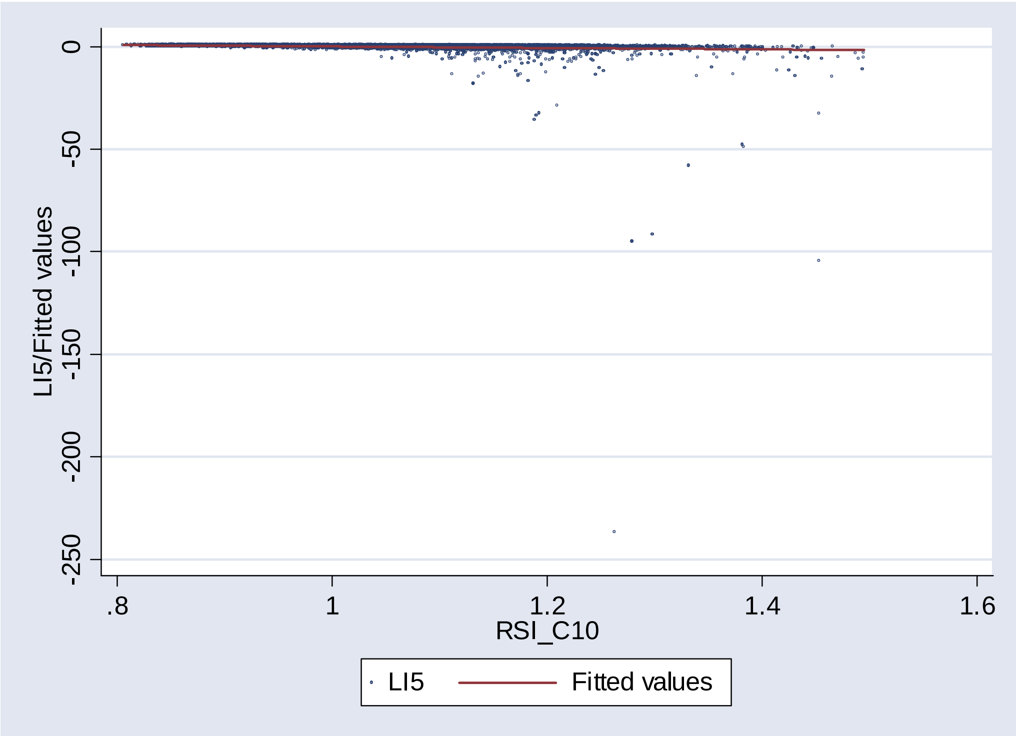
The estimation of the simple (univariate) regression for company 1338-S-DE results in a result that is qualitatively the same as that seen previously for companies 0436-S-D and 0569-S-DE. The LI is predicted to increase with the indispensability of company 1338-S-DE. The reported R-squared on this regression does not indicate a very close fit of the estimated regression equation to the data. This is largely due to the presence of outliers in the data, one can clearly see these observations in Figure 6.27.

Source	SS	df	MS
Model	3564.96403	1	3564.96403
Residual	105764.935	26245	4.02990799
Total	109329.899	26246	4.16558329

Number of obs	26247
F(1, 26245)	884.63
Prob > F	0.0000
R-squared	0.0326
Adj R-squared	0.0326
Root MSE	2.0075

LI5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C10	-3.561465	.1197426	-29.74	0.000	-3.796167	-3.326763
_cons	3.639385	.1228638	29.62	0.000	3.398565	3.880205

Figure 6.27: LI Regression on RSI for 1338-S-DE



Source: LE

Peak & Off-Peak Analysis 1338-S-DE

The peak and off-peak regression analysis estimates statistically significant coefficients on the RSI variables that are of the expected sign. Once again however the intercept dummy variable *dpeak* predicts a lower LI in off-peak periods, holding all else equal.

```
      Source |       SS       df       MS              Number of obs =   26247
-------------+------------------------------           F(  3, 26243) =  346.78
       Model |  4168.90312     3  1389.63437           Prob > F      =  0.0000
    Residual |  105160.996 26243  4.00720177           R-squared     =  0.0381
-------------+------------------------------           Adj R-squared =  0.0380
       Total |  109329.899 26246  4.16558329           Root MSE      =  2.0018

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |  -1.318285   .2769515    -4.76   0.000    -1.861125   -.7754447
   pk_RSI_C10 |  -2.653701    .152898   -17.36   0.000     -2.95339   -2.354013
  opk_RSI_C10 |  -4.202466   .2158136   -19.47   0.000    -4.625473    -3.77946
       _cons |   4.140452   .2304618    17.97   0.000     3.688734     4.59217
```

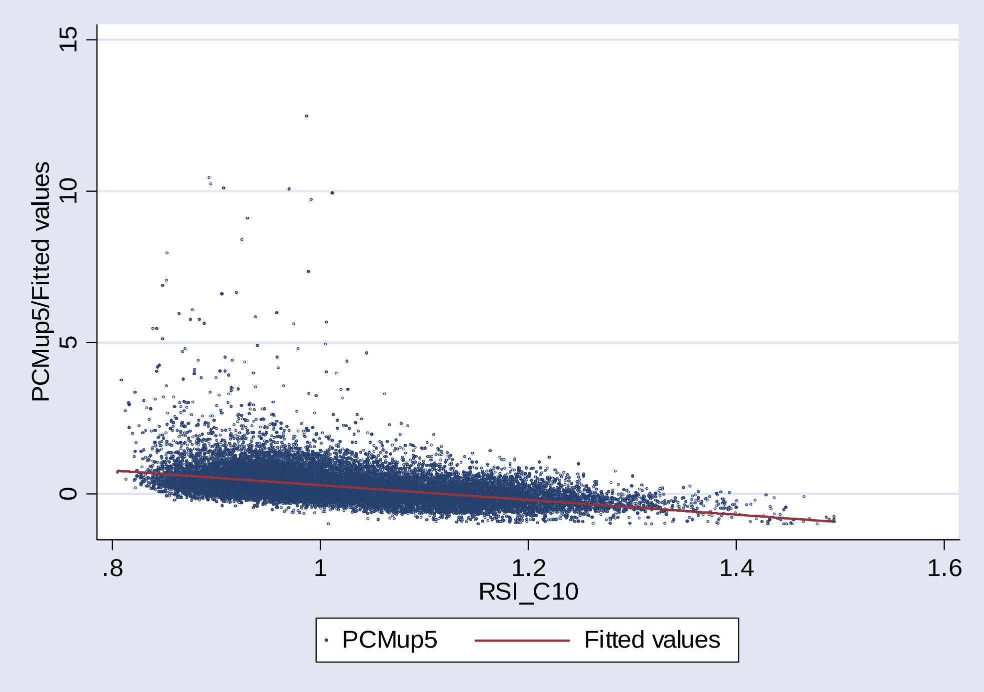
Price-Cost Mark-Up & RSI for Company 1338-S-DE

Swapping the LI for the PCMU as the dependent variable in the regression analysis can once again be seen to produce the general result already presented in relation to the other companies of a better statistical fit to the data, while similarly estimating statistically significant coefficients on the RSI variables of the expected sign. Figure 6.28 presents the predicted regression line resulting from the estimation of the following simple regression.

```
      Source |       SS       df       MS              Number of obs =   26256
-------------+------------------------------           F(  1, 26254) = 3303.08
       Model |  1673.04021     1  1673.04021           Prob > F      =  0.0000
    Residual |  13297.8822 26254  .506508808           R-squared     =  0.1118
-------------+------------------------------           Adj R-squared =  0.1117
       Total |  14970.9225 26255  .570212244           Root MSE      =  .71169

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C10 |  -2.434936    .042367   -57.47   0.000    -2.517978   -2.351895
       _cons |   2.731496   .0434768    62.83   0.000     2.646279    2.816713
```

Figure 6.28: PCMU Regression on RSI for 1338-S-DE



* An extreme outlying observation has been removed from this graph to facilitate a clearer understanding of the relationship.

Source: LE

Based on the scatter of the data points in this figure, it is once again pertinent to estimate a non-linear regression equation in an attempt to test the non-linearity of the relationship. The reported statistics on the estimated regression equation do not suggest that the goodness-of-fit, as a result of adding the quadratic term, is significantly improved as a result of the inclusion, 11.4% with and 11.2% without. Nevertheless, the estimated coefficients are all statistically significant and of the expected sign, indicating a result qualitatively the same as that seen in relation to the two previous companies examined.

Quadratic Specification 1338-S-DE

Source	SS	df	MS
Model	1709.4498	2	854.724902
Residual	13261.4727	26253	.505141228
Total	14970.9225	26255	.570212244

Number of obs	= 26256
F(2, 26253)	= 1692.05
Prob > F	= 0.0000
R-squared	= 0.1142
Adj R-squared	= 0.1141
Root MSE	= .71073

PCMup5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C10	-8.11938	.6708908	-12.10	0.000	-9.434362	-6.804397
RSI_C10sq	2.686736	.3164634	8.49	0.000	2.06645	3.307021
_cons	5.705663	.3529994	16.16	0.000	5.013765	6.397561

Peak & Off-Peak Analysis 1338-S-DE

The allowing for the slope and starting point of the estimated linear regression to differ, the result of adding the slope and intercept dummy variables on peak and off-peak times, has a more significant impact on the goodness-of-fit of the regression equation than does the introduction of a quadratic term. One can see that the results of the estimated regression equation return statistically significant coefficients on all of the variables with evidence of a premium in peak hours. The indispensability of company 1338-S-DE in peak hours is also estimated to bring about greater PCMU in peak hours than would be the case in off-peak hours for an equivalent level of indispensability.

Source	SS	df	MS
Model	2440.43994	3	813.479981
Residual	12530.4825	26252	.477315348
Total	14970.9225	26255	.570212244

Number of obs	= 26256
F(3, 26252)	= 1704.28
Prob > F	= 0.0000
R-squared	= 0.1630
Adj R-squared	= 0.1629
Root MSE	= .69088

PCMup5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dpeak	1.172675	.095384	12.29	0.000	.9857168	1.359633
pk_RSI_C10	-2.20482	.0526636	-41.87	0.000	-2.308043	-2.101596
opk_RSI_C10	-1.434927	.0743113	-19.31	0.000	-1.580582	-1.289273
_cons	1.44188	.0793658	18.17	0.000	1.286319	1.597441

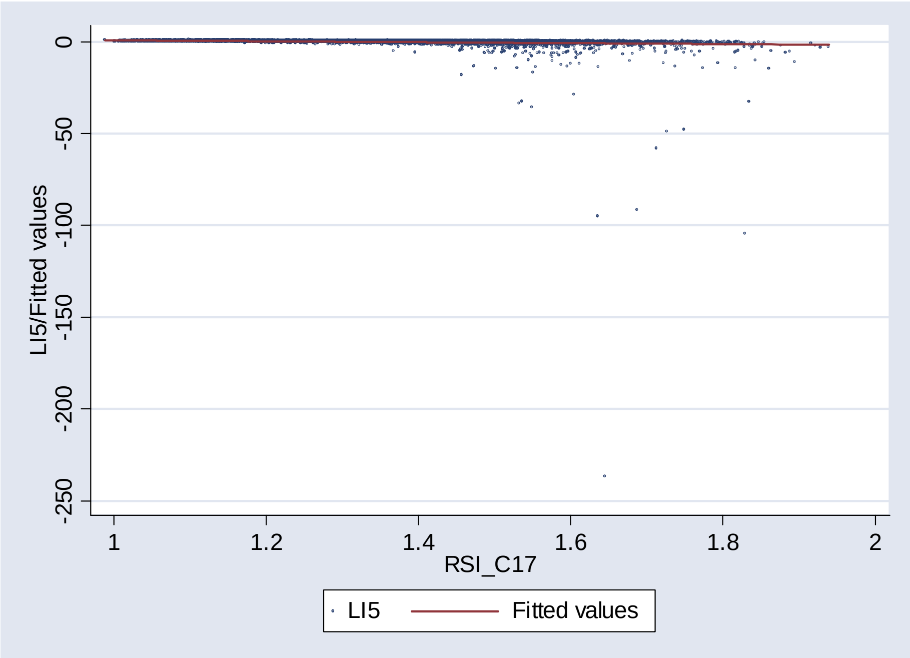
Lerner Index & RSI for Company 1681-S-DE

Finally, in this section a full suite of simple regressions is further carried out for Company 1681-S-DE. The simple regression equation of the LI on the RSI relative to company 1681-S-DE estimates a statistically significant relationship between the variables, of the expected sign. The predicted regression line is presented in Figure 6.29.

```
      Source |       SS       df       MS              Number of obs =   26247
-------------+------------------------------           F(  1, 26245) =  981.57
       Model |  3941.55483     1  3941.55483           Prob > F      =  0.0000
    Residual |  105388.344 26245  4.01555894           R-squared     =  0.0361
-------------+------------------------------           Adj R-squared =  0.0360
       Total |  109329.899 26246  4.16558329           Root MSE      =  2.0039

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C17 |  -2.576229   .0822288   -31.33   0.000    -2.737402   -2.415057
       _cons |   3.376266   .1083542    31.16   0.000     3.163886    3.588646
```

Figure 6.29: LI Regression on RSI for 1681-S-DE



Source: LE

Peak & Off-Peak Analysis 1681-S-DE

Considering a peak and off-peak distinction within the estimated regression of LI on RSI does not significantly increase the goodness-of-fit of the regression and although all of the estimated regression coefficients are statistically significant, only the coefficients on the RSI variables are of the expected sign. As with the previous regression estimated for the other companies, the estimated coefficient on the *dpeak* variable is not of the expected sign.

Source	SS	df	MS
Model	4191.5542	3	1397.18473
Residual	105138.345	26243	4.00633864
Total	109329.899	26246	4.16558329

Number of obs =	26247
F(3, 26243) =	348.74
Prob > F =	0.0000
R-squared =	0.0383
Adj R-squared =	0.0382
Root MSE =	2.0016

LI5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dpeak	-1.119849	.2596665	-4.31	0.000	-1.628809	-.6108881
pk_RSI_C17	-2.003358	.1127421	-17.77	0.000	-2.224338	-1.782377
opk_RSI_C17	-2.962048	.1538928	-19.25	0.000	-3.263686	-2.66041
_cons	3.820407	.2165825	17.64	0.000	3.395893	4.24492

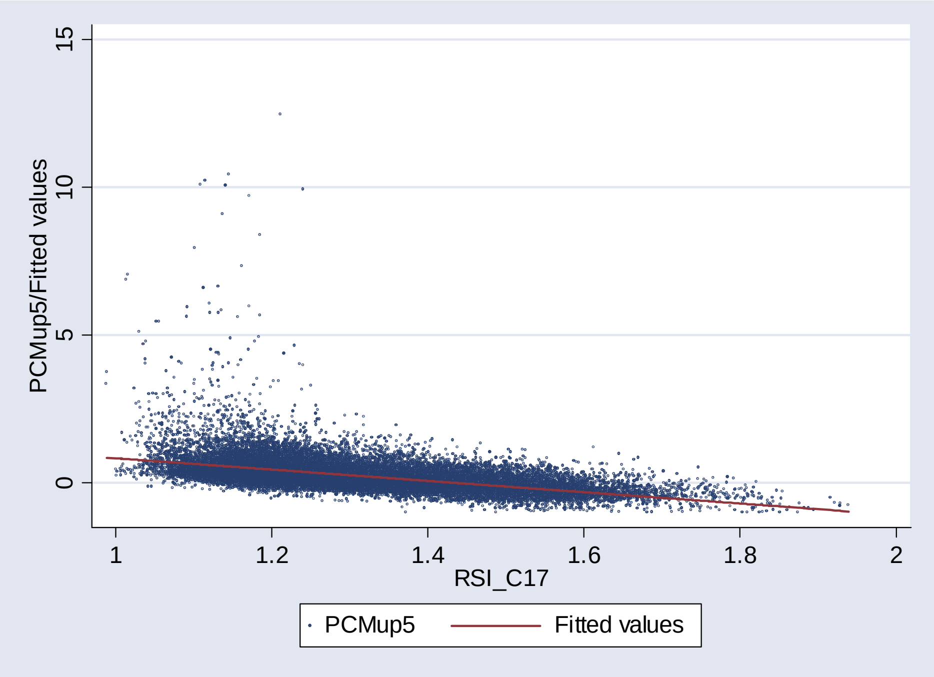
Price-Cost Mark-Up & RSI for Company 1681-S-DE

Replacing LI with PCMU as the dependent variable in the regression equations one can see results in a significant increase in the goodness-of-fit of the estimated simple regression, a result common to the analysis of all four companies in the German market. The estimated coefficient on the RSI variable is statistically significant and of the expected sign. The predicted regression line can be seen in Figure 6.30.

```
      Source |       SS       df       MS              Number of obs =   26256
-------------+------------------------------           F(  1, 26254) = 4487.66
       Model |  2185.44979     1  2185.44979           Prob > F      =  0.0000
    Residual |  12785.4727 26254  .486991417           R-squared     =  0.1460
-------------+------------------------------           Adj R-squared =  0.1459
       Total |  14970.9225 26255  .570212244           Root MSE      =  .69785

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C17 |  -1.915593   .0285952   -66.99   0.000    -1.971641   -1.859545
       _cons |   2.753535   .0376849    73.07   0.000      2.67967    2.827399
```

Figure 6.30: PCMU Regression on RSI for 1681-S-DE



Source: LE

The graphical representation of the data and of the predicted regression line, suggest that one may wish to further test the possibility of a non-linear specification being a better fit for the data. This has been done by adding the square of the RSI variable to the regression equation. The estimated coefficients on the regression equation are statistically significant and of the expected sign, however there is only a very marginal increase in the goodness-of-fit of this regression over the simple regression estimated previously.

Quadratic Specification 1681-S-DE

Source	SS	df	MS
Model	2246.0815	2	1123.04075
Residual	12724.841	26253	.484700452
Total	14970.9225	26255	.570212244

Number of obs	26256
F(2, 26253)	2316.98
Prob > F	0.0000
R-squared	0.1500
Adj R-squared	0.1500
Root MSE	.6962

PCMup5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C17	-6.681421	.4270672	-15.64	0.000	-7.518496	-5.844346
RSI_C17sq	1.757341	.1571241	11.18	0.000	1.449369	2.065313
_cons	5.94101	.2874618	20.67	0.000	5.377569	6.50445

Peak & Off-Peak Analysis 1681-S-DE

Allowing for peak and off-peak differences in the relationship between the PCMU and the RSI of company 1681-S-DE can be seen to result in an estimated regression equation that is a better fit for the data than is the case when simply allowing for a non-linear relationship. The estimated coefficients of this regression equation are all statistically significant and of the expected sign.

Source	SS	df	MS
Model	2624.91467	3	874.971555
Residual	12346.0078	26252	.470288275
Total	14970.9225	26255	.570212244

Number of obs	26256
F(3, 26252)	1860.50
Prob > F	0.0000
R-squared	0.1753
Adj R-squared	0.1752
Root MSE	.68578

PCMup5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dpeak	1.241379	.0888355	13.97	0.000	1.067256	1.415501
pk_RSI_C17	-1.781254	.038561	-46.19	0.000	-1.856836	-1.705673
opk_RSI_C17	-1.073578	.0526461	-20.39	0.000	-1.176767	-.9703884
_cons	1.419672	.0741004	19.16	0.000	1.274431	1.564913

6.9.2 Regression analysis – Part II

To further test the specification of the model and the findings of the simple regressions presented previously in this section, a measure of scarcity is included in the company specific regressions as an explanatory variable in the model. The rationale for this was that a certain amount of mark up in the electricity market might be properly (from an economic standpoint) be reflective merely of the scarcity rents in the market and the economic value of capacity, and the tradeoffs between capacity cost and thermal efficiency. If with the introduction of the scarcity variable both the RSI and scarcity variables are estimated and are not considered to be statistically significant then one could conclude that these two variables are perfectly collinear and as such the RSI coefficient in the previous regressions is simply capturing scarcity rents.

The result of adding the scarcity variable to the simple regression of PCMU on the RSI of company 0436-S-DE is presented in the following regression. The estimated coefficient on the RSI is of the expected sign and it is statistically significant, however the estimated coefficient on the scarcity variable is not of the expected sign and is statistically significant. This coefficient indicates that the more spare capacity there is relative to demand, the higher the mark-up is likely to be. This result is not intuitive and to investigate it further we estimate a further regression that includes a number of dummy variables to capture a number of effects that one might expect to find in the market and that are potentially being identified by the independent variables in the simple regression. This gives rise to problem known as omitted variable bias if the variable that is omitted is correlated with the explanatory variable I the regression thus biasing the estimated coefficient on the included variable.

Price-Cost Mark-Up & RSI for Company 0436-S-DE (including a Scarcity variable)

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F(  2, 26253) = 1544.25
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1608
                                                       Root MSE      =   .6918

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C02 |  -5.926277   .1660402   -35.69   0.000    -6.251724   -5.600829
        Scar |    2.86369   .1272319    22.51   0.000     2.614309    3.113072
       _cons |   5.677902    .136018    41.74   0.000     5.411299    5.944504
```

Including dummy variables for the years, seasons, weekdays, and peak hours in the simple regression estimated including scarcity has the effect of increasing the explanatory power of the model to 24%, indicating an improved goodness-of-fit measure as one might expect given that many of the dummy variables are statistically significant. Apart from the weekday dummy the remainder of the dummy variables added are statistically significant with the estimated coefficients on the annual dummy variables of the expected sign, given the results of the LI and PCMU presented previously, and the peak dummy indicates a positive impact on the PCMU in peak periods as one expects. Importantly, the estimated coefficients on the RSI and scarcity variables are both statistically significant and are of the expected sign. This result indicates that both of these variables can independently have an effect on the PCMU in the market, the effect being to increase PCMU in times of indispensability of company 0436-S-DE and/or in times of relative scarcity of available installed capacity.

Price-Cost Mark-Up & RSI for Company 0436-S-DE (including Scarcity and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F(  8, 26247) = 1918.55
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2414
                                                       Root MSE      =  .65781
```

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C02	-.8381848	.2136866	-3.92	0.000	-1.257022	-.4193475
Scar	-.9423864	.1853336	-5.08	0.000	-1.30565	-.5791224
d2004	-.329562	.0130772	-25.20	0.000	-.355194	-.3039301
d2005	-.4175433	.0154364	-27.05	0.000	-.4477996	-.387287
dpeak	.2935636	.0044093	66.58	0.000	.2849212	.302206
dsummer	.0806026	.007743	10.41	0.000	.0654259	.0957793
dwinter	-.0858685	.0132274	-6.49	0.000	-.1117949	-.0599421
dwkday	-.0061272	.0050711	-1.21	0.227	-.0160668	.0038125
_cons	1.685181	.156164	10.79	0.000	1.379092	1.991271

The results of a similar regression analysis of the impact of adding scarcity and subsequently a number of dummy variables into the simple regression previously estimated for company 0569-S-DE, is qualitatively the same as that found for company 0436-S-DE. The estimated coefficient on the RSI variable is of the expected sign in both regressions but only with the addition of a series of dummy variables, which are both significant and of expected sign, does the estimated coefficient on the scarcity variable follow one's ex-ante expectations on behaviour in the market.

Price-Cost Mark-Up & RSI for Company 0569-S-DE (including a Scarcity variable)

The inclusion of the scarcity variable does not lead one to qualitatively different conclusions on the relationship between the RSI and PCMU variables, as even accounting for scarcity the estimated coefficient on the RSI variable relative to company 0569-S-DE is statistically significant and of the expected sign. The estimated coefficient on the scarcity variable is also statistically significant but is not of the expected sign. The positive coefficient on the variable indicates that as capacity becomes tighter on the system, the expected PCMU would fall.

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F(  2, 26253) = 1265.00
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1452
                                                       Root MSE      =  .69818
```

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C03	-3.089218	.1976286	-15.63	0.000	-3.476581	-2.701855
Scar	1.004795	.1760964	5.71	0.000	.6596368	1.349954
_cons	3.774381	.1784888	21.15	0.000	3.424533	4.124229

The inclusion of annual, seasonal, weekday and peak hour intercept dummy variables in the regression will control for these factors in the regression thus removing any potential for these factors to bias the estimated coefficients of the independent variables already included in the regression equation. Controlling for these factors in the regression equation one can see that the estimated coefficients on the RSI and scarcity variables are statistically significant and of the expected sign. Considering the likelihood that the scarcity variable is correlated with peak hours in general, then the inclusion of the peak hours dummy variable will remove any potential bias in the scarcity variable from the more parsimonious specification. The estimated coefficients on the scarcity variable and *dpeak*,(peak hours dummy variable), are both statistically significant and of the expected sign. Furthermore, the inclusion of these dummy variables in the regression model has significantly increased the goodness-of-fit of the estimated regression.

Price-Cost Mark-Up & RSI for Company 0569-S-DE (including Scarcity and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F(  8, 26247) = 1896.86
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2416
                                                       Root MSE      =  .65771

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |   -1.30438   .1981191    -6.58   0.000    -1.692704   -.9160556
        Scar |  -.4189881   .1836634    -2.28   0.023    -.7789783   -.0589979
       d2004 |  -.3353247   .0120218   -27.89   0.000     -.358888   -.3117613
       d2005 |  -.4338682   .0121073   -35.84   0.000    -.4575993   -.4101372
       dpeak |   .2856255   .0046246    61.76   0.000      .276561      .29469
     dsummer |   .0944963   .0082465    11.46   0.000     .0783327    .1106598
     dwinter |  -.0859189   .0129957    -6.61   0.000    -.1113912   -.0604467
      dwkday |   .0020702   .0048872     0.42   0.672    -.0075091    .0116494
       _cons |   2.181213    .174922    12.47   0.000     1.838356    2.524069
------------------------------------------------------------------------------
```

Including scarcity in the simple regression equation of company 1338-S-DE has an unexpected result, one not observed in relation to any of the other companies examined but one that remains consistent over different specifications, as presented in this section, when scarcity is included as an independent variable. In both regressions presented here the estimated coefficient on both the RSI and scarcity variables are statistically significant and do not change with the inclusion of dummy variables, as has previously been observed for companies 0436-S-DE and 0569-S-DE. However, the estimated coefficient on the RSI variable is consistently positive, indicating a negative relationship between the market's dependence on company 1338-S-DE and the realised mark-ups, the opposite effect from what one would expect to see if the company could exercise market power. This result is the opposite of that found in the first simple regressions estimated for this company which now appear to be the result of scarcity and not the ability of company 1338-S-DE to influence price.

Price-Cost Mark-Up & RSI for Company 1338-S-DE (including a Scarcity variable)

The inclusion of the scarcity variable in the simple regression model for company 1338-S-DE brings about a change in the sign of the estimated coefficient on the RSI variable relative to that estimated in the simple regression model that was in keeping with prior expectations. Both the estimated coefficients on the RSI and scarcity variables are statistically significant. In light of the potential for a bias in these estimates through the omission of a potentially significant explanatory variable that is correlated with the scarcity variable, a further specification is considered below.

```
Regression with robust standard errors                Number of obs =   26256
                                                       F(  2, 26253) = 3036.41
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1681
                                                       Root MSE      =  .68875

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C10 |   5.495224   .1753647    31.34   0.000       5.1515    5.838948
        Scar |  -5.342323   .1019962   -52.38   0.000    -5.542241   -5.142405
       _cons |  -2.938323   .1375262   -21.37   0.000    -3.207882   -2.668764
```

The inclusion of annual, seasonal, weekday, and peak hours, dummy variables do not qualitatively alter the estimated sign of the coefficients on the scarcity and RSI variables. All of the other estimated coefficients, with the exception of the weekday dummy variable, are statistically significant and of the expected sign.

Price-Cost Mark-Up & RSI for Company 1338-S-DE (including Scarcity and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F(  8, 26247) = 1942.83
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2436
                                                       Root MSE      =  .65685
```

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C10	2.010132	.2965671	6.78	0.000	1.428845	2.59142
Scar	-2.940597	.1821315	-16.15	0.000	-3.297585	-2.58361
d2004	-.3067059	.0151669	-20.22	0.000	-.3364339	-.276978
d2005	-.4179007	.0140752	-29.69	0.000	-.4454888	-.3903127
dpeak	.2517064	.0084703	29.72	0.000	.2351041	.2683088
dsummer	.1082964	.0088512	12.24	0.000	.0909476	.1256453
dwinter	-.0792147	.0123893	-6.39	0.000	-.1034983	-.0549311
dwkday	.000184	.0048784	0.04	0.970	-.0093779	.009746
_cons	-.4044798	.2257123	-1.79	0.073	-.8468881	.0379285

In the subsequent regression analysis presented in this section and in a number of alternative specifications estimated as part of this study, the result presented here in relation to the estimated coefficient on the RSI variable of company 1338-S-DE remains robust in the presence of scarcity. This result is not in keeping with our ex-ante expectations on the expected sign of the estimated coefficient of the RSI variable. Scarcity appears to explain the expected behaviour of the market but the estimated coefficient on the RSI variable is counter-intuitive. Further analysis of this result was not undertaken as part of this study as it is potentially brought about by a host of different factors; company strategy, specifics of long-term contracts (the company is a net purchaser of a substantial amount of electricity on an hourly basis), as well as a number of other factors for which detailed data was not collected as part of this study. Nevertheless, this result does not diminish the relevance of the results found throughout this report on the relationship between structure and outcome measures in the European electricity market, it merely represents an interesting case that merits further work as part of future DG Competition studies.

Price-Cost Mark-Up & RSI for Company 1681-S-DE (including a Scarcity variable)

As with the simple regression model presented in Part 1 of this section, the estimated coefficient on the RSI variable relative to company 1681-S-DE is statistically significant and negative in sign. The implication of this is that one would expect to see larger PCMU in periods where company 1681-S-DE is indispensable to meeting demand. The estimated coefficient on the scarcity variable is statistically significant and positive, a result that has previously been seen in relation to companies 0436-S-DE and 0569-S-DE, that is counter intuitive and is potentially biased.

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F(  2, 26253) = 2187.23
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1461
                                                       Root MSE      =  .69782

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C17 |  -2.284079   .1654024   -13.81   0.000    -2.608277   -1.959881
        Scar |   .3556226    .176919     2.01   0.044     .0088518    .7023934
       _cons |   3.074451   .1370688    22.43   0.000     2.805788    3.343113
```

Introducing a number of dummy variables to explicitly control for annual, seasonal, weekday and peak hours effects in the regression specification one can see that the results of the estimated model return statistically significant coefficients on all variables, apart from the weekday dummy variable, that are consistent with prior expectations on their sign. Increases in the indispensability of company 1681-S-DE and a tightening of the available capacity on the system are both independently expected to increase the PCMU in the market.

Price-Cost Mark-Up & RSI for Company 1681-S-DE (including Scarcity and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F(  8, 26247) = 1904.11
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2416
                                                       Root MSE      =  .65771

------------------------------------------------------------------------------
             |               Robust
     PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C17 |  -1.004846     .292106    -3.44   0.001     -1.57739   -.4323024
        Scar |  -.6695662    .2873134    -2.33   0.020    -1.232716   -.1064164
       d2004 |  -.3295606    .0132921   -24.79   0.000    -.3556139   -.3035074
       d2005 |  -.4444536    .0111554   -39.84   0.000    -.4663187   -.4225886
       dpeak |   .2722284    .0083531    32.59   0.000     .2558559     .288601
     dsummer |   .0980692     .009337    10.50   0.000     .0797681    .1163704
     dwinter |  -.0856198    .0132856    -6.44   0.000    -.1116604   -.0595793
      dwkday |   .0032691    .0050375     0.65   0.516    -.0066048    .0131429
       _cons |   1.936628    .2518813     7.69   0.000     1.442926    2.430329
------------------------------------------------------------------------------
```

6.9.3 Regression analysis – Part III

At this point having found, that the RSI and scarcity variables are independently statistically significant and, apart for company 1338-S-DE, of the expected sign thus indicating that the RSI variable is capturing an effect other than just rents owing to scarcity in the market, one may legitimately wish to test one further aspect of the regression findings outlined previously. The similarity of the results on the estimated coefficients on the RSI values for 3 of the 4 companies may lead one to question whether in fact the RSI variables of the different companies are capturing the same effect, something common and other than scarcity. To test this a further regression equation has been estimated which includes the RSI of the two largest companies, as well as a variable capturing the interaction of these two variables, the scarcity variable and two variables designed to capture the impact of behaviour that may be indicative of withholding. A number of dummy variables are also included. As with the test on the independence of the estimated coefficient on RSI from scarcity, if the RSI values of the two companies are in fact identifying the same effect, then their coefficients will not be statistically significant in the estimated regression.

The results of this estimated regression indicate that the RSI of company 1338-S-DE is statistically significant and positive, the unlikely result we found previously, whereas the RSI value of company 0436-S-DE although negative cannot be considered to be statistically significant at with a reasonable degree of certainty. This result potentially raises more questions than it answers as given the opposite signs of the two estimated RSI coefficients one is not likely to consider them to be explaining the same effect, given both have already controlled for scarcity and a number of dummy variables. The estimated coefficient on variable capturing the interaction between the RSI variables is not statistically significant.

The dummy variables are once again qualitatively consistent with the results seen with respect to when the companies were assessed in isolation, as is the estimated coefficient on the scarcity variable. For the first time we have included variables to attempt to capture the possibility of identifying possible withholding behaviour. The estimated coefficients of these two variables indicate that both are of the expected sign but in terms of statistical significance, the gas coefficient is found to be strongly statistically significant while the coal coefficient is significant only at the 10% level. Nevertheless the coefficients indicate that a relative to the optimal despatch, the under-utilisation of coal increases the PCMU while the over-utilisation of gas increases the PCMU.

Price-Cost Mark-Up and RSI for Companies 0436-S-DE and 1338-S-DE (including a Competition, a Scarcity, Withholding and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F( 12, 26243) = 1800.78
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2620
                                                       Root MSE      =  .64884

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C02 |  -.4171425   .3609985    -1.16   0.248    -1.124719    .2904341
     RSI_C10 |   2.210127   .5744558     3.85   0.000     1.084162    3.336091
 RSI_C10_C02 |  -.0175628    .307926    -0.06   0.955    -.6211144    .5859889
        Scar |  -2.161885   .2607702    -8.29   0.000    -2.673008   -1.650761
      C0_gas |   .0001683   .0000164    10.24   0.000     .0001361    .0002006
     C0_coal |  -4.18e-06   2.39e-06    -1.75   0.080    -8.87e-06    5.05e-07
       d2004 |  -.2547957   .0113695   -22.41   0.000    -.2770804   -.2325109
       d2005 |  -.3663471   .0116698   -31.39   0.000    -.3892206   -.3434737
       dpeak |   .2200737    .006014    36.59   0.000      .208286    .2318614
     dsummer |   .1076107   .0083084    12.95   0.000     .0913258    .1238955
     dwinter |  -.1200035    .009453   -12.69   0.000     -.138532    -.101475
      dwkday |  -.0254364   .0059934    -4.24   0.000    -.0371839    -.013689
       _cons |  -.6530311    .549924    -1.19   0.235    -1.730912    .4248497
```

In an attempt to address the potential confusion caused by the result of the estimated RSI coefficients in the previous regression, a further regression has been estimated which includes the RSI variables of all four of the largest companies in the German market, as well as, scarcity, indicative measures of potential withholding and a series of dummy variables. The results of the estimated regression equation are presented below.

Price-Cost Mark-Up and RSI for 4 largest companies in Germany (including a Scarcity, Withholding and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F( 13, 26242) = 1649.71
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2622
                                                       Root MSE      =  .64879

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C02 |  -.7022364   .2282439    -3.08   0.002    -1.149607    -.254866
     RSI_C03 |  -.8009512    .274797    -2.91   0.004    -1.339568   -.2623342
     RSI_C10 |   1.977123   .2223538     8.89   0.000     1.541297    2.412948
     RSI_C17 |   .0090366   .2962471     0.03   0.976    -.5716238    .5896971
        Scar |  -1.096132   .6336714    -1.73   0.084    -2.338162    .1458986
      C0_gas |   .0001688   .0000177     9.53   0.000     .0001341    .0002035
     C0_coal |  -3.06e-06   2.23e-06    -1.37   0.170    -7.43e-06    1.31e-06
       d2004 |  -.2545947   .0113182   -22.49   0.000    -.2767789   -.2324105
       d2005 |  -.3591369   .0104073   -34.51   0.000    -.3795357   -.3387381
       dpeak |   .2196741   .0085894    25.58   0.000     .2028385    .2365097
     dsummer |    .109864   .0102494    10.72   0.000     .0897747    .1299534
     dwinter |  -.1219108   .0103761   -11.75   0.000    -.1422484   -.1015731
      dwkday |  -.0262254   .0055876    -4.69   0.000    -.0371775   -.0152733
       _cons |   .4243271   .6372302     0.67   0.505    -.8246786    1.673333
```

The estimated regression coefficients on the RSI variables in this regression, which includes the RSIs of all four companies, largely supports the findings of the single company regressions and indicates that each of these companies, with the exception of company 1681-S-DE, are capable of independently affecting the PCMU in the market. This result is statistically significant and independent of the likely impact of scarcity. As was previously found, once one includes scarcity, the expected effect of an increase in the indispensability of companies 0436-S-DE and 0569-S-DE is to increase the PCMU in the market. Again one is faced with the unusual proposition that the RSI of company 1338-S-DE is positively correlated with the PCMU, thus the more indispensable the company becomes (the lower the company's RSI), the lower the PCMU is expected to be. Outside of these results the estimated coefficients on the other estimated independent variables are largely consistent with those found previously. Interestingly the scarcity variable although of the expected sign is only significant at the 10% level in this regression.

As a final sensitivity check on the results already presented and as a means of further investigation, a regression has been estimated to take account of the potentially different impact variations in market power can have during peak and off-peak periods. To address this issue the PCMU was regression on the peak and off-peak values of the RSIs of the four largest companies, scarcity and a number of dummy variables.

The results presented below are largely consistent with those found already. In this instance the RSI of all four companies are independently statistically significant, whereas the estimated coefficient on the scarcity variable is not. As one might expect, the increased market power of companies 0436-S-DE and 1681-S-DE during peak periods has a considerable impact on the outcome of the market with greater indispensability of either of these companies leading to greater margins. In off-peak periods the estimated RSI coefficient of company 0436-S-DE is not statistically significant whereas that of company 1681-S-DE indicates the unexpected result of increased PCMU due to lower indispensability. For company 0569-S-DE its market power in off-peak hours is estimated to be more likely to drive margins up than in peak hours but both effects are statistically significant. The unusual result for company 1338-S-DE, now having been decomposed, appears to only to be statistically significant in peak hours. The estimated coefficients on the dummy variables are once again consistent over specifications.

Peak and Off-Peak analysis for 4 largest companies in Germany (including a Scarcity and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26256
                                                       F( 15, 26240) = 1270.55
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2504
                                                       Root MSE      =  .65398
```

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
pk_RSI_C02	-1.730959	.2720843	-6.36	0.000	-2.264259	-1.197659
opk_RSI_C02	.1908735	.2382496	0.80	0.423	-.2761086	.6578557
pk_RSI_C03	-.4954726	.3184105	-1.56	0.120	-1.119574	.1286292
opk_RSI_C03	-1.641667	.2725136	-6.02	0.000	-2.175808	-1.107525
pk_RSI_C10	2.4273	.3206163	7.57	0.000	1.798874	3.055725
opk_RSI_C10	.1324652	.1996826	0.66	0.507	-.2589236	.5238539
pk_RSI_C17	-1.415887	.3052084	-4.64	0.000	-2.014112	-.817662
opk_RSI_C17	.4661052	.2526775	1.84	0.065	-.0291564	.9613668
Scar	-.3969349	.641104	-0.62	0.536	-1.653534	.8596638
d2004	-.3037278	.0156472	-19.41	0.000	-.3343971	-.2730585
d2005	-.4071707	.0148837	-27.36	0.000	-.4363436	-.3779979
dpeak	1.110686	.1054372	10.53	0.000	.9040233	1.317349
dsummer	.1114091	.0103309	10.78	0.000	.0911599	.1316582
dwinter	-.0790084	.0132787	-5.95	0.000	-.1050354	-.0529813
dwkday	-.0258221	.0053295	-4.85	0.000	-.0362683	-.0153759
_cons	1.602814	.6379699	2.51	0.012	.3523587	2.85327

Overall the results of the regression analysis indicates that there is a significant statistical relationship between the RSI and outcome measures in the German electricity market, with company specific indispensability a significant determinant in the resulting Price-Cost Mark-Ups observed in the market.

6.10 Withholding

The GED model of optimal system despatch can provide the modelled hourly generation data for each specific unit, this can be compared with the actual hourly generation patterns of the units in an attempt to identify potential systematic withholding of generation assets. Both the amount of time these measures differ and the quantity of the difference will be important to any conclusions that may be able to be drawn from this analysis. One should also be wary in this regard of the relative size of any potential withholding behaviour and not simply the quantity by which the measures differ, to facilitate this the table below presents the sum of installed capacity (by technology) for the generation units included in the modelling of the German electricity market.

Table 6.49: Total Installed Capacity of modelled Units, by Technology - Germany

Gas	Coal	Nuclear	Pump storage	Other	Total
14,851	41,158	21,007	6,173	4,920	89,373

Source: LE

Table 6.50 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis.

Table 6.50: Potential Withholding, by Technology, for 0436-S-DE, (Number of hours where modelled is greater than actual generation) - Germany					
	Gas	**Coal**	**Nuclear**	**Pump Storage**	**Other**
2003-05	4,736	24,984	17,899	8,314	7,197
% hrs<0	18.0%	95.0%	68.0%	31.6%	27.4%
2003	26	8,233	7,870	2,708	2,742
% hrs<0	0.3%	94.0%	89.8%	30.9%	31.3%
2004	495	8,434	5,436	2,745	1,268
% hrs<0	5.6%	96.0%	61.9%	31.3%	14.4%
2005	4,215	8,317	4,593	2,861	3,187
% hrs<0	48.1%	94.9%	52.4%	32.7%	36.4%

Source: LE

Table 6.51 presents evidence of potential withholding for Company 0436-S-DE.

Table 6.51: Potential Withholding, by Technology, for 0436-S-DE						
	Gas	**Coal**	**Nuclear**	**Pump storage**	**Other**	**Total**
2003-05	232	-1033	-271	-100	-59	-1230
2003	283	-913	-614	-102	-73	-1418
2004	181	-1111	-159	-95	16	-1167
2005	232	-1073	-41	-105	-120	-1106

Source: LE

Table 6.52 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis.

Table 6.52: Potential Withholding, by Technology, for 0569-S-DE, (Number of hours where modelled is greater than actual generation)					
	Gas	**Coal**	**Nuclear**	**Pump Storage**	**Other**
2003-05	753	10,410	24,085	7,105	17,642
% hrs<0	2.9%	39.6%	91.6%	27.0%	67.1%
2003	59	2,053	7,976	2,294	7,183
% hrs<0	0.7%	23.4%	91.1%	26.2%	82.0%
2004	533	2,649	8,087	2,193	6,512
% hrs<0	6.1%	30.2%	92.1%	25.0%	74.1%
2005	161	5,708	8,022	2,618	3,947
% hrs<0	1.8%	65.2%	91.6%	29.9%	45.1%

Source: LE

Table 6.53 presents evidence of potential withholding for Company 0569-S-DE.

Table 6.53: Potential Withholding, by Technology, for 0569-S-DE						
	Gas	Coal	Nuclear	Pump storage	Other	Total
2003-05	68	248	-166	3	-39	114
2003	88	446	-167	4	-51	320
2004	59	430	-171	18	-56	281
2005	59	-133	-161	-13	-11	-259

Source: LE

Table 6.54 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis.

Table 6.54: Potential Withholding, by Technology, for 1338-S-DE, (Number of hours where modelled is greater than actual generation)					
	Gas	Coal	Nuclear	Pump Storage	Other
2003-05	208	19,097	24,868	-	17,956
% hrs<0	0.8%	72.6%	94.5%	-	68.3%
2003	5	6,835	8,696	-	7,244
% hrs<0	0.1%	78.0%	99.3%	-	82.7%
2004	66	6,994	8,724	-	6,559
% hrs<0	0.8%	79.6%	99.3%	-	74.7%
2005	137	5,268	7,448	-	4,153
% hrs<0	1.6%	60.1%	85.0%	-	47.4%

Source: LE

Table 6.55 presents evidence of potential withholding for Company 1338-S-DE.

Table 6.55: Potential Withholding, by Technology, for 1338-S-DE						
	Gas	Coal	Nuclear	Pump storage	Other	Total
2003-05	670	-288	-133	0	-53	196
2003	705	-348	-118	0	-67	173
2004	649	-391	-133	0	-72	52
2005	657	-126	-147	0	-21	362
Source: LE						

Table 6.56 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis.

Table 6.56: Potential Withholding, by Technology, for 1681-S-DE, (Number of hours where modelled is greater than actual generation)					
	Gas	Coal	Nuclear	Pump Storage	Other
2003-05	2,435	10,049	22,985	7,510	58
% hrs<0	9.3%	38.2%	87.4%	28.6%	0.2%
2003	685	4,603	6,642	2,242	24
% hrs<0	7.8%	52.5%	75.8%	25.6%	0.3%
2004	632	2,521	7,828	2,679	15
% hrs<0	7.2%	28.7%	89.1%	30.5%	0.2%
2005	1,118	2,925	8,515	2,589	19
% hrs<0	12.8%	33.4%	97.2%	29.6%	0.2%
Source: LE					

Table 6.57 presents evidence of potential withholding for Company 1681-S-DE.

Table 6.57: Potential Withholding, by Technology, for 1681-S-DE						
	Gas	**Coal**	**Nuclear**	**Pump storage**	**Other**	**Total**
2003-05	197	112	-56	-88	22	187
2003	239	31	-78	-47	22	166
2004	194	181	-51	-117	19	225
2005	157	124	-39	-101	26	169

Source: LE

6.11 Conclusions

The German market was in general found to have a concentrated market structure. Whether this level of concentration is conducive to competition is an open question, but our analysis suggests, at least in some significant number of hours, that poor market outcomes are possible.

Based on available installed capacity, the HHI for Germany was found to be 1,914 on average through the sample period, and the CR(2) was found to be 54% and ranged from a high of 2,158 to a minimum 1,734 over the sample period[11]. Allocating the interconnectors led to a range from 1,160 to 2,603 for HHI and 42.1% to 64.3% for CR(2). We note that threshold values such as 1800 for the HHI and 33% for *CR(n)* are somewhat arbitrary.

In terms of our sensitivity analysis, the German market was again found to be concentrated, in the majority of scenarios under different basis of market share. Variations in availability or in merit capacity over time also impact the concentration measures. Sensitivity analysis regarding the allocation of interconnectors to market shares, basing market shares on generation or in merit capacity, and the attribution of long-term contracts did have some impacts on the concentration measures. The range of mean HHI under these for the measures excluding the interconnector was 1,914 to 2,145, while, as seen above, the HHI based on available installed capacity goes up to 2,603 in our 'added to the biggest player' scenario, and as low as 1,160 in the 'atomistic' scenario (mean values). We note, however, that these variations varied over time and interconnection allocation measure. Even in the atomistic interconnector case the market would still be considered to be moderately concentrated. Across the variety of cases, a significant number of hours are likely to range from concentrated to highly concentrated.

---

[11] There are variations in the standard concentration measures based on a number of factors. First, hourly measures were calculated. Variation and changes in availability (e.g., forced and planned outage, summer deratings, etc) impact the concentration measured in the market as measured by capacity. We also calculated the standard concentration measures based on generation. Here, changes in the share of total generation or in merit generation would cause the standard concentration measures to vary.

The electricity-specific measures of market structure in general confirmed the qualitative conclusions of the HHI and CR(2) for Germany. However, there is more contrast between the two types of indicator with Germany than in some other countries. The RSI and PSI pointed more towards possible poor market structure. In general, the largest two companies' RSIs failed the proposed screening test with RSI<110% in greater than 5% of hours. Similar results were found for the PSI in Germany, with the PSI finding a single company was pivotal in between 49.8% of hours. This percentage of hours of pivotalness is well in excess of any screen for possible market power problems. Thus the electricity specific market structure measures point towards a market structure that is likely to exhibit non competitive outcomes.

Price-cost margins in Germany were significant and higher than the UK or Spain, with an average price cost margin over the full sample period of 35.2% for the LI and price-cost mark-up (51%), and 54.4% for the price cost mark-up over Platts.[12]

Relating the RSI to the price cost margins via regression analysis for Germany showed similar results as to other countries (ES, UK, and NL), with some exceptions. The RSI is a significant explanatory variable for the margins estimated in Germany. The inclusion of additional variables such as scarcity did not change this conclusion, for all but one company 1338-S-DE. Further work is required into this result, which remains robust across specifications in the presence of Scarcity as an independent variable. In general, the inclusion of more than one RSI variable also did not affect the statistical significance or sign of the estimated coefficients on the RSI variables, while some variations in Germany did occur such as changes in the expected signs. Statistical significance was in general robust to a number of changes in the assumptions, including changing specifications, dummy variables for peak and off peak, and violations of the classical linear regression assumptions.

[12] Based on Platts assessment price. Note caveats for France price cost margins previously stated.

Contributions to fixed cost estimates showed substantial sums would have been earned at the competitive price (marginal cost) estimates. This indicated that marginal cost estimates for the German market were not so low than many generators would not earn significant margins towards their fixed costs. These were done as a validation of the competitive price/marginal cost estimates. We estimated that the contribution to fixed cost in Germany would have been consistent with a "generic cost" of a new entrant CCGT. These estimates were to give a general range of possible figures and we were not able to further validate the size of the contribution to fixed cost[13].

The breakdown of power prices into cost estimates plus margin, and the inclusion of carbon revealed that a significant portion of recent price rises in Germany can be attributed to carbon cost inclusion due to the introduction of the EU ETS. In spite of the fact that utilities obtained their emissions allowances for free, one would expect[14] them to price in carbon costs fully, unless they believed doing so would lead to reduced carbon allowances in future rounds.

Estimates of withholding were significant in the regression analysis in Germany. We do not interpret this specifically as estimates of economic withholding as a means of the use of market power, but rather included withholding in the regression as a measure of either economic withholding or other reasons why the modelled despatch may have deviated from the actual despatch. These impacts were statistically significant in some cases on the regressions of margins on RSI, but were small relative to the RSIs and scarcity, and also did not tend to make other variables such as the RSI insignificant.

---

[13] Doing so would have required estimates of the book value, depreciation, and age and technology profile of plant.

[14] We say this from an economic perspective. Apparently recent news reports suggest that German competition Authorities believe that pricing in the full cost of carbon is evidence of abuse of a dominant position. We only note that the via design of EU ETS, it was fully intended that companies price in the opportunity or economic cost of carbon.

The regressions of margins on RSI are important (in that they provide added information for a more borderline cases and relate market outcomes to market structure). Whether Germany in fact is concentrated or highly concentrated, price cost margins (LI and PCMU) were significantly related to market structure via the regressions. This latter finding could indicate that market power use or market imperfections exist/have existed. Of course, alternatively, it is always possible that the regression models as specified are unable to distinguish between this explanation and some alternative unknown, but more benign, rationale.

7 Spain

This chapter contains our analysis of the competitive situation of Spanish wholesale electricity market. In the chapter we report on a host of quantitative indicators, most of which are based on primary data, which has been collected for this purpose by DG Competition. Our data covers all significant operators active in the Spanish market.

We start with a general introduction to the Spanish market, followed by a detailed analysis of market structure and observed outcomes. In the following sections, we analyse in great detail the relationship between structure and outcomes, and extend our investigation to the determinants of observed wholesale prices, and potential evidence of withholding.

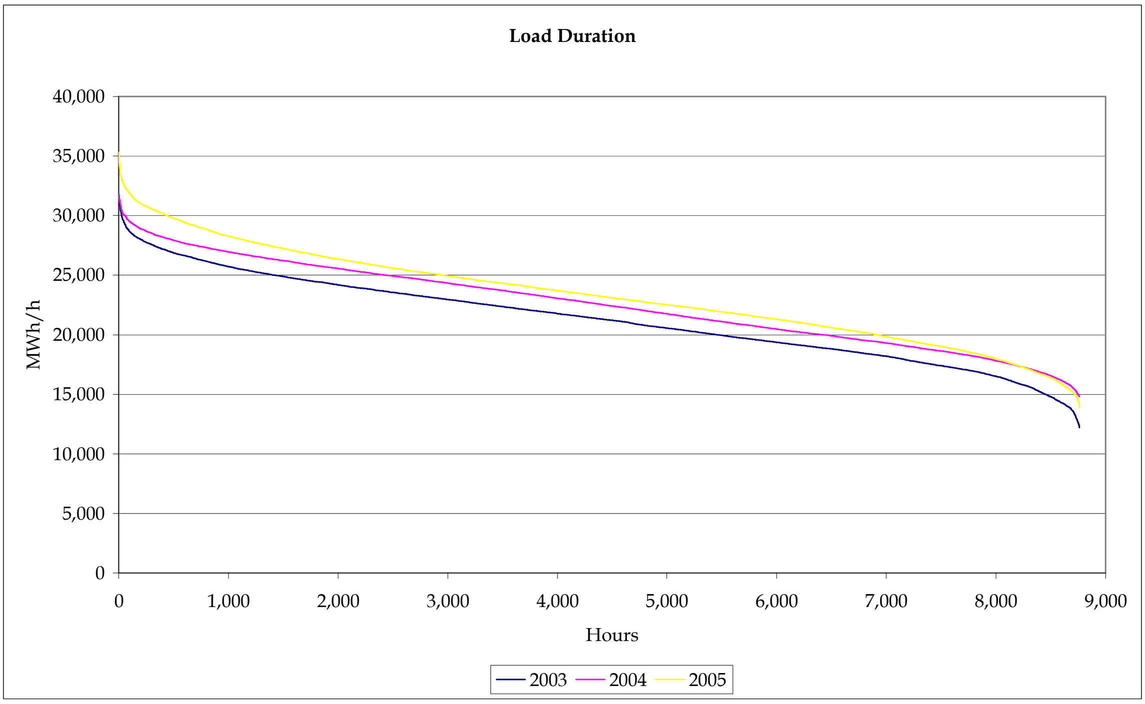
7.1 Introduction to the Spanish Electricity Market

7.1.1 Load Duration Curve

The load duration curve of the Spanish electricity market is an ordered ranking of the electricity demanded in each hour of each year. The load is presented in descending order for each year allowing the reader to quickly determine the amount of hours in each year that demand in Spain (ES) is above the scale on the vertical axis. Figure 7.1 presents the load duration curve for each of the three years of the study. According to this graph, there have been significant increases in the load from years to year in almost all hours but the increase in the peak demand hours of 2005 relative to the other two years is most noticeable.

Importantly, this load represents the constructed load, described in the methodology chapter of this report as the sum of generation over all units in each hour, and this measure of load is the one used for the purpose of this report. The hourly load included within this report is not that reported by the TSO (REE). This approach was adopted so that the results of both the modelling and analysis are accurate and consistently reflect the market for which data is available. Given the quality and quantity of data collected by DG Competition as part of the Sector Inquiry, it means that only small companies with small non-peaking (price setting) units are not contained in our analysis. However to include the demand for electricity potentially served by these units, contained in the TSO load, and not to include them in the formal modelling and analysis would have created an over utilisation of the capacity in the market, represented by all other companies and units. As previously discussed in the methodology chapter, this approach also accounts for flows over the interconnectors with neighbouring countries.

Figure 7.1: Load Duration Curve – Spain



Source: LE.

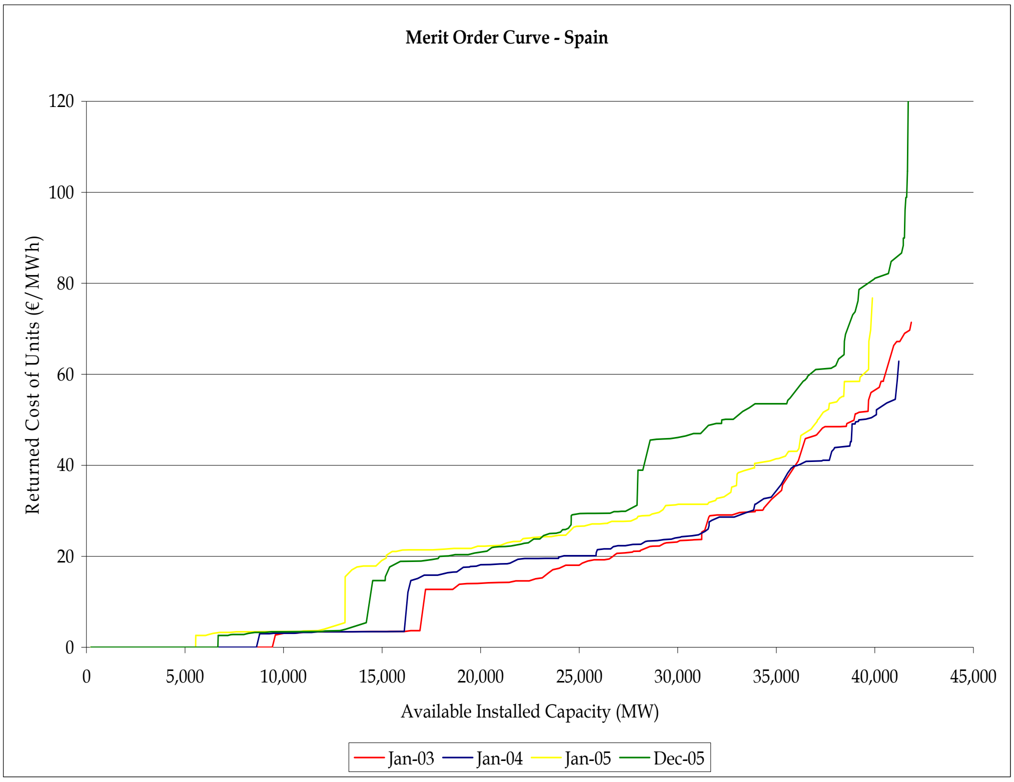
7.1.2 Merit Order Curve

The merit curve is an ascending ordering of the available installed capacity in the system, based on the marginal cost of generation (€/MWh) for each unit on the system. The merit curve can shift based on availability, fuel prices, etc, and thus is specific to a time period or an average. In this instance the merit curve was calculated by taking a monthly average of each unit's available installed capacity and the marginal cost of the unit, calculated using the fuel prices and efficiencies returned by each of the companies for each of their units. These costs are then sorted in ascending order and the corresponding average available capacities aggregated over the market.

The merit order curve for the Spanish electricity market is presented in Figure 7.2. The shape of the curve is evidence of the important role played by generation capacity with zero fuel cost, specifically run-of-river and storage hydro. As one will recall from the discussion in the methodology chapter of this report, the available installed capacity of units of particular technologies, (wind, run-of-river hydro and storage hydro), was limited to the maximum of their generation in each month as an attempt to indirectly account for issues of hydrology and general weather conditions. This approach offers the most satisfactory method of dealing with these issues, the full inclusion of which would far exceed the scope of this current report. As one moves to the right of the merit curve, away from the zero fuel cost capacity one can see that the merit curves remain largely unchanged from year to year, with the notable exception of what appears to be the impact of global gas price increases on the capacity located from 27,000 MW onwards on the December 2005 curve.

Importantly, these merit curves do not capture the impact of the ETS scheme in 2005 and the inclusion of the economic cost of carbon to the generation costs of these units. This issue is addressed subsequently.

Figure 7.2: Merit Order Curve (excl. Carbon) - Spain



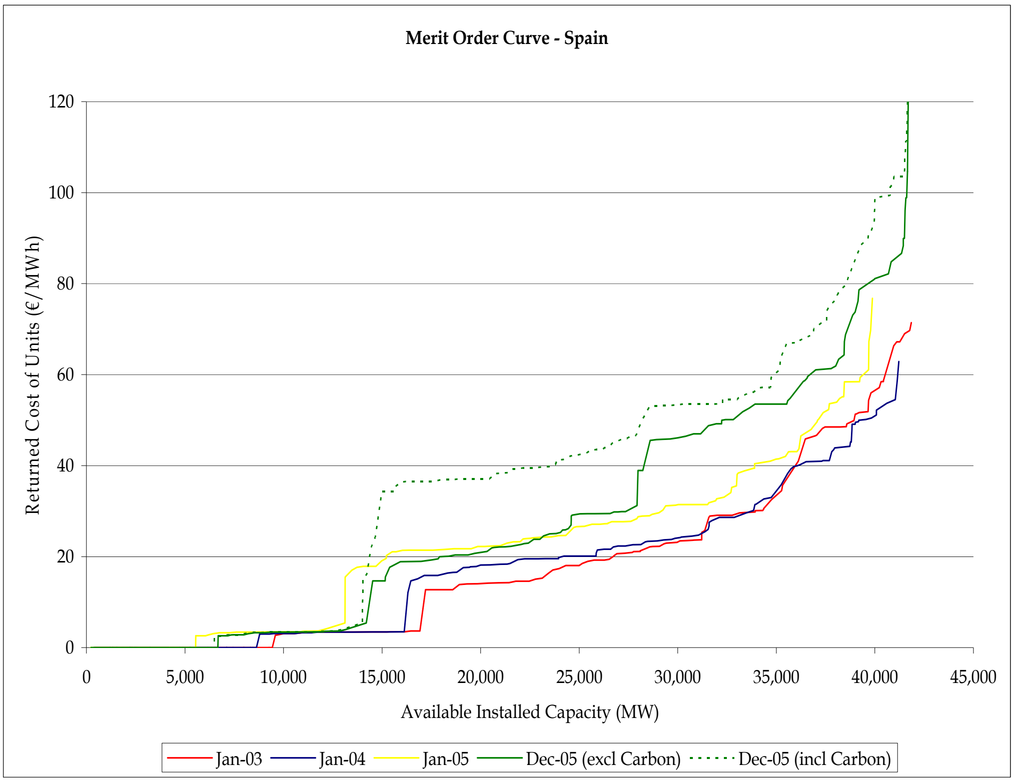
Source: LE.

In order to fully assess the impact on the merit order curve of the introduction of the ETS in 2005, the merit order curve for Spain in December 2005 has been adjusted to include the unit specific €/MWh economic cost of carbon for all generation units liable under this scheme. This is presented in Figure 7.3.

As one can see the initial difference persists to the left of the merit curve, due to the differing availability of units with zero marginal cost of generation (Wind, Storage and Run-of-River Hydro). The considerable quantity of nuclear capacity in Spain remains unaffected but as one moves to the position on the merit curve where one would expect to see the conventional thermal units located, beginning with coal and moving to gas as one moves further to the right, the impact of the inclusion of the full economic cost of carbon on these units is apparent. More carbon intensive coal fired plant shift the most. The impact of this on certain places of the supply curve, about 15,000 MW of capacity is notable. An additional figure following the supply curve shows the percentage breakdown of capacity by fuel type in Spain.

It is important for one to note at this point that the inclusion of the full economic cost of carbon has the potential to change the ordering of the units on the merit curve such that one should not consider the difference between the two December 2005 merit curves to represent the full economic cost of carbon for a particular unit but rather for a particular megawatt, not necessarily one located at that point on the merit curve in the absence of the cost of carbon. The implication of this is that one cannot simply estimate the cost of carbon for the system based on the cost of carbon for the marginal unit as the marginal unit may potentially be different between the carbon and no-carbon case. This is similarly the case for all of the merit curves presented here for different periods, the ordering of the units is potentially different in each period due largely to changes in fuel costs.

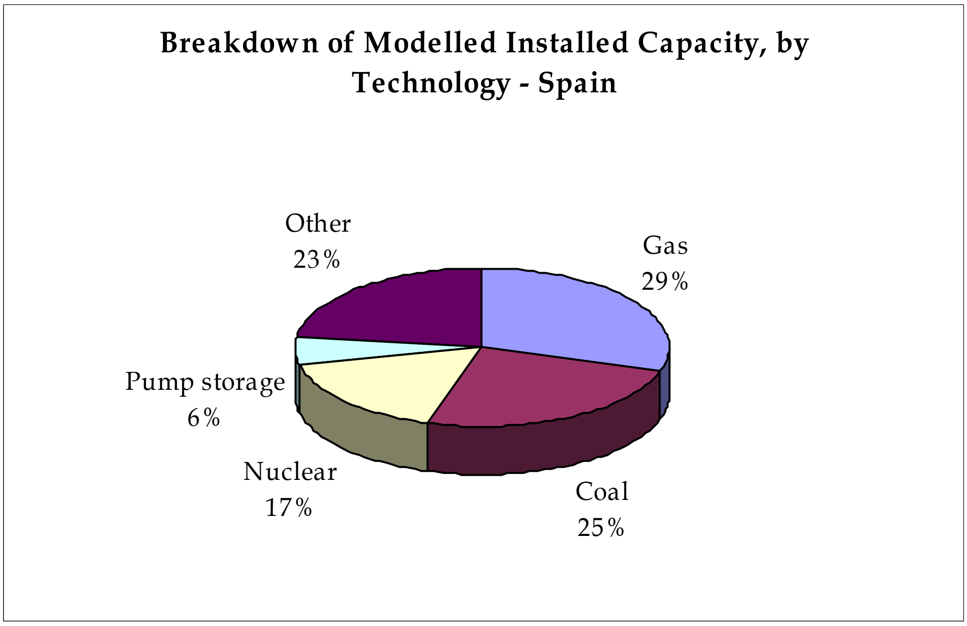
Figure 7.3: Merit Order Curve (incl. Carbon) - Spain



Source: LE.

Figure 7.4 presents an overview of the generation portfolio, by technology, in Spain. This provides a further basis for understanding the observed effect of the introduction of the ETS on the December 2005 merit curve in the previous graph. The figure shows that coal, gas, and 'other', which includes, for example, the various types of oil-powered generators, as well as renewables, make up about three quarters of total generation capacity in the country. There is almost an even split between these three technologies, although gas generation is the most important, at 29% of installed capacity.

Figure 7.4: Breakdown of Modelled Installed Capacity by Technology - Spain



Source: LE.

7.2 Structural Indicators

Traditional structural indicators have been calculated based on a number of different measures of market share for the Spanish electricity market. These indicators can change with availability and market conditions, so *CR(n)* and HHI indicators have been calculated, on an hourly basis, for all companies included in the study. Three different measures of market share (capacity) (generation) have been used to calculate these indicators. A brief overview of these measures is presented here but for a more detailed description one should review the relevant section of the methodology chapter.

Available Installed Capacity (AIC) – The Available Installed Capacity of each company is equal to the sum of maximum operating capacity reported for each unit in the company's portfolio (taking account of warm weather deration and outages). The impact of warm weather derations on the normal operating capacity of units was included as part of DG Competition's data request to companies under the auspices of the Sector Inquiry. Data on outages was similarly returned by the companies and these were seen to take two particular forms: full outages and partial outages. A full outage is recorded where a company reports an outage and the hourly generation in that hour is zero. This unit is regarded to be out of operation and therefore not available in that hour. Companies have also reported partial outages which arise when the period of a reported outage does not correspond with a zero electrical production. In this case we have taken the available capacity to be the maximum hourly generation figure reported by the company, for the specific unit, over the period for which a partial outage has been identified. Further discussion of this as well as a formal exposition of the approach taken is contained in the methodology chapter of this report.

Available Capacity (AC) – Available Capacity is a measure calculated primarily for the purposes of the electricity specific structural indicators, however it is still interesting to assess the results of the traditional measures based on AC both in relation to the other measures of capacity and as an assessment of the HHI approach in general vis-à-vis the more specific measures calculated further on in this chapter. As has previously been stated in the methodology chapter, available capacity is equal to available installed capacity less capacity committed to upward system balancing (reserve) requirements and plus the net purchasing position of companies via long-term contracts.

Total Generation – Both the *CR(n)* and HHI indicators have been calculated using the hourly net electrical generation figures reported by the companies for the full three year period 2003-2005 (26304 hours). The hourly generation of each company is simply the arithmetic sum of generation over all units in the company's portfolio in each hour. If one was to aggregate this over each company, it would be equivalent to the load. Therefore, concentration measures based on total generation reflect the market shares of companies over the load of the system.

In Merit/Economic Capacity - *CR(n)* and HHI indicators have been calculated using the concept of in merit/economic capacity. A station is in merit if its running cost is less than the system marginal cost. This requires the estimation of an hourly system marginal cost and information on the hourly marginal cost of generation for each of the units in a company's portfolio. If the hourly marginal cost of generation of a particular unit is below, or equal to, the system marginal cost, the available generation capacity (as calculated above) is included in the company's available capacity for that hour. Units which report a marginal cost of generation above that of the system marginal cost are excluded. The system marginal cost used for this was the maximum unit cost of any unit reported running on the system in that hour.

CR(n)

The Concentration Ratio (*CR(n)*) of the *n* largest companies in the market is comprised of the sum of the relevant capacity measures (C) of the *n* largest companies in the market, divided by the total sum of capacity in the market. This measure has been calculated using, Available Installed Capacity, Available Capacity, Total Generation, and, In Merit/Economic Capacity.

HHI

Formula: $$HHI = \sum_{i=1} \left(\frac{C_i}{\sum_i C_i} \right)^2$$ where $i = 1, 2, 3, \ldots, N$

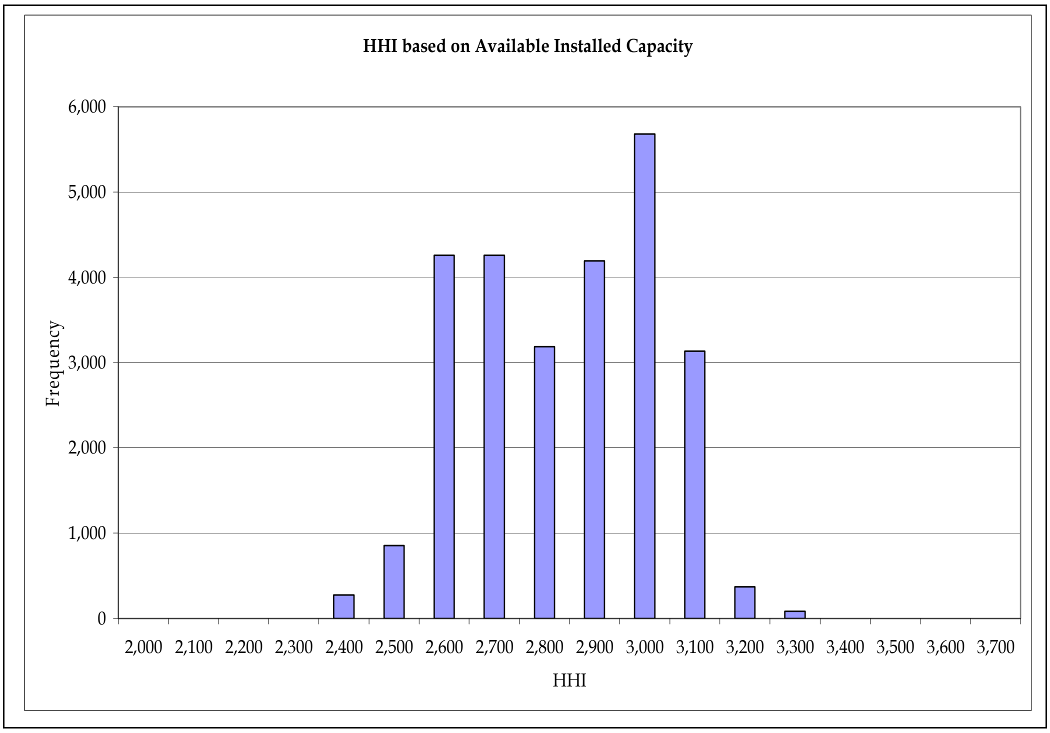
The HHI indicator sums the squares the market shares of all companies in the market, where the market shares of the companies are calculated on an hourly basis using, Available Installed Capacity, Available Capacity, Total Generation, and, In Merit/Economic Capacity. The resulting figures will be assessed vis-à-vis the thresholds for concentration set out by a number of competition authorities, including DG competition, that identify markets with a HHI below 1,000 not to be concentrated, between 1,000 and 1,800 to be moderately concentrated, and above 1,800 to be concentrated. It is important to point out that these thresholds are not the result of rigorous economic analysis but have developed over time as a generally accepted benchmark. These thresholds are therefore not steadfast rules and are adapted in particular situations to accommodate special market conditions.

7.2.1 Results

CR(2) & HHI based on available installed capacity

HHI and *CR(n)* measures have been constructed hourly for the full period of the study. An overall representation of the computed HHI values based in hourly available installed capacity is provided in the following histogram. The histogram shows the distribution of values over the range of values that occurred in the time period. The distribution is centred above about 2,800 and also has two modes or most frequently occurring values. Even the lowest values are above the standard concentration threshold of 1,800, and the highest values are close to double that.

Figure 7.5: Histogram of HHI Values based on Available Installed Capacity (2003-2005) - Spain



Source: LE.

Summary statistics on CR(2) and HHI based on Available Installed Capacity are presented in Table 7.1.

Table 7.1: Summary Statistics of CR(2) & HHI based on Available Installed Capacity - Spain			
	Available Installed Capacity (MW)	**CR(2)**	**HHI**
Average	38,808	71.4%	2,790
Maximum	43,843	78.7%	3,259
Minimum	32,291	60.8%	2,318
Standard Deviation	1874	3.2%	185
Source: LE			

The table shows the summary HHI statistics. Interesting it is evident that HHI can vary significantly over time in electricity markets, and Spain shows a marked variation in both CR(2) and HHI. The minimum CR(2) is 60.8% while the maximum is 78.7% and similarly the HHI goes from 2,318 to 3,259 in range, an almost 50% increase from min to max. In spite of this, the qualitative conclusion that this is a concentrated market is not sensitive to the time period chosen as even the smallest values are above the threshold of 1,800.

As well as the overall representation of the hourly HHI values, a number of pre-selected days have been chosen to assess the existence and prevalence of concentration at different points in weekly and seasonal trends. The pre-selected dates are provided in Table 7.2. The preselected days were chosen to drill down and see if some particular days possibly were more of less concentrated than the averages or wholes.

Table 7.2: Pre-Selected Representative Days[15] - Spain

	Weekday	**Weekend**
January (Winter)	2nd & 4th Wednesday	2nd Sunday
April (Spring)	2nd Wednesday	2nd Sunday
August (Summer)	2nd & 4th Wednesday	2nd Sunday
October (Fall)	2nd Wednesday	2nd Sunday

Source: LE

Table 7.3 presents the results of the CR(2) and HHI analysis for available installed capacity for these pre-selected dates. Although there is variation in the concentration indicators across different days, the overall picture suggests that main trend is a decline in concentration in 2005, rather than variation between individual dates.

[15] The selection of January and August as Winter and Summer respectively is in accordance with the references to these periods contained in the Horizontal Data Request.

Table 7.3: Concentration measures based on available installed capacity - selected days - Spain				
No.	**Date**	**Average Hourly Demand (MWh/h)**	**CR(2)**	**HHI**
1	08/01/03 (W-2)	25,016	75.0%	3,016
2	12/01/03 (S-2)	20,583	74.9%	3,007
3	22/01/03 (W-4)	23,772	74.7%	3,001
4	09/04/03 (W-2)	22,204	76.0%	3,092
5	13/04/03 (S-2)	15,308	75.9%	3,074
6	10/08/03 (S-2)	19,946	75.8%	3,044
7	13/08/03 (W-2)	24,114	72.9%	2,832
8	27/08/03 (W-4)	22,569	72.2%	2,812
9	08/10/03 (W-2)	20,144	73.1%	2,869
10	12/10/03 (S-2)	17,245	74.4%	2,971
11	11/01/04 (S-2)	19,402	74.0%	2,955
12	14/01/04 (W-2)	22,502	73.2%	2,879
13	28/01/04 (W-4)	25,023	74.1%	2,939
14	11/04/04 (S-2)	16,720	74.2%	2,943
15	14/04/04 (W-2)	23,987	74.1%	2,922
16	08/08/04 (S-2)	19,631	71.1%	2,749
17	11/08/04 (W-2)	21,862	70.6%	2,715
18	25/08/04 (W-4)	25,086	71.3%	2,754
19	06/10/04 (W-2)	24,550	68.5%	2,610
20	10/10/04 (S-2)	16,660	69.0%	2,651
21	09/01/05 (S-2)	22,639	68.9%	2,616
22	12/01/05 (W-2)	28,157	68.3%	2,581
23	26/01/05 (W-4)	27,017	68.6%	2,585
24	10/04/05 (S-2)	15,914	65.2%	2,501
25	13/04/05 (W-2)	22,697	63.9%	2,434
26	10/08/05 (W-2)	22,067	68.6%	2,652
27	14/08/05 (S-2)	17,517	68.7%	2,663
28	24/08/05 (W-4)	23,994	68.3%	2,599
29	09/10/05 (S-2)	20,053	69.5%	2,645
30	12/10/05 (W-2)	19,878	66.8%	2,541

Source: LE.

As well as looking at these pre-selected dates HHI and CR(2) measures have also been calculated over the four peak Summer and Winter days within the three year period of the study, as well as the peak days in Spring and Autumn. The results are presented in Table 7.4.

Table 7.4: Concentration measures based on Available Installed Capacity–seasonal peaks - Spain

	Date	Average Hourly Demand (MWh/h)	CR(2)	HHI
Summer	13/7/2005	28,425	66.6%	2,536
	30/6/2004	27,759	72.2%	2,816
	25/6/2003	25,252	75.0%	3,011
Winter	19/12/2005	29,822	68.2%	2,595
	14/1/2003	27,034	74.9%	3,012
	20/2/2004	26,714	74.0%	2,928
Spring	1/3/2005	29,204	68.2%	2,583
	2/3/2004	26,805	73.1%	2,874
	7/3/2003	22,726	74.1%	2,954
Autumn	30/11/2005	29,181	67.5%	2,545
	18/11/2004	26,335	69.1%	2,638
	20/11/2003	24,456	72.9%	2,855

Source: LE.

Interestingly, similar to the ranges and summary statistics, a considerable variation is observed across preselected days, and across seasons. However, similarly again, the qualitative conclusions that the market is concentrated is not apparently sensitive to the day selection or to seasonality.

Available Capacity (allowing for LTCs and Reserves)

The measurement of concentration in electricity markets is also potentially impacted by the presence of long-term contracts and reserves, and so we calculated the HHI and CR(2) accounting for this. In order to assess the impact of long-term contracts and reserve commitments on the HHI and CR(2) measures, these measures have been constructed using Available Capacity. Available capacity differs from available installed capacity as it takes account of each company's long-term contract and upward reserve commitment requirements. Available capacity is the basis for the electricity specific structural measures computed in the following section.

Table 7.5 presents a summary comparison of the results of the HHI and CR(2) measures computed hourly over the full period for Available Capacity and Available Installed Capacity (the basis for all of the above analysis). The results are very similar, indicating that our finding of high concentration is independent of minor changes in market definition. The variation in the concentration measures, however, is comparatively high.

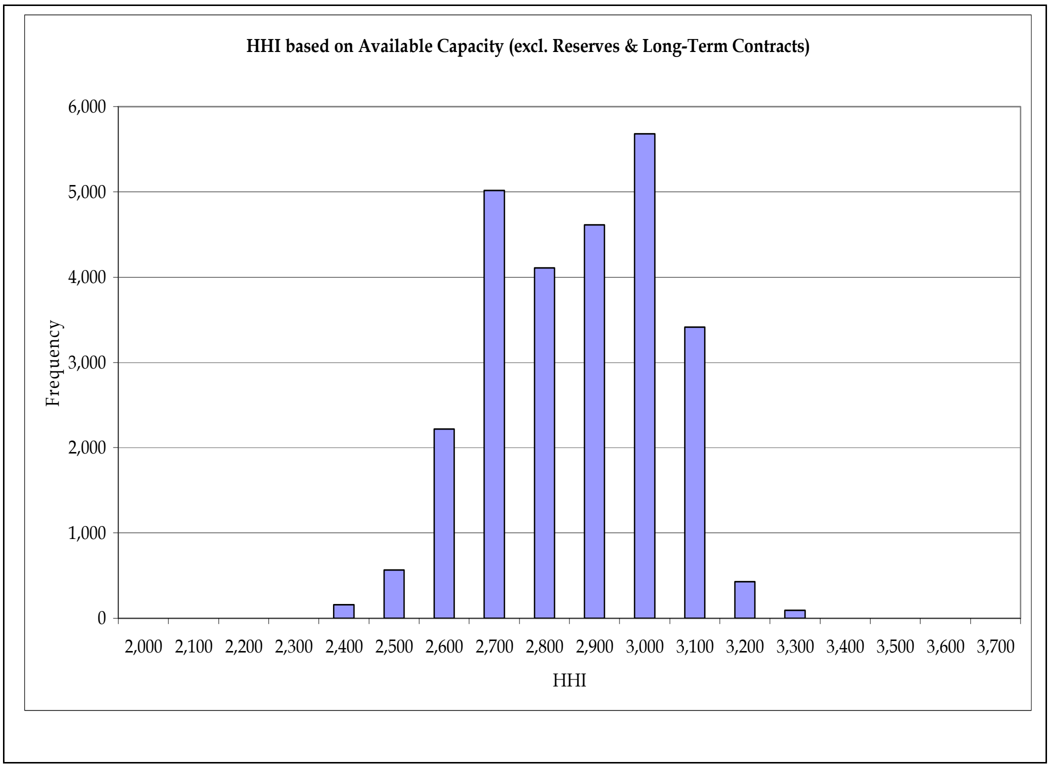
Table 7.5: Comparison of Available Capacity & Available Installed Capacity - Spain

	Available Capacity (MW)		Available Installed Capacity (MW)	
	CR(2)	**HHI**	**CR(2)**	**HHI**
Mean	71.8%	2,813	71.4%	2,790
Max	78.8%	3,266	78.7%	3,259
Min	61.1%	2,344	60.8%	2,318
Standard deviation	3.0%	170	3.2%	185

Source: LE

The histogram in Figure 7.6 below provides the frequency of the computed HHI values based on Available Capacity. As with the summary statistics in Table 7.5, the histograms of both available capacity and available installed capacity are broadly similar. The figure shows a similar distribution.

Figure 7.6: Histogram of HHI values based on Available Capacity (2003-2005) - Spain



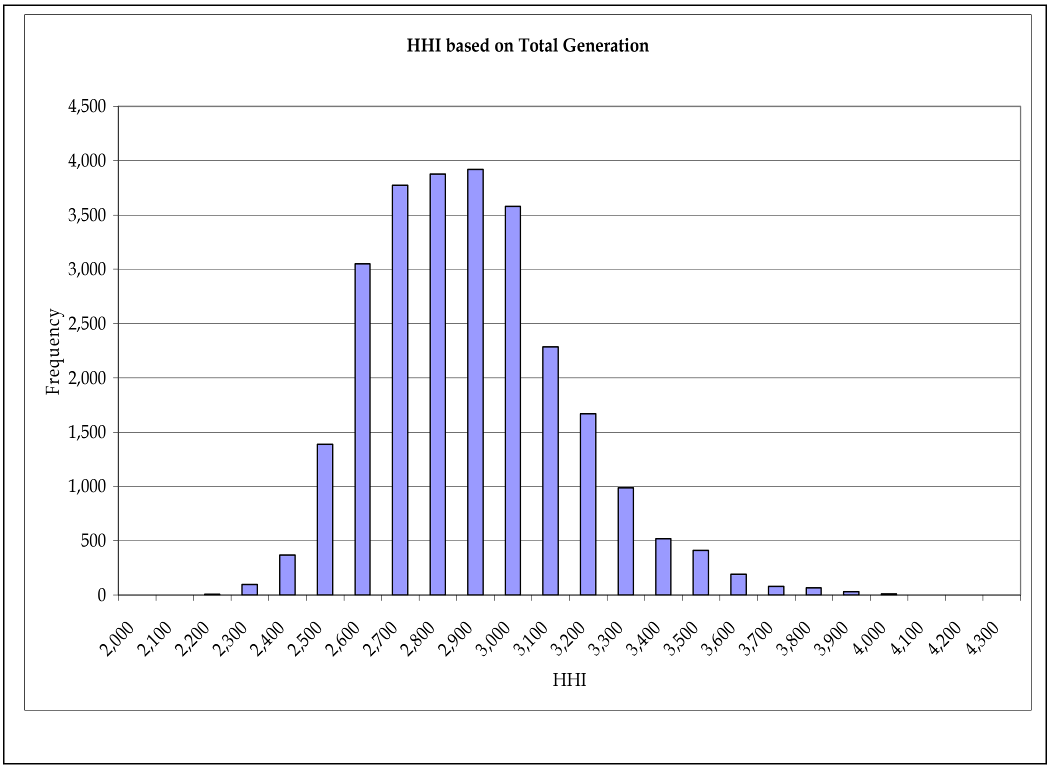
Source: LE.

CR(2) & HHI based on Total Generation

An alternative definition of market share can be based on production, rather than capacity, when calculating market concentration using traditional market concentration indicators. The HHI and CR(2) measures have been re-estimated hourly based on the net electrical production figures returned by the companies, where total generation was summed over a company's units and divided by total market generation to form the market share in each hour.. This data similarly is used to construct the load in Spain.

Figure 7.7 below presents a histogram of the frequency of hourly HHI values computed using hourly generation over the period 2003-2005. Interestingly, the histogram of HHI by generation shows and more regular or 'normal' shape from the capacity figures; which may be an indicator that variations are due to more random elements. However, the centre and range of the distribution remain largely similar. Further, the largest values are near double the standard concentration thresholds.

Figure 7.7: Histogram of HHI values based on Total Generation (2003-2005) -Spain



Source: LE.

Summary statistics on CR(2 and HHI based on Total Generation are presented in Table 7.6. The change of market definition to Total Generation leads to a marked increase in the variability of the concentration measures. However, average concentration over the period remains very similar to the cases described above.

Table 7.6: Summary Statistics of CR(2) & HHI based on Total Generation – Spain			
	Hourly Generation (MWh/h)	**CR(2)**	**HHI**
Average	22,407	70.4%	2,837
Maximum	35,319	85.6%	3,991
Minimum	12,203	57.6%	2,135
Standard Deviation	3724	3.9%	257
Source: LE			

Table 7.7 presents the HHI and CR(2) measures computed for the pre-selected days previously listed in Table 7.2. Looking at the concentration measures on for the preselected days again shows a rather high variability, but no systematic trend in market concentration.

No.	Date	Average Hourly Demand (MWh/h)	CR(2)	HHI
1	08/01/03 (W-2)	25,016	77.6%	3,211
2	12/01/03 (S-2)	20,583	78.6%	3,308
3	22/01/03 (W-4)	23,772	74.7%	3,041
4	09/04/03 (W-2)	22,204	73.5%	2,972
5	13/04/03 (S-2)	15,308	77.2%	3,383
6	10/08/03 (S-2)	19,946	74.1%	3,122
7	13/08/03 (W-2)	24,114	70.7%	2,761
8	27/08/03 (W-4)	22,569	69.6%	2,810
9	08/10/03 (W-2)	20,144	67.0%	2,736
10	12/10/03 (S-2)	17,245	67.6%	2,876
11	11/01/04 (S-2)	19,402	71.7%	2,990
12	14/01/04 (W-2)	22,502	69.3%	2,797
13	28/01/04 (W-4)	25,023	72.3%	2,914
14	11/04/04 (S-2)	16,720	76.0%	3,235
15	14/04/04 (W-2)	23,987	72.0%	2,916
16	08/08/04 (S-2)	19,631	70.0%	2,882
17	11/08/04 (W-2)	21,862	70.5%	2,789
18	25/08/04 (W-4)	25,086	69.8%	2,752
19	06/10/04 (W-2)	24,550	67.7%	2,600
20	10/10/04 (S-2)	16,660	71.6%	3,059
21	09/01/05 (S-2)	22,639	68.7%	2,859
22	12/01/05 (W-2)	28,157	68.7%	2,675
23	26/01/05 (W-4)	27,017	67.4%	2,607
24	10/04/05 (S-2)	15,914	67.3%	2,962
25	13/04/05 (W-2)	22,697	67.5%	2,584
26	10/08/05 (W-2)	22,067	66.7%	2,589
27	14/08/05 (S-2)	17,517	68.3%	2,715
28	24/08/05 (W-4)	23,994	66.0%	2,491
29	09/10/05 (S-2)	20,053	72.7%	2,929
30	12/10/05 (W-2)	19,878	69.6%	2,757

Table 7.7: Concentration measures based on total generation - selected days - Spain

Source: LE.

Table 6 presents the CR(2) and HHI measures based on total generation for the selected seasonal peaks in demand. As the constructed load is the sum of hourly generation, this table presents, for peak demand days, the degree of concentration at the seasonal high points of the load duration curve.

Table 7.8: Concentration measures based on total generation – seasonal peaks - Spain				
	Date	**Average Hourly Demand (MWh/h)**	**CR(2)**	**HHI**
Summer	13/7/2005	28,425	64.1%	2,429
	30/6/2004	27,759	69.4%	2,739
	25/6/2003	25,252	72.7%	2,926
Winter	19/12/2005	29,822	68.7%	2,632
	14/1/2003	27,034	75.3%	3,072
	20/2/2004	26,714	73.8%	2,940
Spring	1/3/2005	29,204	68.7%	2,650
	2/3/2004	26,805	69.8%	2,682
	7/3/2003	22,726	75.7%	3,103
Autumn	30/11/2005	29,181	66.8%	2,529
	18/11/2004	26,335	67.9%	2,569
	20/11/2003	24,456	70.1%	2,764

Source: LE.

Again, interestingly, there is considerable variation in the concentration measures across selected days. Some of this variation is due to seasonality. However, the market remains evidently concentrated across all seasons.

In order to further investigate the degree of concentration at different intervals in the load duration curve, base, shoulder and peak periods have been identified for a selection of the days already presented as part of the analysis of pre-selected days. The definition of base, shoulder and peak used for this analysis is as follows;

- Base is defined as the hours in the year located in the two rightmost quartiles of the load duration curve. The first 50% of hours for which demand is lowest in 2005;
- Shoulder is defined as the hours in the next quartile of the load duration curve, to the left of the base hours;

- Peak is defined as the hours in the first quartile of the load duration curve, which contains the hours for which demand is highest in 2005.

Table 7.9 presents the HHI and CR(2)values during these periods of the selected days, as well as the order of the top two companies in those hours.

Table 7.9: Total Generation – Concentration & Load Duration - Spain

January 2005		Company	CR(2)	HHI
2nd Wednesday	*Base*	NA	NA	NA
	Shoulder	0577&0875	69.2%	2,727
	Peak	0577&0875	68.6%	2,656
August 2005				
2nd Wednesday	*Base*	0577&0875	66.5%	2,582
	Shoulder	0577&0875	66.9%	2,593
	Peak	0577&0875	67.2%	2,603

Source: LE.

A number of entries appear as NA in this table due to the fact that hours corresponding to the definition of the categories do not exist on these pre-selected days. However, one can see that changing the market definition to include base peak and shoulder periods for selected days has not changed the market concentration outlook, qualitatively.

CR(2) & HHI based on In Merit/Economic Capacity

As a still further check of the traditional concentration measures and how they vary with different assumptions and over time, we calculated market shares based on in merit capacity, or capacity available to meet demand that is cost efficient (below the highest cost plant on the system). This was based on returned data. In Merit capacity has been computed based on the realised costs returned by each company. Table 7.10 presents summary statistics on the CR(2) and HHI values computed on an hourly basis. In terms of mean and variability of the concentration measures, defining the market by in merit capacity does not alter our previous conclusions.

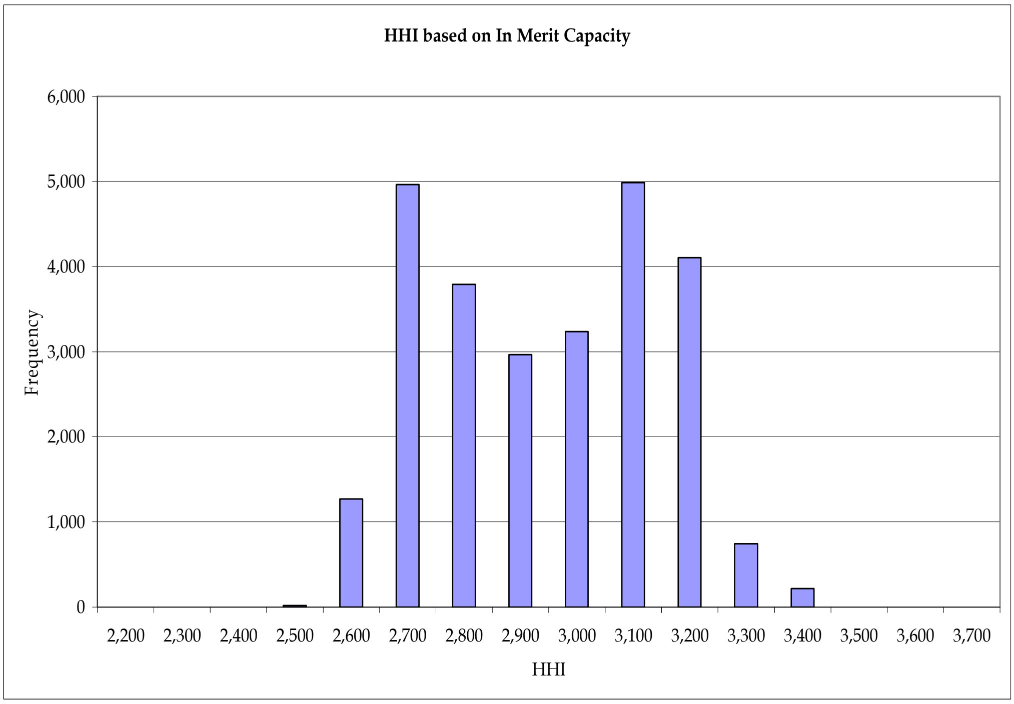
Table 7.10: Summary Statistics of CR(2) & HHI based on In Merit Capacity - Spain

	In Merit Capacity (MW)	CR(2)	HHI
Average	36,555	73.3%	2,896
Maximum	41,628	81.2%	3,429
Minimum	31,050	65.9%	2,475
Standard Deviation	1,741	3.2%	200

Source: LE

The following histogram (Figure 7 8) represents the frequency of HHI values calculated on the basis of in merit capacity.

Figure 7 8: Histogram of HHI vales based on In-Merit Capacity (2003-2005)- Spain



Source:LE.

The histogram of the HHI based on in merit capacity shows a large similarity to the base case available capacity market share definition. There is an apparent slight increase in the central tendency of the HHI, but qualitatively the results are very similar and thus not sensitive to this change in the capacity definition.

7.2.2 Interconnector

An assessment of the potential impact of interconnection has been carried out using the indicators of concentration previously presented based on Available Installed Capacity and Total Generation. Importantly, it was possible to extract details of ownership of reserved capacity and interconnector flows, by company, from the data collected by DG Competition as part of the Sector Inquiry and as a result a sensitivity analysis is conducted to put upper and lower bounds on the potential impact of interconnection on the traditional measures concentration. Two scenarios have been considered and represent a sensitivity analysis of the figures calculated in the absence of the interconnector;

1. Atomistic Competition
2. Largest Company Apportionment

1. Atomistic Competition – Under this scenario the companies' hourly market share is not affected. The aggregated impact of the interconnector is included in the denominator of both CR(1) and HHI measures, such that the net impact of the interconnectors is only added to the market. Thus, the atomistic competition scenario reduces the measured concentration by the maximum amount possible due to the interconnector.

2. Largest Company Apportionment – Under this alternative scenario the hourly impact of the interconnectors is apportioned entirely to the largest company in the market (as measured by available installed capacity). This scenario thus represents the largest increase in measured concentration possible due to the allocation of the interconnector.

The two allocation procedures thus form the upper and lower bounds of the measured concentration due to the interconnector allocation. It is important to note at this stage that the potential impact of the interconnector is accounted for differently in these scenarios depending on the basis for the calculation. The hourly net transfer capacity of the interconnectors is used in calculations based on the Available Installed Capacity of the companies in the market, while actual hourly interconnector flows are used in calculations based on Total Generation. This is important due to the potential impact of the interconnector flows on the expectations of upper and lower bounds. These bounds are true in the case of Available Installed Capacity but as one may realise, this will only be the case if the country is, on average, a net importer of electricity. In the event that the country is regarded to be an exporter, the expected results from these scenarios may be reversed. For a further discussion and formal exposition of how these interconnector scenarios are calculated, one can revert to the methodology chapter of this report.

7.2.3 Results

The following tables represent the sensitivity cases of concentration based on Available Installed Capacity, with hourly available net transfer capacity of the interconnector(s) added to the relevant variables. As implied by the calculation method explained above, concentration figures obtained under the Atomistic scenario are significantly lower than under the standard scenario which ignores the interconnector. Similarly, the CR(2) and HHI measures are now lower under the largest player apportionment scenario. Initially one may consider this to be a somewhat surprising result however, it indicates that relative to the size of the market the decrease in the market shares of all companies, other than the largest, has a greater impact on the result than does apportioning all of the available capacity on the interconnectors to the company with the largest market share.

Table 7.11 presents summary statistics on the results of the interconnector scenarios when applied to the concentration measures based on available installed capacity.

CR(2) and HHI under 2 Assumptions of Interconnector Capacity Allocation, based on Available Installed Capacity

Table 7.11: Summary Statistics Concentration measures based on Available Installed Capacity: Impact of the Interconnector - Spain

	STANDARD (excl. IC based on available installed capacity)		**ATOMISTIC**		**IC ADDED TO BIGGEST PLAYER**	
	CR(2)	**HHI**	**CR(2)**	**HHI**	**CR(2)**	**HHI**
Average	71.4%	2,790	59.6%	1,945	65.1%	2,293
Max	78.7%	3,259	67.7%	2,360	72.3%	2,682
Min	60.8%	2,318	46.9%	1,416	52.9%	1,731
Standard Deviation	3.2%	185	4.0%	210	3.3%	178

Source: LE.

The summary statistics show the impact of the interconnector. The minimum HHIs have fallen significantly, but the averages are still above the 1,800 threshold, while the maximums are considerably above the threshold. Thus, while interconnection helps, it is not likely to make the market unconcentrated.

We additionally repeated the analysis of selected days and seasons. The results are shown in Table 7.12 below. We note that the variability within seasons can be quite large. There is no striking difference in concentration between seasons.

Table 7.12: Results of HHI & CR(2) Analysis of the Impact of the Interconnector, based on hourly Available Installed Capacity - Spain

		STANDARD (excl. IC based on available gen capacity)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	Date	CR(2)	HHI	CR(2)	HHI	CR(2)	HHI
Summer	13/7/2005	66.6%	2,536	53.1%	1,609	60.0%	2,018
	30/6/2004	72.2%	2,816	62.4%	2,105	65.1%	2,283
	25/6/2003	75.0%	3,011	64.1%	2,202	68.7%	2,496
Winter	19/12/2005	68.2%	2,595	55.8%	1,734	62.1%	2,098
	14/1/2003	74.9%	3,012	63.5%	2,163	68.7%	2,490
	20/2/2004	74.0%	2,928	62.5%	2,089	68.0%	2,448
Spring	1/3/2005	68.2%	2,583	56.7%	1,783	62.3%	2,108
	2/3/2004	73.1%	2,874	61.4%	2,029	66.9%	2,374
	7/3/2003	74.1%	2,954	62.8%	2,120	67.6%	2,429
Autumn	30/11/2005	67.5%	2,545	55.0%	1,693	61.5%	2,065
	18/11/2004	69.1%	2,638	57.6%	1,833	62.8%	2,143
	20/11/2003	72.9%	2,855	62.0%	2,066	66.6%	2,366

Source: LE.

In some seasons the concentration seems to be lowered below the threshold, but in some seasons market concentration will be significant regardless of interconnector allocation and flows.

CR(2) and HHI under 2 Assumptions of Interconnector Capacity Allocation, based on Total Generation.

As similar analysis is repeated in the table that follows, with the market share definition being based on total generation and thus the interconnector flow allocations potentially changing.

As Table 7.13 clearly demonstrates the average concentration based on total generation is higher than when calculations are based on available installed capacity. In addition, the difference between the two interconnector scenarios is less pronounced.

Table 7.13: Summary Statistics Concentration measures based on Total Generation: Impact of the Interconnector - Spain

	STANDARD (excl. IC based on total generation)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	CR(2)	HHI	CR(2)	HHI	CR(2)	HHI
Average	70.4%	2,837	70.3%	2,834	70.4%	2,844
Max	85.6%	3,991	90.5%	4,272	86.2%	4,174
Min	57.6%	2,135	54.6%	1,921	58.2%	2,154
Standard Deviation	3.9%	257	4.4%	294	4.0%	276

Source: LE.

The seasonal analysis of the impact of the interconnector on concentration assessed on the basis of total generation is summarised in Table 7.14. Again, there is no clear evidence of seasonal differences in concentration.

Table 7.14: Results of HHI & CR(2) Analysis of the Impact of the Interconnector, based on hourly Total Generation - Spain							
		STANDARD (excl. IC based total generation)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	Date	CR(2)	HHI	CR(2)	HHI	CR(2)	HHI
Summer	13/7/2005	2,429	64.1%	2,523	65.3%	2,392	63.4%
	30/6/2004	2,739	69.4%	2,922	71.6%	2,653	68.4%
	25/6/2003	2,926	72.7%	2,863	71.9%	2,955	73.1%
Winter	19/12/2005	2,632	68.7%	2,706	69.7%	2,617	68.3%
	14/1/2003	3,072	75.3%	3,014	74.6%	3,087	75.6%
	20/2/2004	2,940	73.8%	3,041	75.1%	2,904	73.4%
Spring	1/3/2005	2,650	68.7%	2,617	68.3%	2,665	68.9%
	2/3/2004	2,682	69.8%	2,753	70.7%	2,654	69.5%
	7/3/2003	3,103	75.7%	3,197	76.8%	3,074	75.3%
Autumn	30/11/2005	2,529	66.8%	2,686	68.8%	2,469	65.8%
	18/11/2004	2,569	67.9%	2,487	66.8%	2,602	68.4%
	20/11/2003	2,764	70.1%	2,749	70.0%	2,775	70.2%

Source: LE.

The results from the tables and figures above show that measured concentration in the ES market does not seem particularly sensitive to the interconnector allocation procedure, regardless of the basis of the market share calculation. HHIs and *CR(n)*s stay in the range of moderately unconcentrated (about 1,700) to moderately concentrated (about 3000) for most days and hours, seasons, etc, while CR(2) is in the mid 30% range generally. Only under the max allocation rule, which forms the upper bound of concentration increase, does HHI's maximum surpass 3,000.

7.3 Electricity Specific Structural Measure

As discussed previously, electricity markets display many unique characteristics that indicate limits to the usefulness of tradition measures of market structure. We therefore have endeavoured to estimate electricity-specific structural indicators. Both the Residual Supply Index (RSI) and Pivotal Supplier Index (PSI) are calculated using the aggregated Available Capacities of the units in each companies portfolio, unlike the previous available capacity measure, this measure is complimented by adjusting the hourly available capacity figures (as discussed above) for the long-term contract position of the companies and their commitment to provide reserves for upward regulation. The long-term contract position of the companies has been adjusted to reflect any change in the net position of the companies that occurred over the period 2003-2005. This is also true for the quantity of generation committed to meet reserve requirements; this data has been taken from the TSO response to the 2005 Data Request and not from the generators' responses.

7.3.1 RSI

Since much of our further results and regression results are based on the RSI, we repeat the formula for RSI used in the methodology section. It is noteworthy that the RSI is in general specific to a chosen company. The RSI is calculated for each hour (26,304) in accordance with the following formula;

$$RSI_j = \frac{\left(\sum_{i=1}^{N} ac_i - AC_j\right)}{\sum_{i=1}^{N} hourly\_generation_i}$$

where; $i = 1, 2, \ldots, j, \ldots, N$

The companies' total available capacity and generation in each hour is indexed by i. The RSI indicator usually should have the system load as the denominator in this equation; however for the purposes of this study (for reasons outlined elsewhere) the system load has been constructed as the sum of the net hourly electrical production figures reported by all companies. This indicator has been calculated for both the four largest companies in the market in France, rather than the top two as in other countries, because the four largest companies were all of a similar size and market position. The calculation of the capacity of the largest company or chosen company is indicated by Company *j*.

Previous studies that have used this measure have attempted to apply a threshold value to the computed hourly indicator. The threshold states that if the value of the RSI is less than 110% (1.1) for more than 5% of the time, then this is indicative of a market structure that is likely to be open to non competitive behaviour. This threshold test and the threshold itself was developed by the CAISO and as applied indicates potentially troublesome periods as those where the residual supply is less than 110% of the market demand for electricity and whether or not this systematically occurs in more than 5% of the time. The threshold itself is not the result of in-depth economic analysis but rather based on knowledge of market functioning but as such one may consider tailoring the threshold for each country. This was not done as part of this report as it was considered that the 110% threshold would be appropriate to achieving the objectives of this study and would further allow for a consistent comparison across countries.

7.3.2 PSI

The PSI is calculated for each hour (26,304) in accordance with the formulae presented in the methodology section. The PSI is a zero-one indicator of when a company is needed to meet demand.

As with the RSI indicator, the PSI is traditionally calculated using the system load, however for the purposes of this study the system load is replaced by the sum of the hourly generation of the companies included in the study.

A threshold for this indicator has been constructed as part of previous studies and market analysis. The FERC apply a threshold of 20% to this measure, if the value of the measure 1 for more than 20% of the time then this is indicative of a pivotal supplier. As with the threshold applied in relation to the RSI, this threshold is not the result of rigorous economic analysis and as such should be considered to be an indicator of potential market power issues rather than a steadfast rule in relation to overall conclusions that can be drawn from the results.

7.3.3 Results

RSI Results

Table 7.15 presents the results of the threshold test for the RSI calculated on an hourly basis for both the full period and individually for each year. With the threshold set at 110%, the test requires that the value of the RSI be greater than 110% (1.1) for more than 95% of the time for the largest market participant, in order for the market outcome to be deemed competitive. This table presents the results of the threshold test for all of the large generation companies in Spain. If the percentage of hours the RSI measure is less than 110% is greater than 5% for any of the companies, then the market outcome is considered to be potentially open to non-competitive behaviour in a significant number of hours. As can be seen from the table, two companies 0577-S-ES and 0875-S-ES fail the threshold test in a large number of hours and the other two do not. Our subsequent (regression) analysis therefore focuses on these two.

Table 7.15: RSI Threshold Analysis - Spain

RSI Result	0577-S-ES	0850-S-ES	0875-S-ES	1646-S-ES
2003-05	10,805	0	12,946	164
% hrs< 110%	41.1%	0.0%	49.2%	0.6%
2003	2,823	0	4,072	0
% hrs< 110%	32.2%	0.0%	46.5%	0.0%
2004	3,844	0	4,546	1
% hrs< 110%	43.8%	0.0%	51.8%	0.0%
2005	4,138	0	4,328	163
% hrs< 110%	47.2%	0.0%	49.4%	1.9%

Source: LE

Table 7.16 presents summary statistics on the RSI. A value below 1.10 is considered potentially non competitive. There does not seem to be any apparent large changes over time, and the two companies are in similar position. The range of values, however, indicates that some time periods involve significantly more opportunity to influence prices than others.

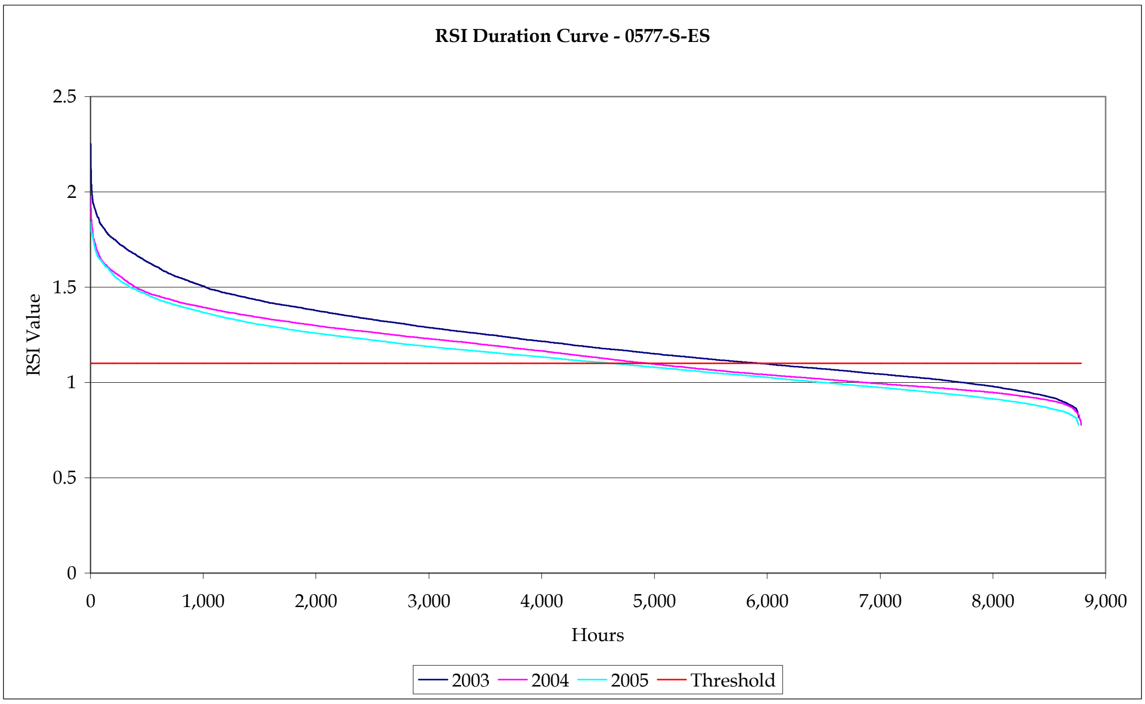
Table 7.16: Summary Statistics on RSI

	0577-S-ES				0875-S-ES			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
mean	1.18	1.23	1.16	1.14	1.13	1.15	1.11	1.13
max	2.25	2.25	1.97	1.84	2.00	2.00	1.80	1.77
min	0.78	0.82	0.78	0.78	0.77	0.80	0.78	0.77

Source: LE

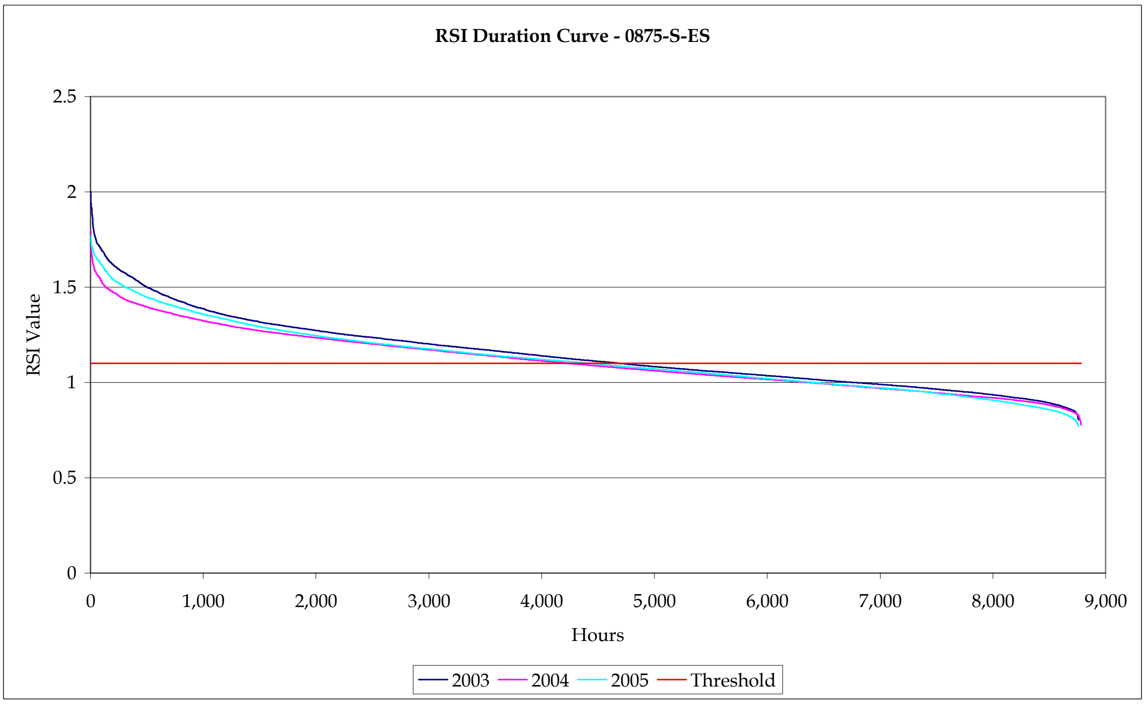
It is useful to consider the RSI for each of the two largest companies as a duration curve. This is done in Figure 7.9 and Figure 7.10 below. The figures shows the number of hours the RSI is above a point on the graph. The red line shows the threshold. The graphs clearly shows that the threshold value is not exceeded for about half of the period in the case of company 0875-S-ES, slightly less in the case of company 0577-S-ES.

Figure 7.9: RSI Duration Curves for 0577-S-ES



Source: LE.

Figure 7.10 RSI Duration Curves for 0875-S-ES



Source: LE.

Alternative RSI Scenarios

Since the RSI is potentially sensitive to different definitions of capacity and interconnector allocations, we check these using sensitivity analysis. As a sensitivity test on the RSI values presented above, the RSI is re-estimated under two alternative scenarios. Firstly, by excluding the long-term contract positions of the companies from the calculation of available capacity, and secondly, by excluding the companies' upward reserve commitments from the same calculation.

Table 7.17 presents the results of the threshold test when long-term contracts have been excluded from the calculation of available capacity. In general, the conclusions from the previous analysis are largely unaffected; the RSIs of each company are not significantly changed by including reserves.

Table 7.17: RSI Threshold Analysis - Scenario 1 (accounts for Reserves only) - Spain				
RSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	10,802	0	12,946	164
% hrs< 110%	41.1%	0.0%	49.2%	0.6%
2003	2,823	0	4,072	0
% hrs< 110%	32.2%	0.0%	46.5%	0.0%
2004	3,844	0	4,546	1
% hrs< 110%	43.8%	0.0%	51.8%	0.0%
2005	4,135	0	4,328	163
% hrs< 110%	47.2%	0.0%	49.4%	1.9%
Source: LE				

Table 7.18 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Spain (based on market share of total installed capacity).

Table 7.18: Summary Statistics on RSI - Scenario 1 (accounts for Reserves only) - Spain								
	0577-S-ES				**0875-S-ES**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
mean	1.18	1.23	1.16	1.14	1.13	1.15	1.11	1.13
max	2.25	2.25	1.97	1.84	2.00	2.00	1.80	1.77
min	0.78	0.82	0.78	0.78	0.77	0.80	0.78	0.77
Source: LE								

Table 7.19 presents the results of the threshold test when upward reserve commitments have been excluded from the calculation of available capacity. The number of hours in which the RSI was below the threshold level of 110%is slightly higher than under the previous scenario.

Table 7.19: RSI Threshold Analysis - Scenario 2 (accounts for LTC only) - Spain				
RSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	11,500	0	13,481	176
% hrs< 110%	43.7%	0.0%	51.3%	0.7%
2003	3,106	0	4,239	0
% hrs< 110%	35.5%	0.0%	48.4%	0.0%
2004	4,057	0	4,722	1
% hrs< 110%	46.2%	0.0%	53.8%	0.0%
2005	4,337	0	4,520	175
% hrs< 110%	49.5%	0.0%	51.6%	2.0%
Source: LE				

We conclude that including long-term contracts has some impact on the number of hours less than the threshold, but the broad qualitative conclusion that the two largest companies have the ability to influence price in a larger than significant number of hours remains the same.

Table 7.20 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Spain (based on market share of total installed capacity). The figures are rather similar to the case with LTC included.

Table 7.20: Summary Statistics on RSI - Scenario 2 (accounts for LTC only) - Spain								
	0577-S-ES				**0875-S-ES**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
mean	1.16	1.21	1.15	1.12	1.12	1.14	1.10	1.12
max	2.23	2.23	1.95	1.82	1.98	1.98	1.78	1.76
min	0.77	0.80	0.77	0.77	0.76	0.80	0.77	0.76
Source: LE								

7.3.4 PSI Results

The results of the PSI analysis for the large generation companies in Spain are presented in Table 7.21. As discussed above the PSI is a (0,1) variable, equal to 1 if the company is deemed to be pivotal to supply in a given hour and zero if not. An established threshold test for this measure is one applied by FERC which considers a market participant to be pivotal, and thus the market outcome not to be competitive, if the PSI for any company is equal to one for more than twenty percent of the time.

Table 7.21 shows the two largest companies in Spain, 0577-S-ES and 0875-S-ES, relatively evenly matched in terms of the hours in which they were the pivotal suppliers, especially in 2005. Seen over the whole period, company 0875-S-ES has been pivotal most frequently, approximately a quarter of the time.

Table 7.21: PSI Threshold Analysis - Spain

PSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	5,219	0	6,759	7
% hrs =1	19.8%	0.0%	25.7%	0.0%
2003	1,033	0	1,990	0
% hrs =1	11.8%	0.0%	22.7%	0.0%
2004	1,919	0	2,422	0
% hrs =1	21.8%	0.0%	27.6%	0.0%
2005	2,267	0	2,347	7
% hrs =1	25.9%	0.0%	26.8%	0.1%

Source: LE

Alternative PSI Scenarios

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenarios. Table 7.22 presents the results of the PSI threshold test having excluded long-term contracts from the analysis. A comparison of the results of this alternative scenario with those in Table 7.21 shows differences to be minute.

Table 7.22: PSI Threshold Analysis - Scenario 1 (accounts for Reserves only) - Spain

PSI Result	0577-S-ES	0850-S-ES	0875-S-ES	1646-S-ES
2003-05	5,221	0	6,759	7
% hrs =1	19.8%	0.0%	25.7%	0.0%
2003	1,033	0	1,990	0
% hrs =1	11.8%	0.0%	22.7%	0.0%
2004	1,923	0	2,422	0
% hrs =1	21.9%	0.0%	27.6%	0.0%
2005	2,265	0	2,347	7
% hrs =1	25.9%	0.0%	26.8%	0.1%

Source: LE

Table 7.23 presents the results of the PSI threshold test under Alternative Scenario 2, whereby upward reserve commitments have been excluded from the calculation of available capacity. In general, the two companies 0577-S-ES and 875 are mostly above 20% threshold, while the other companies are almost never pivotal. This conclusion is not sensitive to the treatment of reserves.

Table 7.23: PSI Threshold Analysis - Scenario 2 (accounts for LTC only) - Spain				
PSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	5,832	0	7,371	8
% hrs =1	22.2%	0.0%	28.0%	0.0%
2003	1,205	0	2,198	0
% hrs =1	13.8%	0.0%	25.1%	0.0%
2004	2,180	0	2,668	0
% hrs =1	24.8%	0.0%	30.4%	0.0%
2005	2,447	0	2,505	8
% hrs =1	27.9%	0.0%	28.6%	0.1%
Source: LE				

7.3.5 Interconnector

To account for the potential impact of the interconnectors on the RSI and PSI measures, two sensitivity cases are calculated within this section to address this issue. Given interconnector capacity reservations and flows are not available at the company level it has been necessary to consider two hypothetical situations in order to assess the impact. The two scenarios are briefly described here;

1. The hourly interconnector capacity (IC_c), aggregated over the interconnectors, is added to the total supply of the market and apportioned in accordance with the companies' market shares (as measured by installed capacity) in the market being assessed. The hourly aggregated interconnector flows (IC_f) are added to the load.
2. The hourly interconnector capacity (IC_c) of each interconnector is added to the total supply of the market and the hourly available capacity of each interconnector is apportioned in accordance with the companies' market shares (as measured by installed capacity) in the markets from which electricity can be imported. The hourly aggregated interconnector flows (IC_f) are added to the load.

It is important to note that in all hours the interconnector flows are not necessarily positive values, they will be negative in hours where the market exports more electricity than it imports, therefore necessarily increasing the residual supply relative to the load, holding other factors equal.

The following sections contain the RSI and PSI analysis under the different interconnector scenarios. Qualitatively, the results are largely unaffected however the interconnector can be seen to have an impact on the degree of market power and concentration in the Spanish market.

7.3.6 Results (Interconnector allocated according to domestic market share)

RSI Results

Table 7.24 presents the results of the threshold test for the RSI calculated on an hourly basis for both the full period and individually for each year with the interconnector allocated in proportion to the domestic market share.

Table 7.24: RSI Threshold Analysis (+IC domestic) - Spain

RSI Result	0577-S-ES	0850-S-ES	0875-S-ES	1646-S-ES
2003-05	7,105	0	8,806	16
% hrs< 110%	27.0%	0.0%	33.5%	0.1%
2003	1,971	0	3,161	0
% hrs< 110%	22.5%	0.0%	36.1%	0.0%
2004	2,554	0	2,987	0
% hrs< 110%	29.1%	0.0%	34.0%	0.0%
2005	2,580	0	2,658	16
% hrs< 110%	29.5%	0.0%	30.3%	0.2%

Source: LE

The allocation of the interconnector seems to have some impact on the percentage of hours the RSI exceeds the threshold, but both companies' RSI are approximately in the 25% to 35% range (of percent of hours the threshold is exceeded). This leads to a qualitatively similar conclusion as before (without the interconnector); the ability to behave anticompetitively exists in a significant number of hours.

Table 7.25 presents summary statistics on the RSI for the two largest companies in Spain.

Table 7.25: Summary Statistics on RSI (+IC domestic) - Spain								
	0577-S-ES				0875-S-ES			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.25	1.28	1.24	1.23	1.20	1.20	1.19	1.22
Max	2.33	2.33	2.08	2.06	2.07	2.07	1.88	1.99
Min	0.82	0.86	0.82	0.83	0.81	0.84	0.81	0.81
Source LE								

Alternative RSI Scenarios

Table 7.26 presents the results of the threshold test when upward reserve commitments have been excluded from the calculation of available capacity. We additionally include both the interconnector allocation and the LTC analysis. The percentage of hours below the threshold on average is slightly higher than in the base case.

Table 7.26: RSI Threshold Analysis (+IC domestic) - Scenario 2 (accounts for LTC only) - Spain				
RSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	7,729	0	9,351	23
% hrs< 110%	29.4%	0.0%	35.5%	0.1%
2003	2,224	0	3,360	0
% hrs< 110%	25.4%	0.0%	38.4%	0.0%
2004	2,773	0	3,173	0
% hrs< 110%	31.6%	0.0%	36.1%	0.0%
2005	2,732	0	2,818	23
% hrs< 110%	31.2%	0.0%	32.2%	0.3%
Source: LE				

Table 7.27 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Spain (based on market share of total installed capacity).

Table 7.27: Summary Statistics on RSI (+IC domestic) - Scenario 2 (accounts for LTC only) - Spain

	0577-S-ES				0875-S-ES			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.24	1.26	1.23	1.22	1.19	1.19	1.18	1.21
Max	2.30	2.30	2.06	2.04	2.05	2.05	1.86	1.98
Min	0.81	0.85	0.81	0.82	0.80	0.83	0.80	0.80

Source: LE

Again, while some impact on the RSI of the main companies is evident, the results are largely insensitive to the reserves and interconnector allocation.

PSI Results

The results of the PSI analysis for the large generation companies in Spain are presented in Table 7.28. As discussed above the PSI is a (0,1) variable, equal to 1 if the company is deemed to be pivotal to supply in a given hour and zero if not. An established threshold test for this measure is one applied by FERC which considers a market participant to be pivotal, and thus the market outcome not to be competitive, if the PSI for any company is equal to one for more than twenty percent of the time.

As table Table 7.28 shows, when the interconnector is taken into account, no Spanish generator exceeded this threshold during the period we investigated.[16] Moreover, in terms of the PSI measure, company 0577-S-ES and company 0875-S-ES appear relatively evenly matched, as before.

[16] It might be noted though, that the 20% threshold can be in general considered as *prima facie* evidence of the existence of market power in a significant number of hours. It may still be considered that being pivotal in say 15% of hours is not acceptable.

Table 7.28: PSI Threshold Analysis (+IC domestic) - Spain				
PSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	2,234	0	3,442	0
% hrs =1	8.5%	0.0%	13.1%	0.0%
2003	596	0	1,172	0
% hrs =1	6.8%	0.0%	13.4%	0.0%
2004	669	0	1,202	0
% hrs =1	7.6%	0.0%	13.7%	0.0%
2005	969	0	1,068	0
% hrs =1	11.1%	0.0%	12.2%	0.0%
Source: LE				

Alternative PSI Scenarios

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenario. Table 7.29 presents the results of the PSI threshold test having excluded upward reserve commitments from the analysis. Excluding upward reserve commitments has no significant quantitative impact.

Table 7.29: PSI Threshold Analysis (+IC domestic) - Scenario 2 (accounts for LTC only) - Spain				
PSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	2,656	0	3,819	0
% hrs =1	10.1%	0.0%	14.5%	0.0%
2003	716	0	1,318	0
% hrs =1	8.2%	0.0%	15.0%	0.0%
2004	866	0	1,330	0
% hrs =1	9.9%	0.0%	15.1%	0.0%
2005	1,074	0	1,171	0
% hrs =1	12.3%	0.0%	13.4%	0.0%
Source: LE				

7.3.7 Results (Interconnector allocated according to foreign market share)

RSI Results

Table 7.30 presents the results of the threshold test for the RSI calculated on an hourly basis for both the full period and individually for each year. The results are somewhat sensitive to the interconnector allocation method. The allocation according to market share in the foreign country evidently raises the RSI, but reduces the number of hours the two largest companies are below the threshold. The number of hours the 110% threshold is exceeded is still well above the suggested 5% critical value.

Table 7.30: RSI Threshold Analysis (+IC foreign) - Spain

RSI Result	0577-S-ES	0850-S-ES	0875-S-ES	1646-S-ES
2003-05	5,257	0	6,664	8
% hrs< 110%	20.0%	0.0%	25.3%	0.0%
2003	1,486	0	2,442	0
% hrs< 110%	17.0%	0.0%	27.9%	0.0%
2004	1,894	0	2,290	0
% hrs< 110%	21.6%	0.0%	26.1%	0.0%
2005	1,877	0	1,932	8
% hrs< 110%	21.4%	0.0%	22.1%	0.1%

Source: LE

Table 7.31 presents summary statistics on the RSI for the two largest companies.

Table 7.31: Summary Statistics on RSI (+IC foreign) - Spain								
	0577-S-ES				0875-S-ES			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.29	1.31	1.28	1.28	1.25	1.24	1.23	1.27
Max	2.39	2.39	2.14	2.13	2.15	2.15	1.95	2.07
Min	0.84	0.88	0.84	0.86	0.84	0.86	0.84	0.84
Source: LE								

Alternative RSI Scenario

Table 7.32 presents the results of the threshold test when upward reserve commitments have been excluded from the calculation of available capacity. Allocating the interconnector and including only long term contracts has a quantitative impact on the RSI, but does not seem to qualitatively, as the RSIs are still below the 110% threshold about 20 to 30% of the time. There does not appear to be much variation over time in this conclusion.

Table 7.32: RSI Threshold Analysis (+IC foreign) - Scenario 2 (accounts for LTC only) - Spain				
RSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	5,870	0	7,131	9
% hrs< 110%	22.3%	0.0%	27.1%	0.0%
2003	1,685	0	2,616	0
% hrs< 110%	19.2%	0.0%	29.9%	0.0%
2004	2,153	0	2,453	0
% hrs< 110%	24.5%	0.0%	27.9%	0.0%
2005	2,032	0	2,062	9
% hrs< 110%	23.2%	0.0%	23.5%	0.1%
Source: LE				

Table 7.33 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Spain (based on market share of total installed capacity).

Table 7.33: Summary Statistics on RSI (+IC foreign) - Scenario 1 (accounts for LTC only) - Spain								
	0577-S-ES				0875-S-ES			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.28	1.30	1.27	1.27	1.24	1.23	1.22	1.26
Max	2.37	2.37	2.12	2.11	2.13	2.13	1.93	2.06
Min	0.83	0.87	0.83	0.86	0.84	0.85	0.84	0.84
Source: LE								

PSI Results

The results of the PSI analysis for the large generation companies in Spain are presented in Table 7.34. As discussed above the PSI is a (0,1) variable, equal to 1 if the company is deemed to be pivotal to supply in a given hour and zero if not. An established threshold test for this measure is one applied by FERC which considers a market participant to be pivotal, and thus the market outcome not to be competitive, if the PSI for any company is equal to one for more than twenty percent of the time.

Including the interconnector according to foreign market shares lowers the percentage of hours at the critical PSI level still further, to about 5% for company 0577 and about 7-9% for company 0875.

Table 7.34: PSI Threshold Analysis (+IC foreign) - Spain				
PSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	1,311	0	2,154	0
% hrs =1	5.0%	0.0%	8.2%	0.0%
2003	403	0	761	0
% hrs =1	4.6%	0.0%	8.7%	0.0%
2004	361	0	737	0
% hrs =1	4.1%	0.0%	8.4%	0.0%
2005	547	0	656	0
% hrs =1	6.2%	0.0%	7.5%	0.0%
Source: LE				

Alternative PSI Scenario

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenario. Table 7.35 presents the results of the PSI threshold test having excluded upward reserve commitments from the analysis. Combining the sensitivity analysis of the interconnector allocation according to foreign market share and including only long term contracts in the calculation of available capacity raises the PSI of company 0577 slightly to about 5-6%, so the results are not too sensitive to this.

Table 7.35: PSI Threshold Analysis (+IC foreign) - Scenario 1 (accounts for LTC only) - Spain				
PSI Result	**0577-S-ES**	**0850-S-ES**	**0875-S-ES**	**1646-S-ES**
2003-05	1,586	0	2,431	0
% hrs =1	6.0%	0.0%	9.2%	0.0%
2003	493	0	856	0
% hrs =1	5.6%	0.0%	9.8%	0.0%
2004	465	0	841	0
% hrs =1	5.3%	0.0%	9.6%	0.0%
2005	628	0	734	0
% hrs =1	7.2%	0.0%	8.4%	0.0%
Source: LE				

Conclusions

Broadly speaking the Spanish wholesale electricity market is moderately concentrated. By either traditional concentration measures or electricity-specific electricity measures such as RSI and PSI, the market is moderately concentrated, or would exhibit a structure that might raise competitive concerns. This conclusion is in general not sensitive to various possible sensitivities to the definition of the market or market shares, the type of market structure measure, or the time period in question, with a few exceptions. In some cases, such as with interconnector allocation and excluding upward reserve commitments, the PSI measures fall below a suggested threshold of 20%.

7.4 Contribution to OMEL Prices

This analysis assesses the contribution of three factors, (the GED system modelled marginal cost, the estimated costs of carbon and the estimated mark-up) to the load weighted average OMEL price. Table 7.36 and Figure 7.11 present the annual contribution of these three factors to the load weighted average OMEL price.

Over the course of the three years, one can see that the average cost of generation increased significantly from year to year. This is likely due to a number of factors including increases in fuel costs and a changing portfolio of generation assets. Over this period the load weighted average OMEL price does not appear to follow the same pattern, the price remains relatively stable in the first two years, it actually decreases slightly in 2004, and then in 2005 there is a substantial increase, an increase that coincides with the introduction of the ETS in January of that year. The full economic cost of CO_2 is, on average, equal to €10.12/MWh in Spain, based on a load weighted average of the cost. This additional cost should be added to the system marginal cost to find the true economic cost of generation, on average, in Spain in 2005. Even with this additional cost factored in, on average, the mark-up on electricity improved markedly on the previous year. Our analysis indicates that the mark-up earned in the market, on average, initially fell from €6.29/MWh in 2003, to €1.39/MWh in 2004, before increasing to a three year high of €12.10/MWh in the final year. Importantly, one should remember that the CO_2 certificates introduced under the ETS were provided to companies for free in 2005, thus not impacting on their actual accounting cost of generation which one may consider to contribute to the overall mark-up.

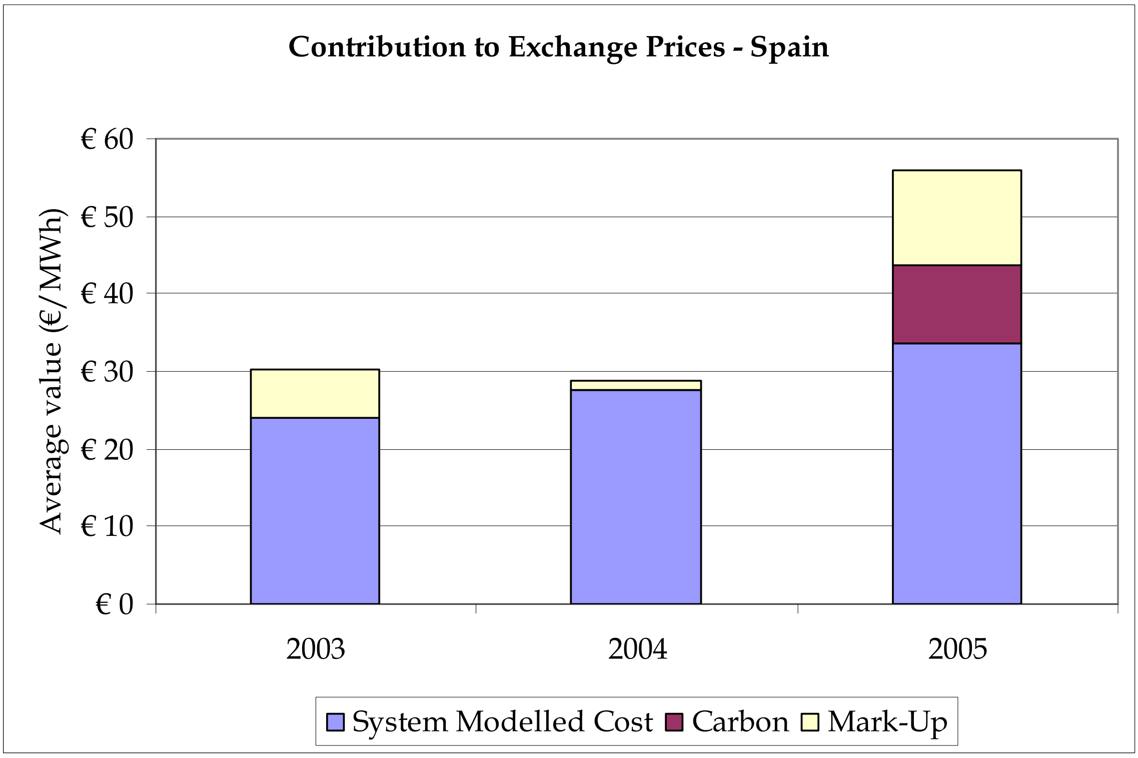
Table 7.36: Contribution of Cost, Carbon and Mark-up to OMEL Prices - Spain

	2003	2004	2005
Sys Modelled MC	€ 23.95	€ 27.51	€ 33.65
Carbon	€ 0.00	€ 0.00	€ 10.12
Mark-Up	€ 6.29	€ 1.39	€ 12.20
Total	€ 30.24	€ 28.89	€ 55.97
OMEL Price	€ 30.24	€ 28.89	€ 55.97

Note: Based on load weighted average of prices and costs
Source: LE

Figure 7.11 provides a graphical representation of the above table. Within each year one can see the load weighted average contributions of each of the three factors to the overall load weighted average OMEL price.

Figure 7.11: Contribution to Exchange Prices - Spain



Source: LE.

7.5 Outcome Measures

This section presents a number of indicators measuring market outcomes. We start by looking at composition of wholesale electricity prices, after which we proceed to investigate margins and mark-ups observed in the market. We conclude this section with a more detailed look at the impact of the cost of carbon under the ETS, and the contribution to fixed cost.

7.5.1 Price-Cost Margin (Lerner Index)

The Price-Cost Margin/Lerner Index (LI) has been calculated hourly based on the System Marginal Cost and the publicly available price of electricity for each hour in the period 2003-2005. The formula for the LI is as follows;

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

However, the use of a simple average has been rejected in favour of a load weighted average approach. Therefore, a more accurate description of the above equation is to consider each of the variables to be load weighted averages of the relevant period. A more formal exposition of this approach is presented in the methodology chapter of this report.

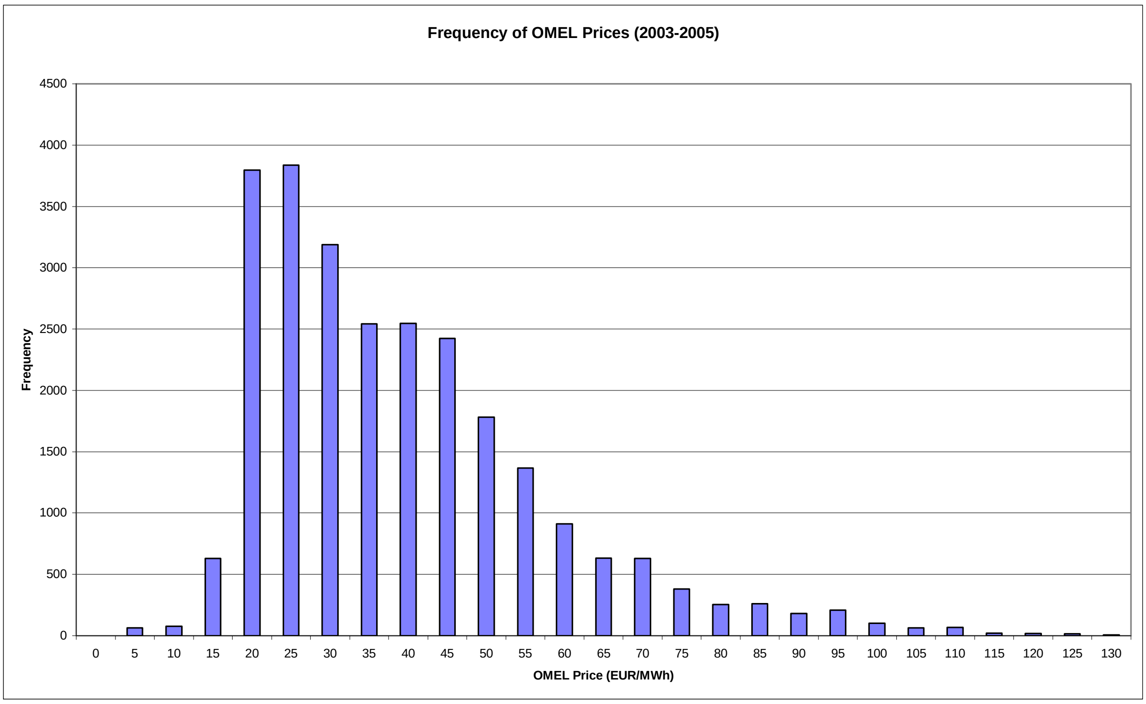
Two different sets of prices are used for this analysis;

3. The hourly day ahead prices published by the Spanish Market operator, Compañía Operadora del Mercado Español de Electricidad (OMEL).

4. Platts Assessments Prices – this data set provides a daily base and peak price for the majority of weekdays in the period and a base price for electricity at weekends.

The frequency of hourly prices (€/MWh) on the OMEL over the period of the study is presented in the following histogram.

Figure 7.12: Frequency of OMEL Prices (2003-2005) - Spain



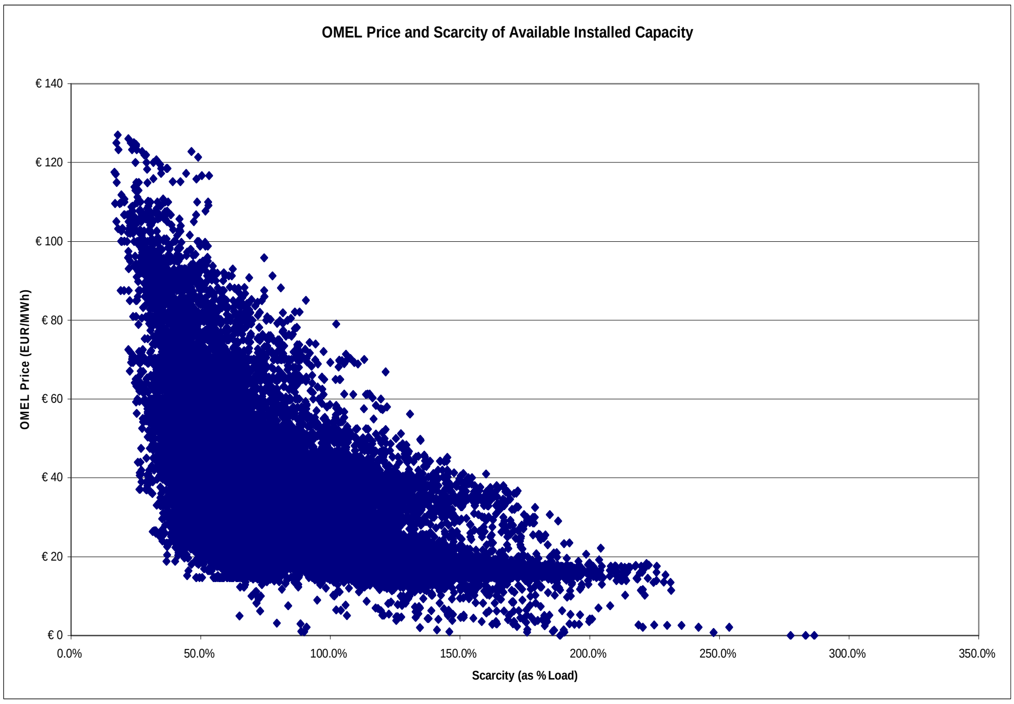
Source: LE.

Figure 7.12 shows the distribution and tendency of the hourly OMEL prices. The lowest prices tend towards zero and the highest prices tend to be above €130/MWh, albeit in a very small percentage of hours. We note that negative markups are not uncommon in electricity markups nor economically unexpected. Because of start up costs and other operational factors and risks, companies are prepared to pay a premium to avoid shutting down at night and off peak (they pay a premium by not buying electricity at the market price and running at a cost above the market price).

In general, it is useful to consider the appropriateness of a candidate price for our margin analysis in every hour. For the OMEL price to be considered a relevant price for electricity in Spain it should be seen to reflect changing market dynamics within the Spanish electricity market. Alternatively, the price of electricity on the OMEL should reflect the scarcity of available generation capacity in any one hour on the system. In general, to the extent that marginal cost in electricity naturally would rise as demand reaches peaks due to the trade-off between thermal efficiency and capital cost in electricity generation technology, the price of electricity on the UKPX should reflect the scarcity of available generation capacity in any one hour on the system. In other words, the price should rise with scarcity and peakiness of the system based on the slope of the merit curve. The following graph represents the relationship between the hourly price of electricity on the OMEL and the scarcity of available generation capacity, expressed as a percentage of the load (sum of generation) in that hour.

The scarcity of available generation capacity in any one hour is computed using the following formula.

Figure 7.13: OMEL & Scarcity of Available Generation Capacity - Spain



Source: LE.

One can see from Figure 7.13 that high OMEL prices correspond to times of relative scarcity of generation capacity, with a higher price generally reflecting scarcity. The correlation coefficient of the two series over the entire sample period is -0.60[17].

The relationship between these two variables indicates that the OMEL price is an appropriate price to use in order to reflect the price of electricity in Spain. However as indicated above, the Platts assessment price of electricity in Spain will also be used in calculations of the LI. This price series provides a base and peak price for electricity on a daily basis on weekdays and a base price for electricity on weekends. As this price is constant for all hours of base and peak in the relevant days, this price may be a more appropriate representation of the price of electricity contracted forward (over periods greater than a day) in Spain, a quantity considerably greater than that traded on a day ahead basis. Further, the Platts price will not reflect scarcity in the hourly sense. Further, there may be forward or other premia in the Platts price that are economically not reflective of non competitive impacts on margins. Nonetheless we use the Platts price as a comparator for a high-level check of the OMEL price.

The analysis also considers two estimates of Marginal Cost for the system;

1. The System Marginal Cost estimated as part of GED's optimal despatch run.

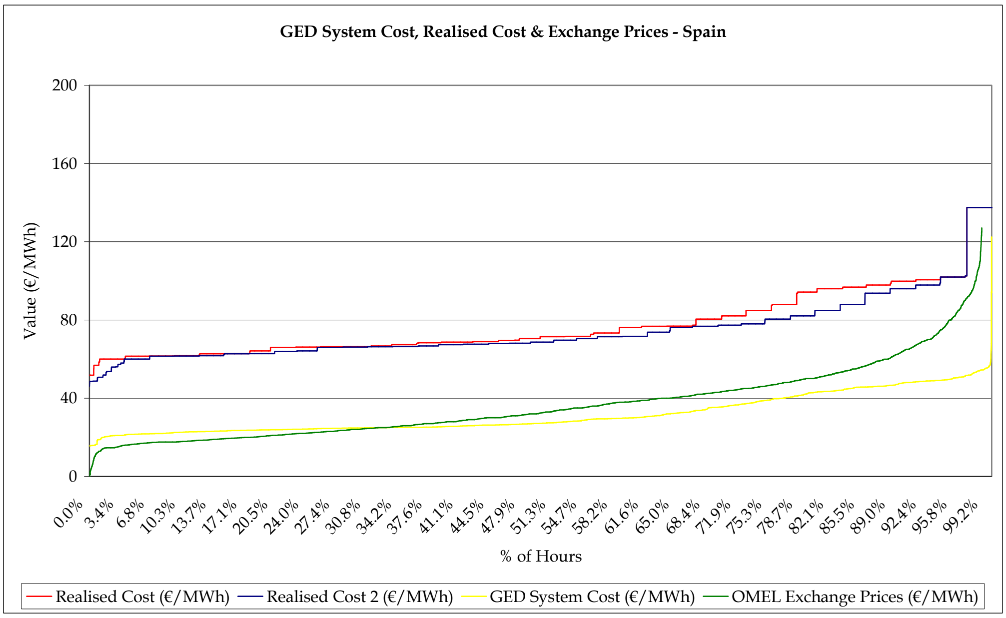
2. A simple stacking of the returned realised cost of generation (fuel cost) provided for each unit, with the highest cost unit generating in any one hour setting the system marginal cost. This cost only considers the fuel cost of generation.

3. Same as 2, with all units with capacity less than 25 MW, or designated must-run or CHP removed from the analysis. This is done in recognition of the fact that those units will not set the market price.

The relationship between these two series and changes over time can be seen in Figure 7.14.

[17] OMEL prices were not available for 12 days in 2005.

Figure 7.14: Comparison of GED System Modelled Cost, Realised Cost and Exchange Prices - Spain



Source: LE.

As one can see from this graph, the maximum system realised cost of generation returned by the companies is always significantly greater than the system marginal cost estimated by GED's optimal despatch simulation. There are a number of potential reasons for this. Simple stacking models are unable to reflect many market conditions in electricity markets. Unit-specific characteristics may require units to run but not set the price, "must-run" units or units that are run to provide system balancing or reserves may have a cost greater than the system marginal cost but as these units are not being dispatched they do not affect the price. The fact that must-run, CHP, and other such units "should" not set the price is common to electricity market marginal cost estimation. This may similarly be the case for some CHP units whose primary function is to provide heat and for whom electricity production is a by-product. These units are not seen as economically relevant price setters because in general they are not representative of capable of providing the next megawatt of energy on the system. Further, in the case of many units, energy is a joint product with other products, and the true marginal cost of energy is economically only the additional cost of production of energy, after the primary product has been produced. Nevertheless, both costs are represented within this analysis. The Realised Cost 2 curve, which takes account of some of the problems by excluding CHP and must-run units, as well as units with capacities up to 25 MW, is also shown in the graph above.

The units with capacities of less than 25MW have been aggregated by companies in their responses' to DG Competition's data request as part of the Sector Inquiry. Both costs and generation output have been aggregated by technology and there is no indication as to whether any of the constituent units are must run. The costs returned by companies are also potentially inclusive of a number of other costs not included in the calculation of the €/MWh fuel cost undertaken on a monthly basis for all other units (those greater than 25MW). Therefore these units have been removed from possibly setting the system cost in the simple stacking model for Realised Cost 2 as it was not possible to determine if only fuel costs were reported and more importantly whether these units were must-run or CHP units, the reason for excluding the other units as part of Realised Cost 2.

One may also notice that there are a number of hours where the GED modelled system cost is greater than the OMEL price, thus indicating that there are a number of hours where companies' cost of generation in a competitive environment is in excess of the observed power exchange prices. Part of this can be explained by recourse to reasons similar to those discussed previously in relation to the divergence between the GED modelled cost and the realised costs of units. Power exchange prices can be representative of the residual values of energy on the system and since in reality, electricity that is placed on the grid can often be produced as a joint product with electricity committed to long-term supply contracts, ancillary services, electricity and heat for on-site industrial processes, and general heat production. Additionally, generators might rationally be willing to pay to avoid shutting down and incurring stop and start costs, thus resulting in them effectively dumping electricity on the system. Furthermore, there are technical and operational reasons power plant operators may wish to avoid shutting down and starting on a daily/frequent basis, such as wear and tear on the machine and the increased probability of a forced outage. This result has similarly been found previously in studies of electricity markets in Europe and the US.

Summary statistics on the GED MC, Realised Cost and Realised Cost 2 are provided in Table 7.37.

Table 7.37: Comparison of GED System Marginal Cost & Realised Marginal Cost - Spain					
		Average	**Minimum**	**Maximum**	**St Dev**
2003-2005	*GED MC*	€ 31.59	€ 15.65	€ 122.36	€ 9.75
	Realised Cost	€ 77.13	€ 51.75	€ 137.60	€ 16.46
	Realised Cost 2	€ 74.34	€ 46.10	€ 137.60	€ 15.75
2003	*GED MC*	€ 23.76	€ 15.65	€ 68.08	€ 2.81
	Realised Cost	€ 66.24	€ 51.75	€ 71.61	€ 3.65
	Realised Cost 2	€ 66.03	€ 46.10	€ 71.61	€ 4.19
2004	*GED MC*	€ 27.42	€ 19.14	€ 65.32	€ 3.42
	Realised Cost	€ 70.74	€ 56.86	€ 100.53	€ 10.40
	Realised Cost 2	€ 65.75	€ 46.78	€ 76.14	€ 5.86
2005	*GED MC*	€ 43.60	€ 29.82	€ 122.36	€ 6.57
	Realised Cost	€ 94.42	€ 70.72	€ 137.60	€ 15.29
	Realised Cost 2	€ 91.27	€ 62.45	€ 137.60	€ 16.22

Source: LE

In general, the realised costs are on the order of two times the modelled marginal system cost. This relationship seems to have been stable over time. The relationship does not hold for the maximum prices, where the maximum modelled marginal cost in general approaches the returned cost, for example, €122 in 2005 and €137/MWh respectively for the modelled marginal cost and the realised cost. Given the difference between Realised Cost and Realised Cost 2, one can clearly see that it is not likely to be the inclusion of the must-run, CHP and less than 25MW units that are driving the difference between the returned costs of the companies and the system marginal cost estimated by GED's optimal despatch modelling of the system.

7.5.2 Results

GED Modelled System Marginal Cost and OMEL Prices

An important element of our analysis is the use the modelled marginal cost and market prices to estimate an indicator of market margins. Table 7.38 presents the average of the hourly Lerner Index values estimated for Spain based on the system marginal cost returned by the GED optimal despatch simulation and the OMEL price.

The average margins, for both LI and PCMU, are the margins at the weighted averages (rather than the average of the margins), where the weights are formed by the annual share of total load in the hour.

Table 7.38: Average LI based on GED System Marginal Cost & OMEL Prices (including carbon) - Spain

	2003-05	2003	2004	2005
Lerner Index	17.2%	20.8%	4.8%	21.8%

Note: Based on load weighted average of prices and costs
Source: LE

Table 7.39: Average LI based on GED System Marginal Cost & OMEL Prices (excluding carbon) - Spain

	2003-05	2003	2004	2005
Lerner Index	26.1%	20.8%	4.8%	39.8%

Note: Based on load weighted average of prices and costs
Source: LE

As measured by the LI, it can be seen that the margins in the Spanish market have changed over time. Margins stood estimated at about 21% in 2003, but, when excluding carbon price/impact, jump to almost 40% in 2005. Without carbon, the margins seem to go down in 2004, but back up in 2005.

It is important to realise that the margins and the incentives in the OMEL may have changed over time due to restructuring payments, called competitive transition charges (CTCs) in the Spanish market. Essentially, companies with large market shares and large shares of the pool of charges (as stranded cost recovery mechanism) had potential incentives to keep prices low. See Fabra (2005) for details.

GED Modelled System Marginal Cost and Platts Assessment Prices

Table 7.40 presents the average of the hourly LI calculated using Platts Assessment prices. In order to calculate the hourly LI it has been necessary to impose the daily reported peak and base prices on all hours that correspond to that period; peak is 08:00 – 00:00 and base is 00:00 – 08:00.

Table 7.40: Average LI based on GED System Marginal Cost & Platts Assessment Prices (Day-Ahead) - Spain

	2003-05	2003	2004	2005
Lerner Index	13.9%	20.0%	3.6%	16.1%

Note: Based on load weighted average of prices and costs
Source: LE

Interestingly the margins based on Platts assessment prices where somewhat similar to the OMEL price based margins in 2003, while they are slightly lower than the OMEL based margins in 2005 (and much lower if including carbon).

Price Cost Mark-Up

An alternative measure of margin is the price cost mark up. As with the Price-Cost Margin/Lerner Index, the Price-Cost Mark-Up (PCMU) has been calculated based on the GED System Cost and the publicly available price of electricity for each hour in the period 2003-2005. The formula for the PCMU is as follows;

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

As with the Lerner Index, the use of a simple average is rejected in favour of a load weighted average approach. Therefore, a more accurate description of the above equation is to consider each of the variables to be load weighted averages of the relevant period. A more formal exposition of this approach is presented in the methodology chapter of this report.

7.5.3 Results

Price-Cost Mark-Up based on GED Modelled System Marginal Cost and OMEL Prices

Table 7.41 presents the average of the hourly PCMU values estimated for Spain based on the system marginal cost returned by the GED optimal despatch simulation and the OMEL price. The margins as measures by the PC mark up are slightly higher in 2005 than the LI. This is largely due to the construction of the indicator.

Table 7.41: Average PCMU based on GED System Marginal Cost & OMEL Prices (including carbon) - Spain

	2003-05	2003	2004	2005
Price-Cost Mark-Up	20.8%	26.2%	5.0%	27.9%

Note: Based on load weighted average of prices and costs
Source: LE

Table 7.42: Average PCMU based on GED System Marginal Cost & OMEL Prices (excluding carbon) - Spain

	2003-05	2003	2004	2005
Price-Cost Mark-Up	35.3%	26.2%	5.0%	66.0%

Note: Based on load weighted average of prices and costs
Source: LE

Price-Cost Mark-Up based on GED Modelled System Marginal Cost and Platts Assessment Prices

Table 7.43 presents the average of the hourly PCMU calculated using Platts Assessment prices. The conclusion, that the Platts prices show lower margins in 2005 than the OMEL based margins, is similar for the PCMU as was the case for the LI.

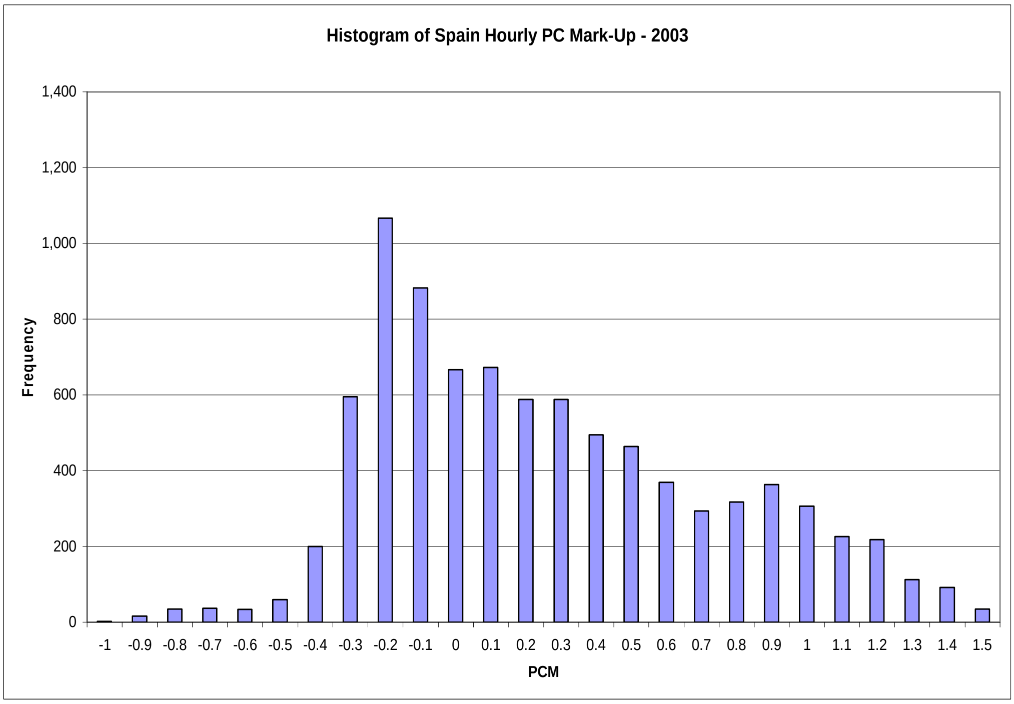
Table 7.43: Average PCMU based on GED System Marginal Cost & Platts Assessment Prices (Day-Ahead) - Spain				
	2003-05	**2003**	**2004**	**2005**
Price-Cost Mark-Up	16.1%	24.9%	3.7%	19.2%
Note: Based on load weighted average of prices and costs *Source: LE*				

7.5.4 Hourly PCMU Histograms

Below are the histograms of the hourly PCMU value in each year (Figure 7.15, Figure 7.16, Figure 7.17 and Figure 7.18). The figures show the distribution of mark ups in the Spanish market using the OMEL prices. The distribution has a noticeable drop off in frequency for margins less than about minus two euro per MWh. Similarly, the distribution shows a frequent mark up occurring around one euro per MWh. Not too much can be positively concluded from this, but the shape of this distribution is evidently influenced by factors which are not purely random or "normally" distributed.

It is also noteworthy that the shape of the distribution of margins in Spain has changed over time. There seems to be a tendency towards higher margins, especially if the impact of carbon is excluded (Figure 7.18).

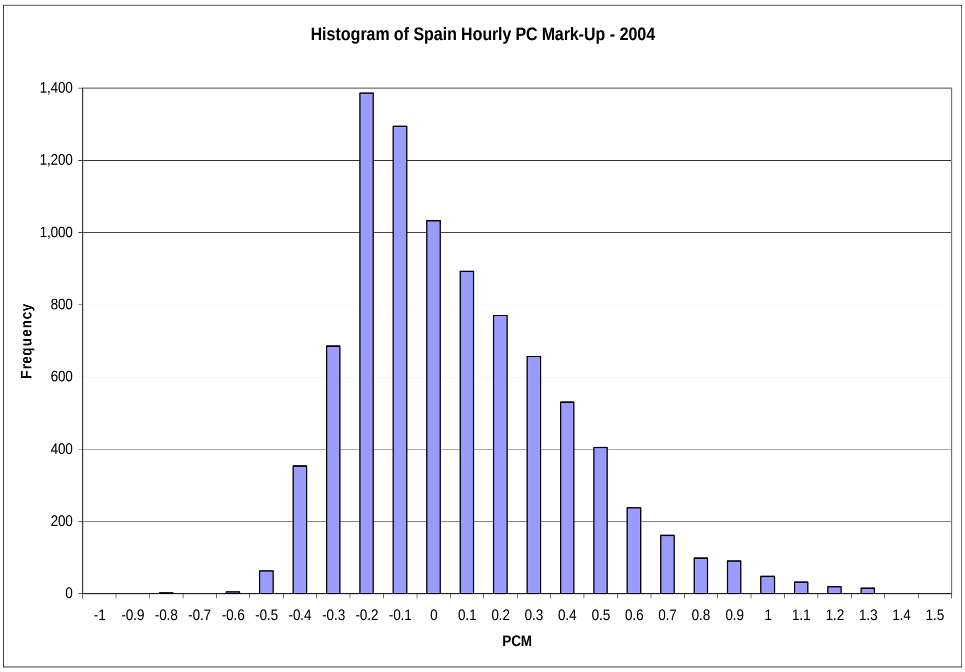
Figure 7.15: Histogram of Spain Hourly Price-Cost Mark-up – 2003



Note: N=8,736

Source: LE.

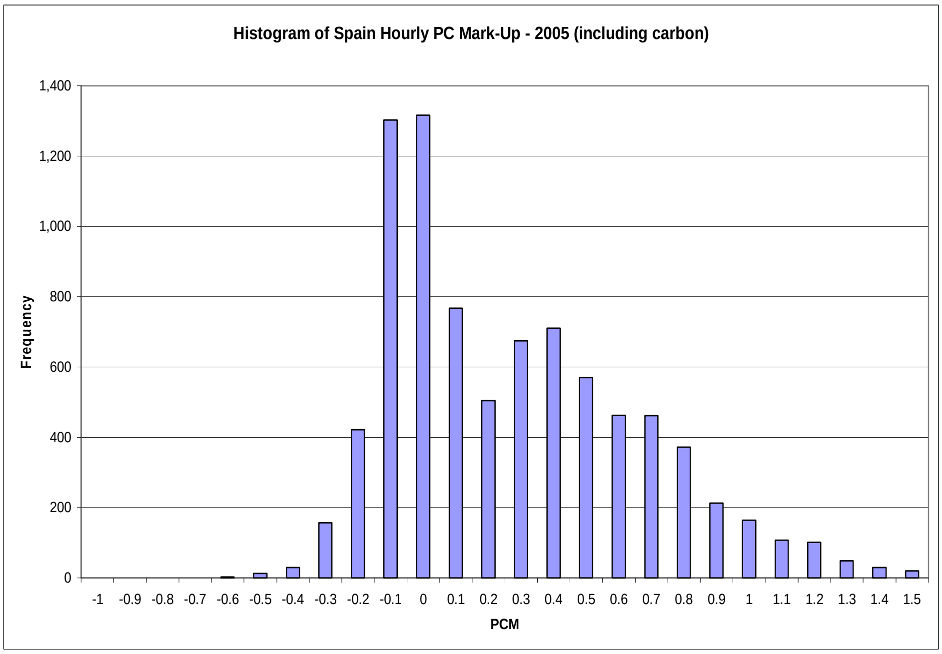
Figure 7.16: Histogram of Spain Hourly Price-Cost Mark-up – 2004



Note: N=8,781

Source: LE.

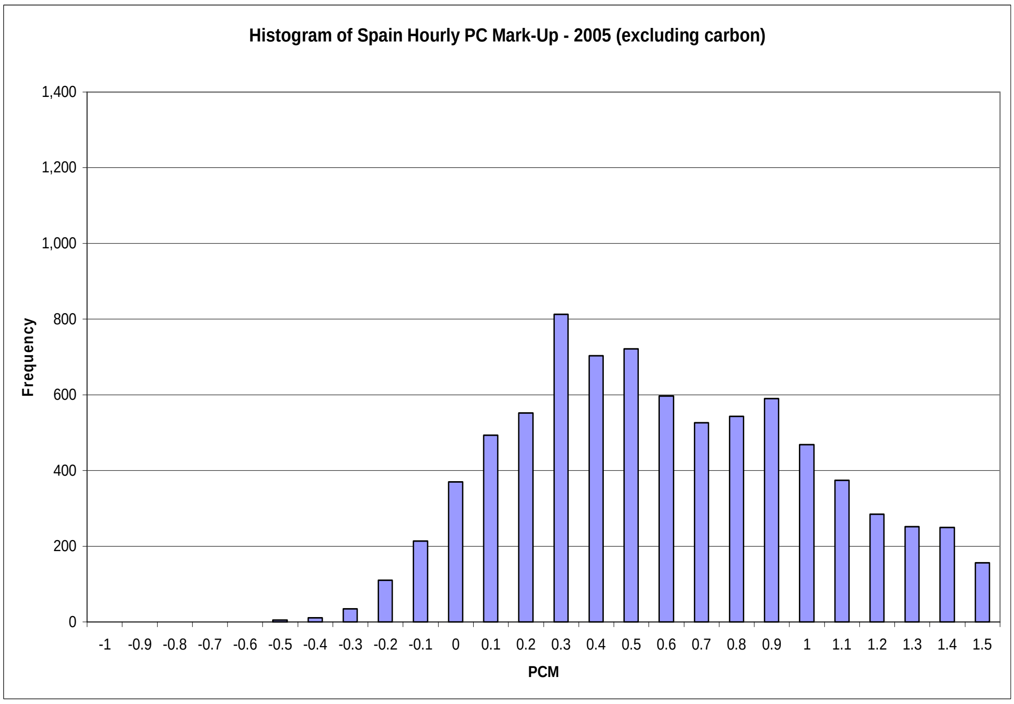
Figure 7.17: Histogram of Spain Hourly Price-Cost Mark-up – 2005 (incl. Carbon)



Note: N=8,450

Source: LE.

Figure 7.18: Histogram of Spain Hourly Price-Cost Mark-up – 2005 (excl. Carbon)



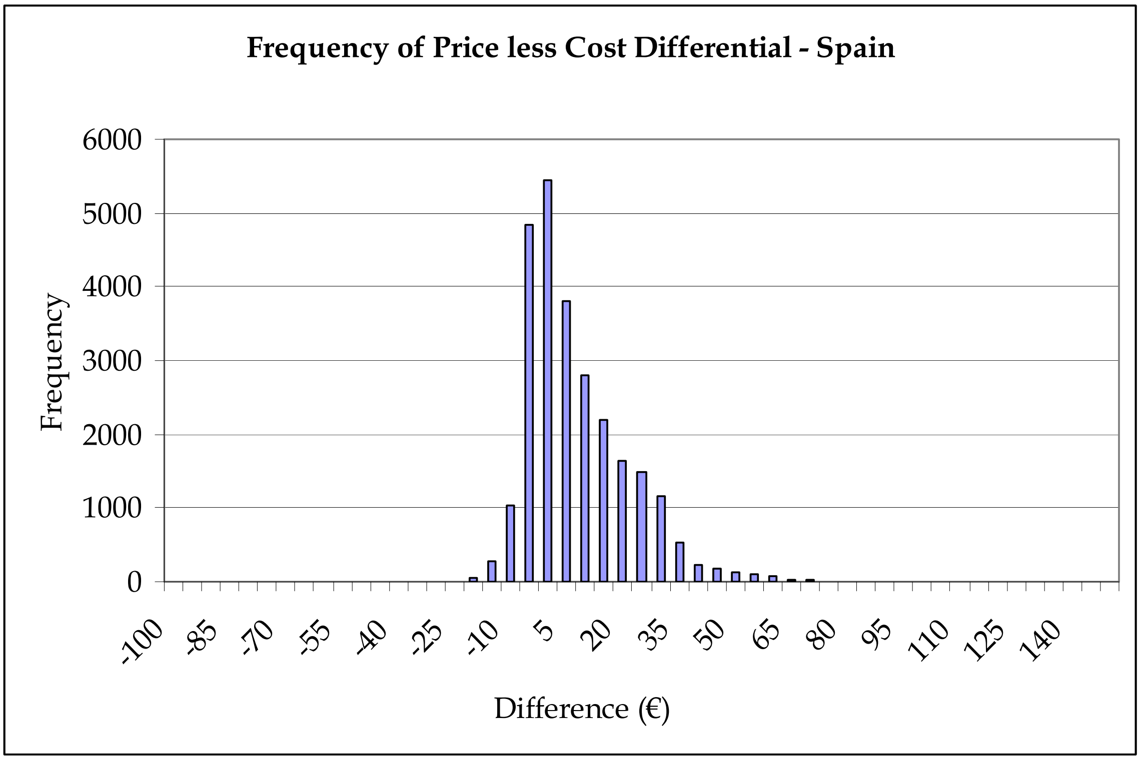
Note: N=8,070

Source: LE.

7.6 Price Cost Differential

In addition to the margins, it is useful to consider the price cost differential, which is an absolute euro value figure, rather than a unitless margin. Underlying both the LI and PCMU analysis is the basic relationship between Price and Cost. The following graph represents the frequency, over the three year period, of the difference between the hourly OMEL price and the System Marginal Cost estimated by GED as a result of their optimal despatch simulation. The shape of the price cost differential seems more regular than the margins analysis. The absolute central tendency seems to lie in the range of 5 to 15 euro per MWh. Occasional absolute mark-ups of over €50 are possible but not likely.

Figure 7.19: Frequency of Price less Cost Differential - Spain



Source: LE.

7.7 Carbon Impact in 2005

As is apparent from the previous analysis, the cost of carbon is included in the GED optimal despatch model for 2005 in order to take account of the introduction of the ETS in that year. In order to quantify the impact of the introduction of this scheme, the GED optimal despatch model of 2005 has been compared with a scenario model of that year, within which the cost of carbon is reduced to zero. Not only will this affect the unit costs of emitting stations but it will also alter the optimal system despatch. Table 7.44 presents, for selected months, the modelled difference between the system marginal cost in the model that includes the cost of carbon and the alternative scenario where the cost of carbon has been reduced to zero.

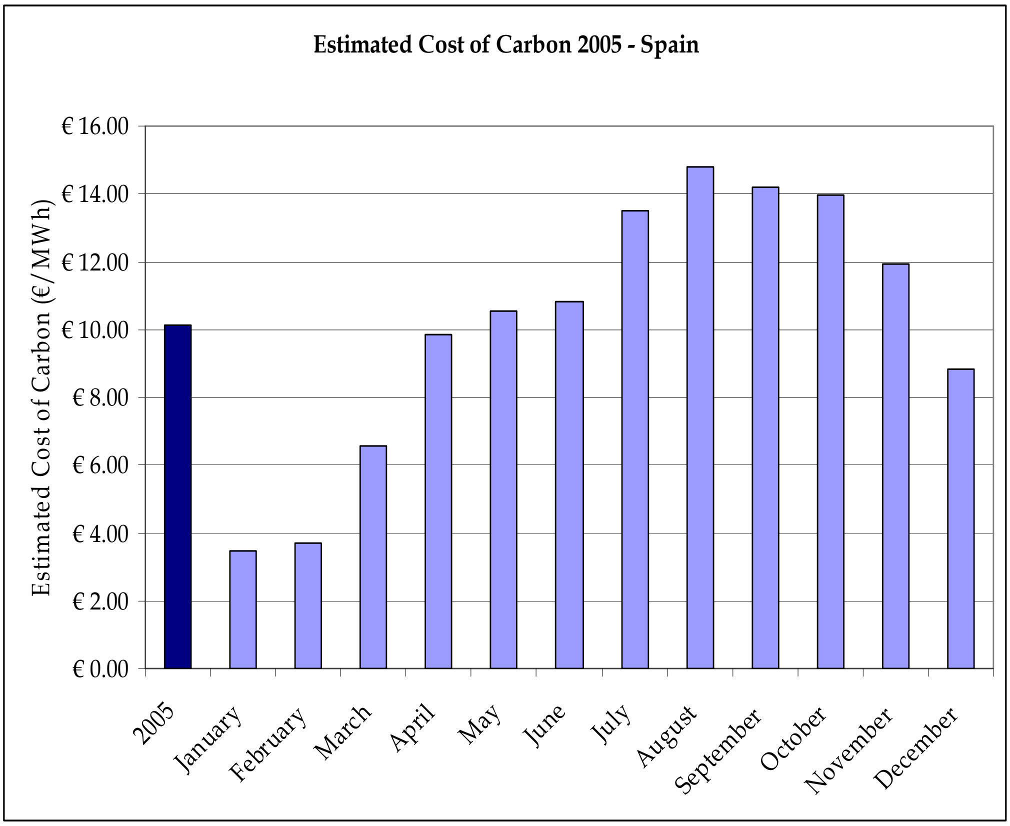
Table 7.44: Summary Statistics on the Modelled Impact of Carbon in 2005 - Spain

	2005	January	April	August	October
Average	€ 10.12	€ 3.49	€ 9.87	€ 14.82	€ 13.95

Note: Based on load weighted average of prices and costs
Source: LE

Figure 7.20 presents the evolution of the estimated cost of carbon over the year. As one can see the cost increases consistently over the period January to August after which it stabilises at around €14.00/MWh before declining to approximately €9/MWh in December.

Figure 7.20: Estimated Cost of Carbon 2005 - Spain



Source: LE.

It is important for one recall at this point the discussion presented in relation to the merit curve both with and without carbon in the introductory section of this chapter. This discussion highlighted the point that one cannot simply estimate the cost of carbon for the system based on the cost of carbon for the marginal unit as the marginal unit may potentially be different between the carbon and no-carbon merit curves as units are not monotonically affected by the ETS and in reality the ordering of units on the merit curve is likely to change as a result of including the specific €/MWh cost of carbon, for each unit.

Furthermore, the estimated impact of the introduction of the EU ETS will depend on how much of the value of CO_2 is factored in by operators, however, it has not been possible to discern this information from the data returned by the companies. Therefore, the amounts reported in this study correspond to the maximum possible impact of the ETS, if generators fully factor in the price of the CO_2 certificate in a competitive environment.

7.8 Contribution to Fixed Costs

So far in this assessment of the Spanish electricity market, the outcome measures that have been presented and discussed relate to the market as a whole; however one should realize that regardless of the marginal cost and price setting plant on the system, generation companies normally possess a portfolio of units located at different points on the merit curve. Units that operate below the price setting unit therefore can earn rents that can be used by companies to contribute to the fixed cost element of their overall cost profile, thus allowing for an environment that will allow for continued investment in the sector. It is important therefore to consider whether the results of the GED system modelling are consistent with this reality, particularly given the considerable variation between the GED system marginal cost and the costs returned by the companies.

In order to test this, the €/MWh cost of generation returned on a unit by unit basis by all of the companies in the study, calculated as the product of fuel cost by heat rate of the units (including warm weather de-ratings), is subtracted from the hourly system marginal cost produced by the GED model, which is equivalent to the market price in a perfectly competitive market, and then this hourly figure is multiplied by the hourly optimal unit despatch, again from the GED modelling of the market. The result of this calculation is summed for each company in each year to give the expected outcome in the market, if the market was to operate optimally.

This analysis, presented in Table 7.45, shows on a company by company basis the total euro value of such rents. This result also indicates that over the three year period all companies in Spain would be capable in contributing to fixed costs under this optimal despatch scenario. In particular the results for the two largest companies indicate their ability to contribute to fixed costs would be of the order of billions of Euro over this period.

Table 7.45: Contribution to Fixed Costs (€'000) - Spain					
Company	**Company ID**	**2003**	**2004**	**2005**	**Total**
C01	**0577-S-ES**	853,472.1	1,029,273.0	1,394,689.0	*3,277,434.1*
C02	**0780-S-ES**	10,868.5	27,328.3	51,293.5	*89,490.2*
C03	**0850-S-ES**	135,484.0	121,964.2	126,943.5	*384,391.7*
C04	**0875-S-ES**	387,150.9	580,013.1	671,181.4	*1,638,345.4*
C05	**1646-S-ES**	110,710.3	183,125.7	351,760.2	*645,596.2*
C06	**1697-S-ES**	53,842.0	99,793.7	67,947.9	*221,583.7*
C07	**2004-S-ES**	0.0	0.0	0.0	*0.0*
C08	**2013-S-ES**	8,182.5	13,516.8	37,216.5	*58,915.8*
C09	**2014-S-ES**	1,640.8	2,802.1	4,355.0	*8,797.8*
C10	**2017-S-ES**	0.0	-9,113.1	9,795.4	*682.4*
C11	**2019-S-ES**	0.0	1,310.2	1,139.5	*2,449.7*
Source: LE					

The usefulness of this analysis shows a variety of factors. First, it shows that the model estimated competitive prices are not generally so low that companies would not earn an operating profit. The margins estimated could apply to a variety of costs, including investment costs and start-costs, fixed O&M, etc. In general, the figures indicate substantial sums that could be applied to investment, but without more detailed analysis we cannot say with certainty whether firms would have an incentive to invest in new generation plant. Finally, the figures show the extent of portfolio impacts in the electricity generation industry. The contribution to fixed cost estimates below accrue to the largest companies because they own plant that can generate at a marginal cost that is substantially below the marginal cost of the last plant to generate electricity on the system (which will set the price in the simulated competitive market).

It is difficult, however, to say with any great precision how big these contributions to fixed cost are relative to the true economic total cost of capital for utilities in these countries. We note that the estimates of contribution to fixed cost below are, in our opinion, conservative, in that they include the running of plant above the marginal cost that cannot set price (e.g., must-run units, and CHP). There will be added differences still, when one considers the differences between accounting (book values) and economic values[18]. Further, while we consider the figures indicative, one cannot say at what level sufficient incentive to invest exists, without a significant amount of additional detailed study. A whole host of factors will influence the actual size of fixed costs, which are not merely the economic amortisation of the purchase price of the physical capital asset.

[18] In other words, for example, firms may have fully depreciated assets that are still economical. Thus the book value might be zero while the economic value high (a hydro plant would be a good example—as these often have long asset lives).

We note, however, that since our purpose is mainly as a model check, we did perform some calculations merely to give an indicative feel for the size of the fixed costs relative to our estimated contributions to fixed cost. To do this, we constructed a generic new build situation investment cost appraisal and amortisation. This would be consider the cost per MW for new build, so existing build that was built years ago at lower per MW investment cost, or that has been depreciated substantially would need lower payments per annum. To do the new build estimate, we considered estimates of the per MW per year cost of a new 400MW CCGT. The figures are from CER[19] and are figures based on judgement and industry sources. We took the life of the plant to be 15 years, and the weighted average cost of capital to be 6.5%. We then took the investment cost of the plant for greenfield new build to be €250m[20]. The investment cost included all connection costs, financing and financial close, legal, construction etc. We considered the scrape value of the site to be €15m. These figures are based on the recent CER best new entrant paper, and are in line with LE's recent professional experience. We repeated the process with a selected 400MW generic coal project from recent USA DOE data, and converted to Euro using current exchange rates[21]. We then amortized the investment cost over the life of the plant, and divided by the number of MW capacity (400) to get a figure per MW per year.

To create a comparable figure, we summed over companies and years and then divided the total contribution to fixed cost figure by 3 to get the average annual figure. We then divided by the average total installed capacity of each market. Thus we have a per MW per year contribution to fixed cost figure.

---

[19] The Commission for Energy Regulation, Ireland.

[20] As a public source check, the cost of Greenfield CCGT is estimated by CER in its 2006 Best New Entrant pricing example. See http://www.cer.ie/cerdocs/cer05088.pdf. They used a WACC of 6-7% with 70% gearing, a 15 year lifespan and a €259m investment cost. €196m was the estimated cost of the EPC contract. We used 250m as the costs of construction and land in Ireland are likely at the top of the range in the EU.

[21] See http://www.netl.doe.gov/coal/refshelf/ncp.pdf, and www.x-rates.com. There were a range of values on the data table available, but the modal figures seemed to indicate an investment cost of $US 1 million per MW. We took the Colorado tri-state Generation and Transmission Project as indicative.

From Table 7.46, we can see that even taking the generic new build (which we argue should be at the upper end of the investment cost scale), Spain's per MW per year estimated contributions to fixed cost are less than the per unit cost of generic new plant[22]. However, it is somewhat unreasonable to consider this to be a weakness in the modelling as the figure presented is that which would be needed to amortise brand new plant at each level of the merit curve. In reality, the majority of plant in the Spanish market is already partially or fully amortised. This is particularly the case with hydro units whose operational lifespan far exceeds their accounting lifespan, a considerable factor in the Spanish market given the share of hydro capacity in the system. Therefore the fact that the contribution to fixed cost figure accounts for in excess of 70% of the replacement cost of a portfolio of brand new assets in Spain, this indicates that generators are making considerable profits, allowing for both variable and fixed costs. Furthermore, a payment for stranded costs was previously in place in Spain to compensate companies for costs that would not be recouped as a result of the shift to the pool system. These payments ended in 2005 but their contribution, coupled with the probability that a large proportion of capacity in Spain is already fully or substantially amortised, will have further reduced the need for the actual level of contributions to fixed costs in Spain to match the cost of amortising a brand new portfolio of generation assets. The indicative profit levels, given the likelihood that a considerable share of generation assets in Spain are already fully amortised or have already received substantial contributions to stranded costs, are likely to allow for new investment to take place, even under a perfectly competitive market scenario.

[22] Interestingly, the story told by the figures above is consistent with recent evidence. For example, Spain had estimated considerable stranded costs in their conversion to a liberalised market. The figures estimated above are consistent with this. In addition, evidently companies had varying incentives to keep the Spanish pool price low or high based on payments they received from the stranded costs pool. For an interesting discussion see "The Spanish Electricity Industry: Plus ça change …", Claude Crampes and Natalia Fabra , CEPR Working paper, 2004.

We note that there will likely be some country-specific details in investment costs, cost of capital, etc, so the "generic" nature of the estimation is a limitation. However, our purpose was to give a broad feel for how big the contribution to fixed cost figures were, rather than a detailed study into investment incentives in Spain. As previously stated, we merely use this as a model check. There may be reasons that investment incentive hurdles are higher or lower.

Table 7.46: Comparison contribution to fixed cost and generic new build - Spain

	€/MW/Year
Generic CCGT 400MW	67,980
Generic Coal 1000MW	61,911
	2003-05 Average
Spain	50,220

Source: LE

Finally it is useful to note that in terms of economics and competition, the mere existence of such operating revenues (or the cost and pricing structure that would generate them) is not necessarily indicative of any particular market failure. Indeed, it is the ability to earn a margin by investing in the latest efficient plant that is expected to provide the incentive to invest for utilities.

7.9 Regression Analysis

In order to investigate the relationship between the above market outcome/market performance measures and the structural indicators previously discussed, we undertook a detailed regression analysis with the objective of testing this link and in the presence of such a link, uncovering the nature of the relationship. In testing this relationship a number of regression models were estimated but in general the approach applied was to develop and explore simple regression models, and then to progress on to more detailed specifications including more explanatory factors, all the time ensuring that the classical linear assumptions were not violated.[23]

The Residual Supply Index, as a continuous variable of market structure that was developed specifically for the electricity industry, was used in the regression analysis as a measure of market structure. Previous research has highlighted the problematic nature of using measures such as the HHI as they both exhibit very little variation and have been found to be largely inappropriate for such analysis in the electricity sector. The PSI does present a possible alternative, however given the binary nature of the variable, it being either 1 or 0, its suitability to regression analysis is limited and would represent substantial restrictions on the analysis that are not presented by the RSI. The simple regression model therefore regresses the hourly market outcome measure, either LI or PCMU, on the hourly RSI value of any one company. Ex ante one may expect the sign on the RSI coefficient to be negative if one considers it likely to be the case that the more indispensable a company becomes, the higher their margins are likely to be.

---

[23] In standard econometric terminology, 'simple' regression refers to regression of the dependent variable on a single independent variable. The standard terminology is to call regression of a dependent variable on more than one explanatory or independent variables 'multiple' regression. We use this standard terminology.

In order to capture the potential for peak and off-peak periods to have different effects, the peak and off-peak RSI values have been separated into different independent variables to allow for the slope of the estimated regression line to differ during these periods. This will allow for potentially different effects on the outcome measure during peak and off-peak periods. A dummy variable has also been created for peak hours. A dummy variable is a zero-one variable that takes a value of one when a particular statement is true and a value of zero when it is not. In this case, during peak hours the dummy variable (*dpeak*) will adopt a value of 1 during peak hours and zero otherwise. Just as the peak and off-peak RSI variables allow for the estimated regression to have a different slope in these different periods and thus a different overall effect on the outcome measure, the inclusion of a dummy variable allows for the starting point of the regression itself to differ in these separate periods, thus creating effectively two different regression lines, if the dummy variable is statistically significant. This will be particularly important if there is a difference in how the market effectively operates in peak and off-peak periods.

Further to this an interaction term has been constructed that is the product of the RSIs of two companies contained in the study. This measure will capture the degree to which the ability of one firm to exercise market power to influence prices is assisted or impeded by the market power of a competing company. Importantly a measure of scarcity has also been included in a number of regression equations. This variable will capture the degree to which scarcity impacts on outcome measures and will separate out the potential for the RSI value to simply capture this effect from what is designed to reflect, the impact of a particular companies indispensability on the outcome of the market. The scarcity variable is defined as the difference between available installed capacity and load, as a percentage of load in each hour. One would expect such a variable to have a negative sign on its coefficient.

Variables have been included to capture the impact of potential withholding on the outcome measures. These variables have been constructed relative to the whole market and are not specific to any one company, as such one can consider the likely sign of these variables if there is a systematic manner in which coal fired capacity is being withdrawn and replace by gas fired capacity. In the event of such an occurrence, one would expect to observe a negative sign on the coefficient of the coal variable and a positive sign on the coefficient of the gas variable.

In order to allow for the impact of a number of patterns, a number of additional dummy variables have been included to capture the impact of yearly, seasonal, and weekday specific effects. Table 7.47 provides a summary of the variables included in the regression analysis.[24]

Table 7.47: Variables used in the Regression Analysis	
Variable	*Description*
LI5	Hourly Lerner Index.
PCMup5	Hourly Price-Cost Mark-Up.
RSI_C0X	The hourly RSI value of Company X.
pk_RSI_C0X	The hourly peak time RSI value of Company X.
opk_RSI_C0X	The hourly off-peak time RSI value of Company X.
RSI_C0X_C0Y	Interaction between the RSI values of Company X & Y. Competition/Collusion variable.
Scar	Scarcity variable defined as the difference between available installed capacity and load, as a percentage of load, in each hour
C0_gas	The combined difference between the Actual & Modelled generation profile of gas units owned by Companies X & Y.
C0_coal	The combined difference between the Actual & Modelled generation profile of coal units owned by Companies X & Y.
d2004	Dummy variable for 2004.
d2005	Dummy variable for 2005.
dpeak	Dummy variable for peak hours.
dsummer	Dummy variable for summer months.
dwinter	Dummy variable for winter months.
dwkday	Dummy variable for weekdays.

Furthermore, for ease of understanding when considering the regression output presented subsequently one may wish to refer to the following table that identifies the company's number with the company's identification, used throughout the report.

[24] The dummy for 2003 was dropped from the estimated regression equations to avoid perfect collinearity with the constant. Results therefore are to be viewed relative to the missing year..

Table 7.48: Variables used in the Regression Analysis - Spain	
Company Number	**Company Identification**
C01	0577-S-ES
C04	0875-S-ES
Source:LE	

7.9.1 Regression Analysis – Part I

The first model we estimated was a simple regression of LI on RSI for the largest company. The coefficient returned is statistically significant and of the expected sign. The R-squared, the amount of explanatory power of the regression, is noticeably low in this regression. The more important figure, though, is the P-value (P>|t|).

Lerner Index & RSI for 0577-S-ES

Our first approach to measuring the relationship between market structure and outcomes is the regression of the RSI on the Lerner Index. The results below show a strong negative relationship, meaning that a high RSI value corresponds to a low value for the Lerner Index, and vice versa. The t-statistic for the coefficient on the RSI variable shows that the coefficient is highly significant.

The R-squared values for the Lerner Index regressions are low. While we note that the statistical significance of the variables in the regression is the more relevant statistic, it could still be considered that the R-squared values for the LI regressions are in general somewhat unsatisfactory, in the sense that very little of the dependent variable (LI) is apparently explained by variation in the independent variables.

While this is in general unsatisfactory for the regression as a whole, it is not particularly surprising, and we suggest that it is consistent with our approach and the definition of the variables. The reasons for the low explanatory value are apparently due to the definition of the Lerner index (LI). The LI is by definition calculated as LI = (P-MC)/P or = 1 - (MC/P). Thus, it can be seen that the LI is bounded from above at 1 as price gets very large. In general, then, when market price P becomes big vis-à-vis estimated marginal cost (MC), two things happen. First, the LI approaches 1, but also, the amount of variation in LI becomes small. Conversely, when price becomes very small, there will be a larger amount of variation in the LI. This is apparently not well correlated with the variation in RSIs and related variables. For this reason, we focus additional attention (in terms of testing additional specifications) on the price cost mark-up regressions later in the section.

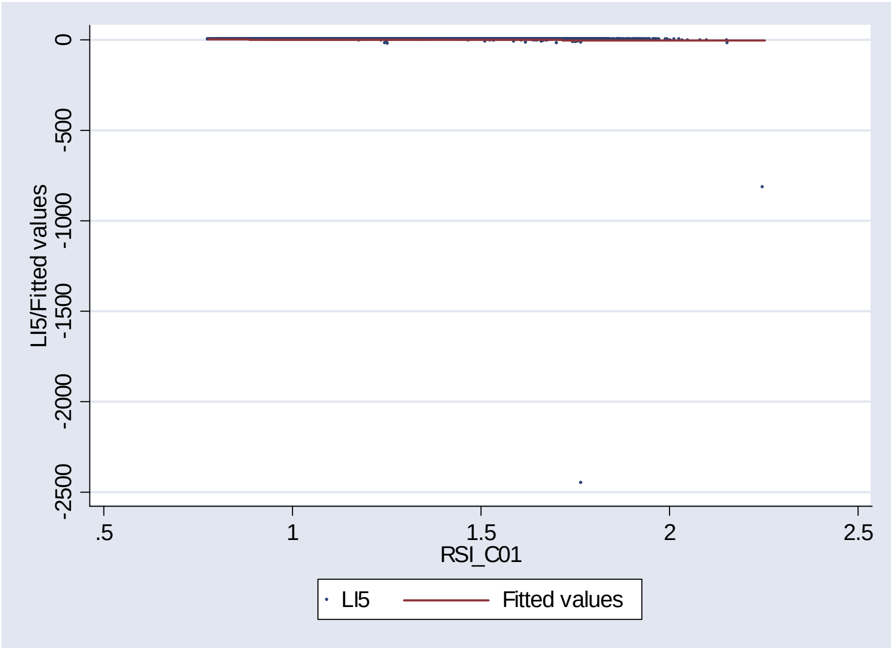
The R-squared values for the price-cost mark-up regressions we report below are higher, in general in the range of 20-50%. The R-squared indicates the percentage of the variation in dependent variable that is explained by the variation in the independent variable. These R-squared values are as expected and are reasonable given the type of data and regressions. Higher R-squared values could have been obtained by including lagged dependent variables or a more complete set of dummy variables (including dummies for hours of the day, for example). However, this would not have served our purpose of studying the relationships between the RSI and other variables and the margins.

```
      Source |       SS       df       MS              Number of obs =   26014
-------------+------------------------------           F(  1, 26012) =   49.58
       Model |  12738.8654     1  12738.8654           Prob > F      =  0.0000
    Residual |   6683064.4 26012  256.922359           R-squared     =  0.0019
-------------+------------------------------           Adj R-squared =  0.0019
       Total |  6695803.27 26013  257.402194           Root MSE      =  16.029

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C01 |   -3.53479   .5019947    -7.04   0.000    -4.518727   -2.550852
       _cons |    4.03802   .5988672     6.74   0.000     2.864207    5.211833
```

The depiction of the regression and the predicted values presented below provides a useful tool for assessing the estimated regression. Apparently outliers and unmeasured factors seem to be impacting the regression. Part of this may be due to the nature of the LI as it is constructed (price in the denominator), which makes its upper bound 1.

Figure 7.21: LI Regression on RSI for 0577-S-ES



Source: LE.

Another element we study is the possibility that the assumptions of the classical linear regression model are violated. To check this we undertook regressions correcting for the violation of these assumption. Using robust standard errors is one such correction. Note that the coefficient estimates are unbiased, even in the presence of nonspherical errors.

Regression with Robust Standard Errors - 0577-S-ES

To correct for heteroskedasticity, we use the Huber-White sandwich estimator of variance[25] in place of the traditional calculation to ensure that our standard errors are robust. The coefficient on the RSI variable is not affected by the regression with robust standard errors. Although the significance has declined somewhat, it is still high. significance of the coefficient estimates. The estimates do not become statistically insignificant below the 95% value (a common standard) although 99% confidence or greater that the coefficient isn't truly zero cannot be achieved .The robust standard errors impact the t values and thus the statistical significance. The results from the standard regressions nonetheless appear to be valid.

```
Regression with robust standard errors                 Number of obs =   26014
                                                       F(  1, 26012) =    4.53
                                                       Prob > F      =  0.0334
                                                       R-squared     =  0.0019
                                                       Root MSE      =  16.029

------------------------------------------------------------------------------
             |               Robust
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C01 |   -3.53479   1.661376    -2.13   0.033    -6.791179   -.2784004
       _cons |    4.03802   1.857734     2.17   0.030     .3967581    7.679281
```

Similarly, a correction for serial correlation is possibly needed, since our data have a time series element. Again, the standard errors are biased under serial correlation but the coeffcieint estimates are not. A standard correction is a Prais-Winston estimator. The Prais-Winston regression method fits a linear regression of the LI on the RSI variable that is corrected for first-order serially correlated residuals using the Prais-Winston (1954) transformed regression estimator[26]. The estimator is a Generalised Least Squares (GLS) estimator.

---

[25] See Huber, P. J. 1967. The behavior of maximum likelihood estimates under nonstandard conditions. In *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*. Berkeley, CA: University of California Press, vol. 1, 221–223. Also White, H. 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica* 48: 817–830.

[26] Prais, S. J. and C. B. Winston. 1954. Trend Estimators and Serial Correlation. *Cowles Commission Discussion PaoerNo. 383*, Chicago.

Prais-Winston Regression method to correct for AR(1) type disturbances - 0577-S-ES

Correcting for the likelihood that the original regression was affected by AR(1) type disturbances has not had a qualitative impact on the results preciously estimated. The RSI coefficient is again significant and of the expected sign and magnitude.

```
Prais-Winsten AR(1) regression -- iterated estimates

Regression with robust standard errors                 Number of obs =   26014
                                                       F(  2, 26012) =    9.69
                                                       Prob > F      =  0.0001
                                                       R-squared     =  0.0019
                                                       Root MSE      =  16.028

------------------------------------------------------------------------------
             |             Semi-robust
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C01 |   -3.54783   1.678143    -2.11   0.035    -6.837083   -.2585771
       _cons |    4.05303   1.876464     2.16   0.031     .3750562    7.731003
-------------+----------------------------------------------------------------
         rho |   .0103033
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    1.881994
Durbin-Watson statistic (transformed) 1.900641
```

Our next set of regressions changes the specification to allow the slopes and intercepts to vary by peak and off peak. This has proved fruitful as the peak impact of RSI on prices is higher (larger magnitude coefficient on peak RSI variable), and the peak LIs on average tend to be higher (positive dpeak coefficient).

Peak & Off-Peak Analysis - 0577-S-ES

```
      Source |       SS       df       MS              Number of obs =   26014
-------------+------------------------------           F(  3, 26010) =   25.17
       Model |  19382.9668     3  6460.98894           Prob > F      =  0.0000
    Residual |   6676420.3 26010  256.686671           R-squared     =  0.0029
-------------+------------------------------           Adj R-squared =  0.0028
       Total |  6695803.27 26013  257.402194           Root MSE      =  16.021

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   5.357009    1.56353     3.43   0.001     2.292405    8.421613
  pk_RSI_C01 |  -5.882887   .6822689    -8.62   0.000    -7.220172   -4.545602
 opk_RSI_C01 |  -.9803244   1.032688    -0.95   0.342     -3.00445    1.043801
       _cons |   1.090451   1.362338     0.80   0.423    -1.579806    3.760708
```

Price-Cost Mark-Up & RSI for Company 0577-S-ES

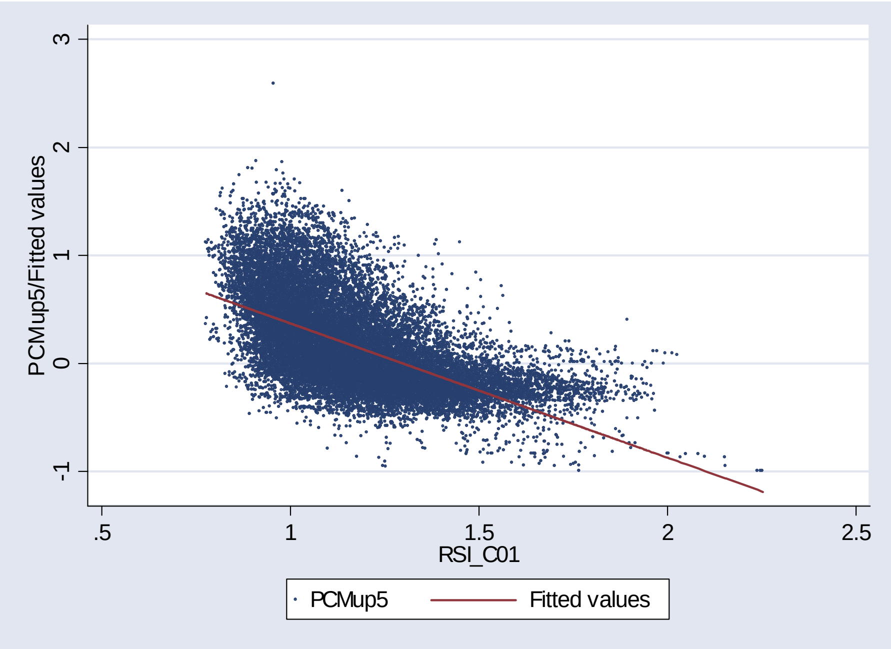
We also estimate the model using the price cost mark-up and the RSI of the largest company. The sign and significance of the model are similar to the results from the LI regression reported earlier.

```
      Source |       SS       df       MS              Number of obs =   26016
-------------+------------------------------           F(  1, 26014) =14388.52
       Model |  1577.24742     1  1577.24742           Prob > F      =  0.0000
    Residual |  2851.61557 26014  .109618496           R-squared     =  0.3561
-------------+------------------------------           Adj R-squared =  0.3561
       Total |  4428.86299 26015  .170242667           Root MSE      =  .33109

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C01 |  -1.242396   .0103574  -119.95   0.000    -1.262697   -1.222095
       _cons |   1.613422   .0123574   130.56   0.000       1.5892    1.637643
```

The graph of the scatter of points and the predicted values of the regression in Figure 7.22 shows the general good fit of the model.

Figure 7.22: PCMU Regression on RSI for 0577-S-ES



Source: LE.

The scatterplot of the observations indicates that one may want to test for a non-linear relationship between the variables rather than a linear one as estimated in the previous regression. In order to do so a quadratic regression specification has been estimated and the results are presented below. The quadratic term is simply the RSI variable squared and it will allow for the rate of change in the RSI variable to vary from a fixed number, the coefficient on the RSI variable, as one moves along the estimated regression line. Intuitively, this allow for the linear relationship of the simple relationship to include a curve that may better fit the data.

As one can see both RSI variables are statistically significant and of the expected sign with the estimated RSI coefficient predicting a fall in the PCMU as a result of increases in the RSI of company 0577-S-ES. Note however that this decrease is predicted to occur at a decreasing rate the higher the RSI value becomes. Furthermore, this estimated regression equation appears to be a slightly better fit for the data as indicated by the R-squared

```
      Source |       SS       df       MS              Number of obs =   26016
-------------+------------------------------           F(  2, 26013) = 8422.29
       Model |  1740.70342     2  870.351709           Prob > F      =  0.0000
    Residual |  2688.15957 26013  .103339083           R-squared     =  0.3930
-------------+------------------------------           Adj R-squared =  0.3930
       Total |  4428.86299 26015  .170242667           Root MSE      =  .32146

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C01 |  -4.866206   .0916698   -53.08   0.000    -5.045884   -4.686528
   RSI_C01sq |   1.440906   .0362299    39.77   0.000     1.369893    1.511918
       _cons |    3.82581   .0569072    67.23   0.000     3.714269    3.937352
------------------------------------------------------------------------------
```

Peak & Off-Peak Analysis - 0577-S-ES

This regression indicates that the likely relationship between the PCMU and RSI of company 0577-S-ES is non-linear but there are a number of other aspects of the relationship that also warrant investigation. The introduction of both slope and intercept dummy variables into the regression equation to attempt to identify differences in the nature of the relationship between the variables during these periods, bring about a result that is broadly consistent with the one found with the LI but which finds the company's indispensability in peak hours to have a greater impact on the market PCMU that it does in off-peak hours, a result one would have expected ex-ante. One can see that the goodness-of-fit of this regression specification is improved and the estimated coefficients have the expected signs and are statistically significant.

Source	SS	df	MS
Model	1740.83656	3	580.278853
Residual	2688.02643	26012	.103337937
Total	4428.86299	26015	.170242667

Number of obs	26016
F(3, 26012)	5615.35
Prob > F	0.0000
R-squared	0.3931
Adj R-squared	0.3930
Root MSE	.32146

PCMup5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dpeak	.9624075	.0313551	30.69	0.000	.9009497	1.023865
pk_RSI_C01	-1.281556	.0136574	-93.84	0.000	-1.308325	-1.254787
opk_RSI_C01	-.624859	.0207204	-30.16	0.000	-.6654721	-.5842459
_cons	.731426	.0273346	26.76	0.000	.6778486	.7850033

Lerner Index & RSI for 0875-S-ES

We next repeat the above analysis for the next largest company, 0875-S-ES. Similar results from the previous company's RSI analysis on the LI are found below. Statistical significance is found but the R-squared is very low.

```
      Source |       SS       df       MS              Number of obs =   26014
-------------+------------------------------           F(  1, 26012) =   39.50
       Model |  10152.8498     1  10152.8498           Prob > F      =  0.0000
    Residual |  6685650.42 26012  257.021775           R-squared     =  0.0015
-------------+------------------------------           Adj R-squared =  0.0015
       Total |  6695803.27 26013  257.402194           Root MSE      =  16.032

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -3.544822   .5640083    -6.29   0.000     -4.65031   -2.439335
       _cons |   3.889243   .6456662     6.02   0.000     2.623702    5.154784
```

Peak & Off-Peak Analysis - 0875-S-ES

A similar result to the previous company's analysis is obtained for the LI when including the possibility of different impacts between peak and off peak.

```
      Source |       SS       df       MS              Number of obs =   26014
-------------+------------------------------           F(  3, 26010) =   19.30
       Model |  14873.1279     3  4957.70929           Prob > F      =  0.0000
    Residual |  6680930.14 26010  256.860059           R-squared     =  0.0022
-------------+------------------------------           Adj R-squared =  0.0021
       Total |  6695803.27 26013  257.402194           Root MSE      =  16.027

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   5.075718   1.644549     3.09   0.002     1.852312    8.299124
  pk_RSI_C04 |  -5.672767   .7514103    -7.55   0.000    -7.145573   -4.199962
 opk_RSI_C04 |  -.9175844    1.14161    -0.80   0.422    -3.155202    1.320033
       _cons |   .9459285   1.426733     0.66   0.507    -1.850546    3.742403
```

Price-Cost Mark-Up & RSI for 0875-S-ES

When including the PCMU as the dependent variable, we get different results, similar to the previous country analysis in Spain. The coefficient on RSI is smaller (than with LI) is negative as expected, and the R-squared is now around 35%.

```
      Source |       SS       df       MS              Number of obs =   26016
-------------+------------------------------           F(  1, 26014) =14040.10
       Model |  1552.44251     1  1552.44251           Prob > F      =  0.0000
    Residual |  2876.42048 26014  .110572018           R-squared     =  0.3505
-------------+------------------------------           Adj R-squared =  0.3505
       Total |  4428.86299 26015  .170242667           Root MSE      =  .33252

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -1.384859   .0116875  -118.49   0.000    -1.407767   -1.361951
       _cons |   1.718276   .0133806   128.42   0.000     1.692049    1.744503
------------------------------------------------------------------------------
```

As with the company 0577-S-ES an attempt has been made here to consider the likelihood of the relationship between the variables in the simple regression case being non-linear. The results of the estimated regression are presented here.

Quadratic Specification – 0875-S-ES

```
      Source |       SS       df       MS              Number of obs =   26016
-------------+------------------------------           F(  2, 26013) = 8715.18
       Model |   1776.9503     2   888.47515           Prob > F      =  0.0000
    Residual |  2651.91269 26013  .101945669           R-squared     =  0.4012
-------------+------------------------------           Adj R-squared =  0.4012
       Total |  4428.86299 26015  .170242667           Root MSE      =  .31929

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -6.554793   .1107377   -59.19   0.000    -6.771845   -6.337741
   RSI_C04sq |   2.152538    .045869    46.93   0.000     2.062632    2.242444
       _cons |   4.745113   .0657669    72.15   0.000     4.616206     4.87402
------------------------------------------------------------------------------
```

As one can see the estimated impact of the quadratic term is quantitatively the same as it was for company 0577-S-ES. PCMU is expected to decrease, at a decreasing rate, the higher the RSI of company 0875-S-ES becomes.

Peak & Off-Peak Analysis – 0875-S-ES

As with company 0577-S-ES, better results are obtained when including peak and off peak intercept and slope dummy variables. The R-squared goes to 40% and the expected signs and magnitudes stay the same, as does the statistical significance.

```
      Source |       SS       df       MS              Number of obs =   26016
-------------+------------------------------           F(  3, 26012) = 5705.94
       Model |  1757.77462     3  585.924874           Prob > F      =  0.0000
    Residual |  2671.08837 26012  .102686774           R-squared     =  0.3969
-------------+------------------------------           Adj R-squared =  0.3968
       Total |  4428.86299 26015  .170242667           Root MSE      =  .32045

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   1.095901   .0328678    33.34   0.000     1.031478    1.160323
  pk_RSI_C04 |  -1.433287   .0149961   -95.58   0.000     -1.46268   -1.403894
 opk_RSI_C04 |  -.6480929   .0228258   -28.39   0.000    -.6928327    -.603353
       _cons |   .7177454   .0285267    25.16   0.000     .6618315    .7736593
```

7.9.2 Regression Analysis – Part II

We continue to check the robustness of the model by including additional explanatory variables. Using the PCMU, we also included a scarcity variable as a potential measure of scarcity. The idea is to check to see that the relationship between margin and RSI is not merely reflecting the correlation of price and scarcity, which in many cases might be economically acceptable or even desirable.

From the results below, we see that inclusion of the scarcity variable does not impact the regression on the whole. The expected signs are maintained and the statistical significance of both variables is evident. Interestingly, the magnitude of the RSI coefficient has fallen, but it is still larger than the scarcity variable. The regression is apparently splitting the impact between the two competing explanatory variables. The R-squared is in a similar range at 36%.

Price-Cost Mark-Up & RSI for Company 0577-S-ES (including a Scarcity variable)

```
Regression with robust standard errors                 Number of obs =   26016
                                                       F(  2, 26013) = 6899.03
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.3587
                                                       Root MSE      =  .33043

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C01 |  -.6317591   .0562889   -11.22   0.000    -.7420885   -.5214297
        Scar |  -.4184083   .0383475   -10.91   0.000    -.4935716    -.343245
       _cons |   1.220843   .0378016    32.30   0.000      1.14675    1.294936
```

Due to the potential that a number of relevant variables have not been included in this parsimonious regression specification, variables that are correlated with the independent variables, a richer specification has been specified to account for a number of these potential variables. The inclusion of annual, seasonal, weekday and peak hour intercept dummy variables in the regression controls for these factors in the regression thus removes any potential for these factors to bias the estimated coefficients of the independent variables already included in the regression equation. Controlling for these factors in the regression equation one can see that the estimated coefficients on the RSI and scarcity variables are statistically significant, however the sign on the RSI variable of company 0577-S-ES is now estimated o be positive. All of the estimated coefficients in this regression are statistically significant and the resulting goodness-of-fit measure indicates that this specification is capable of explaining approximately 47% of the variation in the dependent variable. This result indicates that, *ceteris paribus*, increases in the indispensability of company 0577-S-ES to meeting the load on the system is expected to lead to a reduction in the PCMU in the market. Both the estimated coefficients on scarcity and *dpeak* separately indicate higher PCMU in peak periods and in hours of increased tightness on the system.

Price-Cost Mark-Up & RSI for Company 0577-S-ES (including a Scarcity and dummy variables)

```
Regression with robust standard errors               Number of obs =   26016
                                                      F(  8, 26007) = 2519.06
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.4665
                                                      Root MSE      =  .30141
```

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C01	.1942104	.0529228	3.67	0.000	.0904788	.2979419
Scar	-.9463309	.0372456	-25.41	0.000	-1.019334	-.8733275
d2004	-.2845172	.0049202	-57.83	0.000	-.2941612	-.2748733
d2005	-.1406711	.0053234	-26.42	0.000	-.1511053	-.1302369
dpeak	.135191	.0043225	31.28	0.000	.1267186	.1436634
dsummer	.0141105	.004657	3.03	0.002	.0049826	.0232385
dwinter	-.0772697	.0048048	-16.08	0.000	-.0866874	-.0678519
dwkday	-.0271851	.0047814	-5.69	0.000	-.0365568	-.0178134
_cons	.7471437	.036261	20.60	0.000	.6760701	.8182174

Price-Cost Mark-Up & RSI for Company 0875-S-ES (including a Scarcity variable)

We again include a scarcity variable with the RSI for company 0875-S-ES as independent variables in the specified regression. The size of the impact of scarcity is similar to the RSI, but each is still statistically significant, indicating that the two variables are not perfectly collinear and independently explaining a significant portion of the dependent variable.

```
Regression with robust standard errors                 Number of obs =   26016
                                                       F(  2, 26013) = 6699.80
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.3600
                                                       Root MSE      =   .3301

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -.5560583   .0385051   -14.44   0.000    -.6315303   -.4805863
        Scar |  -.5165172   .0226899   -22.76   0.000    -.5609906   -.4720438
       _cons |   1.182987   .0280062    42.24   0.000     1.128093     1.23788
```

The inclusion of annual, seasonal, weekday, and peak hours, dummy variables do not qualitatively alter the estimated sign of the coefficients on the scarcity and RSI variables. All of the other estimated coefficients, with the exception of the weekday dummy variable, are statistically significant and are largely of the expected sign.

Price-Cost Mark-Up & RSI for Company 0875-S-ES (including a Scarcity and dummy variables)

Regression with robust standard errors

Number of obs	= 26016
F(8, 26007)	= 2511.19
Prob > F	= 0.0000
R-squared	= 0.4668
Root MSE	= .30132

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C04	-.3081976	.0595881	-5.17	0.000	-.4249935	-.1914018
Scar	-.629104	.0374085	-16.82	0.000	-.7024266	-.5557814
d2004	-.2739135	.0053421	-51.27	0.000	-.2843842	-.2634427
d2005	-.1087967	.0078031	-13.94	0.000	-.1240911	-.0935022
dpeak	.1333771	.0042285	31.54	0.000	.125089	.1416652
dsummer	.0133516	.0046351	2.88	0.004	.0042665	.0224366
dwinter	-.0828352	.0050285	-16.47	0.000	-.0926912	-.0729791
dwkday	-.0273616	.0047628	-5.74	0.000	-.036697	-.0180262
_cons	1.066176	.0393832	27.07	0.000	.9889826	1.143369

7.9.3 Regression analysis – Part 3

At this point having found that the RSI and scarcity variables are independently statistically significant and largely of the expected sign, thus indicating that the RSI variable is capturing an effect other than just rents owing to scarcity in the market, one may legitimately wish to test one further aspect of the regression findings outlined previously. The similarity of the results on the estimated coefficients on the RSI values for the two largest companies in Spain may lead one to question whether in fact the RSI variables of the different companies are capturing the same effect, something common and other than scarcity. To test this a further regression equation has been estimated which includes the RSI of the two largest companies, as well as a variable capturing the interaction of these two variables, the scarcity variable and two variables designed to capture the impact of behaviour that may be indicative of withholding. A number of dummy variables are also included. As with the test on the independence of the estimated coefficient on RSI from scarcity, if the RSI values of the two companies are in fact identifying the same effect, then their coefficients will not be statistically significant in the estimated regression.

The results of this estimated regression indicate that the RSI values of companies 0577-S-ES and 0875-S-ES are statistically significant and negative. The estimated coefficient on the variable capturing the interaction between the two RSIs is positive and statistically significant, thus indicating that the ability of one firm to exercise market power and increase prices is moderated by the relative indispensability of its competitor. In other words, as company A becomes more indispensable, and company B's position remains relatively unchanged in the market, company A's ability to exercise market power and raise prices will be moderated. The dummy variables are once again qualitatively consistent with the results seen with respect to when the companies were assessed in isolation, as is the estimated coefficient on the scarcity variable. For the first time we have included variables to attempt to capture the possibility of identifying possible withholding behaviour. The estimated coefficients of these two variables indicate that both are of the expected sign and are statistically significant. The estimated coefficients indicate that relative to the optimal despatch, the under-utilisation of coal increases the PCMU while the over-utilisation of gas increases the PCMU.

Price-Cost Mark-Up & RSI of Companies 0577-S-ES and 0875-S-ES (including a Competition, a Scarcity, Withholding and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26016
                                                       F( 12, 26003) = 2467.23
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.5119
                                                       Root MSE      =  .28834

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C01 |  -2.113111   .0807546   -26.17   0.000    -2.271395   -1.954828
     RSI_C04 |  -2.283594   .0845975   -26.99   0.000     -2.44941   -2.117778
 RSI_C01_C04 |    1.71847   .0476759    36.04   0.000     1.625022    1.811917
        Scar |   -.731268   .0673098   -10.86   0.000    -.8631988   -.5993371
      C0_gas |   .0001035   6.74e-06    15.36   0.000     .0000903    .0001167
     C0_coal |    -.00002   3.72e-06    -5.36   0.000    -.0000273   -.0000127
       d2004 |  -.2742772   .0053869   -50.92   0.000    -.2848358   -.2637186
       d2005 |  -.0805268   .0096152    -8.37   0.000    -.0993732   -.0616805
       dpeak |   .0803634   .0045284    17.75   0.000     .0714875    .0892394
     dsummer |   .0082127   .0045828     1.79   0.073      -.00077    .0171953
     dwinter |  -.0790802   .0048256   -16.39   0.000    -.0885386   -.0696219
      dwkday |  -.0662607   .0045843   -14.45   0.000    -.0752462   -.0572752
       _cons |   3.584141   .0957553    37.43   0.000     3.396455    3.771827
----------------------------------------------------------------------
```

As a final sensitivity check on the results already presented and as a means of further investigation, a regression has been estimated to take account of the potentially different impact variations in market power can have during peak and off-peak periods. To address this issue the PCMU was regressed on the peak and off-peak values of the RSIs of the two largest companies, scarcity, variables to capture potential withholding, and a number of dummy variables.

The results presented below are largely consistent with those found already. In this instance the estimated RSI coefficients of both companies are independently statistically significant and at least in peak hours, where one may legitimately be more concerned about market power, one finds that the increased indispensability of either company is expected to increase the PCMU in the market. In off-peak periods the estimated RSI coefficient of company 0577-S-ES indicate a similar result but this is not the case for company 0875-S-ES. The estimated regression coefficient on this variable suggests increased indispensability leads to lower PCMU in off-peak hours. The estimated coefficients on the dummy variables and the variables included to capture the potential presence of behaviour consistent with withholding are once again consistent over specifications.

Peak and Off-Peak analysis for Companies 0577-S-ES and 0875-S-ES (including a Scarcity, Withholding and dummy variables)

```
Regression with robust standard errors                Number of obs =   26016
                                                      F( 13, 26002) = 1992.82
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.4961
                                                      Root MSE      =  .29297
```

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
pk_RSI_C01	-.1610116	.0654928	-2.46	0.014	-.2893812	-.032642
opk_RSI_C01	-.2003931	.0695843	-2.88	0.004	-.3367822	-.0640039
pk_RSI_C04	-.7175657	.0738138	-9.72	0.000	-.8622448	-.5728867
opk_RSI_C04	.1030141	.0693882	1.48	0.138	-.0329907	.2390188
Scar	-.3602756	.0713035	-5.05	0.000	-.5000343	-.2205168
C0_gas	.0001201	6.69e-06	17.96	0.000	.000107	.0001332
C0_coal	-.0000386	3.72e-06	-10.38	0.000	-.0000459	-.0000313
d2004	-.263209	.0054793	-48.04	0.000	-.2739488	-.2524692
d2005	-.0249306	.009965	-2.50	0.012	-.0444625	-.0053987
dpeak	1.060999	.0286618	37.02	0.000	1.00482	1.117178
dsummer	.020383	.0046579	4.38	0.000	.0112532	.0295128
dwinter	-.0732924	.004894	-14.98	0.000	-.0828849	-.0636998
dwkday	-.0446524	.0047371	-9.43	0.000	-.0539374	-.0353673
_cons	.5583585	.0725693	7.69	0.000	.4161187	.7005984

Overall the results of the regression analysis indicates that there is a significant statistical relationship between the RSI and outcome measures in the Spanish electricity market, with company specific indispensability a factor in the resulting Price-Cost Mark-Ups observed in the market.

7.10 Withholding

The GED model of optimal system despatch can provide the modelled hourly generation data for each specific unit. This can be compared with the actual hourly generation patterns of the units in an attempt to identify potential systematic withholding of generation assets.

We note that there are a variety of reasons why the modelled generation pattern may not match the actual. One such reason, for example, could involve the possibility of multiple optima or multiple 'nearly optimal' solutions to the least cost despatch problem. Another reason might involve the treatment of partial outages in our model, which is explained in detail in the methodology chapter. Thus we cannot distinguish with too much certainty that the measured withholding truly represents evidence of anti competitive behaviour.

Nonetheless, the withholding is interesting, because in some cases it was shown to be a significant determinant of price cost margins in the regression analysis above. In order to place the following results into context, we first present an overview of the total installed capacity in Spain, split by generation technology.

Table 7.49: Total Installed Capacity of modelled Units, by Technology - Spain

Gas	Coal	Nuclear	Pump storage	Other	Total
13,796	11,358	7,609	2,634	10,491	45,887

Source: LE

Table 7.50 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis for company 0577-S-ES. The number of hours in which our model led to more generation than was actually reported by the company is high for all the different technologies, but particularly high for nuclear and coal generation.

Table 7.50: Potential Withholding, by Technology, for 0577-S-ES, (Number of hours where modelled is greater than actual generation) - Spain					
	Gas	**Coal**	**Nuclear**	**Pump Storage**	**Other**
2003-05	19,451	22,552	22,669	9,357	13,587
% hrs<0	73.9%	85.7%	86.2%	35.6%	51.7%
2003	5,172	7,882	5,870	2,979	4,415
% hrs<0	59.0%	90.0%	67.0%	34.0%	50.4%
2004	8,042	7,769	8,039	3,159	4,421
% hrs<0	91.6%	88.4%	91.5%	36.0%	50.3%
2005	6,237	6,901	8,760	3,219	4,751
% hrs<0	71.2%	78.8%	100.0%	36.7%	54.2%

Source: LE

Table 7.51 presents evidence of potential withholding for Company 0577-S-ES expressed in MW.

Table 7.51: Potential Withholding, by Technology, for 0577-S-ES						
	Gas	**Coal**	**Nuclear**	**Pump storage**	**Other**	**Total**
2003-05	-252	-402	2	-31	-54	-738
2003	-66	-563	332	-18	-42	-357
2004	-525	-421	-62	-17	-48	-1,073
2005	-166	-220	-265	-58	-73	-782

Source: LE

Table 7.52 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis. Again, tour model predicted higher generation across all technologies represented in the portfolio of company 0850-S-ES.

Table 7.52: Potential Withholding, by Technology, for 0850-S-ES, (Number of hours where modelled is greater than actual generation)					
	Gas	Coal	Nuclear	Pump Storage	Other
2003-05	12,616	20,257	22,540	-	7,437
% hrs<0	48.0%	77.0%	85.7%	-	28.3%
2003	1,339	8,508	5,591	-	2,505
% hrs<0	15.3%	97.1%	63.8%	-	28.6%
2004	4,697	7,004	8,192	-	2,403
% hrs<0	53.5%	79.7%	93.3%	-	27.4%
2005	6,580	4,745	8,757	-	2,529
% hrs<0	75.1%	54.2%	100.0%	-	28.9%

Source: LE

Table 7.53 presents evidence of potential withholding for Company 0850-S-ES expressed in MW.

Table 7.53: Potential Withholding, by Technology, for 0850-S-ES						
	Gas	Coal	Nuclear	Pump storage	Other	Total
2003-05	22	-78	11	-	0	-45
2003	110	-187	40	-	0	-38
2004	14	-65	-3	-	0	-53
2005	-59	19	-3	-	0	-43

Source: LE

Table 7.52 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis. Again, our model significantly overestimated the company's generation.

Table 7.54: Potential Withholding, by Technology, for 0875-S-ES, (Number of hours where modelled is greater than actual generation)					
	Gas	**Coal**	**Nuclear**	**Pump Storage**	**Other**
2003-05	8,896	3,768	18,689	8,450	20,367
% hrs<0	33.8%	14.3%	71.1%	32.1%	77.4%
2003	6,310	3,360	5,046	2,643	6,522
% hrs<0	72.0%	38.4%	57.6%	30.2%	74.5%
2004	1,337	36	6,491	3,199	6,635
% hrs<0	15.2%	0.4%	73.9%	36.4%	75.5%
2005	1,249	372	7,152	2,608	7,210
% hrs<0	14.3%	4.2%	81.6%	29.8%	82.3%

Source: LE

Table 7.53 presents evidence of potential withholding for Company 0875-S-ES expressed in MW.

Table 7.55: Potential Withholding, by Technology, for 0875-S-ES						
	Gas	**Coal**	**Nuclear**	**Pump storage**	**Other**	**Total**
2003-05	450	442	-7	-14	-362	510
2003	-204	49	104	-6	-382	-438
2004	555	637	-49	-22	-370	752
2005	999	641	-77	-15	-334	1,215

Source: LE

Table 7.52 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis. Our estimates of potential withholding are high also in the case of company 1646-S-ES.

Table 7.56: Potential Withholding, by Technology, for 1646-S-ES, (Number of hours where modelled is greater than actual generation)					
	Gas	**Coal**	**Nuclear**	**Pump Storage**	**Other**
2003-05	6,918	10,935	9,425	-	6,125
% hrs<0	26.3%	41.6%	35.8%	-	23.3%
2003	0	2,396	1,152	-	2,436
% hrs<0	0.0%	27.4%	13.2%	-	27.8%
2004	552	4,514	367	-	1,976
% hrs<0	6.3%	51.4%	4.2%	-	22.5%
2005	6,366	4,025	7,906	-	1,713
% hrs<0	72.7%	45.9%	90.3%	-	19.6%

Source: LE

Table 7.53 presents evidence of potential withholding for Company 1646-S-ES expressed in MW.

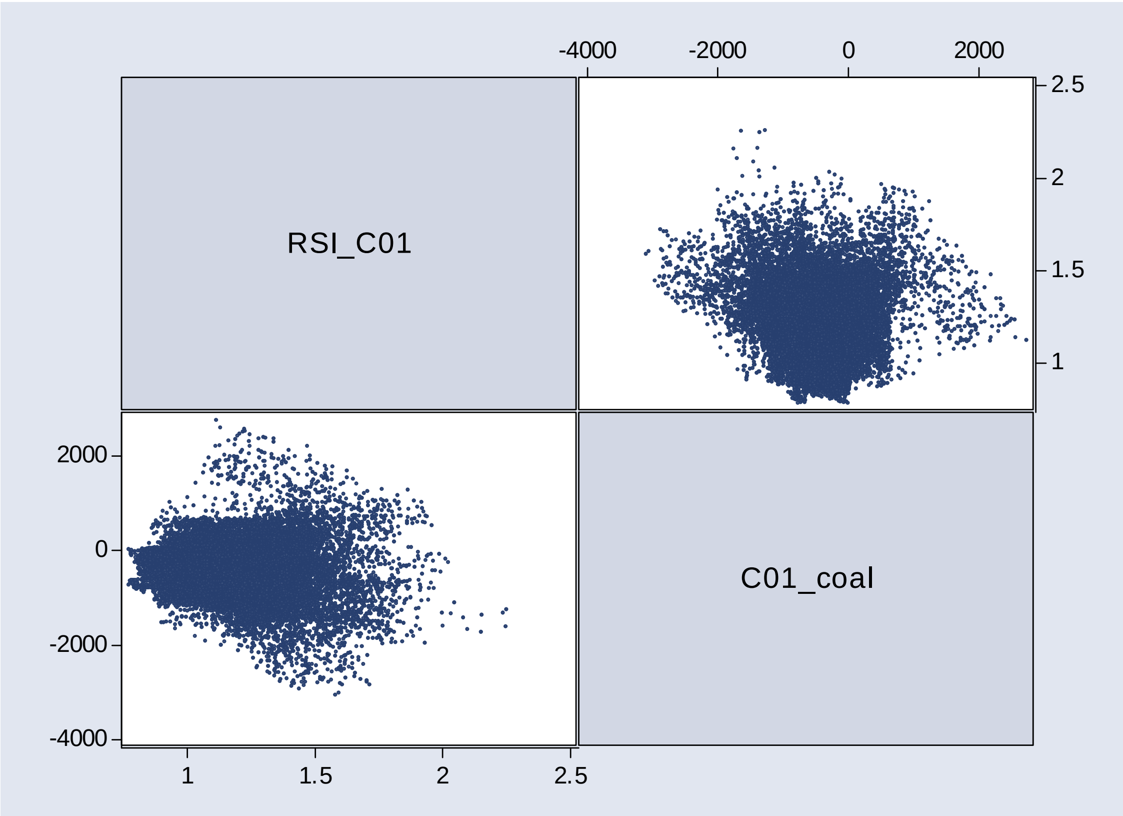
Table 7.57: Potential Withholding, by Technology, for 1646-S-ES						
	Gas	**Coal**	**Nuclear**	**Pump storage**	**Other**	**Total**
2003-05	-50	321	105	-	74	450
2003	16	502	197	-	76	791
2004	103	239	126	-	58	527
2005	-271	222	-8	-	87	31

Source: LE

Analysis of Company 0577-S-ES and Withholding

The figure below shows potential withholding of coal generation by company 0577-S-ES. No particular trend is visible.

Figure 7.23. Comparison of the use of coal fired technology and the hourly RSI of Company 0577-S-ES

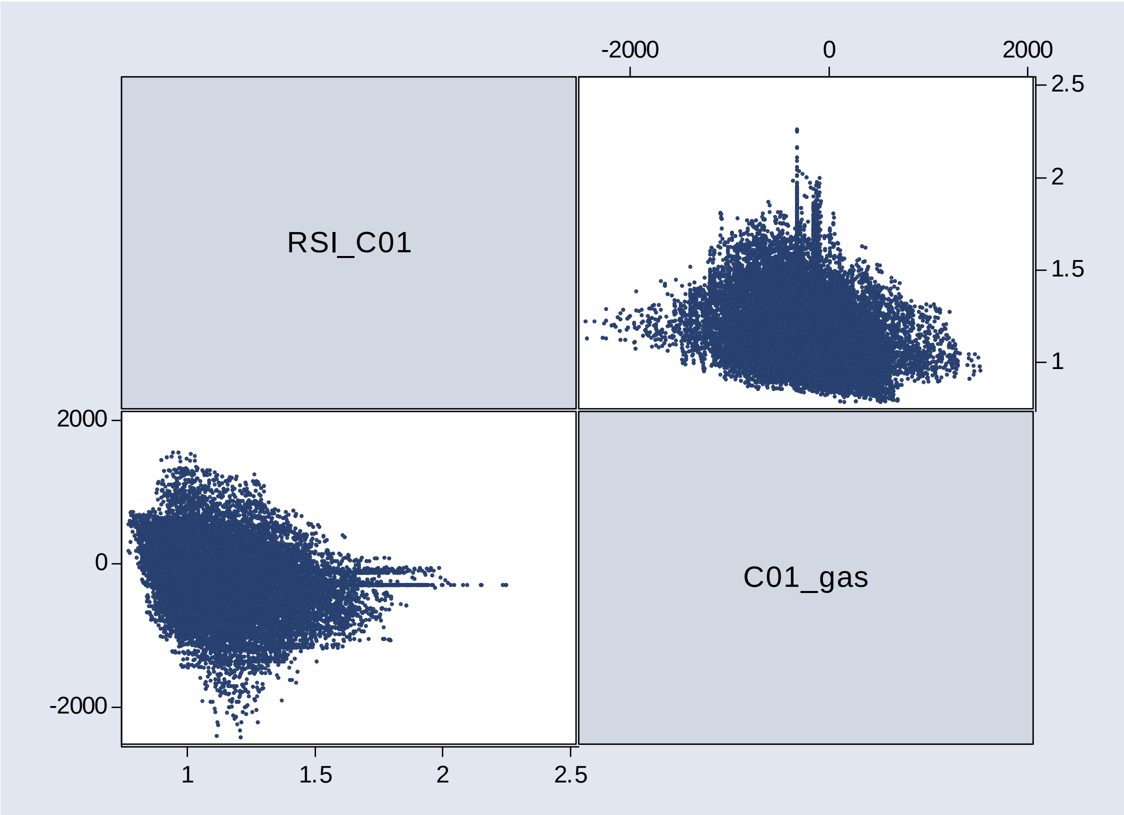


Source: LE.

Comparison of the use of gas fired technology and the hourly RSI of Company 0577-S-ES

The potential withholding of gas generation plotted against the hourly RSI of company 0577-S-ES is presented in the figure below. Again there seems to be no .clear relationship between the two variables.

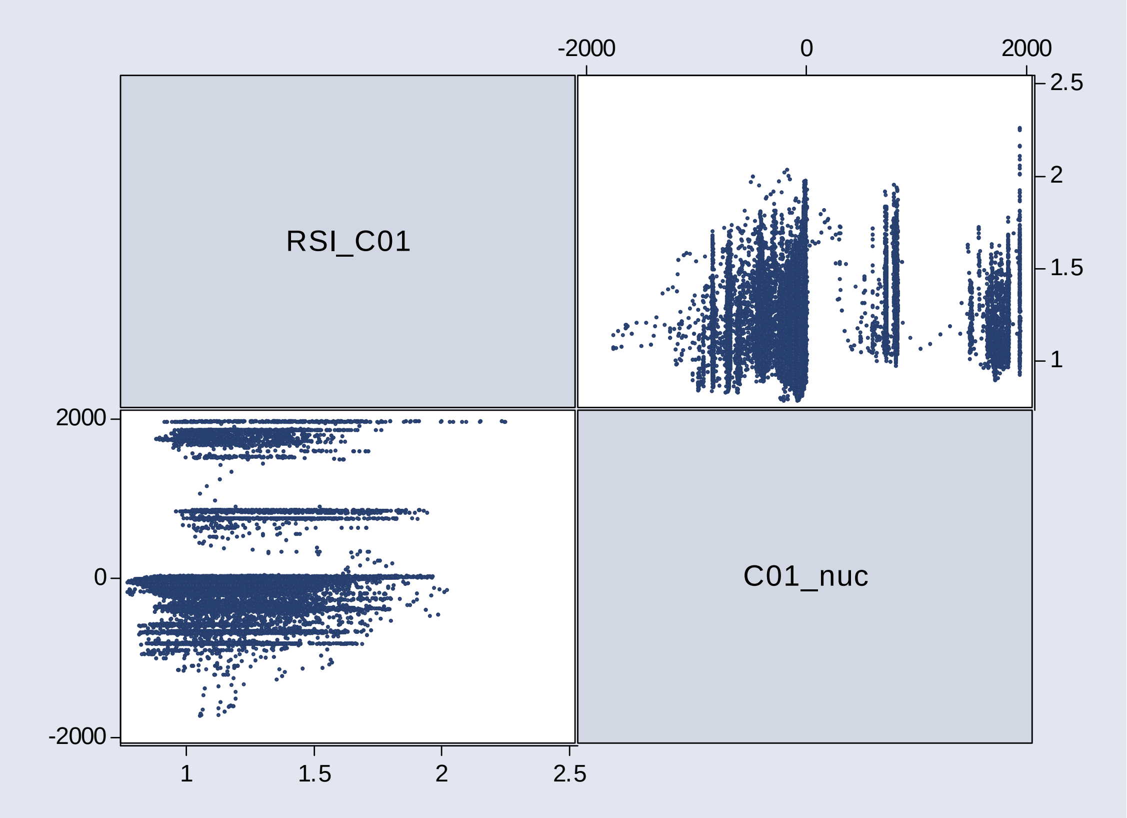
Figure 7.24: Comparison of the use of gas fired technology and the hourly RSI of Company 0577-S-ES



Source: LE.

Potential withholding of nuclear generation does not seem to be systematically related to RSI values either. The plot of the two variables is shown in Figure 7.25.

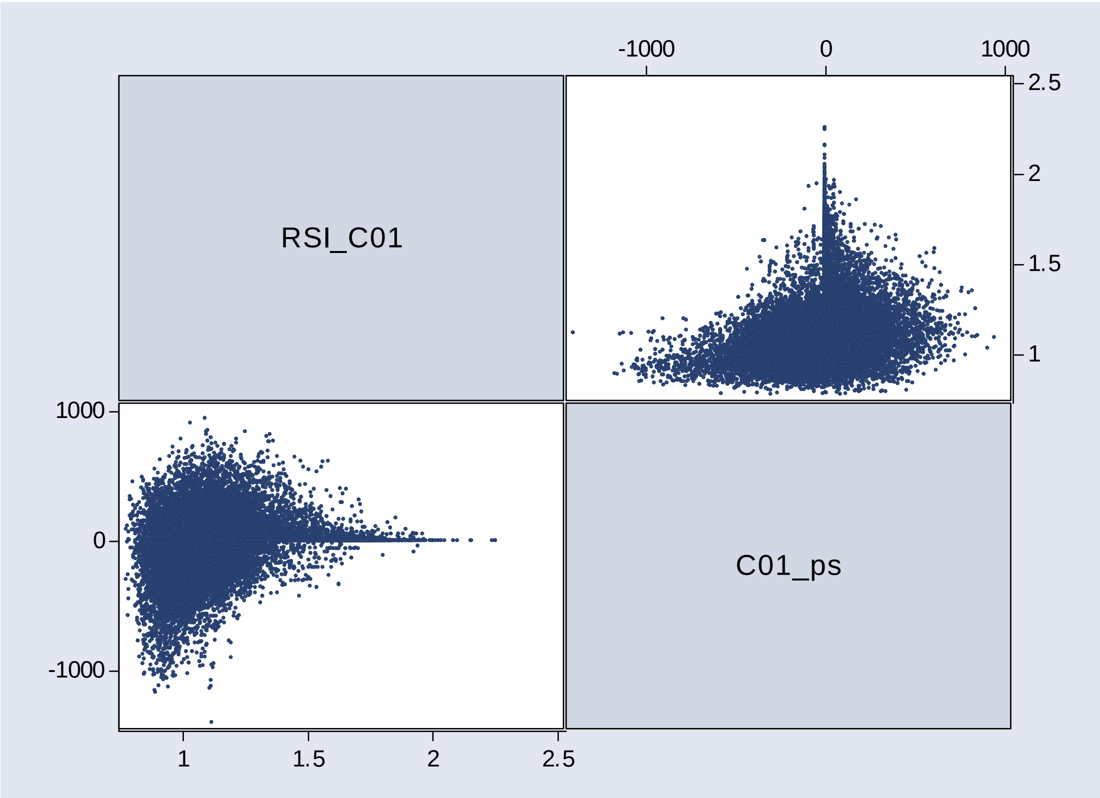
Figure 7.25: Comparison of the use of nuclear technology and the hourly RSI of Company 0577-S-ES



Source: LE.

The same lack of a clear relationship between the RSI and our measure of potential withholding is evident for pumped storage generation (Figure 7.26).

Figure 7.26: Comparison of the use of pumped storage technology and the hourly RSI of Company 0577-S-ES



Source: LE.

The figures presented on withholding add further evidence that as measured withholding does not appear to be systematic. Withholding variables were, however, included in the regression analysis, and often impacted margins significantly. We believe that strong conclusions about withholding are not possible at this time.

7.11 Conclusions

Our analysis of the Spanish electricity market found the market, in general, to be concentrated. Whether in fact this level of concentration is conducive to competition is an open question, but our analysis suggests, at least in some significant number of hours, that poor market outcomes are possible.

Market structure as measured by traditional concentration measures HHI and CR(2) indicated the market was concentrated. Based on available capacity, the HHI for Spain was found to be 2,813 on average through the sample period[27], and the CR(2) was found to be 71.8%. Allocating the interconnectors led to a range from 1,945 to 2,293 for HHI and 59.6% to 65.1% for CR(2). We note that threshold values such as 1,800 for the HHI and 33% for *CR(n)* are somewhat arbitrary.

Sensitivity analysis regarding the allocation of interconnectors to market shares, basing market shares on generation or in merit capacity, and the attribution of long term contracts did have some impacts on the concentration measures, but not so much so as to alter the qualitative conclusions. The range of HHI went from 2,790 based on available installed capacity to 2,896 based on in merit capacity. We also note that the level of physical interconnection from Spain to France and from Spain the Portugal is very low.

The electricity-specific measures of market structure confirmed the qualitative conclusions of the HHI and CR(2) for Spain. In general, the largest two companies' RSIs failed the proposed screening test with RSI>110% in less than 5% of hours. Similar results were found for the PSI in Spain, with the PSI finding a single company was pivotal in between 25.7% of hours.

Price cost margins in Spain were higher than in the UK, but lower than in France and Germany, with an average price cost margin over the sample period of 13.9% for the LI and 16.1% for the price cost mark-up.[28]

---

[27] Unless explicitly mentioned, all figures reported in this section represent the mean over the whole period 2003-2005.

[28] Based on Platts assessment price.

Relating the RSI to the price cost margins via regression analysis for Spain showed similar results as to other countries. The RSI is a significant explanatory variable for the margins estimated in Spain. The inclusion of additional variables such as scarcity did not change this conclusion, nor did the inclusion of more than one RSI variable. Statistical significance was in general robust to a number of changes in the assumptions, including changing specifications, dummy variables for peak and off peak, and violations of the classical linear regression assumptions.

Contributions to fixed cost estimates showed that marginal cost estimates for the Spanish market were not so low than many generators would not earn significant margins towards their fixed costs, even if they traded at the perfectly competitive price. In Spain, the per MW contributions to fixed cost were somewhat lower per MW than in other countries, and were somewhat lower than our generic new entrant comparison. This may have been due to hydro or due to other issues such as stranded costs, but we have not been able to investigate this further. Our belief is, however, that the validation of the model results largely holds, as the sums in the contribution to fixed costs remain large. Further, the generic new entrant scenario was meant as a high hurdle, and it should be noted that many plant in Spain are likely fully or largely amortised.

The breakdown of power prices into cost estimates plus margin, and the inclusion of carbon revealed that a significant portion of recent price rises in Spain can be attributed to carbon cost inclusion due to the introduction of the EU ETS. In spite of the fact that utilities obtained their emissions allowances for free, one would expect them to price in carbon costs fully, unless they believed doing so would lead to reduced carbon allowances in future rounds.

Estimates of withholding were significant in Spain. We do not interpret this specifically as estimates of economic withholding as a means of the use of market power, but rather included withholding in the regression as a measure of either economic withholding or other reasons why the modelled despatch may have deviated from the actual despatch. These impacts were significant in some cases on the regressions of margins on RSI, but were small relative to the RSIs and scarcity, and also did not tend to make other variables such as the RSI insignificant.

Our final conclusions on Spain are that the Spanish market seems evidently moderately concentrated by both traditional and new electricity-specific market structure measures. We note that the existence of large hydro and nuclear resources in Spain likely mean that at moderately concentrated levels, such a market structure could either provide anticompetitive opportunities or provide rather competitive outcomes. Hydro availability likely plays a large role. The relating of structure to outcome via the RSI regressions becomes all the more crucial as an empirical test.

Price cost margins (LI and PCMU) were significantly related to market structure via the regression on RSI. This latter finding could either indicate that more subtle forms of market power use or market imperfections exist/have existed or, alternatively, that the models as specified are unable to distinguish between this explanation and some alternative unknown, but more benign, rationale.