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

Part III

Presented to DG Comp 26th February 2007

Prepared by

London Economics

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

Part III – Results for the Netherlands and Great Britain

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8 The Netherlands

This chapter contains our analysis of the competitive situation of the wholesale electricity market in the Netherlands. 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.

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.

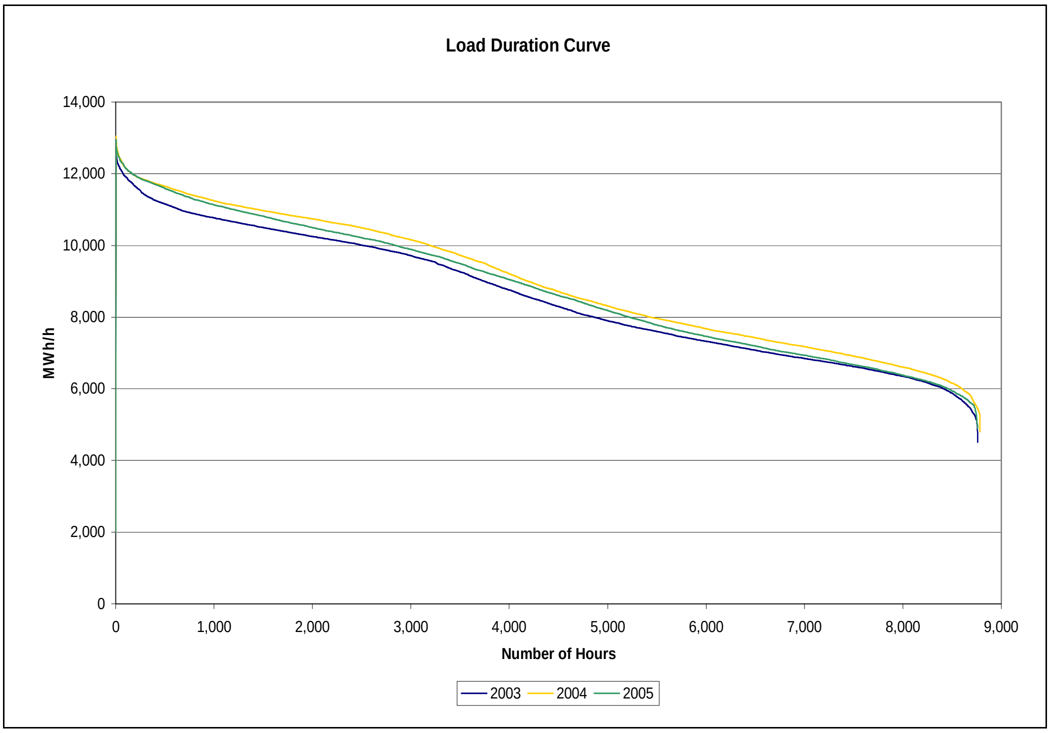
8.1 Introduction to the Netherlands Electricity Market

8.1.1 Load Duration Curve

The load duration curve for the electricity market in the Netherlands 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 the Netherlands (NL) is above the scale on the vertical axis. Figure 8.1 presents the load duration curve for each of the three-year period of the study. One can see that both the peak and minimum demand levels have remained largely static over the period, although demand for electricity in 2004 appears to have been higher on average than in the other two years.

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 (TenneT). 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 8.1: Load Duration Curve - Netherlands



Source: LE.

8.1.2 Merit Order Curve

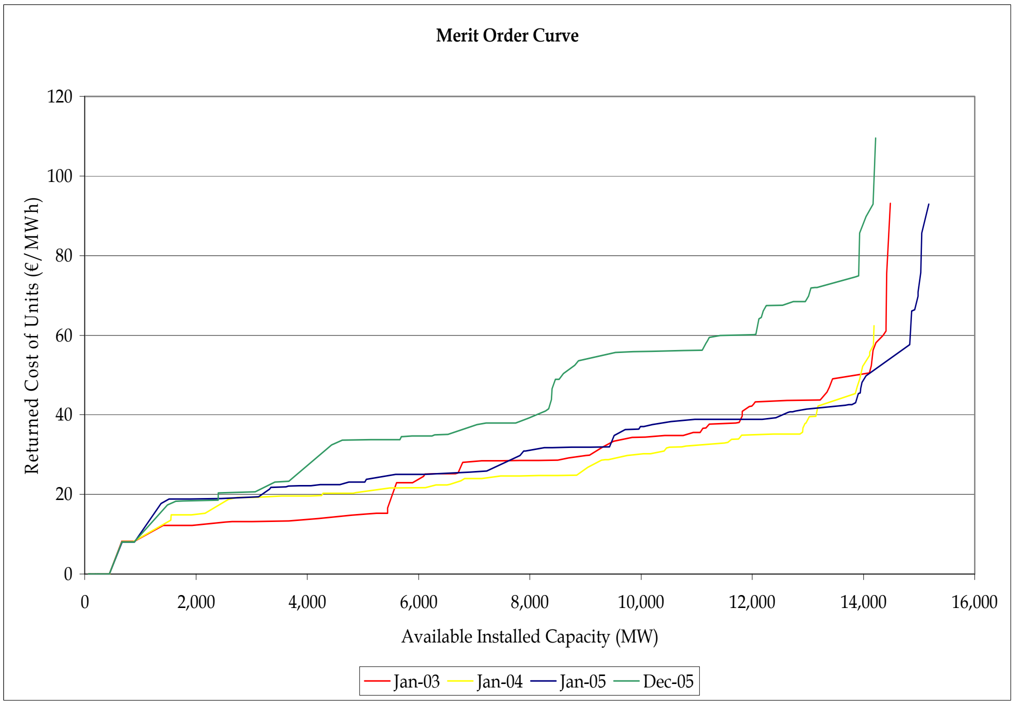
The merit curve is an ascending ordering of the available installed capacity in the system, based on the marginal cost of generation (€/MWh) for each unit on the system. The merit curve can shift based on availability, fuel prices, etc, and thus is specific to a time period or an average. In this instance 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 Dutch electricity market is presented in Figure 8.2. Looking at the merit curve from left to right one can see there is no difference in the installed capacity of units with zero fuel costs over the course of the study. 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. In the case of the Netherlands, there are no storage or run-of-river hydro units on the system. Similarly, the very small quantity of nuclear capacity can be seen to be stable, in term of cost and availability, over the period of the study.

To the right of the zero cost and nuclear capacity on the merit curve one can see the effect of substantial variation in the price of coal and natural gas over the period of the study. The most substantial increase occurs in the December 2005 curve, reflecting a period of globally high gas prices. There also appears to be a substantial change in the available installed capacity of the system in January 2005, relative to the other months assessed. This difference is due to an increase in the average availability of a number of units during this period. Compared with December 2005, the quantity of available installed capacity is over 800MW less than in January of the same year. For a more detailed discussion of how available installed capacity is calculated for each hour one should revert to the methodology chapter of this report but more briefly it is largely due to both full and partial planned maintenance and forced outages of units within these months, that cause the average hourly availability of them to decline.

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 8.2: Merit Order Curve (excl. Carbon) - Netherlands

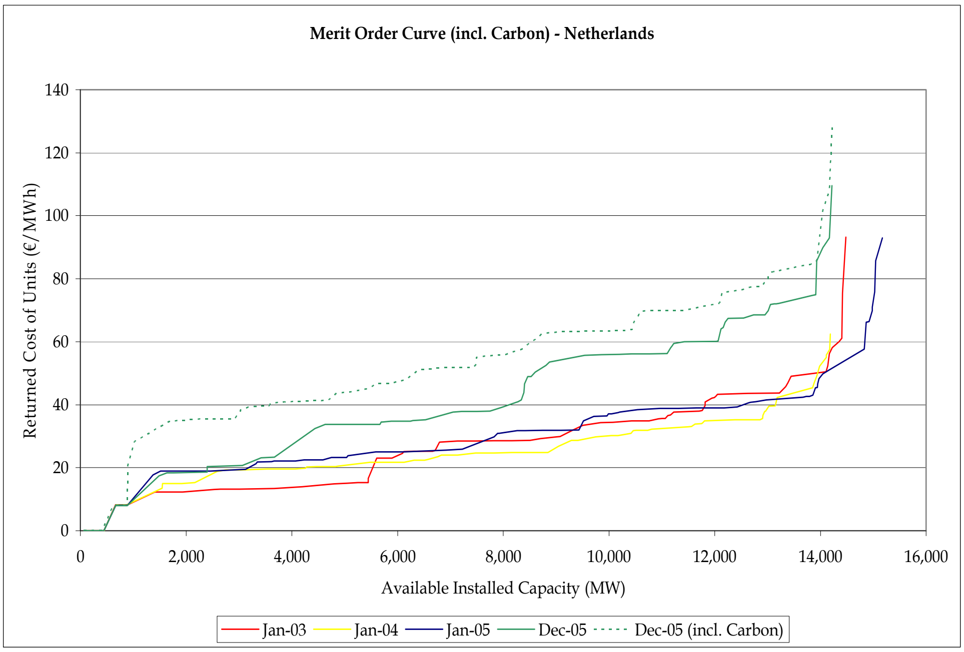


Source: LE.

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 the Netherlands 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 nuclear capacity in the Netherlands remains unaffected by the introduction of the ETS as does the generation capacity with zero fuel costs such as wind. However, for the majority of units represented in the merit curve, conventional thermal units, 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 8.3: Merit Order Curve (incl. Carbon) - Netherlands

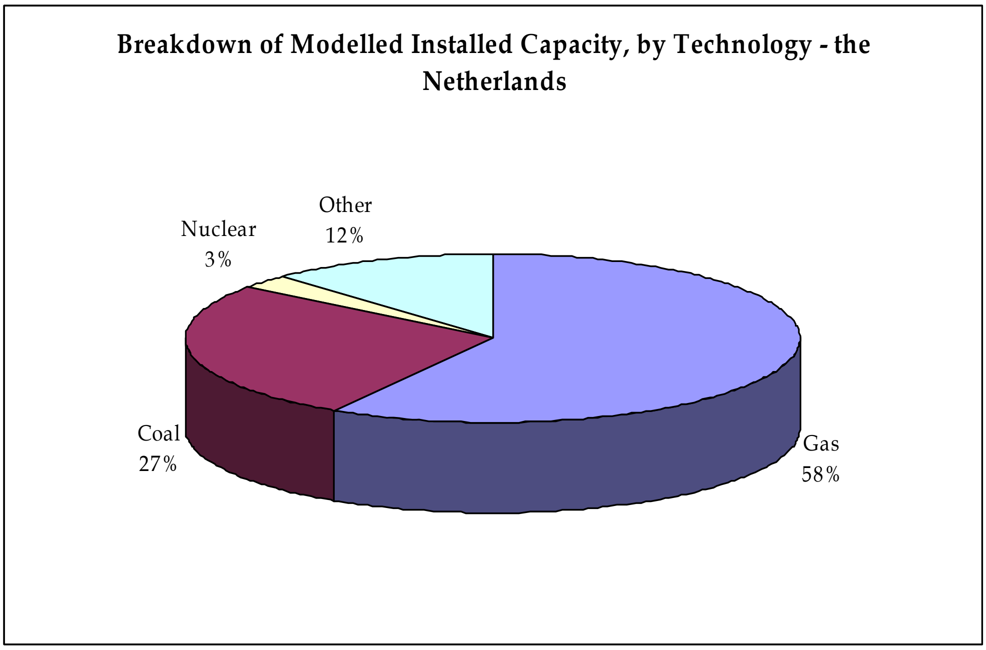


Source: LE.

As one can see, the effect of carbon is most pronounced where we expect the coal fired plants to be located on the merit curve, however the overall size of the effect narrows as we move to the right of the merit curve.

This can largely be explained by the preponderance of gas generation evident from the breakdown of installed capacity in the Netherlands by technology, which is shown in Figure 8.4. Gas-burning generators make up 58% of all installed capacity in the country, more than twice as much coal-burning units, which represent the next most important generation technology. Nuclear generation is a very small factor in the Netherlands.

Figure 8.4: Breakdown of Installed Capacity, by Technology - Netherlands



Source: LE.

8.2 Structural Indicators

Traditional structural indicators have been calculated based on a number of different measures of market share for the Dutch 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

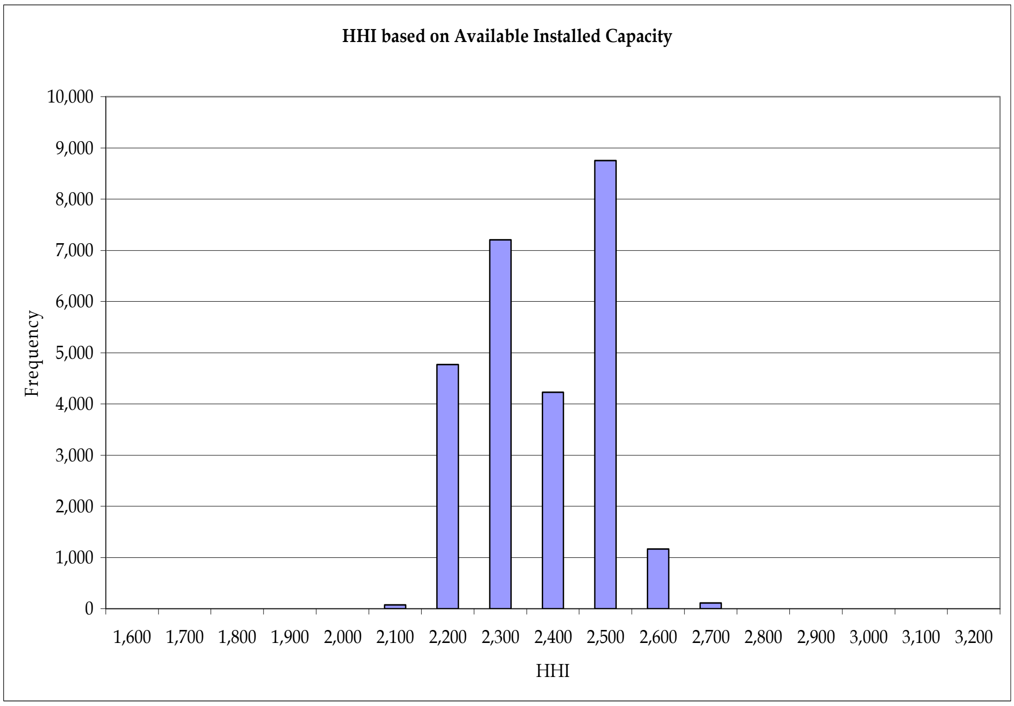
The HHI indicator sums the squares the market shares of all companies in the market, where the market shares of the companies are calculated on an hourly basis using, Available Installed Capacity, Available Capacity, Total Generation, and, In Merit/Economic Capacity. The HHI indicator sums the squares 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.

8.2.1 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 8.5: Histogram of HHI Values based on Available Installed Capacity (2003-2005) - Netherlands



Source: LE.

The distribution of hourly HHI values is largely contained in the range 2,200 – 2,600 and appears to be bi-modal with two separated peaks at 2,300 and 2,500. The summary statistics on the hourly HHI is presented in Table 8.1.

From this one can observe that in no single hour does the HHI fall below the competitive threshold of 1,800. The CR(2) values also indicate a significant degree of concentration in the market with the largest two companies in each hour commanding a 57.7% market share, on average.

Table 8.1: Summary Statistics of CR(2) & HHI based on Available Installed Capacity - Netherlands			
	Available Installed Capacity (MW)	**CR(2)**	**HHI**
Average	14,341	57.7%	2,332
Maximum	16,463	67.4%	2,647
Minimum	10,808	50.5%	2,053
Standard Deviation	828	2.8%	123
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. These somewhat arbitrary dates are intended to check for whether particular effects impact on the degree of concentration in the market, effects that would not otherwise be observed when looking at the full period. The pre-selected dates are provided in Table 8.2.

Table 8.2: Pre-Selected Representative Days[1] - Netherlands		
	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 8.3 presents the results of the CR(2) and HHI analysis for available installed capacity for these pre-selected dates. The figures presented do not vary significantly over the period or from the average values returned over the entire period. Therefore, there does not appear to be a seasonal impact on the previous conclusion that the Netherlands market appears to be concentrated.

[1] 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 8.3: Concentration measures based on Available Installed Capacity – selected days - Netherlands				
No.	Date	Average Hourly Demand (MWh/h)	CR(2)	HHI
1	08/01/03 (W-2)	10,603	58.8%	2,458
2	12/01/03 (S-2)	7,576	59.2%	2,459
3	22/01/03 (W-4)	9,905	61.7%	2,492
4	09/04/03 (W-2)	9,182	61.5%	2,486
5	13/04/03 (S-2)	7,084	61.3%	2,480
6	10/08/03 (S-2)	6,643	60.6%	2,489
7	13/08/03 (W-2)	8,284	59.3%	2,456
8	27/08/03 (W-4)	9,281	61.8%	2,493
9	08/10/03 (W-2)	8,843	60.4%	2,421
10	12/10/03 (S-2)	6,200	59.8%	2,463
11	11/01/04 (S-2)	7,487	57.0%	2,399
12	14/01/04 (W-2)	9,585	56.4%	2,394
13	28/01/04 (W-4)	10,141	56.6%	2,400
14	11/04/04 (S-2)	6,728	67.4%	2,647
15	14/04/04 (W-2)	9,224	64.6%	2,550
16	08/08/04 (S-2)	6,946	56.8%	2,212
17	11/08/04 (W-2)	9,421	57.7%	2,243
18	25/08/04 (W-4)	9,504	56.8%	2,204
19	06/10/04 (W-2)	9,344	52.2%	2,151
20	10/10/04 (S-2)	6,940	53.7%	2,152
21	09/01/05 (S-2)	7,332	57.2%	2,237
22	12/01/05 (W-2)	9,742	57.3%	2,243
23	26/01/05 (W-4)	10,330	55.2%	2,197
24	10/04/05 (S-2)	6,924	58.8%	2,372
25	13/04/05 (W-2)	9,627	57.5%	2,303
26	10/08/05 (W-2)	8,059	55.3%	2,228
27	14/08/05 (S-2)	5,953	55.1%	2,252
28	24/08/05 (W-4)	8,983	56.6%	2,237
29	09/10/05 (S-2)	6,534	62.1%	2,392
30	12/10/05 (W-2)	9,092	61.6%	2,336

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 contained in Table 8.4. The table shows that seasonality had a negligible impact on concentration. It is possible, however, to identify an overall decline in concentration since 2003 across seasons.

Table 8.4: Concentration measures based on Available Installed Capacity– seasonal peaks - Netherlands

	Date	Average Hourly Demand (MWh/h)	CR(2)	HHI
Summer	17/07/2003	9,653	60.3%	2,471
	31/08/2004	10,039	56.0%	2,240
	20/06/2005	9,401	57.4%	2,248
Winter	20/02/2003	10,821	60.0%	2,456
	21/12/2004	11,196	55.7%	2,244
	24/02/2005	10,739	54.5%	2,227
Spring	27/03/2003	9,923	61.4%	2,482
	02/03/2004	10,682	57.6%	2,415
	08/03/2005	10,354	59.8%	2,269
Autumn	27/11/2003	10,102	59.0%	2,463
	07/09/2004	10,978	56.1%	2,232
	23/11/2005	11,061	56.1%	2,240

Source: LE.

The degree of concentration on the peak seasonal demand days in the Netherlands does not appear to be significantly different from the degree of concentration previously seen in relation to the arbitrarily chosen dates. As a result the overall conclusion remains unchanged, the Netherlands market appears concentrated when measured on the basis of available installed capacity.

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 8.5 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. According to Table 8.5 the inclusion of LTCs and reserves lowers the concentration observed in the market.

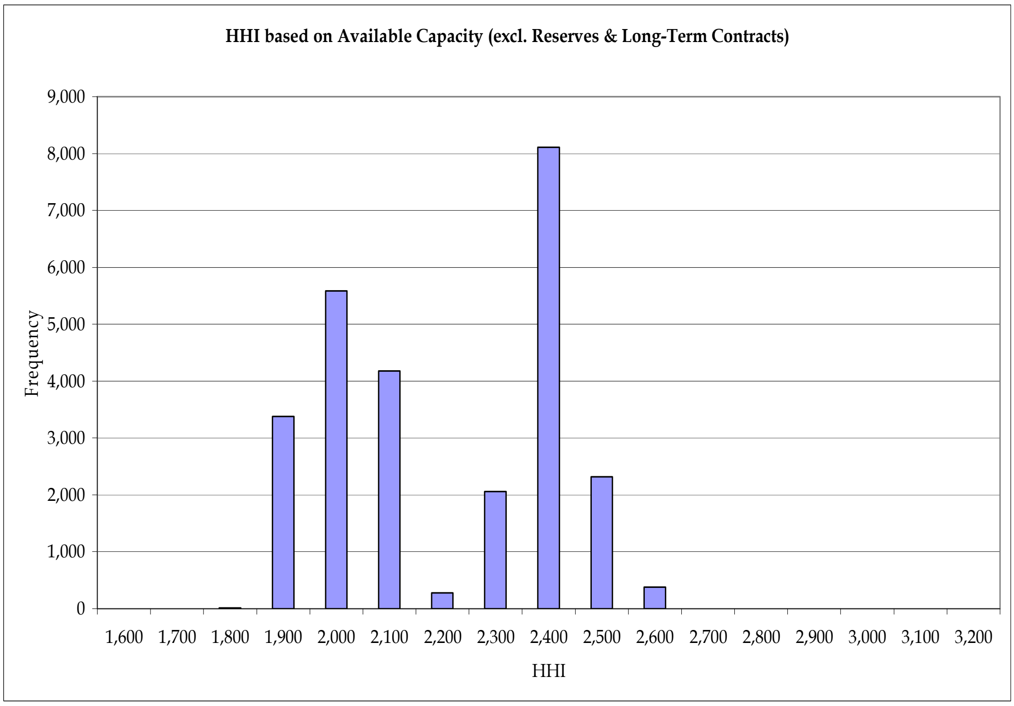
Table 8.5: Comparison of Available Capacity (accounting for LTCs and Reserves) & Available Installed Capacity - Netherlands

	Available Capacity (MW)		Available Installed Capacity (MW)	
	CR(2)	**HHI**	**CR(2)**	**HHI**
Mean	54.5%	2,153	57.7%	2,332
Max	66.2%	2,589	67.4%	2,647
Min	45.7%	1,762	50.5%	2,053
Standard deviation	4.1%	211	2.8%	123

Source: LE

The histogram presented below provides the frequency of the computed HHI values based on Available Capacity. As with the summary statistics in Table 4, the histograms of both available capacity and available installed capacity are broadly similar. Once again there is a notable bi-polar distribution with a smaller mean and median value in the concentration measures based on available capacity. Therefore, one may conclude that reserve commitments and long-term contracts have a relatively small impact on the degree of concentration in the Netherlands electricity market. Although the impact is to marginally reduce the degree of concentration, there is only a very small number of hours, out of 26,304, that report a HHI value below the 1,800 threshold.

Figure 8.6: Histogram of HHI values based on Available Capacity (2003-2005) - Netherlands



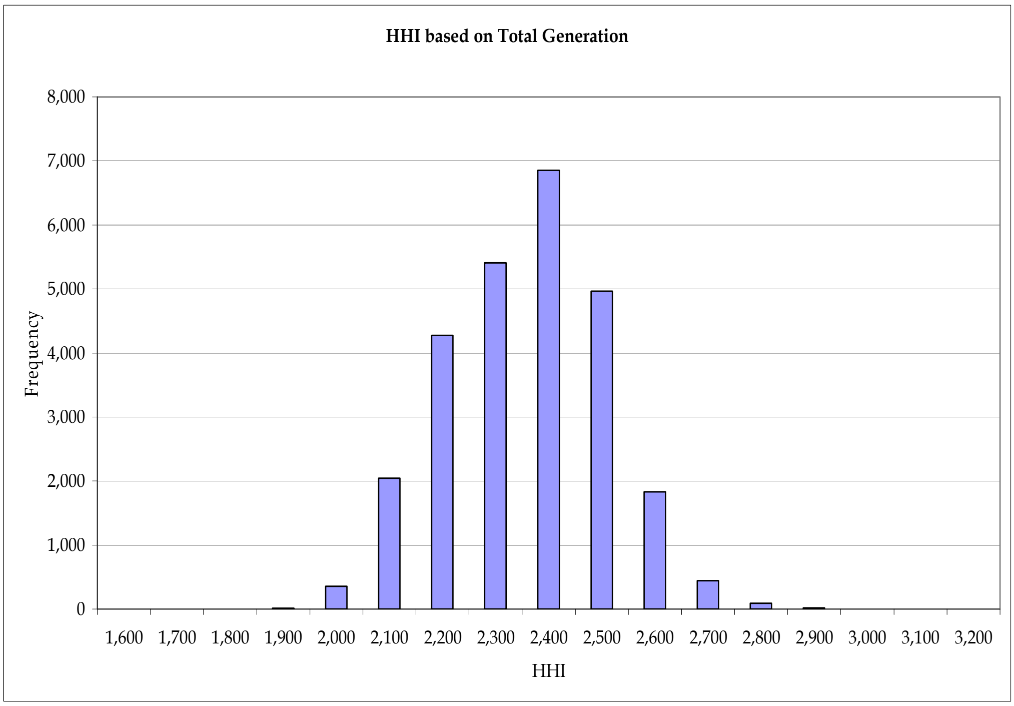
Source: LE.

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 the Netherlands for the purpose of this study, as previously discussed.

The Figure below presents a histogram of the frequency of hourly HHI values computed using hourly generation over the period 2003-2005. As one can see the shape of the distribution has altered considerably compared to bi-modal distribution that resulted from the capacity measures. However, the overall result of the analysis is broadly similar, as is confirmed by the summary statistics in Table 8.6. As with available installed capacity, there is not a single hour out of the 26,304 where the HHI value is below the 1,800 threshold.

Figure 8.7: Histogram of HHI values based on Total Generation (2003-2005) - Netherlands



Source: LE.

Table 8.6: Summary Statistics of CR(2) & HHI based on Total Generation - Netherlands			
	Hourly Generation (MWh/h)	**CR(2)**	**HHI**
Average	8,638	57.5%	2,308
Maximum	12,914	72.2%	3,397
Minimum	4,407	47.3%	1,861
Standard Deviation	1,784	3.2%	149
Source: LE			

Table 8.7 presents the HHI and CR(2) measures computed for the pre-selected days previously listed in Table 8.2. These values remain largely consistent with the summary statistics and the results previously discussed in relation to measures of capacity. They show that the daily variation in concentration has been moderate over the period 2003-2005.

Table 8.7: Concentration measures based on total generation - selected days - Netherlands				
No.	**Date**	**Average Hourly Demand (MWh/h)**	**CR(2)**	**HHI**
1	08/01/03 (W-2)	10,603	57.8%	2,419
2	12/01/03 (S-2)	7,576	61.1%	2,463
3	22/01/03 (W-4)	9,905	57.8%	2,406
4	09/04/03 (W-2)	9,182	59.5%	2,493
5	13/04/03 (S-2)	7,084	63.0%	2,667
6	10/08/03 (S-2)	6,643	58.8%	2,465
7	13/08/03 (W-2)	8,284	54.2%	2,322
8	27/08/03 (W-4)	9,281	59.1%	2,424
9	08/10/03 (W-2)	8,843	66.3%	2,623
10	12/10/03 (S-2)	6,200	60.6%	2,526
11	11/01/04 (S-2)	7,487	57.4%	2,285
12	14/01/04 (W-2)	9,585	57.3%	2,367
13	28/01/04 (W-4)	10,141	53.2%	2,316
14	11/04/04 (S-2)	6,728	56.7%	2,391
15	14/04/04 (W-2)	9,224	57.6%	2,371
16	08/08/04 (S-2)	6,946	56.7%	2,216
17	11/08/04 (W-2)	9,421	58.0%	2,315
18	25/08/04 (W-4)	9,504	56.1%	2,181
19	06/10/04 (W-2)	9,344	51.0%	2,052
20	10/10/04 (S-2)	6,940	58.1%	2,161
21	09/01/05 (S-2)	7,332	53.6%	2,127
22	12/01/05 (W-2)	9,742	55.0%	2,150
23	26/01/05 (W-4)	10,330	55.0%	2,161
24	10/04/05 (S-2)	6,924	62.5%	2,531
25	13/04/05 (W-2)	9,627	57.0%	2,374
26	10/08/05 (W-2)	8,059	51.3%	2,033
27	14/08/05 (S-2)	5,953	57.1%	2,166
28	24/08/05 (W-4)	8,983	56.7%	2,222
29	09/10/05 (S-2)	6,534	55.5%	2,374
30	12/10/05 (W-2)	9,092	59.0%	2,228
Source: LE.				

Table 8.8 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. The lack of significant variation from both the sample average, the values returned on the arbitrarily selected dates and from the other seasonal peak dates in this table, leads one to conclude that seasonality does not contribute in a substantial manner to the determination of market concentration in the Netherlands, when the market definition is based on actual generation.

Table 8.8: Concentration measures based on total generation – seasonal peaks - Netherlands

	Date	Average Hourly Demand (MWh/h)	CR(2)	HHI
Summer	17/07/2003	9,653	59.2%	2,460
	31/08/2004	10,039	55.9%	2,257
	20/06/2005	9,401	59.1%	2,382
Winter	20/02/2003	10,821	58.0%	2,414
	21/12/2004	11,196	55.4%	2,211
	24/02/2005	10,739	56.9%	2,207
Spring	27/03/2003	9,923	59.1%	2,436
	02/03/2004	10,682	57.6%	2,425
	08/03/2005	10,354	57.6%	2,200
Autumn	27/11/2003	10,102	59.7%	2,499
	07/09/2004	10,978	53.5%	2,195
	23/11/2005	11,061	57.6%	2,250

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 8.9 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. Herein lies an interesting results, the largest company in the Netherlands is consistently the top company in all of these periods, however there is a pattern in the company that emerges as the second largest with 1193-S-NL being overtaken by 0511-S-NL in all but the base load hours. This pattern may be indicative of the generation portfolios owned by these firms, with one contributing largely to baseload demand while the other owns more mid-merit and peaking capacity.

Table 8.9: Total Generation – Concentration & Load Duration – Netherlands

January 2005		Company	CR(2)	HHI
2nd Wednesday	*Base*	0712&1193	53.2%	2,026
	Shoulder	0712&0511	51.7%	1,996
	Peak	0712&0511	55.5%	2,057
August 2005				
2nd Wednesday	*Base*	0712&1193	48.6%	1,869
	Shoulder	0712&0511	50.0%	1,892
	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 8.10 presents summary statistics on the CR(2) and HHI values computed on an hourly basis. The average concentration over the period 2003-2005 is not markedly different compares with the results computed under different market definitions.

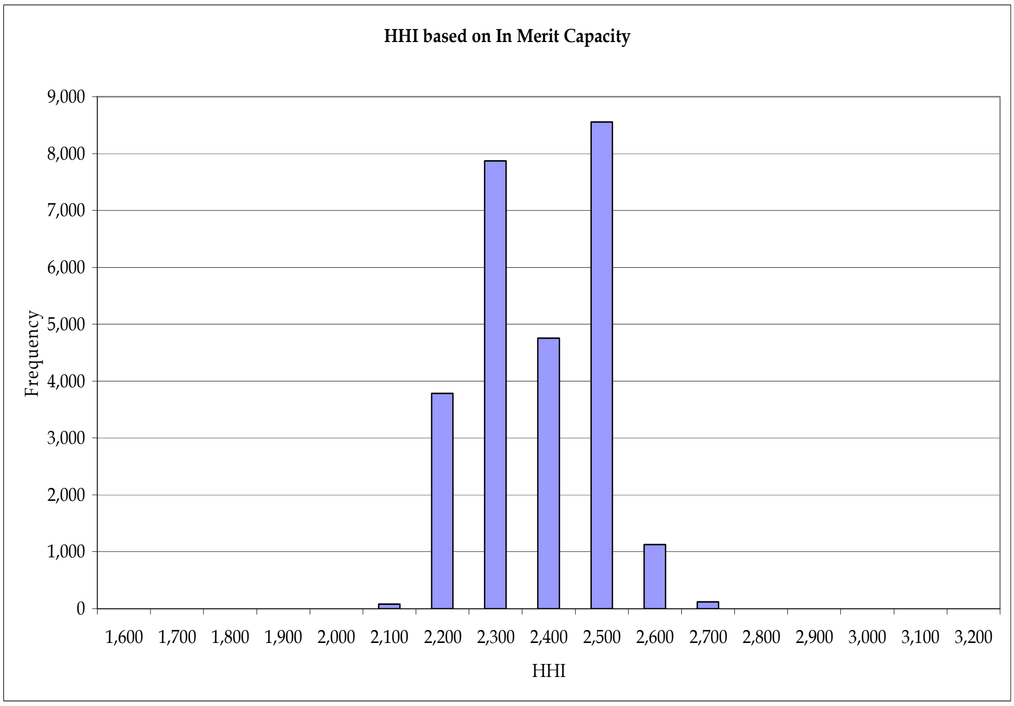
Table 8.10: Summary Statistics of CR(2) & HHI based on In Merit Capacity - Netherlands

	In Merit Capacity (MW)	CR(2)	HHI
Average	14,185	57.7%	2,236
Maximum	16,390	67.4%	2,653
Minimum	10,474	50.5%	2,068
Standard Deviation	842	2.8%	117

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 Netherlands electricity market. The market is concentrated, based on DG Competition guidelines, and is not notable affected by seasonality or changes in the metric used to measure market share.

Figure 8.8: Histogram of HHI values based on In-Merit Capacity (2003-2005) - Netherlands



Source: LE.

8.2.2 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(2) 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.

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

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. Table 8.11 allows a direct comparison of the results under different scenarios. The impact of the way the interconnector is factored into the analysis is clear from the large differences in concentration shown in the table.

Table 8.11: Summary Statistics Concentration measures based on Available Installed Capacity: Impact of the Interconnector - Netherlands

	STANDARD (excl. IC based on available installed capacity)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	CR(2)	HHI	CR(2)	HHI	CR(2)	HHI
Average	57.7%	2,332	40.5%	1,151	70.2%	3,304
Max	67.4%	2,647	46.7%	1,283	77.4%	3,835
Min	50.5%	2,053	34.4%	938	65.0%	2,896
Standard Deviation	2.8%	123	1.9%	61	2.1%	164

Source: LE.

Table 8.12 represents our cross-seasonal analysis; as in the base case, seasonality does not seem to affect the level of concentration under the different interconnector scenarios.

Table 8.12: Concentration measures based on Available Installed Capacity: Impact of the Interconnector - Netherlands

		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	17/07/2003	60.3%	2,471	42.7%	1,243	71.8%	3,416
	31/08/2004	56.0%	2,240	40.5%	1,170	68.2%	3,138
	20/06/2005	57.4%	2,248	39.8%	1,085	70.4%	3,480
Winter	20/02/2003	60.0%	2,456	42.7%	1,247	71.5%	3,337
	21/12/2004	55.7%	2,244	40.5%	1,189	67.7%	3,100
	24/02/2005	54.5%	2,227	39.4%	1,164	67.1%	3,127
Spring	27/03/2003	61.4%	2,482	43.9%	1,266	72.4%	3,410
	02/03/2004	57.6%	2,415	40.3%	1,182	70.3%	3,284
	08/03/2005	59.8%	2,269	42.0%	1,121	71.7%	3,364
Autumn	27/11/2003	59.0%	2,463	40.7%	1,169	71.8%	3,412
	07/09/2004	56.1%	2,232	40.8%	1,179	68.1%	3,099
	23/11/2005	56.1%	2,240	40.3%	1,151	68.6%	3,167

Source: LE.

The net transfer capacity available to the Netherlands electricity market through interconnectors with Belgium and Germany can be seen to have a potentially large impact on the degree of market concentration in the market. Under the atomistic assumption the HHI falls below the threshold of 1,800 in all hours, it is above 1,800 in the absence of the interconnector in all hours. However, under the largest firm apportionment both the HHI and CR(2) measures increase substantially and substantially increase the degree of concentration in the market.

Table 8.13 shows the impact of the interconnector on market concentration based on available installed capacity when the largest company's share of the interconnector is limited to 400MW, as per Dutch regulation. In this instance the previous result can be seen to be reversed with the HHI falling below the threshold value in all hours. This result is due to the fact that the regulation causes this scenario to more closely resemble the atomistic scenario than the largest firm scenario from the previous table. The largest firm benefits from a maximum of just 400MW of additional capacity from the interconnectors under this scenario whereas the market benefits by the full capacity of the interconnectors. Therefore even if the maximum interconnector capacity was added to the capacity of the largest firm in all hour, this would only represent a 400MW addition to the largest company in the calculation of HHI and CR(2) that was not present in the atomistic calculation. Table 8.14 reconfirms that seasonality does not affect the concentration measures in any significant way.

Table 8.13: Summary Statistics Concentration measures based on Available Installed Capacity: Impact of the Interconnector (400MW limit) - Netherlands

	STANDARD (excl. IC based on available installed capacity)		IC ADDED TO BIGGEST PLAYER	
	CR(2)	HHI	CR(2)	HHI
Average	57.7%	2,332	42.5%	1,239
Max	67.4%	2,647	48.8%	1,379
Min	50.5%	2,053	36.6%	1,038
Standard Deviation	2.8%	123	1.9%	63

Source: LE.

Table 8.14: Concentration measures based on Available Installed Capacity: Impact of the Interconnector – Limit of 400MW per company - Netherlands

		STANDARD (excl. IC based on available installed capacity)		IC (400MW limit)ADDED TO BIGGEST PLAYER	
	Date	**CR(2)**	**HHI**	**CR(2)**	**HHI**
Summer	17/07/2003	60.3%	2,471	44.7%	1,335
	31/08/2004	56.0%	2,240	42.3%	1,253
	20/06/2005	57.4%	2,248	41.9%	1,188
Winter	20/02/2003	60.0%	2,456	44.7%	1,336
	21/12/2004	55.7%	2,244	42.3%	1,268
	24/02/2005	54.5%	2,227	41.2%	1,245
Spring	27/03/2003	61.4%	2,482	45.8%	1,359
	02/03/2004	57.6%	2,415	42.2%	1,261
	08/03/2005	59.8%	2,269	43.9%	1,213
Autumn	27/11/2003	59.0%	2,463	42.6%	1,253
	07/09/2004	56.1%	2,232	42.6%	1,261
	23/11/2005	56.1%	2,240	42.2%	1,237

Source: LE.

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

If one bases the market definition and measures of concentration on total generation rather than on available installed capacity, then it also prudent to consider interconnector flows rather than capacity as the relevant variable to account for the impact of the interconnector. Unlike available capacity over the interconnectors in the Netherlands, the aggregated interconnector flows may range from positive to negative between different hours, therefore a priori the impact of interconnectors on traditional measures of concentration may be considered somewhat ambiguous. However, as the Netherlands is a net importer of electricity one would expect a result similar to that observed in relation to available installed capacity.

Table 8.15 presents summary statistics on the impact of accounting for interconnector flows under both scenarios. As one can see the average returned values for the entire period are within a smaller range than was returned in relation to available installed capacity. Qualitatively however they indicate to the same results, unlike other countries which are net exporters and thus the impact of flows versus capacity, on average, are reversed.

Table 8.15: Summary Statistics Concentration measures based on Total Generation: Impact of the Interconnector - Netherlands

	STANDARD (excl. IC based on total generation)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	CR(2)	HHI	CR(2)	HHI	CR(2)	HHI
Average	57.5%	2,308	47.0%	1,546	65.3%	2,873
Max	72.2%	3,397	65.6%	2,867	78.7%	4,322
Min	47.3%	1,861	31.7%	807	49.1%	1,998
Standard Deviation	3.2%	149	4.2%	243	3.8%	325

Source: LE.

Table 8.16 presents the results on the potential impact of the interconnector on the seasonal peak demand days in the Netherlands over the period 2003-2005.

Table 8.16: Concentration measures based on Total Generation: Impact of the Interconnector - Netherlands

		STANDARD (excl. IC based on total generation)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	Date	**CR(2)**	**HHI**	**CR(2)**	**HHI**	**CR(2)**	**HHI**
Summer	17/07/2003	57.5%	2,460	53.9%	2,045	62.7%	2,673
	31/08/2004	54.5%	2,257	52.4%	1,987	58.7%	2,431
	20/06/2005	57.5%	2,382	48.6%	1,607	66.5%	3,060
Winter	20/02/2003	56.1%	2,414	55.0%	2,189	59.7%	2,507
	21/12/2004	53.5%	2,211	48.6%	1,715	60.5%	2,539
	24/02/2005	54.7%	2,207	50.5%	1,750	61.6%	2,527
Spring	27/03/2003	56.8%	2,436	54.1%	2,047	62.4%	2,603
	02/03/2004	55.7%	2,425	50.7%	1,883	62.5%	2,624
	08/03/2005	56.1%	2,200	51.2%	1,751	62.0%	2,525
Autumn	27/11/2003	57.9%	2,499	50.6%	1,801	65.7%	2,828
	07/09/2004	52.3%	2,195	51.9%	2,070	54.8%	2,256
	23/11/2005	55.9%	2,250	52.9%	1,907	60.9%	2,409

Source: LE.

Overall, the impact of interconnector flows on the traditional concentration measures based on total generation are largely consistent with those already presented in relation to available installed capacity. Following on from this, the 400MW limit has been applied similarly to both of these scenarios and Table 8.17 and Table 8.18 present analogous results for both interconnector scenarios as have previously been presented. On average the regulatory limit can benseen to reduce the degree of concentration in the market to below the 1,800 threshold. However, in cases of peak demand the impact can be seen to be lessened.

Table 8.17: Summary Statistics Concentration measures based on Total Generation: Impact of the Interconnector (400MW limit) - Netherlands

	STANDARD (excl. IC based on total generation)		IC ADDED TO BIGGEST PLAYER	
	CR(2)	HHI	CR(2)	HHI
Average	57.5%	2,308	50.9%	1,773
Max	72.2%	3,397	71.3%	3,388
Min	47.3%	1,861	35.7%	997
Standard Deviation	3.2%	149	4.3%	272

Source: LE.

Table 8.18: Concentration measures based on Total Generation: Impact of the Interconnector – Limit of 400MW per company - Netherlands					
		STANDARD (excl. IC based on total generation)		IC ADDED TO BIGGEST PLAYER	
	Date	CR(2)	HHI	CR(2)	HHI
Summer	17/07/2003	57.5%	2,460	57.8%	2,302
	31/08/2004	54.5%	2,257	56.3%	2,256
	20/06/2005	57.5%	2,382	52.2%	1,851
Winter	20/02/2003	56.1%	2,414	58.6%	2,425
	21/12/2004	53.5%	2,211	51.8%	1,913
	24/02/2005	54.7%	2,207	53.9%	1,965
Spring	27/03/2003	56.8%	2,436	57.9%	2,291
	02/03/2004	55.7%	2,425	54.1%	2,068
	08/03/2005	56.1%	2,200	54.8%	1,978
Autumn	27/11/2003	57.9%	2,499	54.1%	2,001
	07/09/2004	52.3%	2,195	55.5%	2,303
	23/11/2005	55.9%	2,250	56.3%	2,103

Source: LE.

8.3 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.

8.3.1 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;

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

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.

8.3.2 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.

8.3.3 Results

RSI Results

Table 8.19 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 the Netherlands. 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 cannot be considered to be competitive.

Table 8.19: RSI Threshold Analysis - Netherlands

RSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	913	8,623	11,721	5,981
% hrs< 110%	*3.5%*	*32.8%*	*44.6%*	*22.7%*
2003	395	3,122	3,924	1,893
% hrs< 110%	*4.5%*	*35.6%*	*44.8%*	*21.6%*
2004	208	3,109	3,794	2,087
% hrs< 110%	*2.4%*	*35.4%*	*43.2%*	*23.8%*
2005	310	2,392	4,003	2,001
% hrs< 110%	*3.5%*	*27.3%*	*45.7%*	*22.8%*

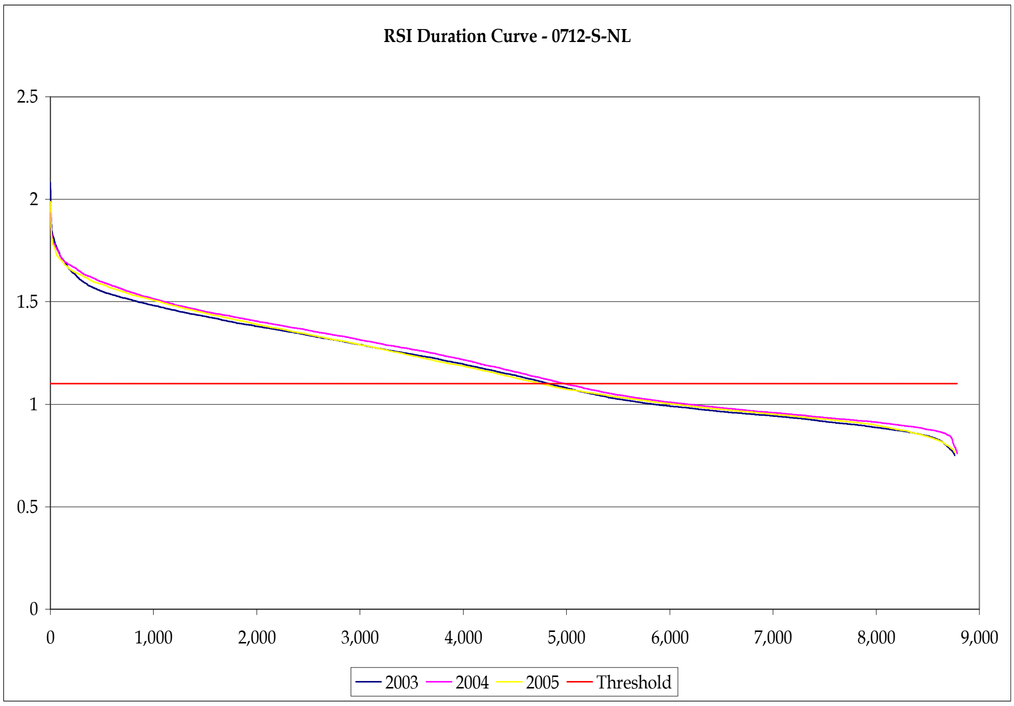
Source: LE

The results of the RSI threshold test contained in Table 8.19 indicate that three of the four largest companies in the Netherlands are necessary, in more than 5% of hours, to meet demand. This is not necessarily a result one could conclude from the summary statistics on the RSI measures presented in Table 8.20 as they indicate that for both the largest two companies in the Netherlands, their average RSI values in all periods, exceed the 1.1 threshold limit.

Table 8.20: Summary Statistics on RSI - Netherlands								
	0712-S-NL				**0511-S-NL**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.18	1.17	1.20	1.18	1.29	1.26	1.27	1.34
Max	2.08	2.08	1.97	1.99	2.20	2.15	2.16	2.20
Min	0.75	0.75	0.76	0.77	0.78	0.78	0.82	0.88
Source: LE								

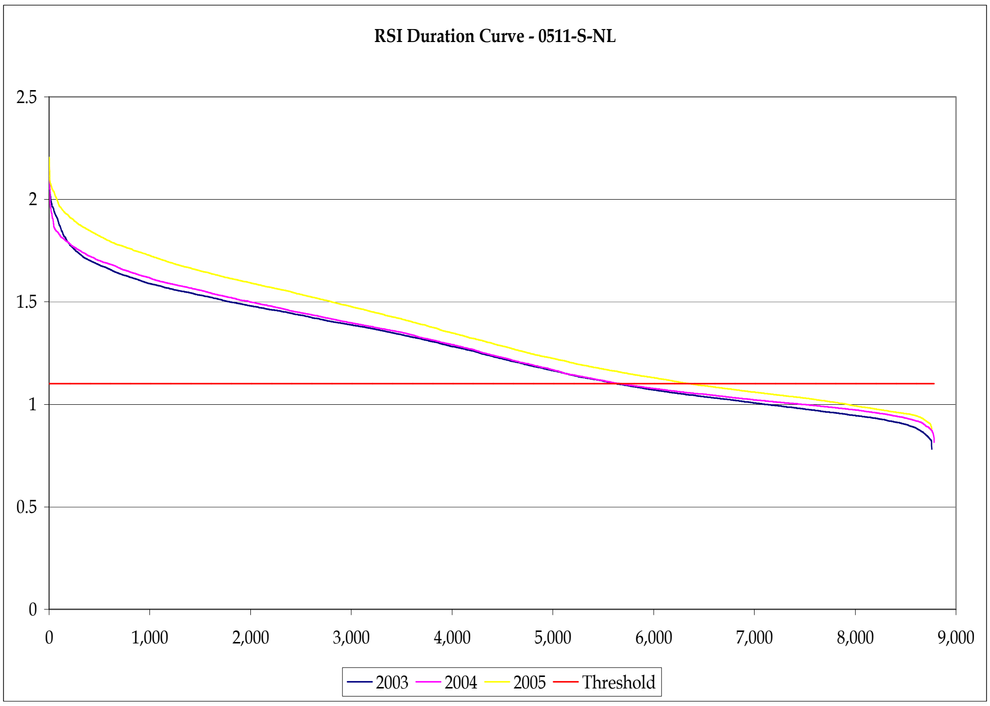
The following figures represent the RSI Duration curve for companies 0712-S-NL and 0511-S-NL.

Figure 8.9: RSI Duration Curve for Company 0712-S-NL



Source: LE.

Figure 8.10: RSI Duration Curve for Company 0511-S-NL



Source: LE.

The duration curves for company 0712-S-NL (Figure 8.9) do not exhibit notable variation between the three years of the study. However for company 0511-S-NL (Figure 8.10), 2005 sees an increase in both the amount of time the company's RSI value is in excess of the threshold as well as a significant increase in the RSI value. This indicates that the amount of time company 0511-S-NL is deemed indispensable has fallen relative to previous years, however at times when the company is indispensable the overall effect on the RSI is significantly less as can be seen by the convergence of the curves below the threshold.

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. As a preliminary remark on this section it is worth noting that apart from the relatively considerable amount of electricity sold by company 0511-S-NL, there is no other factor that should substantially alter the results already presented.

Table 8.21 presents the results of the threshold test when long-term contracts have been excluded from the calculation of available capacity.

Table 8.21: RSI Threshold Analysis - Scenario 1 (accounts for Reserves only) - Netherlands

RSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	888	9,363	11,100	6,043
% hrs< 110%	*3.4%*	*35.6%*	*42.2%*	*23.0%*
2003	385	3,346	3,716	2,074
% hrs< 110%	*4.4%*	*38.2%*	*42.4%*	*23.7%*
2004	201	3,354	3,596	2,274
% hrs< 110%	*2.3%*	*38.2%*	*40.9%*	*25.9%*
2005	302	2,663	3,788	1,695
% hrs< 110%	*3.4%*	*30.4%*	*43.2%*	*19.3%*

Source: LE

Table 8.22 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in the Netherlands (based on market share of total installed capacity).

Table 8.22: Summary Statistics on RSI - Scenario 1 (accounts for Reserves only) - Netherlands								
	0712-S-NL				0511-S-NL			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.21	1.20	1.22	1.21	1.27	1.24	1.25	1.31
Max	2.13	2.13	2.01	2.04	2.16	2.11	2.12	2.16
Min	0.77	0.77	0.78	0.79	0.76	0.76	0.80	0.86
Source: LE								

Table 8.23 presents the results of the threshold test when long-term contracts have been excluded from the calculation of available capacity.

Table 8.23: RSI Threshold Analysis - Scenario 2 (accounts for LTC only) – Netherlands				
RSI Result	**0439-S-NL**	**0511-S-NL**	**0712-S-NL**	**1193-S-NL**
2003-05	955	8,899	11,909	6,186
% hrs< 110%	*3.6%*	*33.8%*	*45.3%*	*23.5%*
2003	401	3,195	3,992	1,921
% hrs< 110%	*4.6%*	*36.5%*	*45.6%*	*21.9%*
2004	231	3,197	3,844	2,128
% hrs< 110%	*2.6%*	*36.4%*	*43.8%*	*24.2%*
2005	323	2,507	4,073	2,137
% hrs< 110%	*3.7%*	*28.6%*	*46.5%*	*24.4%*
Source: LE				

Table 8.24 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in the Netherlands (based on market share of total installed capacity).

Table 8.24: Summary Statistics on RSI - Scenario 2 (accounts for LTC only) – Netherlands								
	0712-S-NL				0511-S-NL			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
mean	1.18	1.17	1.19	1.17	1.28	1.25	1.27	1.33
max	2.06	2.06	1.96	1.97	2.19	2.14	2.15	2.19
min	0.74	0.74	0.75	0.76	0.78	0.78	0.81	0.87
Source: LE								

The results of these alternative scenarios do nothing to alter the qualitative conclusions reached previously in relation to the indispensability of the top three companies in the Netherlands. Overall the scenarios have not affected the quantitative results significantly either with both the frequency and relative size of indispensability remaining largely unchanged from the original RSI analysis.

PSI Results

The results of the PSI analysis for the large generation companies in the Netherlands are presented in Table 8.25. 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 8.25: PSI Threshold Analysis - Netherlands

PSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	24	3,805	8,232	1,305
% hrs =1	*0.1%*	*14.5%*	*31.3%*	*5.0%*
2003	24	1,657	2,914	389
% hrs =1	*0.3%*	*18.9%*	*33.3%*	*4.4%*
2004	0	1,313	2,608	567
% hrs =1	*0.0%*	*14.9%*	*29.7%*	*6.5%*
2005	0	835	2,710	349
% hrs =1	*0.0%*	*9.5%*	*30.9%*	*4.0%*

Source: LE

The results of the PSI analysis are broadly similar to those of the RSI just discussed but with one significant difference, the frequency with which companies are deemed to be pivotal. If one applies the FERC threshold rule to the results presented in the above table, then one should conclude that only company 0712-S-NL is pivotal more than 20% of the time. Nevertheless given there is at least one firm in excess of this threshold, one can conclude that the resulting market outcome is not likely to be competitive. Overall the frequency with which these four companies are deemed to be pivotal is significantly less than was the case under RSI analysis.

Alternative PSI Scenarios

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenarios. Table 8.26 presents the results of the PSI threshold test having excluded long-term contracts from the analysis. Taking reserves into consideration leads to an increase in the hours with non-zero PSI-values for company 0511-S-NL, and a decrease for company 0712-S-NL.

The impact of removing the relatively considerable net long-term contract position of company 0511-S-NL has the expected outcome with the frequency of it being deemed pivotal increasing as a result, making it pivotal in both 2003 and 2004. This indicates that reserve commitments can have a significant effect on the PSI measure. However, the effect is not so big as to change the qualitative conclusions, as both companies are still pivotal over significant periods.

Table 8.26: PSI Threshold Analysis - Scenario 1 (accounts for Reserves only)) - Netherlands

PSI Result	**0439-S-NL**	**0511-S-NL**	**0712-S-NL**	**1193-S-NL**
2003-05	23	4,835	7,030	1,396
% hrs =1	*0.1%*	*18.4%*	*26.7%*	*5.3%*
2003	23	1,957	2,504	493
% hrs =1	*0.3%*	*22.3%*	*28.6%*	*5.6%*
2004	0	1,752	2,200	690
% hrs =1	*0.0%*	*19.9%*	*25.0%*	*7.9%*
2005	0	1,126	2,326	213
% hrs =1	*0.0%*	*12.9%*	*26.6%*	*2.4%*

Source: LE

Table 8.27 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.

Table 8.27: PSI Threshold Analysis - Scenario 2 (accounts for LTC only) - Netherlands				
PSI Result	**0439-S-NL**	**0511-S-NL**	**0712-S-NL**	**1193-S-NL**
2003-05	26	4,129	8,555	1,436
% hrs =1	*0.1%*	*15.7%*	*32.5%*	*5.5%*
2003	25	1,752	3,028	408
% hrs =1	*0.3%*	*20.0%*	*34.6%*	*4.7%*
2004	0	1,444	2,696	587
% hrs =1	*0.0%*	*16.4%*	*30.7%*	*6.7%*
2005	1	933	2,831	441
% hrs =1	*0.0%*	*10.7%*	*32.3%*	*5.0%*
Source: LE				

Overall, the sensitivity tests on the PSI measure again do not have a large impact on our qualitative conclusions; company 0712-S-NL remains pivotal in all years.

8.3.4 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. The results indicate the potentially large impact of interconnection in the Netherlands on the indispensability previously found in relation to the largest companies.

8.3.5 Results (Interconnector allocated according to domestic market share)

RSI Results

Table 8.28 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 an 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, the frequency with which companies are deemed to be indispensable to meeting the load. Company 0712-S-NL remains indispensable in all years, however company 0511-S-NL ceases to be indispensable under the threshold test in 2005 while company 1193-S-NL ceases to be indispensable in all years. Correspondingly, the average values of the RSI can be seen to increase for the country's largest two firms in Table 8.29.

Table 8.28: RSI Threshold Analysis (+IC domestic) - Netherlands

RSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	0	1,756	5,022	241
% hrs< 110%	*0.0%*	*6.7%*	*19.1%*	*0.9%*
2003	0	836	1,934	34
% hrs< 110%	*0.0%*	*9.5%*	*22.1%*	*0.4%*
2004	0	540	1,250	103
% hrs< 110%	*0.0%*	*6.1%*	*14.2%*	*1.2%*
2005	0	380	1,838	104
% hrs< 110%	*0.0%*	*4.3%*	*21.0%*	*1.2%*

Source: LE

Table 8.29 presents summary statistics on the RSI.

Table 8.29: Summary Statistics on RSI (+IC domestic) - Netherlands								
	0712-S-NL				0511-S-NL			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.38	1.38	1.41	1.35	1.49	1.46	1.49	1.51
Max	2.39	2.28	2.39	2.30	2.46	2.46	2.38	2.44
Min	0.87	0.91	0.90	0.87	0.94	0.94	0.98	0.98
Source: LE								

Alternative RSI Scenarios

Table 8.30 presents the results of the threshold test when one only considers the impact of long-term contracts on the available installed capacity of each company. The change induced is small, a 1% increase in the number of hours below the 110% threshold for companies 0511-S-NL and 0712-S-NL.

Table 8.30: RSI Threshold Analysis (+ IC domestic) - Scenario 2 (accounts for LTCs only) - Netherlands				
RSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	0	1,961	5,288	277
% hrs< 110%	*0.0%*	*7.5%*	*20.1%*	*1.1%*
2003	0	924	2,051	36
% hrs< 110%	*0.0%*	*10.5%*	*23.4%*	*0.4%*
2004	0	595	1,310	115
% hrs< 110%	*0.0%*	*6.8%*	*14.9%*	*1.3%*
2005	0	442	1,927	126
% hrs< 110%	*0.0%*	*5.0%*	*22.0%*	*1.4%*
Source: LE				

Table 8.31 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in the Netherlands (based on market share of total installed capacity).

Table 8.31: Summary Statistics on RSI (+ IC domestic) - Scenario 2 (accounts for LTCs only) - Netherlands								
	0712-S-NL				0511-S-NL			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.37	1.37	1.41	1.34	1.48	1.46	1.48	1.50
Max	2.38	2.27	2.38	2.29	2.45	2.45	2.37	2.43
Min	0.86	0.91	0.90	0.86	0.93	0.93	0.97	0.97

Source: LE

Under this alternative scenario, by not including the capacity committed to upward regulation by companies in the calculation of the capacity available to each company, company 0511-S-NL is once again below the threshold more than 5% of the time in all years. The results for the remaining companies remain broadly similar to those already discussed.

8.3.6 PSI Results

The results of the PSI analysis for the large generation companies in the Netherlands are presented in Table 8.25. 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. The impact of including the interconnector is substantial: none of the companies now appears to be pivotal to a degree that raises competition concerns.

Table 8.32: PSI Threshold Analysis (+IC Domestic) - Netherlands

PSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	0	46	842	1
% hrs =1	*0.0%*	*0.2%*	*3.2%*	*0.0%*
2003	0	36	364	0
% hrs =1	*0.0%*	*0.4%*	*4.2%*	*0.0%*
2004	0	9	122	0
% hrs =1	*0.0%*	*0.1%*	*1.4%*	*0.0%*
2005	0	1	356	1
% hrs =1	*0.0%*	*0.0%*	*4.1%*	*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 8.33 presents the results of the PSI threshold test having accounted only for long-term contracts in the calculation of available capacity.

Table 8.33: PSI Threshold Analysis (+IC Domestic) - Scenario 2 (accounts for LTC only) - Netherlands

PSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	0	59	942	1
% hrs =1	*0.0%*	*0.2%*	*3.6%*	*0.0%*
2003	0	45	410	0
% hrs =1	*0.0%*	*0.5%*	*4.7%*	*0.0%*
2004	0	11	140	0
% hrs =1	*0.0%*	*0.1%*	*1.6%*	*0.0%*
2005	0	3	392	1
% hrs =1	*0.0%*	*0.0%*	*4.5%*	*0.0%*

Source: LE

The effect of apportioning the interconnector capacity of the Netherlands to companies based on their domestic market share in both the general and alternative scenarios, is to substantially reduce the frequency of hours that companies are regarded as pivotal in the Netherlands market. Overall the one company that was previously regarded a pivotal under this measure, in the absence of the interconnector, now falls far below the FERC threshold in all years.

8.3.7 Results (Interconnector allocated according to foreign market share)

RSI Results

Table 8.34 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.

Table 8.34: RSI Threshold Analysis (+IC foreign) - Netherlands				
RSI Result	**0439-S-NL**	**0511-S-NL**	**0712-S-NL**	**1193-S-NL**
2003-05	0	2,955	213	1
% hrs< 110%	*0.0%*	*11.2%*	*0.8%*	*0.0%*
2003	0	1,495	72	0
% hrs< 110%	*0.0%*	*17.1%*	*0.8%*	*0.0%*
2004	0	809	24	0
% hrs< 110%	*0.0%*	*9.2%*	*0.3%*	*0.0%*
2005	0	651	117	1
% hrs< 110%	*0.0%*	*7.4%*	*1.3%*	*0.0%*
Source: LE				

Table 8.35 presents summary statistics on the RSI.

Table 8.35: Summary Statistics on RSI (+IC foreign) - Netherlands								
	0712-S-NL				**0511-S-NL**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.56	1.57	1.59	1.52	1.45	1.42	1.46	1.47
Max	2.67	2.60	2.67	2.55	2.37	2.36	2.37	2.32
Min	1.02	1.05	1.06	1.02	0.89	0.89	0.96	0.96
Source: LE								

Alternative RSI Scenarios

Table 8.36 presents the results of the threshold test when only long-term contracts have been factored into the calculation of available capacity.

Table 8.36: RSI Results (+IC foreign) - Scenario 2 (accounts for LTC only) - Netherlands

RSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	0	3,185	265	1
% hrs< 110%	*0.0%*	*12.1%*	*1.0%*	*0.0%*
2003	0	1,571	88	0
% hrs< 110%	*0.0%*	*17.9%*	*1.0%*	*0.0%*
2004	0	887	31	0
% hrs< 110%	*0.0%*	*10.1%*	*0.4%*	*0.0%*
2005	0	727	146	1
% hrs< 110%	*0.0%*	*8.3%*	*1.7%*	*0.0%*

Source: LE

Table 8.37 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in the Netherlands (based on market share of total installed capacity).

Table 8.37: Summary Statistics on RSI (+IC foreign) - Scenario 2 (accounts for LTC only) - Netherlands

	0712-S-NL				0511-S-NL			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.55	1.56	1.58	1.52	1.44	1.41	1.45	1.46
Max	2.66	2.58	2.66	2.54	2.36	2.35	2.36	2.31
Min	1.01	1.04	1.06	1.01	0.88	0.88	0.96	0.95

Source: LE

By altering the means of apportionment of the interconnector to reflect the company's ownership of generation assets in the neighbouring countries with which the country being examined in connected by one or more interconnectors, the results change considerably under both the general and alternative scenario. Company 0712-S-NL is no longer indispensable in any more than 1.7% of hours in either of the three years. However, the frequency with which company 0511-S-NL is indispensable as a result of the threshold test has increased relative to the apportionment of interconnector capacity based on domestic market share. Company 0511-S-NL is the only company that can be considered and thus bringing about a market outcome that is unlikely to be competitive, this result holds under both the general and alternative scenarios.

PSI Results

The results of the PSI analysis for the large generation companies in the Netherlands are presented in Table 8.38.

Table 8.38: PSI Threshold Analysis (+IC foreign) - Netherlands

PSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	0	194	0	0
% hrs =1	*0.0%*	*0.7%*	*0.0%*	*0.0%*
2003	0	156	0	0
% hrs =1	*0.0%*	*1.8%*	*0.0%*	*0.0%*
2004	0	28	0	0
% hrs =1	*0.0%*	*0.3%*	*0.0%*	*0.0%*
2005	0	10	0	0
% hrs =1	*0.0%*	*0.1%*	*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 8.39 presents the results of the PSI threshold test having included long-term contracts only in the formulation of available capacity.

Table 8.39: PSI Threshold Analysis - Scenario 2 (accounts for LTC only) - Netherlands

PSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	0	263	0	0
% hrs =1	*0.0%*	*1.0%*	*0.0%*	*0.0%*
2003	0	203	0	0
% hrs =1	*0.0%*	*2.3%*	*0.0%*	*0.0%*
2004	0	45	0	0
% hrs =1	*0.0%*	*0.5%*	*0.0%*	*0.0%*
2005	0	15	0	0
% hrs =1	*0.0%*	*0.2%*	*0.0%*	*0.0%*

Source: LE

Unlike the observed result in relation to the RSI measure under these assumptions, the PSI measure only identifies company 0511-S-NL as being pivotal 1.0% of the time over the full three year period. This result is consistent with that found previously with the interconnector capacity apportioned in accordance with domestic market share.

8.3.8 Results (Interconnector allocated according to domestic market share with 400MW limit)

In order to take account of the regulated limits on the quantity of electricity that can be imported by a company in any one hour, the analysis that has just been presented outlining the possible impacts of the interconnectors with Belgium and France is re-estimated here in order to reflect the current regulatory environment in the Netherlands and the impact of such regulation on the results previously outlined. The results are summarised at the end of the section.

RSI Results

Table 8.40 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.

Table 8.40: RSI Threshold Analysis (+IC Domestic limit) - Netherlands

RSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	0	25	586	5
% hrs< 110%	*0.0%*	*0.1%*	*2.2%*	*0.0%*
2003	0	16	217	0
% hrs< 110%	*0.0%*	*0.2%*	*2.5%*	*0.0%*
2004	0	3	90	0
% hrs< 110%	*0.0%*	*0.0%*	*1.0%*	*0.0%*
2005	0	6	279	5
% hrs< 110%	*0.0%*	*0.1%*	*3.2%*	*0.1%*

Source: LE

Table 8.41 presents summary statistics on the RSI.

Table 8.41: Summary Statistics on RSI (+IC Domestic limit) - Netherlands								
	0712-S-NL				0511-S-NL			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.52	1.53	1.55	1.49	1.61	1.60	1.61	1.62
Max	2.60	2.53	2.60	2.49	2.68	2.68	2.62	2.54
Min	0.99	1.02	1.03	0.99	1.05	1.05	1.09	1.06
Source: LE								

Alternative RSI Scenarios

Table 8.42 presents the results of the threshold test when only long-term contracts have been included in the calculation of available capacity.

Table 8.42: RSI Threshold Analysis (+IC domestic limit) - Scenario 2 (accounts for LTC only)- Netherlands				
RSI Result	**0439-S-NL**	**0511-S-NL**	**0712-S-NL**	**1193-S-NL**
2003-05	0	29	694	5
% hrs< 110%	*0.0%*	*0.1%*	*2.6%*	*0.0%*
2003	0	18	269	0
% hrs< 110%	*0.0%*	*0.2%*	*3.1%*	*0.0%*
2004	0	4	107	0
% hrs< 110%	*0.0%*	*0.0%*	*1.2%*	*0.0%*
2005	0	7	318	5
% hrs< 110%	*0.0%*	*0.1%*	*3.6%*	*0.1%*
Source: LE				

Table 8.43 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in the Netherlands (based on market share of total installed capacity).

Table 8.43: Summary Statistics on RSI (+ IC domestic limit) - Scenario 2 (accounts for LTC only) - Netherlands								
	0712-S-NL				**0511-S-NL**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.52	1.52	1.54	1.48	1.60	1.59	1.61	1.61
Max	2.60	2.52	2.60	2.48	2.67	2.67	2.61	2.53
Min	0.99	1.02	1.03	0.99	1.05	1.05	1.08	1.05
Source: LE								

PSI Results

The results of the PSI analysis for the large generation companies in the Netherlands are presented in Table 8.44. 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. None of the large companies is pivotal under this scenario.

Table 8.44: PSI Threshold Analysis (+IC domestic limit) - Netherlands				
PSI Result	**0439-S-NL**	**0511-S-NL**	**0712-S-NL**	**1193-S-NL**
2003-05	0	0	2	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	2	0
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*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 8.45 presents the results of the PSI threshold test. No company is pivotal under this scenario.

Table 8.45: PSI Threshold Analysis (+IC domestic limit)- Scenario 2 (accounts for LTC only)) – Netherlands

PSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
2003-05	0	0	3	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	3	0
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*

Source: LE

8.3.9 Results (Interconnector allocated according to foreign market share with 400MW limit)

RSI Results

Table 8.46 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.

Table 8.46: RSI Threshold Analysis (+IC foreign limit) - Netherlands				
RSI Result	**0439-S-NL**	**0511-S-NL**	**0712-S-NL**	**1193-S-NL**
2003-05	0	25	213	1
% hrs< 110%	*0.0%*	*0.1%*	*0.8%*	*0.0%*
2003	0	16	72	0
% hrs< 110%	*0.0%*	*0.2%*	*0.8%*	*0.0%*
2004	0	3	24	0
% hrs< 110%	*0.0%*	*0.0%*	*0.3%*	*0.0%*
2005	0	6	117	1
% hrs< 110%	*0.0%*	*0.1%*	*1.3%*	*0.0%*
Source: LE				

Table 8.47 presents summary statistics on the RSI.

Table 8.47: Summary Statistics on RSI (+IC foreign limit) - Netherlands								
	0712-S-NL				**0511-S-NL**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.56	1.57	1.59	1.52	1.61	1.60	1.61	1.62
Max	2.67	2.60	2.67	2.55	2.68	2.68	2.62	2.54
Min	1.02	1.05	1.06	1.02	1.05	1.05	1.09	1.06
Source: LE								

Alternative RSI Scenario

Table 8.48 presents the results of the threshold test when only long-term contracts are included in the calculation of available capacity.

Table 8.48: RSI Threshold Analysis (+IC foreign limit)- Scenario 2 (accounts for LTC only) - Netherlands				
RSI Result	**0439-S-NL**	**0511-S-NL**	**0712-S-NL**	**1193-S-NL**
2003-05	0	29	265	1
% hrs< 110%	*0.0%*	*0.1%*	*1.0%*	*0.0%*
2003	0	18	88	0
% hrs< 110%	*0.0%*	*0.2%*	*1.0%*	*0.0%*
2004	0	4	31	0
% hrs< 110%	*0.0%*	*0.0%*	*0.4%*	*0.0%*
2005	0	7	146	1
% hrs< 110%	*0.0%*	*0.1%*	*1.7%*	*0.0%*

Source: LE

Table 8.49 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in the Netherlands (based on market share of total installed capacity).

Table 8.49: Summary Statistics on RSI (+IC foreign limit) - Scenario 2 (accounts for LTC only) - Netherlands								
	0712-S-NL				**0511-S-NL**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.55	1.56	1.58	1.52	1.60	1.59	1.61	1.61
Max	2.66	2.58	2.66	2.54	2.67	2.67	2.61	2.53
Min	1.01	1.04	1.06	1.01	1.05	1.05	1.08	1.05

Source: LE

PSI Results

The results of the PSI analysis for the large generation companies in the Netherlands are presented in Table 8.50.

Table 8.50: PSI Threshold Analysis (+IC foreign limit) - Netherlands

PSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
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 (Foreign Market Share)

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenario. Table 8.51 presents the results of the PSI threshold test.

Table 8.51: PSI Threshold Analysis (+IC foreign limit) – Scenario 2 (accounts for LTC only) - Netherlands

PSI Result	0439-S-NL	0511-S-NL	0712-S-NL	1193-S-NL
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

Including the potential impact of the interconnectors, under a number of different scenarios, while adhering to the 400MW hourly import limit produces a consistent result across all measures of RSI and PSI that have previously been presented in this document. The result is to find that in all cases, none of the four large companies in the Netherlands can be considered pivotal or indispensable to meeting the load in a sufficient number of hours to allow one to conclude that the resulting outcome is non-competitive. This result differs from all previous scenarios and is directly the result of the regulatory limits imposed on market participants in the Netherlands.

8.4 Contribution to APX 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 APX price. Table 8.52 and Figure 8.11 present the annual contribution of these three factors to the load weighted average APX price.

From the information contained in the following table one can see that there has be relatively little change in the load weighted average cost (€/MWh) of electricity generation in the Netherlands over the period 2003-2004. Nevertheless, the load weighted average APX price can be seen to fall substantially from 2003 to 2004. As a result one can see the substantial decrease in the load weighted average mark-up in 2004. Relative to the cost of generation in these two years, the cost in 2005 has increased substantially. Although there has been in increase in the exchange price, sufficient to return a positive mark-up in the absence of the new cost of carbon, the introduction of the ETS in 2005 has contributed a further cost of €9.52 to the cost of generation on a load weighted average basis over the year. This figure represents the full economic cost of carbon and does not reflect the fact that companies received their CO_2 certificates for free.

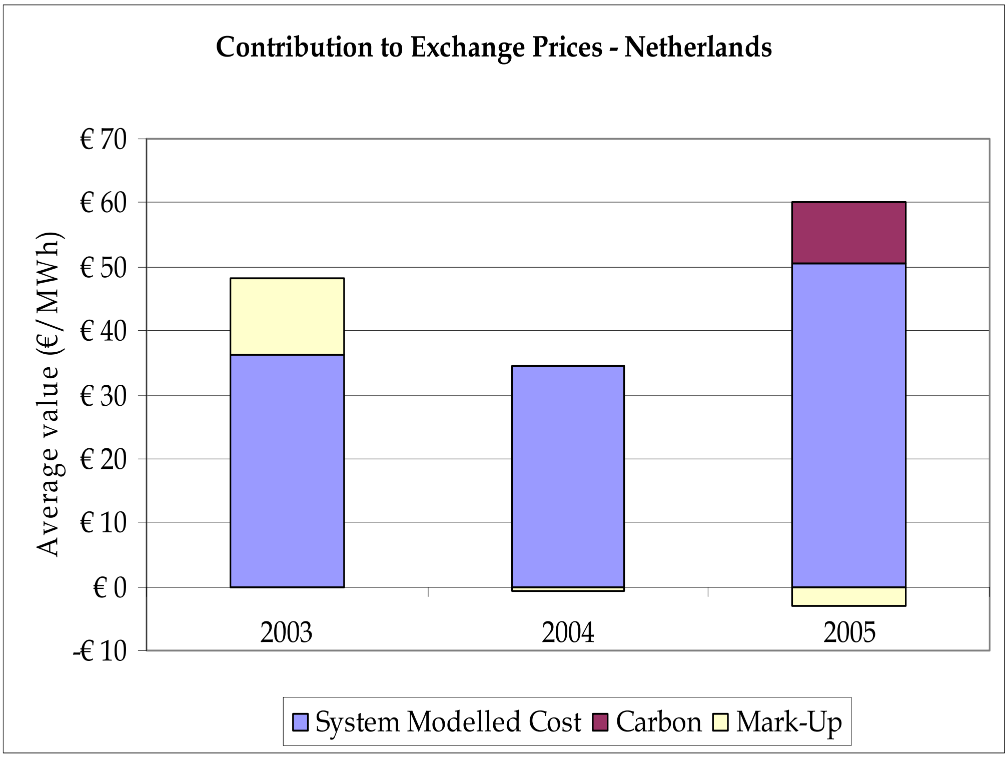
Table 8.52: Contribution of Cost, Carbon and Mark-up to APX Prices - Netherlands

	2003	2004	2005
Sys Modelled MC	€ 36.26	€ 34.64	€ 50.50
Carbon	€ 0.00	€ 0.00	€ 9.52
Mark-Up	€ 11.99	-€ 0.63	-€ 3.09
Total	€ 48.24	€ 34.01	€ 56.93
APX Price	€ 48.24	€ 34.01	€ 56.93

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

Figure 8.11 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 APX price.

Figure 8.11: Contribution to Exchange Prices- Netherlands (2003-2005)



Source: LE.

8.5 Outcome Measures

8.5.1 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;

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

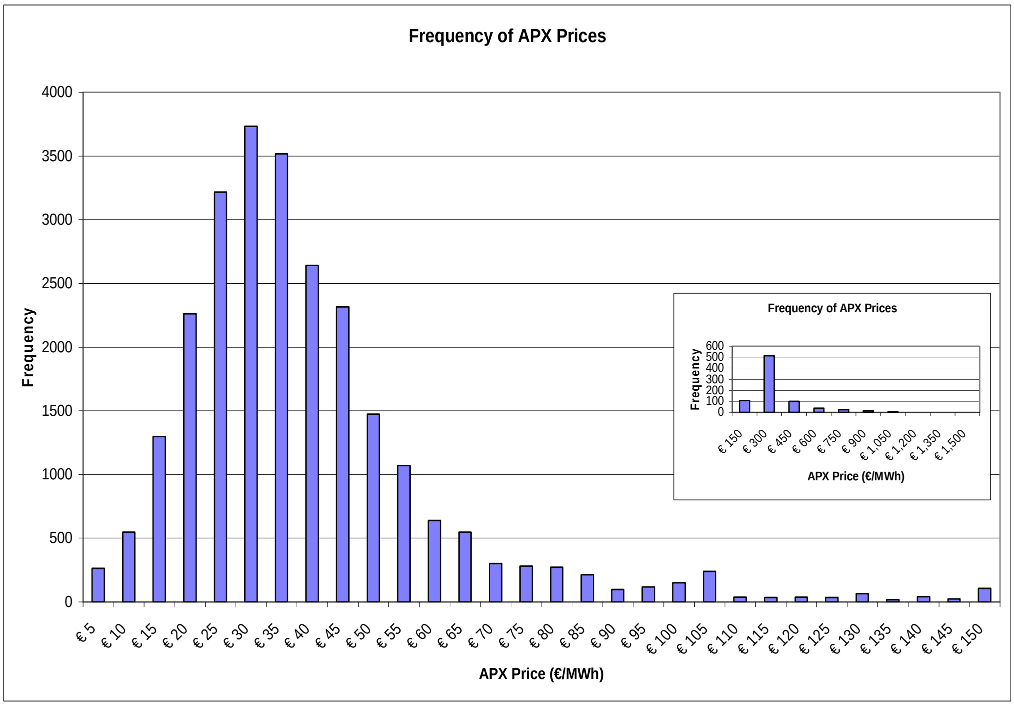
However, the use of a simple average has been rejected in favour of a load weighted average approach. Therefore, a more accurate description of the above equation is to consider each of the variables to be load weighted averages of the relevant period. A more formal exposition of this approach is presented 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 Amsterdam Power Echange (APX).
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 APX over the period of the study is presented in the following histogram.

Figure 8.12: Frequency of APX Prices - Netherlands



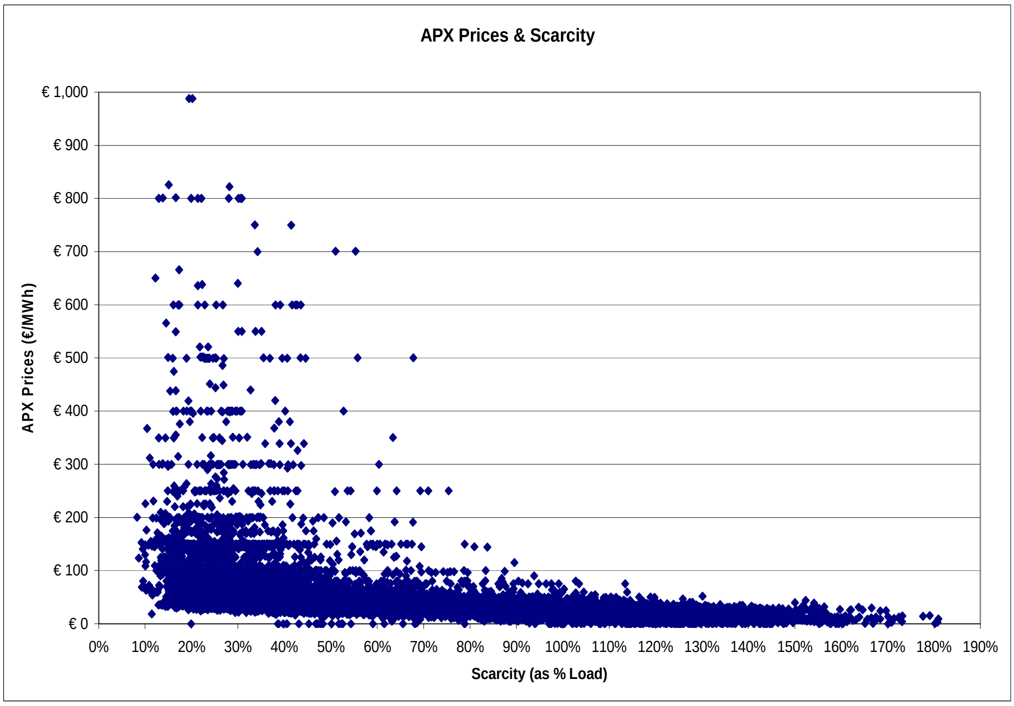
Source: LE.

For the APX price to be considered a relevant price for electricity in the Netherlands it should be seen to reflect changing market dynamics within the Dutch electricity market. Alternatively, the price of electricity on the APX 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 APX 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 8.13: APX & Scarcity of Available Generation Capacity - Netherlands

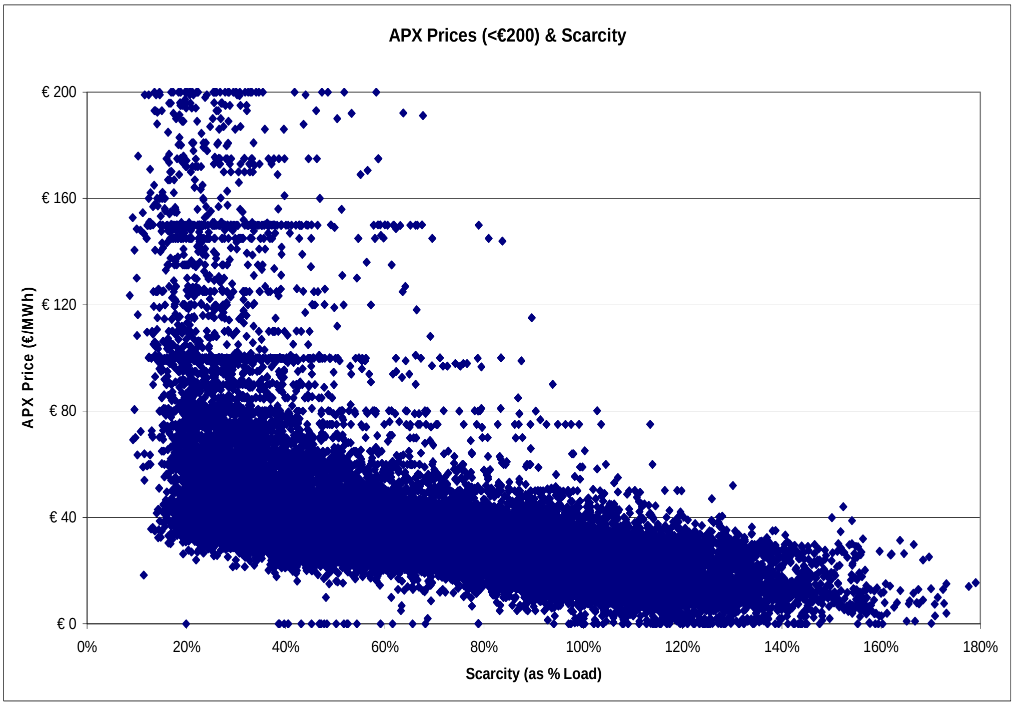


Source: LE.

One can see from Figure 8.13 that high APX prices correspond to times of relative scarcity of generation capacity. The correlation coefficient of the two series over the entire sample period is -0.41.

Given the relative concentration of prices below €200, this above graph has been re-produced only to take account of prices less than €200, thus allowing for a more detailed assessment of this relationship over the most frequently realised prices. This relationship is presented in the following Figure 8.14.

Figure 8.14: Scatterplot of Scarcity and APX Prices (2003-2005) – Netherlands



Source: LE.

The relationship between these two variables indicates that the APX price is an appropriate price to use in order to reflect the price of electricity in the Netherlands. However as indicated above, the Platts assessment price of electricity in the Netherlands shall 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 the Netherlands, a quantity considerably greater than that traded on a day ahead basis.

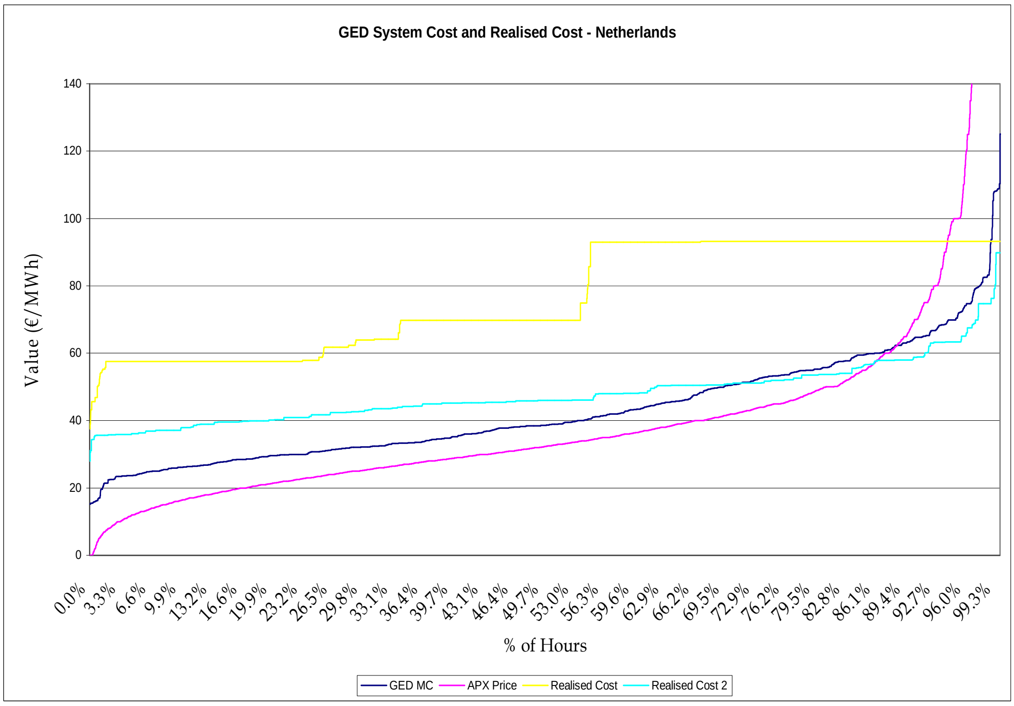
The analysis also considers three estimates of cost for the system;

1. The System Cost estimated as part of GED's optimal dispatch 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 8.15.

Figure 8.15: Comparison of GED System Modelled Cost, Realised Cost, Realised Cost 2 & APX Prices (2003-2005) - Netherlands



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 dispatch 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 APX 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 system cost, the realised cost and realised cost 2 are provided in Table 8.53.

Table 8.53: Comparison of GED System Cost & Realised Cost - Netherlands					
		Average	**Minimum**	**Maximum**	**St Dev**
2003-2005	*GED Cost*	€ 42.42	€ 15.22	€ 125.03	€ 16.26
	Realised Cost	€ 76.55	€ 37.63	€ 93.20	€ 15.74
	Realised Cost 2	€ 47.86	€ 28.09	€ 89.82	€ 8.80
2003	*GED Cost*	€ 34.76	€ 15.22	€ 93.14	€ 10.62
	Realised Cost	€ 92.68	€ 37.63	€ 93.20	€ 4.74
	Realised Cost 2	€ 46.51	€ 28.09	€ 79.28	€ 6.64
2004	*GED Cost*	€ 33.61	€ 23.46	€ 75.64	€ 7.86
	Realised Cost	€ 58.73	€ 43.24	€ 80.31	€ 3.46
	Realised Cost 2	€ 44.79	€ 31.06	€ 80.31	€ 6.89
2005	*GED Cost*	€ 58.91	€ 32.46	€ 125.03	€ 14.51
	Realised Cost	€ 78.29	€ 48.80	€ 93.00	€ 11.31
	Realised Cost 2	€ 52.29	€ 31.85	€ 89.82	€ 10.49
Source: LE					

Table 8.54 presents the amount of in merit generation located within the first quartile of the difference between the GED System Cost and Realised Cost 2, where Realised Cost 2 exceeds the GED system Cost. Therefore, almost all of the difference in in merit generation caused by the difference between the GED System Cost and Realised Cost 2, would similarly be brought about by a difference just 25% of the one presented in both the previous graph and table. Almost all of the additional in merit generation has a cost only slightly above the GED System Cost and is not due to the higher end of the realised cost 2 range.

Table 8.54: Comparison of In Merit Generation based on GED System Cost & Realised Cost 2 - Netherlands				
	2003-05	**2003**	**2004**	**2005**
Average	88.6%	87.6%	88.5%	92.2%
Source: LE				

8.5.2 Results

In the analysis of the APX 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.

This may all 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 System Cost and APX Prices

Table 8.55 presents the Lerner Index (LI) values calculated using the load weighted average APX prices and marginal costs for the Netherlands, the system cost being that was returned by the GED optimal dispatch simulation.

Table 8.55: Average LI based on GED System Marginal Cost & APX Prices (including carbon) - Netherlands				
	2003-05	**2003**	**2004**	**2005**
Lerner Index	5.8%	24.8%	-1.9%	-5.4%
Based on load weighted average prices and costs *Source: LE*				

Over the three year period the LI value is positive but this is clearly being driven by the very high value reported in 2003, which has masked the negative LI values returned for the Netherlands in 2004 and more significantly in 2005. However, the outcome measures in the Dutch market has been systematically underestimated due to the presence of a large amount of CHP units in the system which produce electricity as a by-product of heat production. Despite all efforts made to separate out the potential for a significant over-representation of out-of-merit generation in the final modelling, with the aide of additional data from the operators, it was not possible to model this situation akin to its actual operation. As a result of this difficulty, one should consider these results with this caveat in mind. The results for 2003 indicate that a significant margin was earned in that year, despite the moderate to concentrated structure of the market. Importantly, one should recall that this value is also likely to be underestimated due the CHP effect already outlined.

If one considers the LI value in a situation where the cost of carbon has been excluded from the system marginal cost in 2005, the value in 2005 is no longer negative. However, it is still important to consider the potential impact of the over-representation of out-of-merit capacity in the modelling of the system. The results of this case are presented in Table 8.56.

Table 8.56: Average LI based on GED System Marginal Cost & APX Prices (excluding carbon) - Netherlands				
	2003-05	**2003**	**2004**	**2005**
Lerner Index	12.6%	24.8%	-1.9%	11.3%
Based on load weighted average prices and costs *Source: LE*				

GED Modelled System Marginal Cost and Platts Assessment Prices

Table 8.57 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 – 23:00 and base is 00:00 – 07:00. The general trend in this table is close to that observed in relation to the APX prices, although none of the LI values here are negative. Importantly, one should recall that this approach is likely to 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 APX. However, premia in forward sales and contract types may or may not have a basis in a market power related explanation.

Table 8.57: Average LI based on GED System Marginal Cost & Platts Assessment Prices (Day-Ahead) – Netherlands

	2003-05	2003	2004	2005
Lerner Index	13.7%	31.6%	4.1%	0.9%

Based on load weighted average prices and costs
Source: LE

8.5.3 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.

8.5.4 Results

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

Table 8.58 presents the PCMU values for the Netherlands calculated using the load weighted average APX prices and the system cost that was returned by the GED optimal dispatch simulation. Over the three year period the load weighted average PCMU is 6.1%. However as was the case with the LI, the ability of firms to receive a price in excess of costs in 2003 generates this result as the PCMU for 2004 and 2005, inclusive of the cost of carbon, both return negative numbers. However, one is once again reminded of the relatively large amount of CHP units in this particular market.

Table 8.58: Average PCMU based on GED System Marginal Cost & APX Prices (including carbon) - Netherlands				
	2003-05	**2003**	**2004**	**2005**
Price-Cost Mark-Up	6.1%	33.1%	-1.8%	-5.1%
Based on load weighted average prices and costs *Source: LE*				

If one considers the PCMU absent of the cost of carbon in 2005 then the load weighted average mark-up earned by companies in the Netherlands in 2005 switches from -5.1% to 12.7%, thus leaving just 2004 with a negative but small PCMU of -1.8%.

Table 8.59: Average PCMU based on GED System Marginal Cost & APX Prices (excluding carbon) - Netherlands				
	2003-05	**2003**	**2004**	**2005**
Price-Cost Mark-Up	14.4%	33.1%	-1.8%	12.7%
Based on load weighted average prices and costs *Source: LE*				

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

The load weighted average PCMU obtained by using Platts assessment prices and the GED system marginal cost is presented in Table 8.60. As with the APX prices, one also observes a downward trend over time in the returned values. However, over the three year period the average load weighted PCMU is 15.9% based on this more stable price stream, as opposed to 6.1% based on the APX. As noted before this may be due to forward premia and contract type, factors which may or may not have a basis in a market power related explanation of outcomes.

Table 8.60: Average PCMU based on GED System Marginal Cost & Platts Assessment Prices (Day-Ahead) - Netherlands

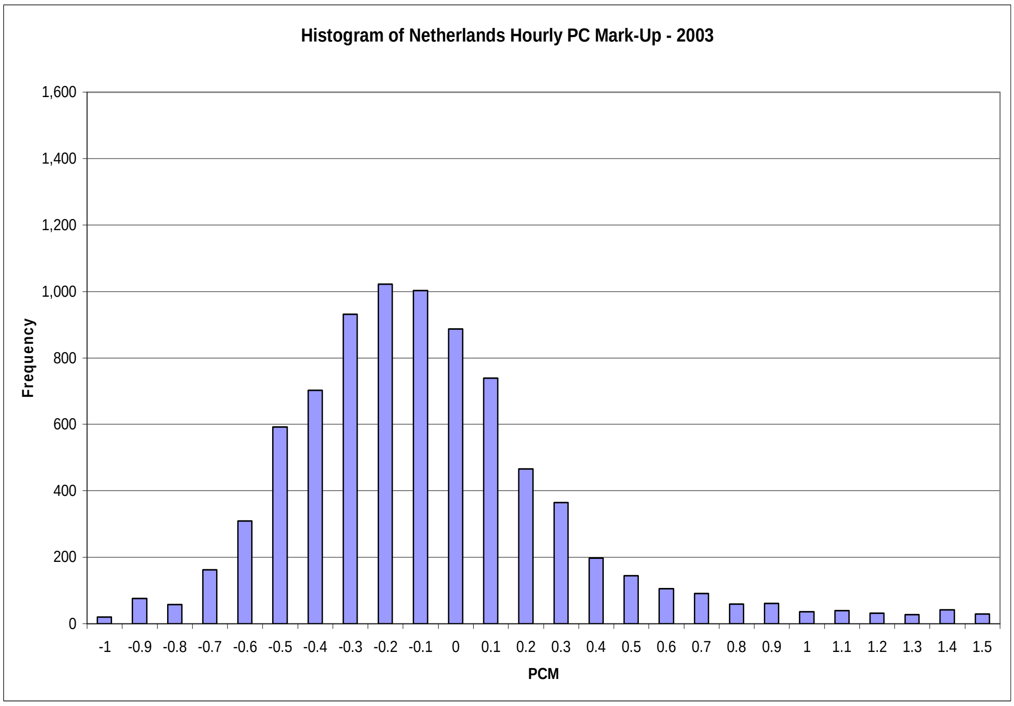
	2003-05	2003	2004	2005
Price-Cost Mark-Up	15.9%	46.3%	4.3%	0.9%

Based on load weighted average prices and costs
Source: LE

8.5.5 Hourly PCMU Histograms

As previously discussed the outcome measures presented in this section are based on load weighted average values of the relevant prices and costs, the appropriate values to be included in such measures of the market outcomes. However in order to gain a more comprehensive understanding and to compliment the results previously discussed, the following histograms provide a graphic representation of the frequency values of hourly Price-Cost Mark-Ups. These results are not load weighted and serve to present the general distribution of the market outcomes.

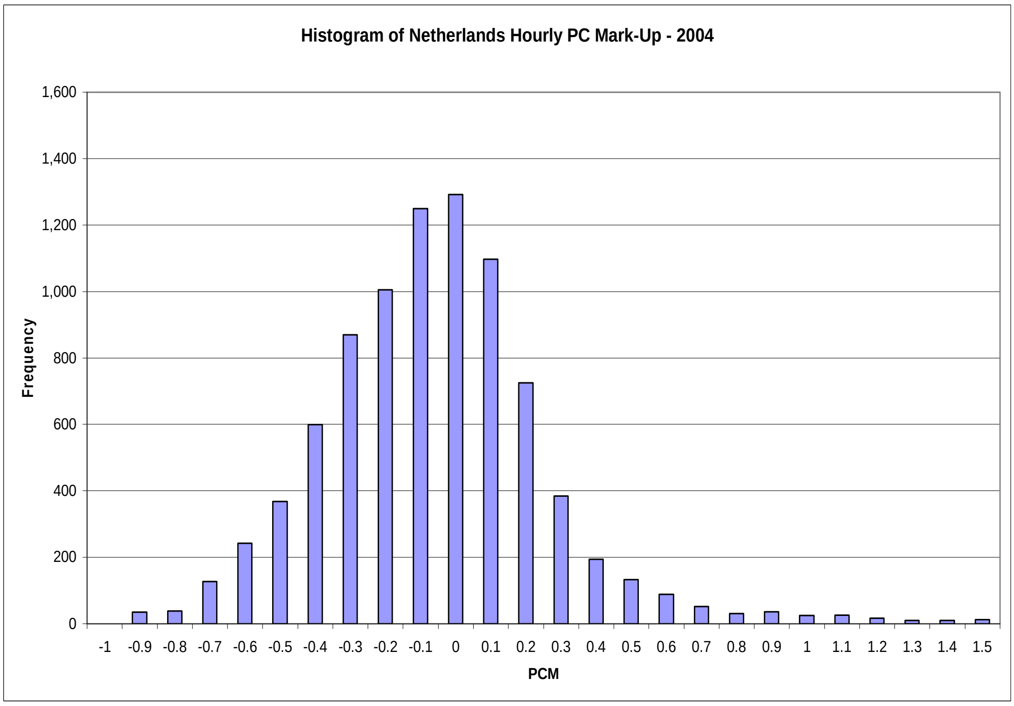
Figure 8.16: Histogram of Netherlands Hourly Price-Cost Mark-up – 2003 - Netherlands



Note: N= 8,199

Source: LE.

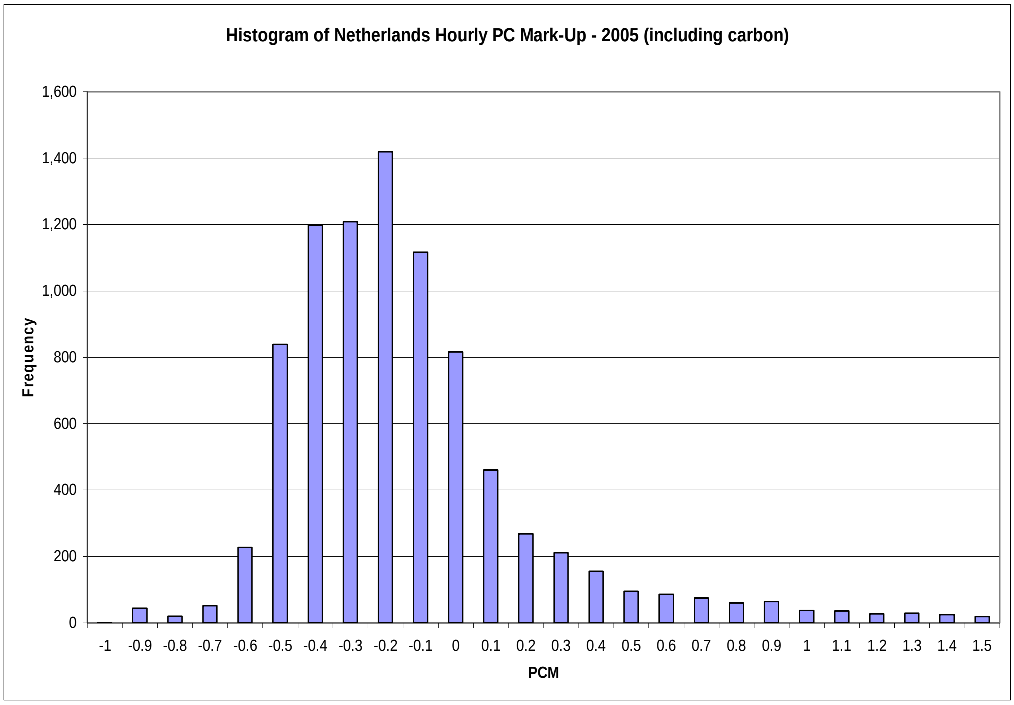
Figure 8.17: Histogram of the Netherlands Hourly Price-Cost Mark-up - 2004



Note: N= 8,670

Source: LE.

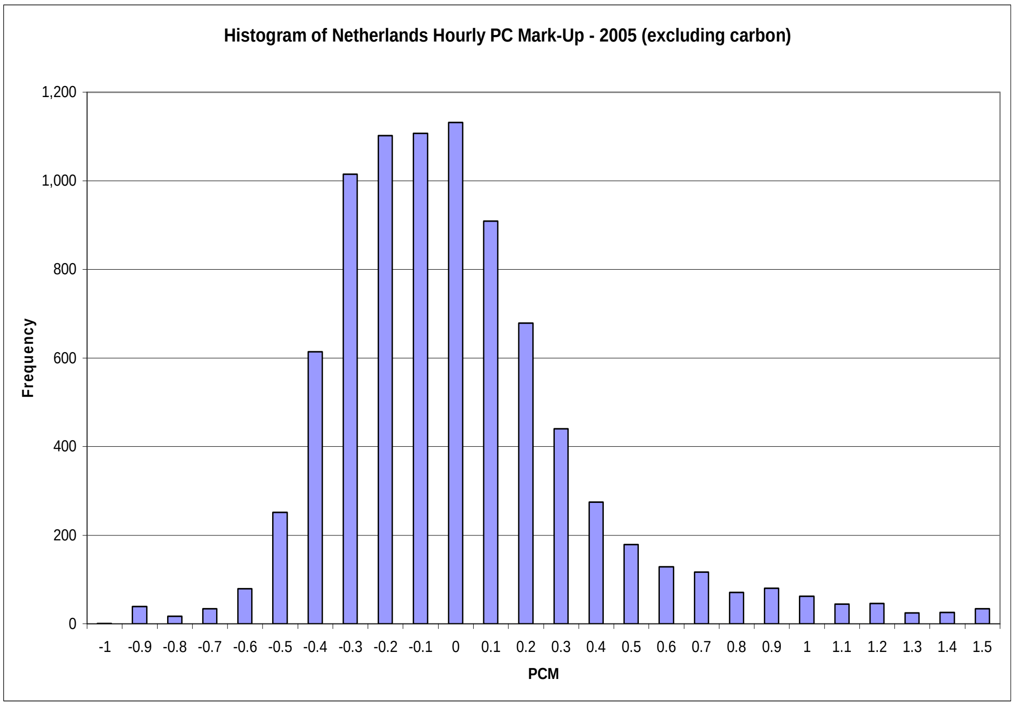
Figure 8.18: Histogram of the Netherlands Hourly Price-Cost Mark-up – 2005 (incl. Carbon)



Note: N= 8,596

Source: LE.

Figure 8.19: Histogram of the Netherlands Hourly Price-Cost Mark-up – 2005 (excl. Carbon)



Note: N= 8,508

Source: LE.

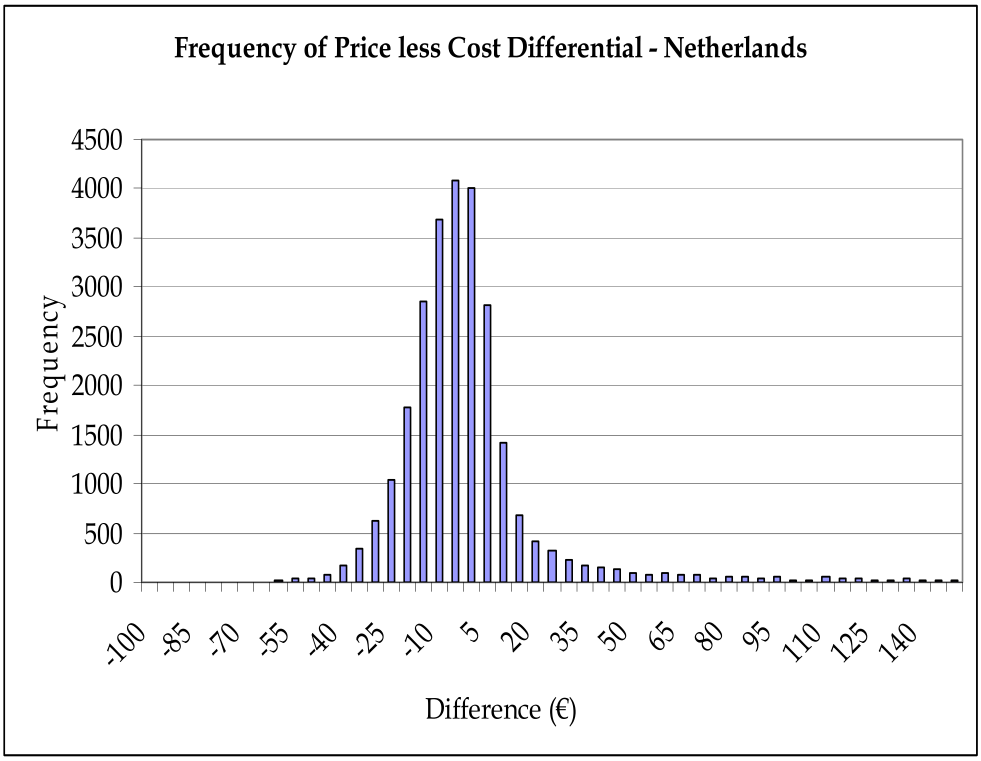
The above histograms represent the distribution of hourly Price-Cost Mark-Up values individually for the years of the study. There are three common points in relation to these histograms that merit discussion, namely the number of observations, the shape of the distribution and the frequency of particular values and how they relate to the load weighted average values presented previously in this chapter. In the four histograms presented one should be aware that all of the data points are not represented, 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.

One will also notice the long right hand tail, or right hand skewness, of the distribution in each of the histograms. This indicates that relatively high PCMUs are observed in the market with greater frequency than are similarly low PCMUs, this type of distribution will generate a significant difference between the mean and median of the observations. Finally, the distributions all appear to be centred around values in the range -0.2 – 0.0 and given their shape indicate that the PCMU, as an outcome of the Netherlands market, is negative or zero in approximately half of the hours in the year. Nevertheless, as previously discussed there may be many reasons for this to legitimately be the case, particularly in off-peak hours, and given the relationship of these distributions to the calculated annual PCMUs based on load weighted average prices and costs, it appears as if the peak and off-peak periods are significantly different in operation and thus in their market outcomes.

8.6 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 APX price and the System Cost estimated by GED as a result of their optimal dispatch simulation. As one can see the distribution broadly mirrors that already seen in the histograms of the hourly PCMU measures presented previously. This distribution is centred around 0 and exhibits a considerable right hand tail which one might expect as price spikes are possible but prices themselves are bounded below by zero. This distribution indicates that on average prices exceed costs in the Netherlands and in a substantially greater number of hours this difference large relative to times when costs actually exceed prices.

Figure 8.20: Frequency of the Price *less* Cost Differential (2003-2005) - Netherlands



Source: LE.

8.7 Carbon Impact in 2005

As is apparent from the previous analysis, the cost of carbon is included in the GED optimal dispatch 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 dispatch 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 dispatch. Table 8.61 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.

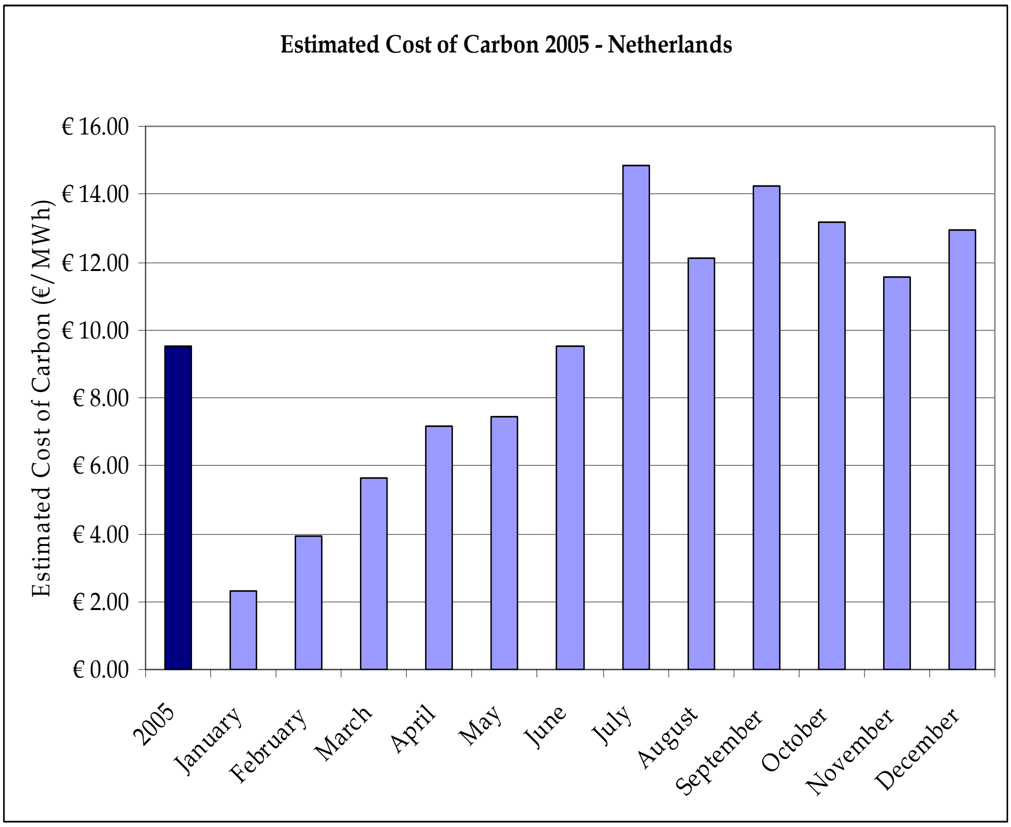
Table 8.61: Summary Statistics on the Modelled Impact of Carbon in 2005 - Netherlands

	2005	January	April	August	October
Average	€ 9.52	€ 2.29	€ 7.19	€ 12.11	€ 13.18

Based on load weighted average prices and costs
Source: LE

Figure 8.21 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 largely stabilises in the €12 - €14 range.

Figure 8.21: Average Monthly Cost of Carbon – 2005 – Netherlands



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.

8.8 Contribution to Fixed Costs

So far in this assessment of the Netherlands 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 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 modeling 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 warmweather 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 dispatch, again from the GED modeling 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 8.62, shows on a company by company basis the total euro value of such rents. As can be seen by the figure, the big companies identified in the RSI analysis as companies 0439-S-NL, 0511-S-NL, 0712-S-NL & 1193-S-NL, would still earn a sufficient amount under this optimal scenario to contribute to fixed costs in a substantial manner consistently on an annual basis. This result also indicates that all companies in the Netherlands would be capable in contributing to fixed costs under this optimal dispatch scenario and its resulting system marginal cost, which in a perfectly competitive market would correspond with the price they would receive for their electricity.

Table 8.62: Contribution to Fixed Costs (€'000) - Netherlands					
Company	**Company ID**	**2003**	**2004**	**2005**	**Total**
C01	**0383-S-NL**	98,994.5	82,074.2	148,891.0	329,959.6
C02	**0439-S-NL**	210,725.3	149,863.3	79,092.7	439,681.3
C03	**0511-S-NL**	256,825.5	211,884.0	142,804.9	611,514.4
C04	**0582-S-NL**	0.0	0.0	0.0	0.0
C05	**0712-S-NL**	375,394.9	251,917.0	633,023.8	1,260,335.7
C06	**1193-S-NL**	223,846.0	166,949.7	286,358.6	677,154.3
C07	**2003-S-NL**	0.0	67,579.2	137,049.3	204,628.5
C08	**2010-S-NL**	13,200.7	11,994.6	26,607.3	51,802.6
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[2]. 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.

[2] 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[3] 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[4]. 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[5]. We then amortized the investment cost over the life of the plant, and divided by the 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.

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[3] The Commission for Energy Regulation, Ireland.

[4] 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.

[5] 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 the table, we can see that even taking the generic new build (which we argue should be at the upper end of the investment cost scale), The Netherlands's per MW per year estimated contributions to fixed cost exceed the per unit cost of generic new plant. Alone this result indicates that, on average, the profit levels being earned in the Netherlands, under a perfectly competitive market scenario, are at least sufficient to allow for new investment to take place. Considering the market outcomes in the market 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 Netherlands 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, on average, by operators in the Netherlands 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 The Netherlands. As previously stated, we merely use this as a model check. There may be reasons that investment incentive hurdles are higher or lower.

Table 8.63: Comparison contribution to fixed cost and generic new build - Netherlands

	€/MW/Year
Generic CCGT 400MW	67,980
Generic Coal 1000MW	61,911
	2003-05 Average
The Netherlands	73,119

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.

8.9 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[6].

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 PCM, 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.

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[6] 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[7]. Table 8.64 provides a summary of the variables included in the regression analysis.

Table 8.64: 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.

[7] 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 8.65: Variables used in the Regression Analysis - Netherlands	
Company Number	**Company Identification**
C03	0511-S-NL
C05	0712-S-NL
Source:LE	

8.9.1 Regression Analysis – Part I

In this first section of the regression analysis, a number of simple regression models are presented. In standard econometric terminology, 'simple' regression refers to regression of the dependent variable on a single independent variable, univariate regression. 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. These simple models are further corrected for possible violations of the standard classical regression model assumptions. The first group of regression separately regress the hourly Lerner Index values on the RSI values of the two largest companies in the Netherlands market, starting with the largest 0712-S-NL.

Lerner Index & RSI for 0712-S-NL

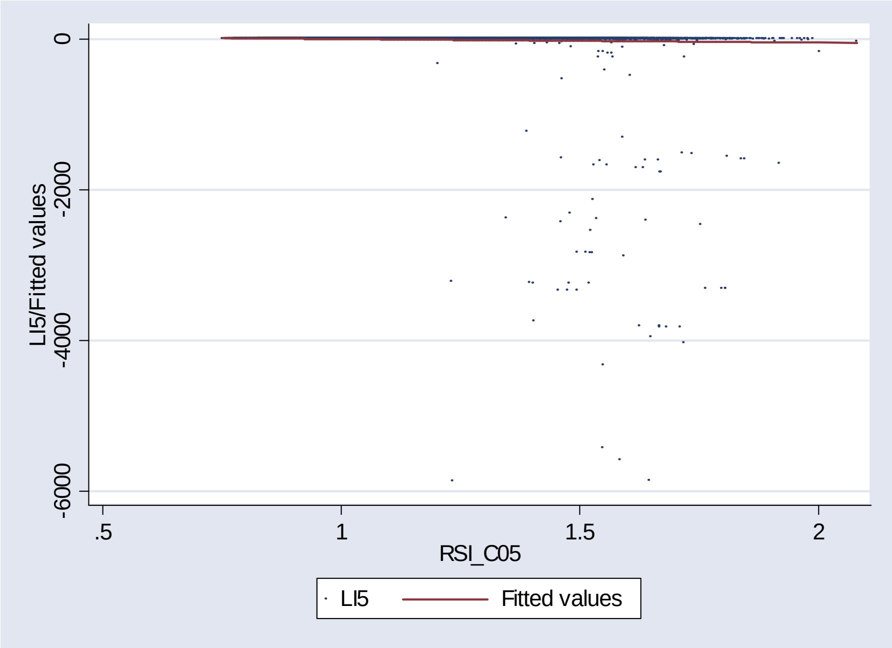
```
      Source |       SS       df       MS              Number of obs =   26283
-------------+------------------------------           F(  1, 26281) =  155.72
       Model |  3207024.71     1  3207024.71           Prob > F      =  0.0000
    Residual |   541250367 26281  20594.7402           R-squared     =  0.0059
-------------+------------------------------           Adj R-squared =  0.0059
       Total |   544457391 26282  20715.9802           Root MSE      =  143.51

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C05 |  -46.38479   3.717086   -12.48   0.000    -53.67049    -39.0991
       _cons |    48.1677   4.489688    10.73   0.000     39.36767    56.96773
```

The estimated coefficient on the RSI value of company 0712-S-NL (C05) is of the expected sign and is strongly statistically significant with a t value indicating that the coefficient is significant at the 99% level.

The R-squared on this regression is however very low, indicating that the model overall does not have much explanatory power. 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.

As one can see from the following figure of the predicted regression line, the LI value increases with the company's indispensability, however the graph does indicate the possible presence of non-spherical error terms.

Figure 8.22: LI Regression on RSI for 0712-S-NL



Source: LE.

In order to correct for possible errors in interpretation of the estimated coefficients brought about by non-spherical disturbances that violate the classical linear regression assumptions, two additional regression equations have been estimated and are presented below. As one can see from both of these regressions, the qualitative results remains unchanged and quantitatively the effect is negligible. In both regressions the estimated sign and impact of the estimated coefficient mirrors that of the previous regression and although the t statistics on these variables have declined, the coefficients are still significant at the 99% level.

Regression with Robust Standard Errors – 0712-S-NL

To correct for heteroskedasticity, we use the Huber-White sandwich estimator of variance[8] in place of the traditional calculation to ensure that our standard errors are robust.

```
Regression with robust standard errors                 Number of obs =   26283
                                                       F(  1, 26281) =   51.88
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.0059
                                                       Root MSE      =  143.51

------------------------------------------------------------------------------
             |               Robust
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C05 |  -46.38479   6.440143    -7.20   0.000    -59.00782   -33.76177
       _cons |    48.1677   6.810163     7.07   0.000     34.81941    61.51599
```

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[9]. The estimator is a Generalised Least Squares (GLS) estimator.

---

[8] 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.

[9] 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 – 0712-S-NL

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

      Source |       SS       df       MS              Number of obs =   26283
-------------+------------------------------           F(  1, 26281) =   50.41
       Model |  742084.673     1  742084.673           Prob > F      =  0.0000
    Residual |   386854436 26281  14719.9283           R-squared     =  0.0019
-------------+------------------------------           Adj R-squared =  0.0019
       Total |   387596521 26282  14747.6037           Root MSE      =  121.33

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C05 |  -43.86762   6.177439    -7.10   0.000    -55.97574   -31.75951
       _cons |   45.18898   7.488683     6.03   0.000     30.51075     59.8672
-------------+----------------------------------------------------------------
         rho |   .5341072
------------------------------------------------------------------------------
Durbin-Watson statistic (original)    0.931817
Durbin-Watson statistic (transformed) 2.143970
```

On the basis of the results already presented one has a preliminary indication of the relationship between the LI and the RSI of Company 0712-S-NL. In order to investigate this further 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. All of the coefficients in the estimated regression equation are significant and the coefficients on the RSI variables in both peak and off-peak hours are of the expected sign, however this result would indicate that company 0712-S-NL's indispensability in off-peak hours has a greater impact on increasing the LI than it does in peak hours.

Peak & Off-Peak Analysis – 0712-S-NL

Source	SS	df	MS
Model	3781574.48	3	1260524.83
Residual	540675817	26279	20574.4441
Total	544457391	26282	20715.9802

Number of obs	26283
F(3, 26279)	61.27
Prob > F	0.0000
R-squared	0.0069
Adj R-squared	0.0068
Root MSE	143.44

LI5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
dpeak	-70.92834	14.4239	-4.92	0.000	-99.19997	-42.65671
pk_RSI_C05	-40.97211	5.900469	-6.94	0.000	-52.53735	-29.40687
opk_RSI_C05	-89.91718	9.1163	-9.86	0.000	-107.7856	-72.04874
_cons	111.9946	12.91559	8.67	0.000	86.67935	137.3099

A similar set of regressions were estimated based on regressing the hourly PCM on the RSI of Company 0712-S-NL. 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 regression model is approximately 11% 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 PCM to regression analysis in circumstances where prices can fall to a negligible amount however this proposition has not been exhaustively tested.

Price-Cost Mark-Up & RSI for Company 0712-S-NL

Source	SS	df	MS
Model	2701.51865	1	2701.51865
Residual	22468.6678	26302	.854257006
Total	25170.1864	26303	.956932153

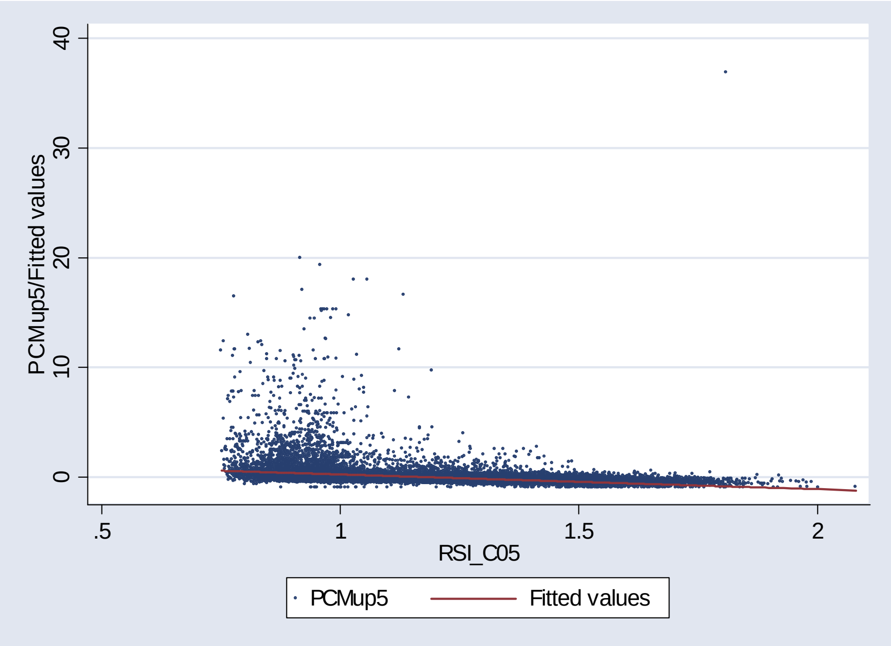
Number of obs	26304
F(1, 26302)	3162.42
Prob > F	0.0000
R-squared	0.1073
Adj R-squared	0.1073
Root MSE	.92426

PCMup5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C05	-1.34591	.0239335	-56.24	0.000	-1.392821	-1.298999
_cons	1.577654	.0289045	54.58	0.000	1.520999	1.634308

The R-squared values for the price cost mark-up regressions are in general in the range of 10-15%. 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.

The following figure presents the predicted regression line from the regression equation estimated above. The predicted line is in red and one can more clearly see the predicted relationship between the two variables here with the PCM increasing at times of greater indispensability of the company's available generation capacity. The figure also indicates the presence of non-spherical disturbances but as before with the LI, these have been corrected for and the qualitative results remain unchanged with negligible changes to the quantitative estimates.

Figure 8.23: PCMU Regression on RSI 0712-S-NL



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. 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 0712-S-NL. 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 – 0712-S-NL

```
      Source |       SS       df       MS              Number of obs =   26304
-------------+------------------------------           F(  2, 26301) = 1810.45
       Model |  3045.88685     2  1522.94343           Prob > F      =  0.0000
    Residual |  22124.2996 26301  .841196136           R-squared     =  0.1210
-------------+------------------------------           Adj R-squared =  0.1209
       Total |  25170.1864 26303  .956932153           Root MSE      =  .91717

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C05 |  -6.362027   .2490511   -25.55   0.000     -6.85018   -5.873873
   RSI_C05sq |   2.036108   .1006324    20.23   0.000     1.838863    2.233353
       _cons |   4.546965   .1495317    30.41   0.000     4.253875    4.840056
```

This regression indicates that the likely relationship between the PCMU and RSI of company 0712-S-NL 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 PCM 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 12% of the variation in the PCM over the three years.

Peak & Off-Peak Analysis – 0712-S-NL

```
      Source |       SS       df       MS              Number of obs =   26304
-------------+------------------------------           F(  3, 26300) = 1196.18
       Model |  3022.04183     3  1007.34728           Prob > F      =  0.0000
    Residual |  22148.1446 26300  .842134776           R-squared     =  0.1201
-------------+------------------------------           Adj R-squared =  0.1200
       Total |  25170.1864 26303  .956932153           Root MSE      =  .91768

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   1.576412    .092276    17.08   0.000     1.395546    1.757278
   pk_RSI_C05 |  -1.400807    .037744   -37.11   0.000    -1.474788   -1.326827
  opk_RSI_C05 |  -.3454958   .0583237    -5.92   0.000    -.4598134   -.2311781
       _cons |   .0968545   .0826306     1.17   0.241     -.065106    .2588149
```

The simple regression analysis has similarly been applied to the markets second largest company 0511-S-NL, with almost identical results. All of the estimated coefficients are of the same sign and quantitatively are very similar to those estimated for company 0712-S-NL.

Lerner Index & RSI for 0511-S-NL

```
      Source |       SS       df       MS              Number of obs =   26283
-------------+------------------------------           F(  1, 26281) =  125.53
       Model |  2588158.65     1  2588158.65           Prob > F      =  0.0000
    Residual |   541869233 26281  20618.2882           R-squared     =  0.0048
-------------+------------------------------           Adj R-squared =  0.0047
       Total |   544457391 26282  20715.9802           Root MSE      =  143.59

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |  -37.04394   3.306344   -11.20   0.000    -43.52455   -30.56333
       _cons |   41.13685   4.365672     9.42   0.000     32.57989     49.6938
```

Peak & Off-Peak Analysis - 0511-S-NL

The peak/off-peak analysis again shows negative coefficients for both periods, and both are highly significant.

```
      Source |       SS       df       MS              Number of obs =   26283
-------------+------------------------------           F(  3, 26279) =   45.10
       Model |  2789129.38     3  929709.792           Prob > F      =  0.0000
    Residual |   541668262 26279  20612.2098           R-squared     =  0.0051
-------------+------------------------------           Adj R-squared =  0.0050
       Total |   544457391 26282  20715.9802           Root MSE      =  143.57

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |  -41.37027   13.71697    -3.02   0.003    -68.25628   -14.48426
  pk_RSI_C03 |  -32.83746   5.146464    -6.38   0.000    -42.92481   -22.75011
 opk_RSI_C03 |  -59.51505   7.926467    -7.51   0.000    -75.05135   -43.97875
       _cons |    76.9405   12.27419     6.27   0.000     52.88243    100.9986
```

Price-Cost Mark-Up & RSI for 0511-S-NL

The regression based on company 0511-S-NL's mark-up shows the same characteristic features as the other mark-up regressions, very significant coefficients with the expected sign, as well as a reasonably good fit for this type of regression.

```
      Source |       SS       df       MS              Number of obs =   26304
-------------+------------------------------           F(  1, 26302) = 3272.47
       Model |  2785.12716     1  2785.12716           Prob > F      =  0.0000
    Residual |  22385.0593 26302  .851078217           R-squared     =  0.1107
-------------+------------------------------           Adj R-squared =  0.1106
       Total |  25170.1864 26303  .956932153           Root MSE      =  .92254

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |  -1.215003   .0212393   -57.21   0.000    -1.256633   -1.173373
       _cons |   1.554873   .0280414    55.45   0.000     1.499911    1.609836
```

Quadratic Specification - 0511-S-NL

As with the company 0712-S-NL 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.

```
      Source |       SS       df       MS              Number of obs =   26304
-------------+------------------------------           F(  2, 26301) = 1934.14
       Model |  3227.30677     2  1613.65338           Prob > F      =  0.0000
    Residual |  21942.8797 26301  .834298303           R-squared     =  0.1282
-------------+------------------------------           Adj R-squared =  0.1282
       Total |  25170.1864 26303  .956932153           Root MSE      =   .9134

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |  -5.989611   .2084587   -28.73   0.000    -6.398201    -5.58102
   RSI_C03sq |   1.765735   .0766985    23.02   0.000     1.615401    1.916068
       _cons |   4.649714   .1372681    33.87   0.000     4.380661    4.918767
```

As one can see the estimated impact of the quadratic term is quantitatively the same as it was for company 0712-S-NL. PCMU is expected to decrease, at a decreasing rate, the higher the RSI of company 0511-S-NL becomes.

Peak & Off-Peak Analysis - 0511-S-NL

Considering the peak and off-peak distinction in relation to company 0511-S-NL one can once again see, qualitatively, the same result as has previously been presented in relation to company 0712-S-NL. The estimated regression equation predicts that the PCMU is greater in peak hours holding all else equal and that the indispensability of company 0511-S-NL in peak hours has a greater impact on the PCMU than it does in off peak hours. Interestingly, this result coincides with the observed increase in market share for this company as the market becomes more concentrated as seen in the section wherein the structural indicators were discussed.

```
      Source |       SS       df       MS              Number of obs =   26304
-------------+------------------------------           F(  3, 26300) = 1243.82
       Model |  3127.44889     3  1042.48296           Prob > F      =  0.0000
    Residual |  22042.7375 26300  .838126903           R-squared     =  0.1243
-------------+------------------------------           Adj R-squared =  0.1242
       Total |  25170.1864 26303  .956932153           Root MSE      =  .91549

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   1.554062   .0874662    17.77   0.000     1.382623      1.7255
   pk_RSI_C03 |  -1.272675   .0328146   -38.78   0.000    -1.336993   -1.208356
  opk_RSI_C03 |  -.3229633   .0505443    -6.39   0.000    -.4220329   -.2238937
       _cons |   .1070192   .0782682     1.37   0.172    -.0463907    .2604291
```

8.9.2 Regression Analysis – Part II

To further test the specification of the model, we included as a regressor a measure of scarcity. 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 PCM on the RSI of company 0712-S-NL is presented in the following regression. One can clearly see that both the RSI and scarcity variable are of the expected sign and are both strongly statistically significant, thus indicating that the indispensability of company 0712-S-NL is positively correlated with the PCM and that this result is explained simply by the presence of scarcity rents, although these are clearly a factor in the market outcome.

Price-Cost Mark-Up & RSI for Company 0712-S-NL (including a Scarcity variable)

```
Regression with robust standard errors                 Number of obs =   26304
                                                       F(  2, 26301) = 1090.26
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1094
                                                       Root MSE      =  .92323

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C05 |  -.3703749   .0988687    -3.75   0.000    -.5641629   -.1765869
        Scar |  -.6781109   .0635541   -10.67   0.000    -.8026803   -.5535414
       _cons |   .9165821   .0760544    12.05   0.000     .7675114    1.065653
```

Building on this regression a number of dummy variables have been included on the right hand side of the regression equation to attempt to build on the explanatory power of the model and identify further effects that one might reasonable expect to observe in such a market. The estimated regression follows directly.

Price-Cost Mark-Up & RSI for Company 0712-S-NL (including a Scarcity and dummy variables)

```
Regression with robust standard errors                Number of obs =   26304
                                                      F(  8, 26295) =  622.96
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.1343
                                                      Root MSE      =  .91031

------------------------------------------------------------------------------
             |               Robust
     PCMup5  |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    RSI_C05  |   .1846238   .1094206     1.69   0.092    -.0298464    .3990941
       Scar  |  -1.054416     .07446   -14.16   0.000    -1.200362   -.9084707
      d2004  |  -.2307253   .0157064   -14.69   0.000    -.2615107   -.1999399
      d2005  |  -.2739787   .0158639   -17.27   0.000    -.3050727   -.2428846
      dpeak  |   .1067609   .0094843    11.26   0.000     .0881711    .1253507
    dsummer  |  -.0256399    .013814    -1.86   0.063    -.0527162    .0014364
    dwinter  |  -.1512364   .0133328   -11.34   0.000    -.1773695   -.1251034
     dwkday  |  -.1325222    .010118   -13.10   0.000     -.152354   -.1126904
      _cons  |   .7692247   .0852932     9.02   0.000     .6020454     .936404
```

Increasing the number of explanatory variables, by including a number of dummy variables, has produced a somewhat surprising result, the coefficient on the RSI variable has become positive however this should not be of concern as the variable is no longer considered to be statistically significant under this specification. The coefficient on the scarcity variable remains of the expected sign and is strongly significant and the introduction of the dummy variables has increased the explanatory power of the model. As for the dummy variables, the annual dummies have the expected sign given what we have seen previously in relation to the higher LI and PCM values returned in 2003 relative to the other two years. The coefficient on the peak dummy variable indicates that PCM is higher in peak periods relative to off-peak, whereas the winter dummy variable indicates that PCMs are lower in winter relative to other seasons in the year in the Netherlands. Unusually the estimated coefficient on the weekday dummy is negative indicating higher PCMs on weekends, intuitively this does not appear consistent with estimated coefficient on the peak dummy. Overall this result is not consistent with the results of the previous regression equation which found that the estimated coefficients on the RSI and scarcity variables were independently statistically significant and of their expected sign.

The introduction of a scarcity variable into the right hand side of the regression equation of PCM on the RSI of company 0511-S-NL, results in the estimated coefficients of both the RSI and scarcity variables being independently statistically significant and of the expected sign.

Price-Cost Mark-Up & RSI for Company 0511-S-NL (including a Scarcity variable)

```
Regression with robust standard errors                 Number of obs =   26304
                                                       F(  2, 26301) = 1042.10
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1109
                                                       Root MSE      =  .92242

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |  -.8851914    .073674   -12.01   0.000    -1.029596   -.7407864
        Scar |  -.2574175   .0542433    -4.75   0.000    -.3637373   -.1510978
       _cons |      1.316   .0617444    21.31   0.000     1.194978    1.437022
```

If one expands the regression specification to replicate the regression equation estimated previously for company 0712-S-NL, for company 0511-S-NL, one finds a largely similar result. One notable change between the two regressions is that the estimated coefficient on company 0511-S-NL's RSI variable is now both positive and statistically significant. This result is not found in any of the other regression specifications and can be considered a somewhat special case that may merit further investigation.

Price-Cost Mark-Up & RSI for Company 0511-S-NL (including a Scarcity and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26304
                                                       F(  8, 26295) =  641.98
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1347
                                                       Root MSE      =  .91009

------------------------------------------------------------------------------
             |               Robust
     PCMup5  |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |   .6435423   .1494813     4.31   0.000      .3505508    .9365337
        Scar |  -1.420624   .1235833   -11.50   0.000     -1.662854   -1.178394
       d2004 |  -.2376858   .0166867   -14.24   0.000     -.2703926    -.204979
       d2005 |  -.3218159   .0236252   -13.62   0.000     -.3681226   -.2755092
       dpeak |   .1013768   .0094129    10.77   0.000       .082927    .1198265
     dsummer |  -.0396057   .0138254    -2.86   0.004     -.0667043   -.0125072
     dwinter |  -.1462586   .0132919   -11.00   0.000     -.1723114   -.1202058
      dwkday |  -.1340387   .0101237   -13.24   0.000     -.1538817   -.1141957
       _cons |   .4478111   .1002614     4.47   0.000      .2512933    .6443289
```

8.9.3 Regression analysis – Part 3

At this point having found, at least in the simple regression case, that the RSI and scarcity variables are independently statistically significant and 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 of the two companies may lead one to question whether in fact these two variables are capturing the same effect. To test this a further regression equation has been estimated which includes the RSI of both 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.

Price-Cost Mark-Up & RSI for Company 0712-S-NL & Company 0511-S-NL (including a Competition, a Scarcity, Withholding and dummy variables)

```
Regression with robust standard errors                 Number of obs =   26304
                                                       F( 12, 26291) =  502.75
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.1644
                                                       Root MSE      =  .89443

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C03 |   -2.25849   .2292137    -9.85   0.000    -2.707761   -1.809219
     RSI_C05 |   -2.35145   .2328161   -10.10   0.000    -2.807782   -1.895118
 RSI_C03_C05 |    2.24843   .1585753    14.18   0.000     1.937613    2.559246
        Scar |  -1.871446    .163138   -11.47   0.000    -2.191205   -1.551687
      C0_gas |   .0001109   .0000162     6.84   0.000     .0000791    .0001427
     C0_coal |  -.0002411   .0000382    -6.31   0.000    -.0003159   -.0001662
       d2004 |  -.1796995   .0152363   -11.79   0.000    -.2095634   -.1498356
       d2005 |  -.2465352   .0222169   -11.10   0.000    -.2900816   -.2029888
       dpeak |   .0395178   .0105123     3.76   0.000     .0189131    .0601225
     dsummer |   .0224394   .0132692     1.69   0.091    -.003569     .0484478
     dwinter |  -.2031911   .0146291   -13.89   0.000    -.231865    -.1745173
      dwkday |  -.2127517   .0121933   -17.45   0.000    -.2366512   -.1888522
       _cons |   3.698605   .2868184    12.90   0.000     3.136426    4.260785
```

The results of this regression indicate that the individual company effects are independently statistically significant and that they both remain independently statistically different from the scarcity variable. 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 qualitative results on the coefficients of the dummy variables are unchanged from the previous regressions. However, the introduction of the variables designed to identify the possibility of potential withholding have been estimated to have statistically significant coefficients with the expected sign, as the amount of coal fired generation modelled in the optimal dispatch exceeds that which occurred in actuality, the PCM increases but an increase in the PCM is also brought about independently through more gas fired capacity being used relative to the amount modelled under the GED optimal system dispatch.

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

8.10 Withholding

Withholding is a strategy that may be entered into by companies in an attempt to manipulate the price of electricity on the market. Conceptually such a strategy would involve a company withholding generation capacity generally located to the left of the merit curve, but in any event it must be in merit, thus causing capacity further to the right of the merit curve, that previously was not required to meet the specific load level, to turn on an therefore set the market price at a higher level. Importantly, the capacity that is forced to come online does not have to belong to the company exercising the withholding strategy as everyone will get the same market price for electricity irrespective of who owns the unit setting the market price.

The GED model of optimal system dispatch 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. Thus we cannot distinguish with too much certainty whether 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.

First, in order to set our findings on potential withholding in the context of the size of the market in the Netherlands, we present in Table 8.66 breakdown of total installed capacity by technology.

Table 8.66: Total Installed Capacity of modelled Units, by Technology - Netherlands

Gas (MW)	Coal (MW)	Nuclear (MW)	Other (MW)	Total (MW)
9,564	4,333	453	1,947	16,298

Source: LE

The following analysis presents the results of our withholding analysis and indicates both the size of the average differential between actual and modelled generation and the persistence of this differential over time. A similar structure for analysis is applied to each of the large companies in the Netherlands with a brief discussion included for the two largest companies, 0712-S-NL and 0511-S-NL.

Table 8.67 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis.

Both coal and gas plants owned by company 0439-S-NL generated less than our model predicted for a substantial part of the period we studied.

Table 8.67: Potential Withholding, by Technology, for 0439-S-NL, (Number of hours where modelled is greater than actual generation)

	Gas	Coal	Nuclear	Other
2003-05	17,060	19,311	0	0
% hrs<0	64.9%	73.4%	0.0%	0.0%
2003	5,573	5,930	0	0
% hrs<0	63.6%	67.7%	0.0%	0.0%
2004	6,438	8,571	0	0
% hrs<0	73.3%	97.6%	0.0%	0.0%
2005	5,049	4,810	0	0
% hrs<0	57.6%	54.9%	0.0%	0.0%

Source: LE

Table 8.68 presents evidence of potential withholding for Company 0439-S-NL .

Table 8.68: Potential Withholding (MW), by Technology, for 0439-S-NL					
	Gas (MW)	Coal (MW)	Nuclear (MW)	Other (MW)	Total (MW)
2003-05	-38	-83	0	0	-120
2003	-38	-118	0	0	-156
2004	-74	-212	0	0	-285
2005	-1	81	0	0	80
Source: LE					

Table 8.69 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis. Company 0511-S-NL, too, shows that actual generation lay significantly below modelled generation for a large proportion of hours between 2003 and 2005. However, the differential decreased very rapidly in 2005.

Table 8.69: Potential Withholding, by Technology, for 0511-S-NL, (Number of hours where modelled is greater than actual generation)				
	Gas	Coal	Nuclear	Other
2003-05	12,266	18,104	0	0
% hrs<0	46.6%	68.8%	0.0%	0.0%
2003	4,713	8,466	0	0
% hrs<0	53.8%	96.6%	0.0%	0.0%
2004	6,351	7,439	0	0
% hrs<0	72.3%	84.7%	0.0%	0.0%
2005	1,202	2,199	0	0
% hrs<0	13.7%	25.1%	0.0%	0.0%
Source: LE				

From the data contained in this table, and in the table below, it appears as if this company has potentially withheld a significant amount of coal fired generation capacity, particularly in 2003 and 2004. In 2003 for example, the actual amount of coal fired generation was less than that resulting from the optimal modelling of the system 97.5 percent of the time and on average over the year the difference between actual and modelled generation was (-209MW). This indicates a systematic and significant difference the actual and modelled generation of the company's coal fired generation assets. In 2003 the modelled hourly generation of the company's gas fired generation capacity was similarly above the actual hourly pattern.

Table 8.70 presents evidence of potential withholding for Company 0511-S-NL.

Table 8.70: Potential Withholding (MW), by Technology, for 0511-S-NL

	Gas (MW)	Coal (MW)	Nuclear (MW)	Other (MW)	Total (MW)
2003-05	70	-80	0	0	-10
2003	-30	-206	0	0	-236
2004	-215	-120	0	0	-336
2005	456	86	0	0	542

Source: LE

Table 8.71 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis.

Table 8.71: Potential Withholding, by Technology, for 0712-S-NL, (Number of hours where modelled is greater than actual generation)

	Gas	Coal	Nuclear	Other
2003-05	7,041	20,724	3,993	25,345
% hrs<0	26.8%	78.8%	15.2%	96.4%
2003	1,145	7,889	501	8,504
% hrs<0	13.1%	90.1%	5.7%	97.1%
2004	344	4,981	885	8,087
% hrs<0	3.9%	56.7%	10.1%	92.1%
2005	5,552	7,854	2,607	8,754
% hrs<0	63.4%	89.7%	29.8%	99.9%

Source: LE

As was the case for company 0511-S-NL, company 0712-S-NL exhibits a systematic pattern of behaviour consistent with a sub-optimal utilisation of their coal fired generation capacity of a significant proportion. However in the case of this company for the period as a whole as well as for the years 2003 and 2004, this result is complimented with a consistent pattern of actual gas fired generation that is greater than that resulting from GED optimal dispatch. This result does not hold in 2005 but for the two previous years the average amount of coal fired capacity that was not optimally utilised was fully accounted for by the higher than modelled level of generation reported for the company's gas fired generation capacity.

Table 8.72 presents evidence of potential withholding for Company 0712-S-NL in MW.

Table 8.72: Potential Withholding (MW), by Technology, for 0712-S-NL					
	Gas (MW)	Coal (MW)	Nuclear (MW)	Other (MW)	Total (MW)
2003-05	233	-138	-2	-5	88
2003	357	-195	2	-5	158
2004	454	-27	0	-4	424
2005	-111	-192	-9	-5	-318
Source: LE					

Table 8.73 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis. In the case of company 1193-S-NL the frequency with which actual generation exceeds modelled generation appears to decline over time for both coal and gas fired technology. This is further supported by the average quantity of the differential which appears to be similarly declining.

Table 8.73: Potential Withholding, by Technology, for 1193-S-NL, (Number of hours where modelled is greater than actual generation)				
	Gas	Coal	Nuclear	Other
2003-05	6,470	4,689	0	22,180
% hrs<0	24.6%	17.8%	0.0%	84.3%
2003	677	803	0	8,222
% hrs<0	7.7%	9.2%	0.0%	93.9%
2004	484	1,517	0	8,161
% hrs<0	5.5%	17.3%	0.0%	92.9%
2005	5,309	2,369	0	5,797
% hrs<0	60.6%	27.0%	0.0%	66.2%
Source: LE				

Table 8.74 presents evidence of potential withholding for Company 1193-S-NL in MW.

Table 8.74: Potential Withholding (MW), by Technology, for 1193-S-NL

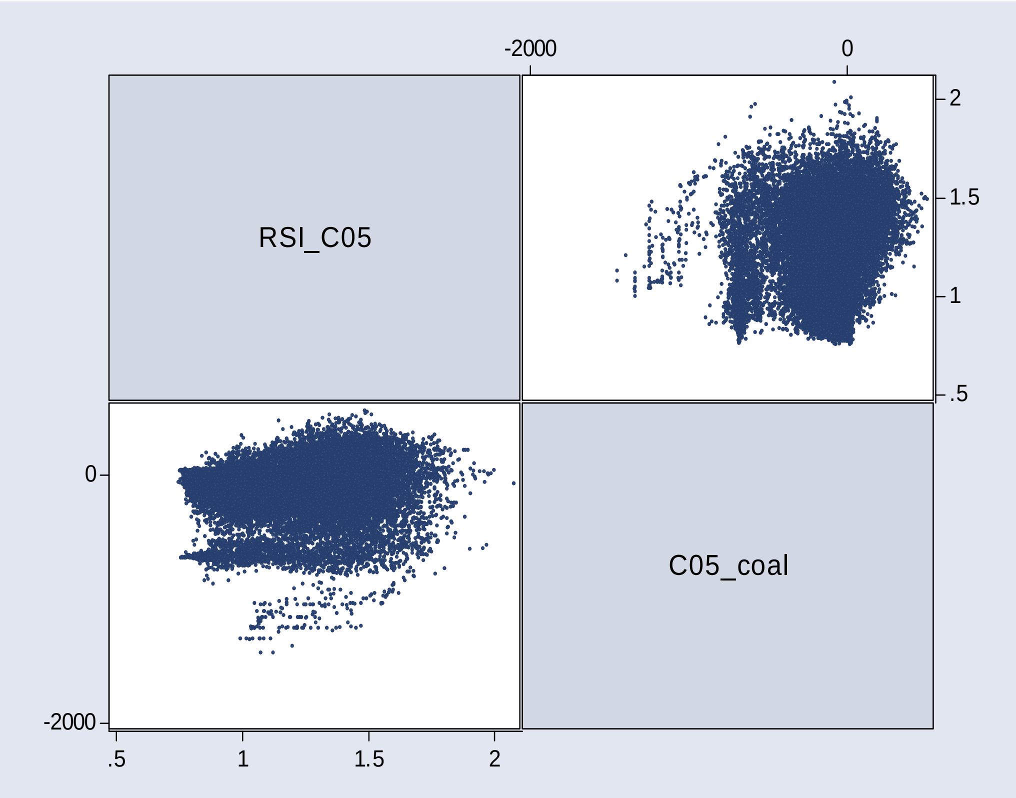
	Gas (MW)	Coal (MW)	Nuclear (MW)	Other (MW)	Total (MW)
2003-05	168	123	0	-93	197
2003	281	143	0	-81	343
2004	238	142	0	-127	252
2005	-17	83	0	-71	-5

Source: LE

Analysis of Company 0712-S-NL and Withholding

The following figures present graphically the relationship between the quantity of potential withholding and the RSI variable of company 0712-S-NL, on an hourly basis. Neither of these graphs indicate the systematic use of withholding at times when the market was dependent on the firms utilisation of its available installed capacity.

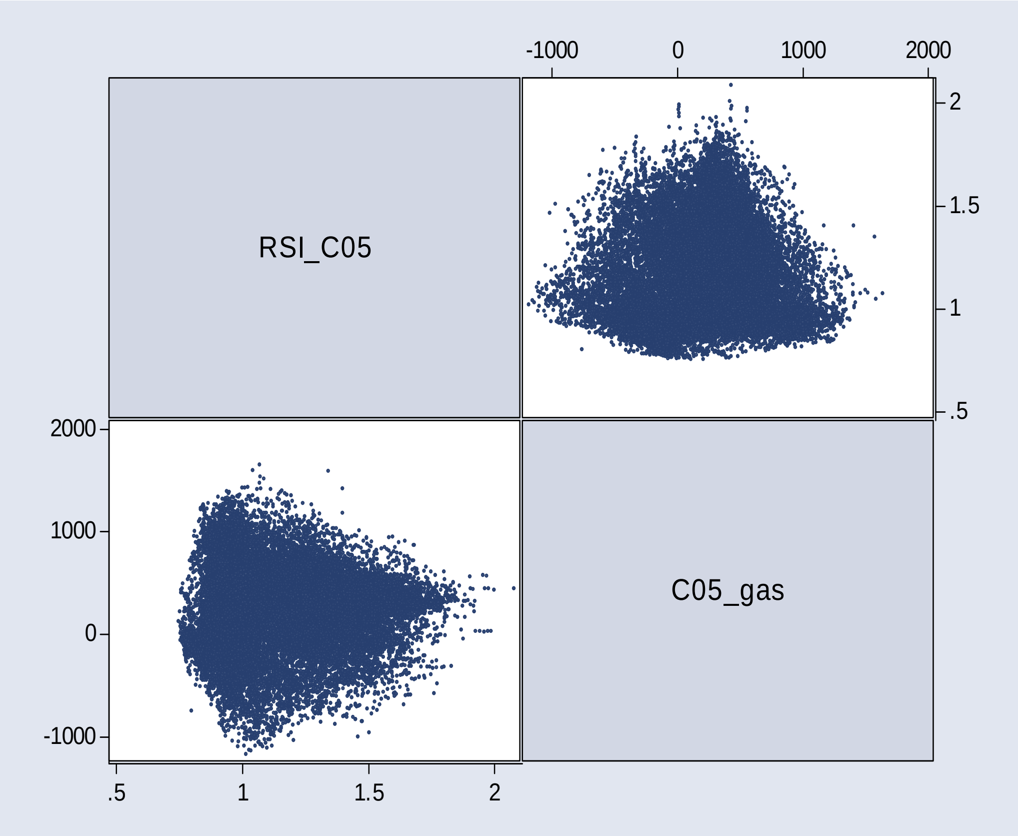
Figure 8.24:Comparison of the use of coal fired technology and the hourly RSI of Company 0712-S-NL



Source: LE.

Scatterplot Matrix of 0712-S-NL and Withholding, by technology

Figure 8.25:Comparison of the use of gas fired technology and the hourly RSI of Company 0712-S-NL



Source: LE.

From the results presented in this section, it does not appear as if the strategy of withholding is a systematically being employed by companies in the market to a large extent. Although some differences are prevalent and persistent over time, the size of these differences are not large, on average, relative to the size of the market. Furthermore, there are a number of operational and technical reasons both in relation to the units and the modelling of the system that may have an influence on these results. A more in-depth investigation of these issues in an attempt to rule out possible price manipulation through withholding is not the focus of this study and thus is left for a more thorough investigation to be undertaken in to this matter if the perceived extent of the problem is believed to merit it.

8.11 Conclusions

The wholesale electricity market in the Netherlands was in general found to be concentrated, but the traditional concentration measures showed the most variations among countries studied across time and allocation of the interconnectors. 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.

Market structure as measured by traditional concentration measures HHI and CR(2) ranged from unconcentrated to highly concentrated.

The Netherlands was one of the more sensitive countries in terms of the sensitivity of traditional concentration measures to variations, particularly with respect to the allocation of the interconnector and the current regulatory regime in the Netherlands.

Based on available capacity, the HHI for the Netherlands was found to be 2,153 on average through the sample period, and the CR(2) was found to be 54.5%[10]. Measuring concentration by available installed capacity and allocating the interconnectors led to a range from 938 to 3,835 for HHI and 34.4% to 77.4% for CR(2). We note that threshold values such as 1800 for the HHI and 33% for CR(*n*) are somewhat arbitrary.

[10] There are variations in the 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 Netherlands was somewhat unique in terms of our sensitivity analysis. Due to a high level of interconnectivity, in general, the Netherlands might be considered borderline unconcentrated to highly concentrated, depending on whether interconnection is allocated to large companies already holding capacity in the country, or whether interconnection capacity is allocated to competitors. Sensitivity analysis regarding the allocation of interconnectors to market shares, basing market shares on generation or in merit capacity, as well as the attribution of long-term contracts did have some impacts on the concentration measures. The range of HHI under these measures was 1,239 to 3,304 on average. Variations in time matter less than interconnection, but also cause some changes in the estimated concentration measures.

We also note that interconnection policy between the Netherlands is one of the more advanced and transparent in the EU, with open auctions to allocate interconnection capacity, use-it-or-lose-it rules, limits on any one company obtaining an excess share of capacity, among other things. In spite of all this, there is some evidence that the Netherlands does not function as a market fully integrated with Germany (see EC DG Comp second report on the electricity sector 2006), but investigating the details of this were beyond the scope of this report.

The electricity-specific measures of market structure to a certain extent confirmed the qualitative conclusions of the HHI and CR(2) for the Netherlands. Some hours show market structure that is conducive to non-competitive outcomes. 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 the Netherlands, with the PSI finding a single company was pivotal in between 31.3% of hours.

Price cost margins in the Netherlands were lower than in Great Britain, but lower still than in Germany, with an average price cost margin over the full 2003-05 sample period of 13.7% for the LI (APX), 14.4% for the price-cost mark-up based on the APX, and 15.9% for the price cost mark-up (PCMU) based on Platts prices.[11] There were significant variations in the margins over time, for example with the PCMU weighted average of 33.1%, -1.8%, and 12.7% for 2003, 2004, and 2005[12] respectively. Importantly, however, one should recall that the presence of a relatively large number of CHP units in the Netherlands is likely to underestimate mark-ups in our analysis due the over representation of out of merit generation. This problem persists despite our best efforts to address this specific operation of CHP units.

Relating the RSI to the price cost margins via regression analysis for the Netherlands showed similar results as to other countries (UK, DE, ES). The RSI is a significant explanatory variable for the margins estimated in the Netherlands. 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 Dutch market were not so low that the marginal cost estimates would not have earned operators substantial sums. We do not interpret whether the sum would have been sufficient to cover fixed capital costs in the market[13].

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[11] Excluding the impact of carbon in 2005.

[12] Excluding the estimated cost of carbon from 2005.

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

The breakdown of power prices into cost estimates plus margin, and the inclusion of carbon revealed that a significant portion of recent price changes in the Netherlands can be attributed to carbon cost inclusion due to the introduction of the EU ETS. This is in spite of apparent negative margins. Our estimates were that the cost of carbon added about €6 to the average APX price, but that the full cost of carbon was about €9. Whether operators were willing to allow negative margins due to receiving ETS allowance for free cannot be fully determined from our analysis. 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 calculated for the Netherlands. Withholding was defined as the difference between actual and modelled generation. These results should be interpreted with a large amount of caution because we cannot be sure how much the deviations between modelled generation and actual generation are due to market power related causes. Nonetheless these variables were included in some of the multiple regression equations and were statistically significant in the Netherlands. 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. Thus the deviations between modelled and actual generation were controlled for in this way. 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 the Netherlands are that the Dutch market seems either borderline concentrated to concentrated depending on the measures taken and the allocation of the interconnectors. In some hours, though, the market is likely to be relatively highly concentrated. The Netherlands also had some very low margins in a number of off-peak hours.

In such borderline cases, the regressions of margins on RSI become more important (in that they provide added information for a more borderline case). Whether the Netherlands in fact is concentrated or not, 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.

9 Great Britain

This chapter contains our analysis of the competitive situation of the British 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 British market.

We start with a general introduction to the British 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.

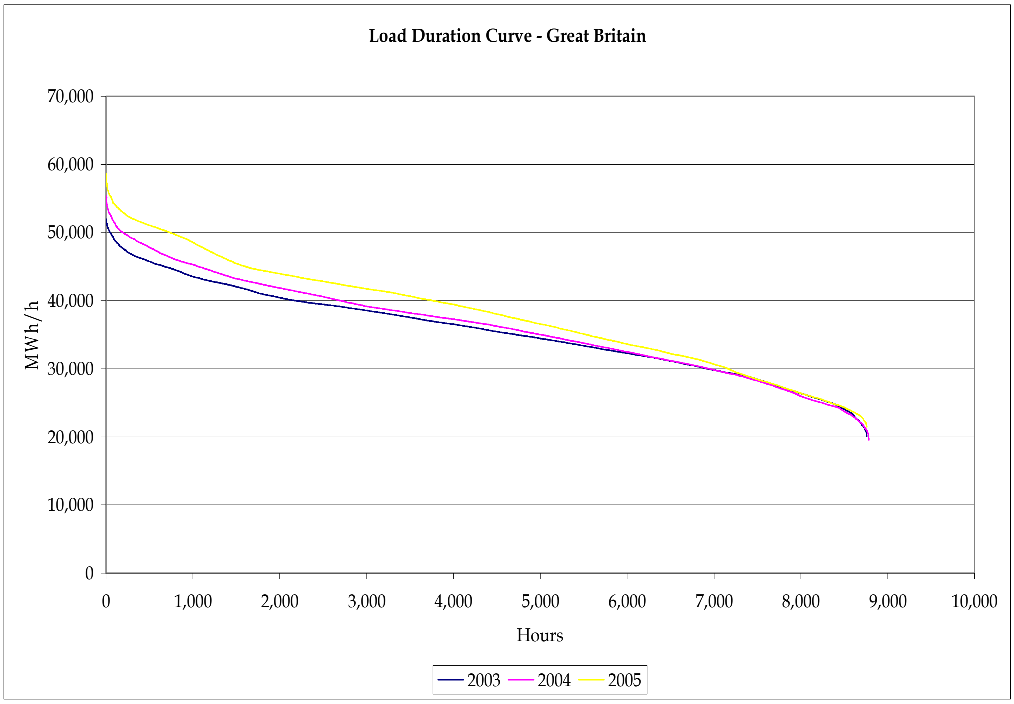
9.1 Introduction to the Great Britain Electricity Market

9.1.1 Load Duration Curve

The load duration curve of the Great Britain 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 Great Britain (GB) is above the scale on the vertical axis. Figure 9.1 presents the load duration curve for each of the three years of the study. According to this graph, the distribution of demand between its peak and its minimum remained relatively stable since 2003.

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 (NGC). 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 9.1: Load Duration Curve – Great Britain



Source: LE.

9.1.2 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 curve for Great Britain is presented in Figure 9.2[14]. As one can see the curves do not differ significantly over the period January 2003 to January 2005. These merit curves indicate a relatively stable market environment. One can immediately see there is very little capacity with zero fuel cost (run-of-river hydro, storage hydro, wind) in Great Britain. This capacity then appears to be followed by nuclear capacity before coal, gas and plants that operate on fuel oil or other expensive fuels emerge as one moves to the right of the curve.

The cost of each of these respective technologies for each of the companies and units involved, appears to remain very stable in all but the final period, December 2005. This break from the stability of the previous curves is largely due to substantial fuel price increases in the UK in late 2005, particularly for natural gas. As one can see, the units located on the curve in areas one would expect to find nuclear and coal plants, do not experience cost increases similar to that experienced by units located on the merit curve in what is likely to be gas fired technology. Further to this, there appears to be a significant increase in the average available installed capacity over time in the market, this is partly due to two factors. Firstly, the introduction of new, largely gas fired, capacity into the system over the period covered by this study and secondly changes in the average available capacity of the units already present on the system. A considerable part of the difference in installed capacity is due to the curves representing the average available installed capacity of the respective units over the course of the month. Therefore, if units suffer a partial or full outage over the period of the month presented, the average available capacity if that unit is reduced.

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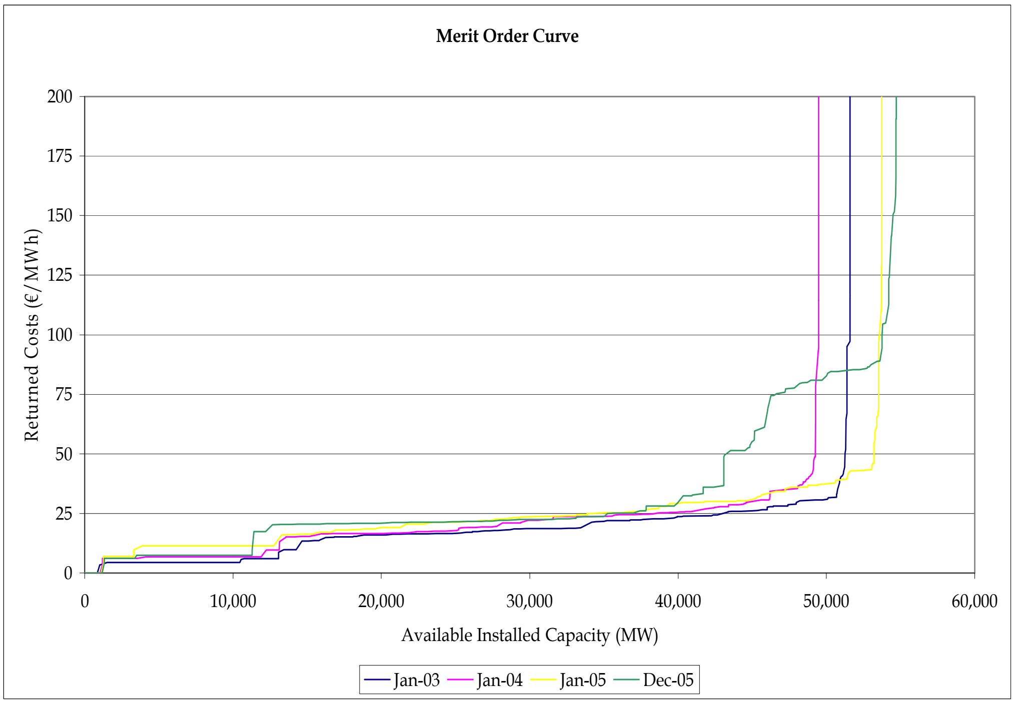
[14] One unit with Average available capacity of <2MW has been excluded from the graph, as its costs in all periods are greater than €270.

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 9.2: Merit Order Curve (excl. Carbon) – Great Britain



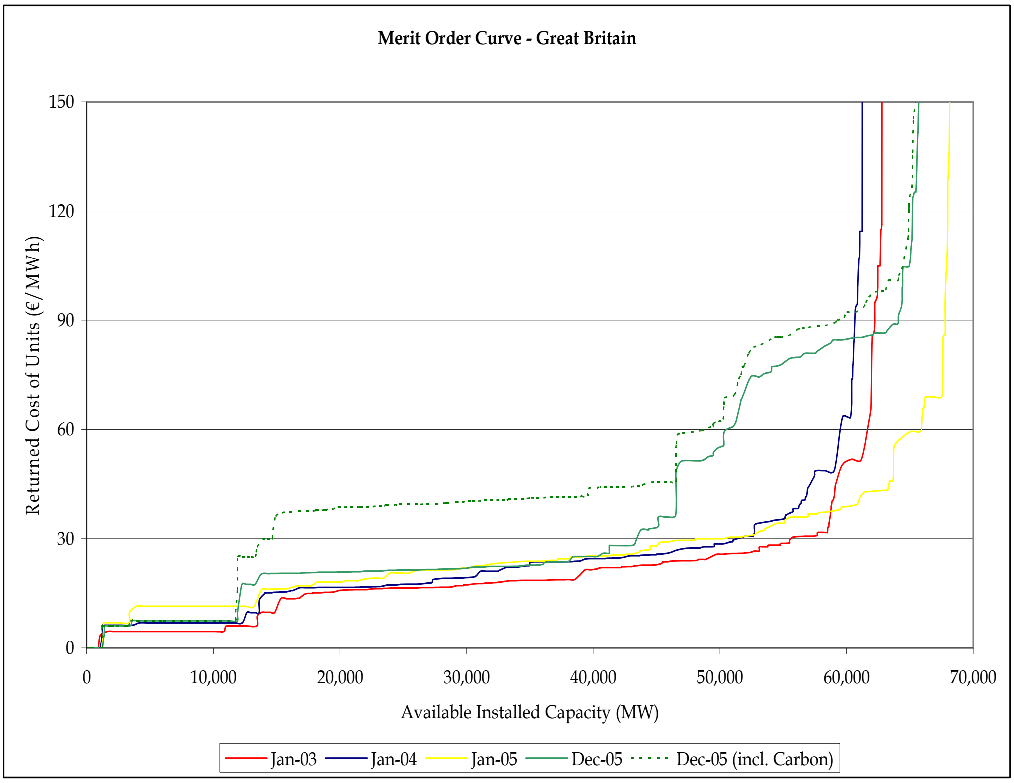
Source: LE.

9.1.3 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 Great Britain 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 would expect the zero fuel cost capacity and the nuclear powered capacity is not affected by the introduction of the ETS. 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. Immediately, there is a sharp increase in the cost of what was previously to be considered cheap conventional thermal technology. This capacity is likely to be coal but may in some cases include relatively old thermally inefficient gas fired capacity but as one moves to the right of the merit curve one notices the difference narrowing as more expensive gas fired technology is reached.

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

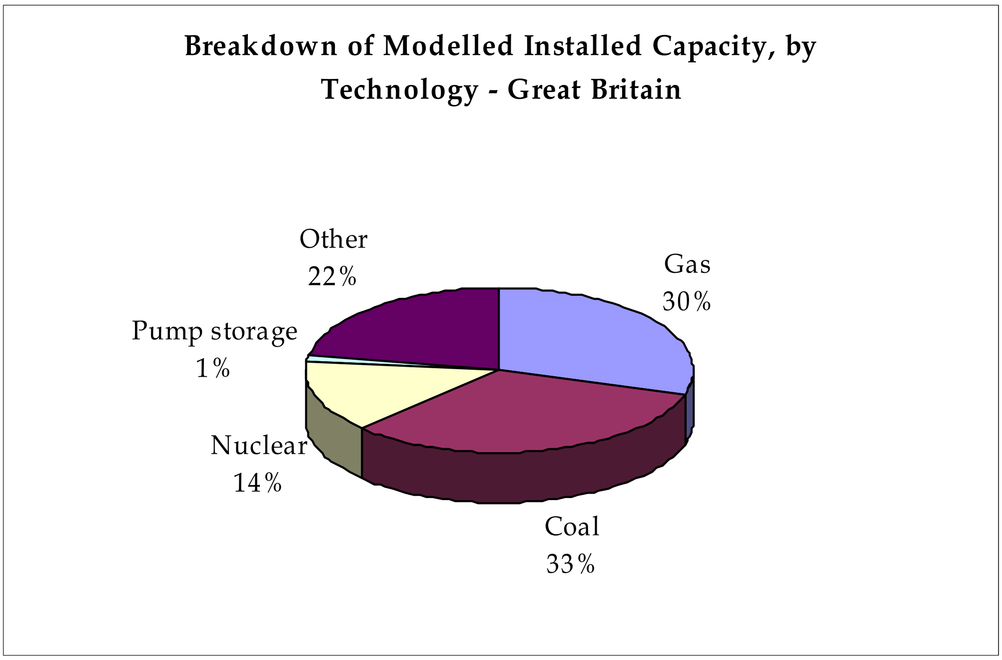
Figure 9.3: Merit Order Curve (incl. Carbon) – Great Britain



Source: LE.

Figure 9.4 below shows the breakdown of capacity by technology in Great Britain. This figure provides a further insight into the effects observed in the merit curve and the impact of carbon. One can clearly see from this that coal and gas fired capacity accounts for 63% of the market in Great Britain. Importantly for the impact to the ETS, a significant number of the coal fired plants in Great Britain are relatively old and report poor thermal efficiencies, thus making full economic cost of generation significantly more costly under the Scheme.

Figure 9.4: Breakdown of Modelled Installed Capacity, by Technology – Great Britain



Source: LE.

9.2 Structural Indicators

Traditional structural indicators have been calculated based on a number of different measures of market share for the British 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 $i = 1, 2, 3, \ldots, N$

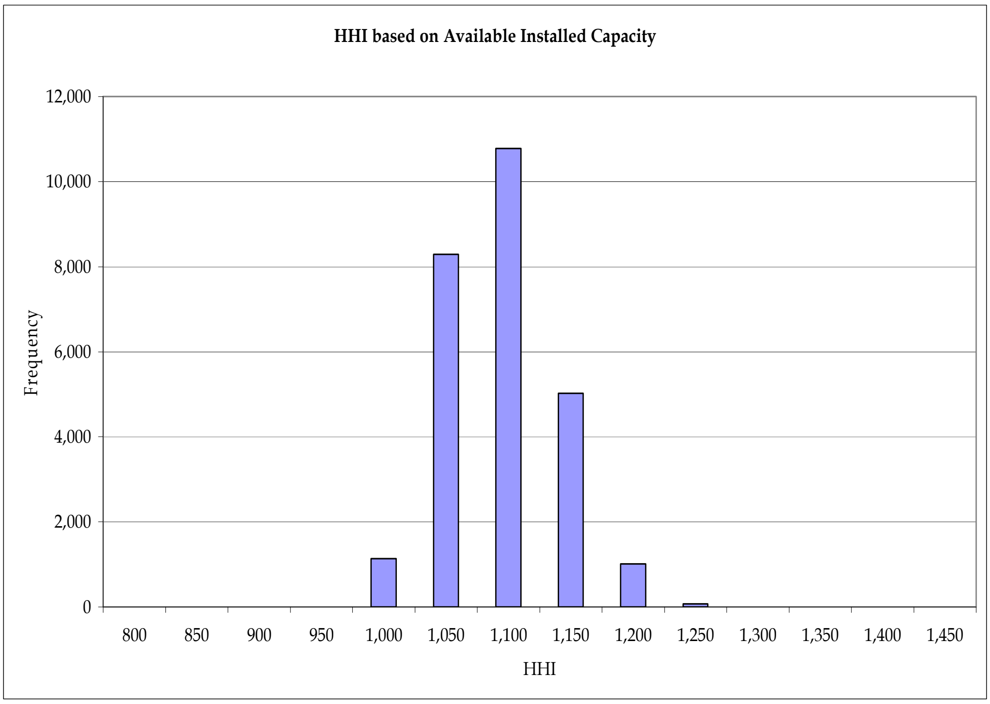
The HHI indicator sums the squares the market shares of all companies in the market, where the market shares of the companies are calculated on an hourly basis using, Available Installed Capacity, Available Capacity, Total Generation, and, In Merit/Economic Capacity. The HHI indicator sums the squares 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.

9.2.1 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.

Figure 9.5: Histogram of HHI Values based on Available Installed Capacity (2003-2005) – Great Britain



Source: LE.

Summary statistics on CR(2) and HHI based on Available Installed Capacity are presented in Table 9.1. The histogram above shows the central tendency and spread of the measure of concentration HHI. While it is clear that significant variation in HHI occurs, this is tightly grouped around a low level of concentration 1,100, which is below the standard threshold value of 1,800. This is evident as well from the table below. The table shows the CR(n) as well. The HHI and CR(n) lead to similar conclusions: that the market in Great Britain is moderate to unconcentrated.

Table 9.1: Summary Statistics of CR(2) & HHI based on Available Installed Capacity – Great Britain			
	Average Hourly Available Installed Capacity (MW)	CR(2)	HHI
Average	60,562	32.6%	1,068
Maximum	71,832	40.0%	1,246
Minimum	48,193	27.9%	965
Standard Deviation	4,294	2.2%	43
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. Preselected days were tested to see if, as a spot check, perhaps concentration problems existed at more precise times in the market. The pre-selected dates are provided in Table 8.2.

Table 9.2: Pre-Selected Representative Days[15] – Great Britain		
	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 8.3 presents the results of the CR(2) and HHI analysis for available installed capacity for these pre-selected dates. As can be seen from the table, there is not much variation across the pre-selected days, and the qualitative conclusion that the market is moderately unconcentrated is not impacted.

[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 9.3: Concentration measures based on Available Installed Capacity - selected days – Great Britain				
No.	**Date**	**Average Hourly Demand (MWh/h)**	**CR-2**	**HHI**
1	08/01/03 (W-2)	45,577	33.7%	1,103
2	12/01/03 (S-2)	39,625	34.5%	1,102
3	22/01/03 (W-4)	43,707	34.7%	1,130
4	09/04/03 (W-2)	40,198	34.7%	1,091
5	13/04/03 (S-2)	32,868	33.9%	1,077
6	10/08/03 (S-2)	29,093	36.8%	1,145
7	13/08/03 (W-2)	33,468	36.4%	1,127
8	27/08/03 (W-4)	34,959	35.5%	1,091
9	08/10/03 (W-2)	38,406	32.8%	1,067
10	12/10/03 (S-2)	31,319	31.0%	1,041
11	11/01/04 (S-2)	35,105	34.0%	1,120
12	14/01/04 (W-2)	43,491	34.0%	1,098
13	28/01/04 (W-4)	46,271	32.7%	1,084
14	11/04/04 (S-2)	30,824	34.2%	1,103
15	14/04/04 (W-2)	37,985	33.8%	1,076
16	08/08/04 (S-2)	30,047	30.3%	1,068
17	11/08/04 (W-2)	36,709	31.3%	1,088
18	25/08/04 (W-4)	36,455	31.8%	1,091
19	06/10/04 (W-2)	38,871	31.5%	1,088
20	10/10/04 (S-2)	33,837	32.1%	1,086
21	09/01/05 (S-2)	38,121	31.3%	1,046
22	12/01/05 (W-2)	46,255	31.4%	1,045
23	26/01/05 (W-4)	49,033	31.4%	1,047
24	10/04/05 (S-2)	35,232	30.6%	1,005
25	13/04/05 (W-2)	41,893	31.2%	1,013
26	10/08/05 (W-2)	35,421	30.5%	1,027
27	14/08/05 (S-2)	29,582	34.0%	1,084
28	24/08/05 (W-4)	35,885	31.6%	1,026
29	09/10/05 (S-2)	32,792	30.7%	1,011
30	12/10/05 (W-2)	41,117	29.7%	987
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. This was done to see if seasonality is affecting concentration or market structure in Great Britain. The results are presented in Table 9.4.

Table 9.4: Concentration measures based on Available Installed Capacity– seasonal peaks – Great Britain

	Date	Average Hourly Demand (MWh/h)	CR-2	HHI
Summer	31/08/2005	38,389	30.8%	1,024
	09/08/2004	38,001	30.5%	1,074
	03/06/2003	36,799	35.8%	1,119
Winter	27/01/2005	50,148	30.9%	1,043
	20/12/2004	49,120	29.2%	1,038
	06/02/2003	46,318	34.7%	1,132
Spring	03/03/2005	49,852	30.8%	1,034
	03/03/2004	46,056	33.8%	1,107
	12/03/2003	42,927	34.7%	1,131
Autumn	30/11/2005	50,028	29.7%	1,044
	30/11/2004	47,650	28.7%	1,018
	27/11/2003	42,914	33.0%	1,072

Source: LE.

There is some variation by season, more noticeable in the CRn measures. CRn goes from the 28.7% to almost 36%. The increases are mirrored by the HHI. This increase incurs in the spring however, a time when capacity is not likely to be tight. So we conclude that seasonality is not significantly impacting concentration the Great Britain market, as measured by traditional concentration measures.

Available Capacity (allowing for LTCs and Reserves)

Reserves and long term contracts can have an important impact on measured concentration in electricity markets. It is therefore important to control for such factors. 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 8.5 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 table below shows concentration is not sensitive to the change in definition of capacity.

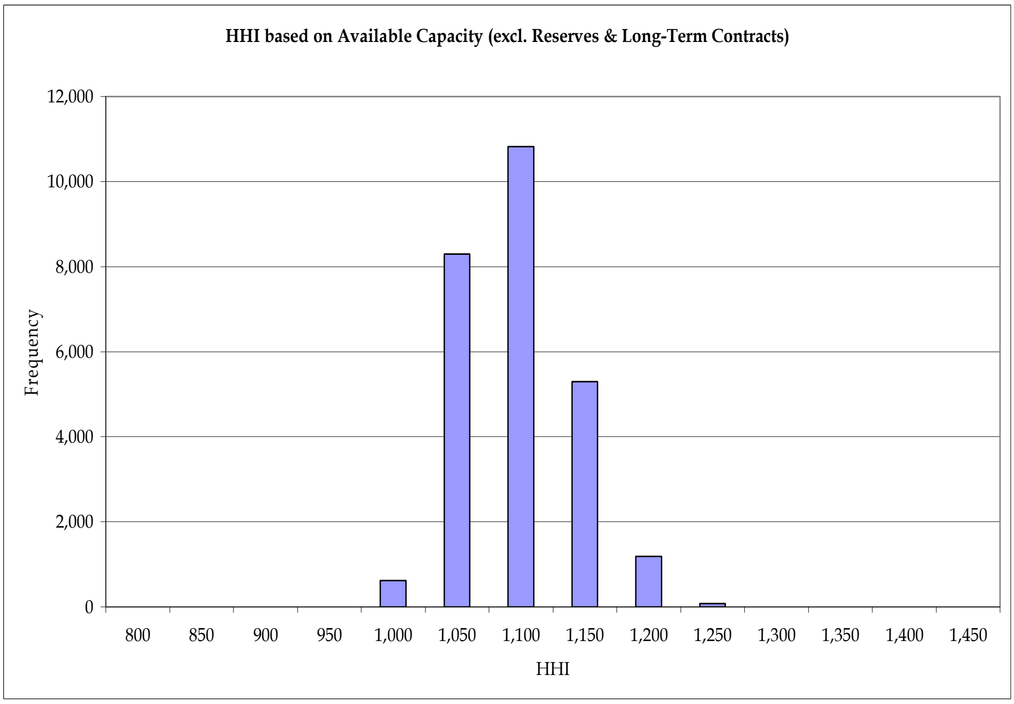
Table 9.5: Comparison of Available Capacity & Available Installed Capacity – Great Britain

	Available Capacity (MW)		Available Installed Capacity (MW)	
	CR(2)	**HHI**	**CR(2)**	**HHI**
Mean	31.2%	1,072	32.6%	1,068
Max	38.2%	1,223	40.0%	1,246
Min	26.4%	967	27.9%	965
Standard deviation	1.7%	47	2.2%	43

Source: LE

The histogram presented below in Table 8.6 provides the frequency of the computed HHI values based on Available Capacity. The histogram shows the central tendency and spread of the distribution of values. As with the summary statistics in Table 8.5, the histograms of both available capacity and available installed capacity are broadly similar and the qualitative conclusion is the same.

Figure 9.6: Histogram of HHI Values based on Available Installed Capacity (2003-2005) – Great Britain



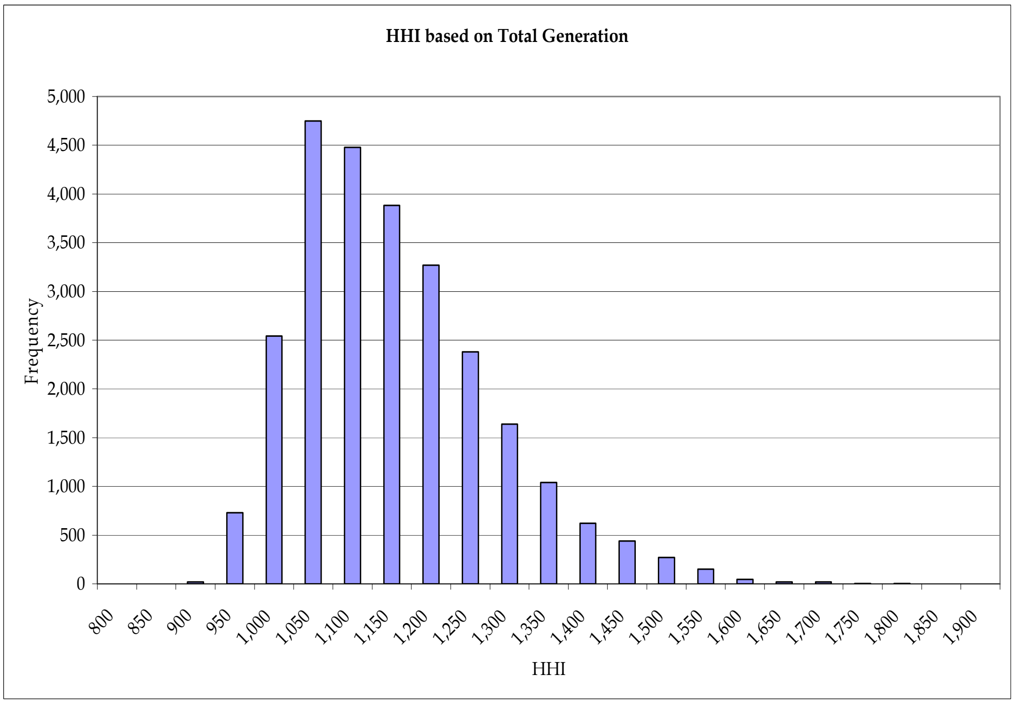
Source: LE.

CR(2) & HHI based on Total Generation

An alternative definition often used as a sensitivity in electricity market concentration is to base market share calculations on total generation. This excludes generation in many hours that are available to meet peak demand, but put 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 net electrical production figures returned by the companies. This data similarly is used to construct the load in Great Britain.

The Figure below presents a histogram of the frequency of hourly HHI values computed using hourly generation over the period 2003-2005. The histogram is noticeably different from the capacity-based measures. There are more hours to the right of the mean where the frequency of higher HHIs occurs. This is natural as available capacity is a less narrow market definition than total generation. Still, the mean and median of the distribution is only slightly shifted right, and the number of times the HHI reaches the 1,800 threshold is very small. In fact, from the table, the maximum HHI is just below the 1,800 threshold.

Figure 9.7: Histogram of HHI Values based on Total Generation (2003-2005)- – Great Britain



Source: LE.

Summary statistics on CR(2) and HHI based on Total Generation are presented in Table 8.6.

Table 9.6: Summary Statistics of CR(2) & HHI based on Total Generation – Great Britain			
	Average Hourly Generation (MWh/h)	**CR(2)**	**HHI**
Average	37,881	35.4%	1,129
Maximum	59,402	49.4%	1,775
Minimum	22,037	25.8%	863
Standard Deviation	6,950	3.7%	125
Source: LE			

While the CRn and HHI have increased using total generation, the qualitative conclusion that the market is moderately unconcentrated is not affected.

Table 8.7 presents the HHI and CR(2) measures computed for the pre-selected days previously listed in Table 8.2. The preselected days show broadly similar results to the annual averages and summary statistics. Although the CR(2) varies between 27.5% and 40.1% (and the HHI between 936 and 1,269), there is no clear trend visible in those figures.

Table 9.7: Concentration measures based on total generation - selected days – Great Britain

No.	Date	Average Hourly Demand (MWh/h)	CR-2	HHI
1	08/01/03 (W-2)	45,577	39.0%	1,232
2	12/01/03 (S-2)	39,625	40.0%	1,259
3	22/01/03 (W-4)	43,707	40.1%	1,269
4	09/04/03 (W-2)	40,198	35.6%	1,176
5	13/04/03 (S-2)	32,868	37.2%	1,199
6	10/08/03 (S-2)	29,093	38.8%	1,212
7	13/08/03 (W-2)	33,468	36.5%	1,133
8	27/08/03 (W-4)	34,959	35.0%	1,112
9	08/10/03 (W-2)	38,406	33.4%	1,086
10	12/10/03 (S-2)	31,319	33.7%	1,084
11	11/01/04 (S-2)	35,105	36.6%	1,220
12	14/01/04 (W-2)	43,491	35.6%	1,141
13	28/01/04 (W-4)	46,271	33.2%	1,078
14	11/04/04 (S-2)	30,824	37.7%	1,187
15	14/04/04 (W-2)	37,985	37.2%	1,135
16	08/08/04 (S-2)	30,047	36.1%	1,119
17	11/08/04 (W-2)	36,709	33.9%	1,077
18	25/08/04 (W-4)	36,455	31.4%	1,003
19	06/10/04 (W-2)	38,871	30.4%	1,046
20	10/10/04 (S-2)	33,837	30.4%	1,009
21	09/01/05 (S-2)	38,121	37.0%	1,173
22	12/01/05 (W-2)	46,255	36.1%	1,183
23	26/01/05 (W-4)	49,033	35.9%	1,128
24	10/04/05 (S-2)	35,232	32.5%	1,011
25	13/04/05 (W-2)	41,893	31.3%	1,002
26	10/08/05 (W-2)	35,421	35.0%	1,134
27	14/08/05 (S-2)	29,582	39.6%	1,297
28	24/08/05 (W-4)	35,885	34.7%	1,155
29	09/10/05 (S-2)	32,792	29.3%	938
30	12/10/05 (W-2)	41,117	27.5%	936

Source: LE.

Table 9.8 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. The conclusion is that seasonality is not a large determinant of concentration using total generation as the basis for the market share calculation.

Table 9.8: Concentration measures based on total generation – seasonal peaks – Great Britain

	Date	Average Hourly Demand (MWh/h)	CR(2)	HHI
Summer	31/08/2005	38,389	33.3%	1,054
	09/08/2004	38,001	34.6%	1,065
	03/06/2003	36,799	38.2%	1,276
Winter	27/01/2005	50,148	35.1%	1,091
	20/12/2004	49,120	29.9%	1,002
	06/02/2003	46,318	37.1%	1,185
Spring	03/03/2005	49,852	34.2%	1,097
	03/03/2004	46,056	36.8%	1,166
	12/03/2003	42,927	36.6%	1,154
Autumn	30/11/2005	50,028	31.5%	1,048
	30/11/2004	47,650	31.5%	1,040
	27/11/2003	42,914	35.9%	1,143

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 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 8.9 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 largest company is always the market leader, but the number two company changes across the days.

Table 9.9: Total Generation – Concentration & Load Duration – Great Britain

January 2005		**Company**	**CR(2)**	**HHI**
2nd Wednesday	*Base*	0242&1477	40.9%	1,390
	Shoulder	0242&0453	39.5%	1,300
	Peak	0242&1477	34.0%	1,100
August 2005				
2nd Wednesday	*Base*	0242&0453	37.0%	1,206
	Shoulder	0242&0453	32.6%	1,057
	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. Table 8.10 presents summary statistics on the CR(2) and HHI values computed on an hourly basis. The results are not sensitive to this definition of the basis for the market share calculation.

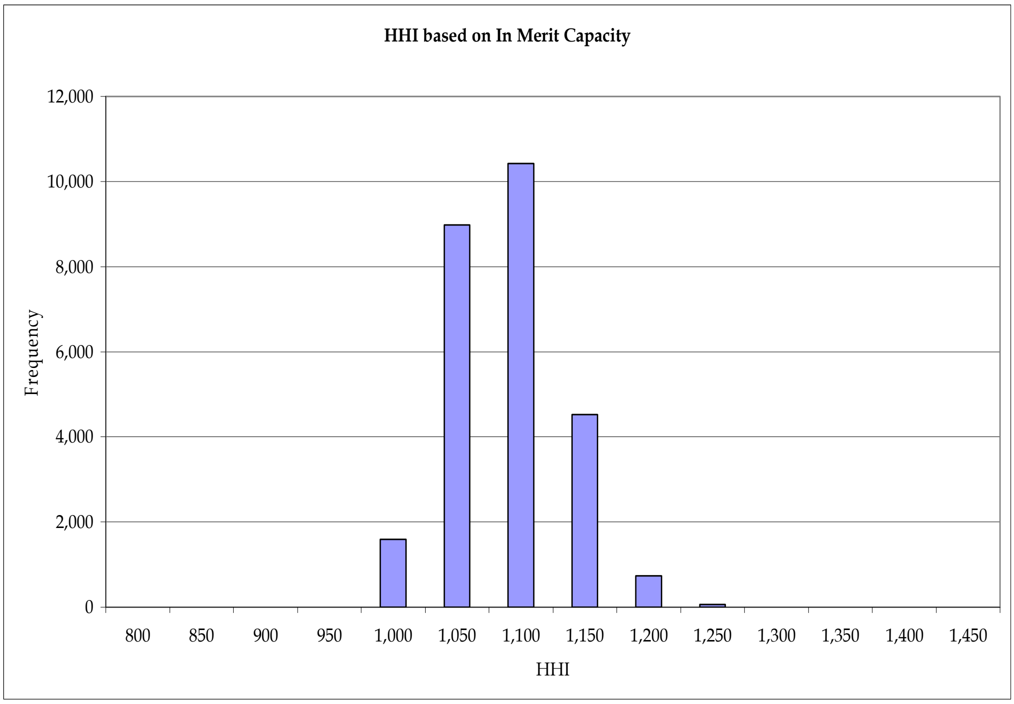
Table 9.10: Summary Statistics of CR(2) & HHI based on In Merit Capacity – Great Britain

	In Merit Capacity (MW)	CR(2)	HHI
Average	59,923	32.6%	1,063
Maximum	71,244	39.8%	1,240
Minimum	47,541	27.6%	960
Standard Deviation	4,314	2.1%	43

Source: LE

The following histogram represents the frequency of HHI values calculated on the basis of in merit capacity (Figure 9.8).

Figure 9.8: Histogram of HHI Values based on In-Merit Capacity (2003-2005) – Great Britain



Source: LE.

9.2.2 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, as is the case in France, 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.

9.2.3 Results

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

Table 9.11 shows the comparison between the base case, in which the interconnector is ignored completely, and our two allocation scenarios. The concentration measures based on available installed capacity are not affected in any significant way by the treatment of the interconnector.

Table 9.11: Summary Statistics Concentration measures based on Available Installed Capacity: Impact of the Interconnector – Great Britain

	STANDARD (excl. IC based on available installed capacity)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	CR-2	HHI	CR-2	HHI	CR-2	HHI
Average	32.6%	1,068	31.6%	1,004	34.6%	1,115
Max	40.0%	1,246	38.5%	1,118	42.3%	1,277
Min	27.9%	965	27.1%	918	28.5%	999
Standard Deviation	2.2%	43	2.1%	38	2.2%	48

Source: LE.

Seasonal analysis of the influence of interconnector, shown in Table 9.12, shows no marked seasonal impact. However, there has been a decrease in concentration since 2003.

Table 9.12: Results of HHI & CR(2) Analysis of the Impact of the Interconnector, based on hourly Available Installed Capacity – Great Britain							
		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	31/08/2005	30.8%	1,024	29.8%	961	33.0%	1,071
	09/08/2004	30.5%	1,074	29.5%	1,006	32.7%	1,111
	03/06/2003	35.8%	1,119	34.6%	1,045	37.9%	1,188
Winter	27/01/2005	30.9%	1,043	30.1%	985	32.9%	1,084
	20/12/2004	29.2%	1,038	28.4%	980	31.2%	1,070
	06/02/2003	34.7%	1,132	33.9%	1,080	36.2%	1,170
Spring	03/03/2005	30.8%	1,034	29.9%	974	32.9%	1,075
	03/03/2004	33.8%	1,107	32.8%	1,041	35.8%	1,158
	12/03/2003	34.7%	1,131	33.8%	1,077	36.2%	1,169
Autumn	30/11/2005	29.7%	1,044	28.8%	985	31.2%	1,071
	30/11/2004	28.7%	1,018	27.8%	960	30.6%	1,047
	27/11/2003	33.0%	1,072	32.0%	1,010	35.0%	1,118

Source: LE.

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

Repeating the preceding analysis with a different market definition based on total generation, rather than capacity, shows the magnitude of our concentration measures to be robust against such changes.

Table 9.13: Summary Statistics Concentration measures based on Total Generation: Impact of the Interconnector – Great Britain

	STANDARD (excl. IC based on total generation)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	CR-2	HHI	CR-2	HHI	CR-2	HHI
Average	35.4%	1,129	34.6%	1,080	36.8%	1,189
Max	49.4%	1,775	49.0%	1,648	51.2%	2,083
Min	25.8%	863	24.8%	788	24.9%	889
Standard Deviation	3.7%	125	3.7%	132	4.2%	160

Source: LE.

Again, as Table 9.14 shows, seasonality has no discernible influence on concentration measures. However, overall concentration still appears to have declined over the period 2003-2005.

Table 9.14: Results of HHI & CR(2) Analysis of the Impact of the Interconnector, based on hourly Total Generation – Great Britain

		STANDARD (excl. IC based total generation)		ATOMISTIC		IC ADDED TO BIGGEST PLAYER	
	Date	CR-2	HHI	CR-2	HHI	CR-2	HHI
Summer	31/08/2005	33.3%	1,054	32.6%	1,008	34.6%	1,117
	09/08/2004	34.6%	1,065	33.9%	1,027	35.7%	1,107
	03/06/2003	38.2%	1,276	39.9%	1,389	35.6%	1,181
Winter	27/01/2005	35.1%	1,091	35.9%	1,143	33.7%	1,049
	20/12/2004	29.9%	1,002	29.5%	975	30.9%	1,027
	06/02/2003	37.1%	1,185	37.2%	1,192	36.9%	1,181
Spring	03/03/2005	34.2%	1,097	34.0%	1,085	34.5%	1,112
	03/03/2004	36.8%	1,166	37.6%	1,218	35.4%	1,116
	12/03/2003	36.6%	1,154	37.1%	1,186	35.7%	1,132
Autumn	30/11/2005	31.5%	1,048	31.1%	1,024	32.2%	1,069
	30/11/2004	31.5%	1,040	31.6%	1,042	31.5%	1,044
	27/11/2003	35.9%	1,143	35.9%	1,142	35.9%	1,150

Source: LE.

The results from the tables above show that measured concentration in the British market does not seem particularly sensitive to the interconnector allocation procedure, regardless of the basis of the market share calculation. HHIs and CRns stay in the moderate to unconcentrated range of 1000 to 1,200 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 2,000.

9.3 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.

9.3.1 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;

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

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.

9.3.2 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.

9.3.3 Results

RSI Results

Table 8.19 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 Great Britain. 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 cannot be considered to be a competitive one.

Table 9.15: RSI Threshold Analysis – Great Britain

RSI Result	0242-S-GB	0453-S-GB	1340-S-GB	1477-S-GB
2003-05	320	437	327	612
% hrs< 110%	*1.2%*	*1.7%*	*1.2%*	*2.3%*
2003	192	150	150	31
% hrs< 110%	*2.2%*	*1.7%*	*1.7%*	*0.4%*
2004	35	93	86	199
% hrs< 110%	*0.4%*	*1.1%*	*1.0%*	*2.3%*
2005	93	194	91	382
% hrs< 110%	*1.1%*	*2.2%*	*1.0%*	*4.4%*

It can be seen in Table 8.19 above that the threshold is not violated for any company in any year for more than the 5% number hours. Consequently there are at first sight no grounds for serious concerns about market power in Great Britain.

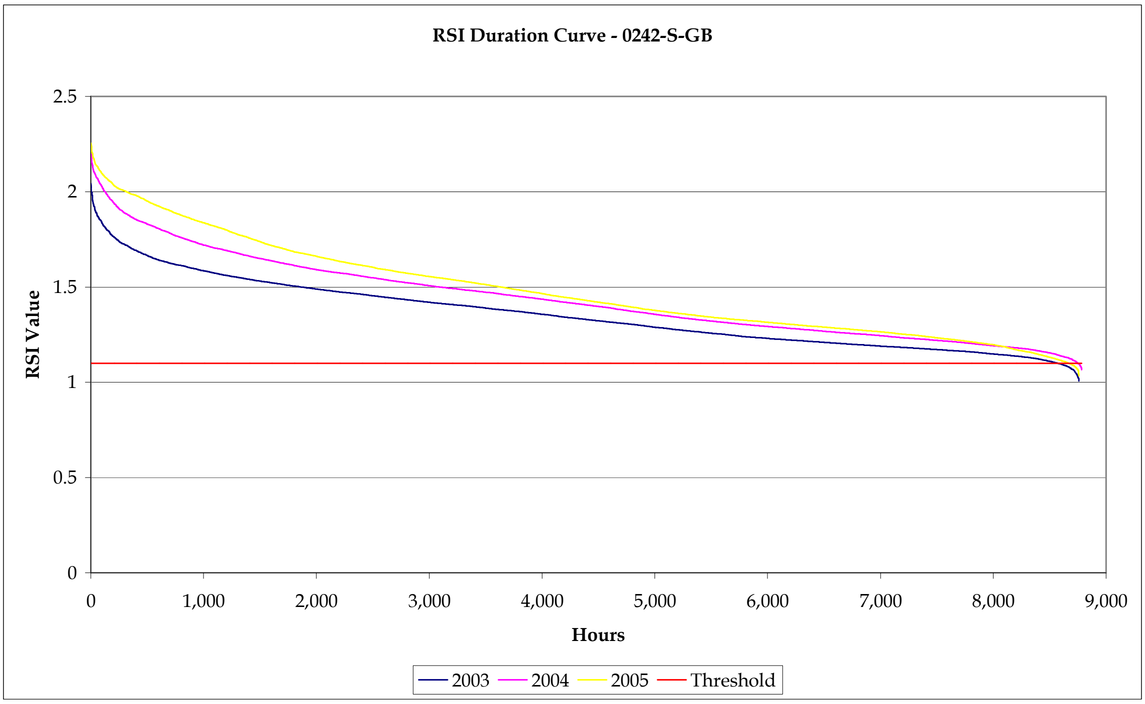
Table 8.20 presents summary statistics on the RSI for the two largest companies, 0242-S-GB and 0453-S-GB.

Table 9.16: Summary Statistics on RSI – Great Britain								
	0242-S-GB				0453-S-GB			
	2003-2005	2003	2004	2005	2003-2005	2003	2004	2005
Mean	1.43	1.36	1.44	1.48	1.42	1.40	1.44	1.43
Min	1.01	1.01	1.07	1.03	1.00	1.02	1.04	1.00
Max	2.25	2.04	2.20	2.25	2.21	2.20	2.21	2.16

RSI Duration Curves

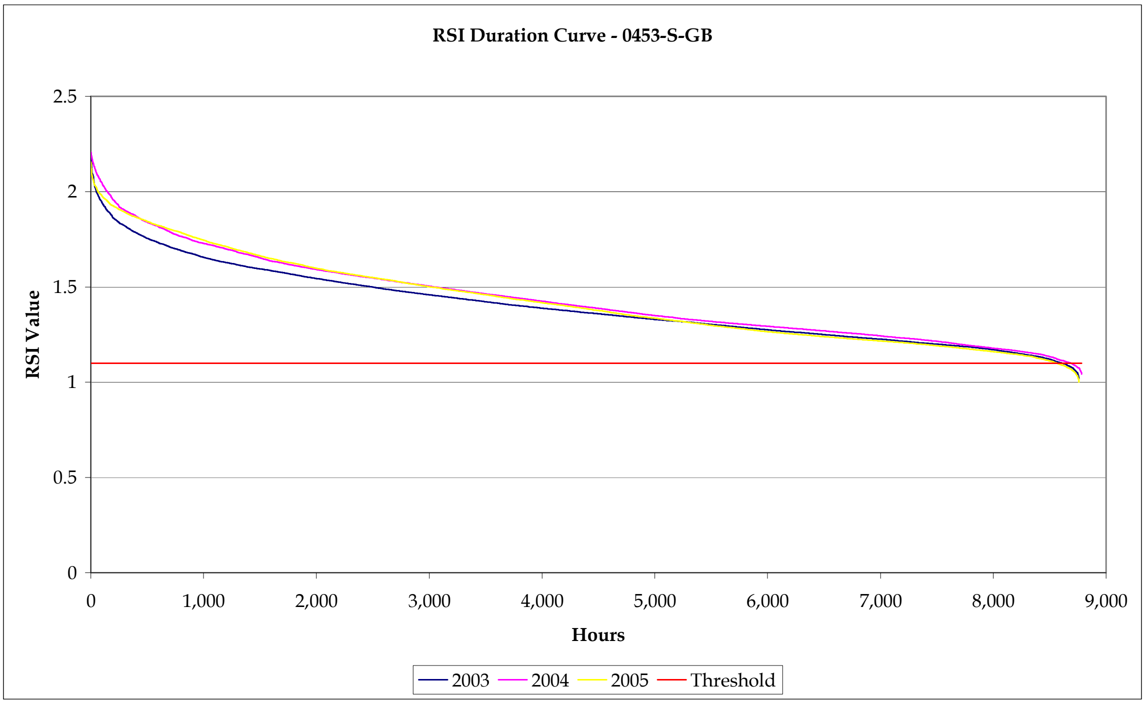
Since the RSI is a continuous measure and calculated hourly, we can also consider an RSI duration curve (a mirror of the cumulative distribution) to show the number or % of hours that RSI is above a certain value. This gives an idea of the distribution as well as the mean of the measure over time. We present below a duration curve on RSI for the two largest companies. The figures show that the threshold is not violated and that for the vast majority of hours the RSI is not even near the threshold of 110%.

Figure 9.9: RSI Duration Curve for Company 0242-S-GB



Source: LE.

Figure 9.10: RSI Duration Curve for Company 0453-S-GB



Source: LE.

Alternative RSI Scenarios

The existence of long term contracts and reserve commitments can impact the RSI and PSI similarly as they can the traditional measures of concentration. It is therefore necessary to check these sensitivities. 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 8.21 presents the results of the threshold test when long-term contracts have been excluded from the calculation of available capacity. The percentage of hours in which the RSI was below the threshold of 110% is again small, nowhere exceeding 5%.

Table 9.17: RSI Threshold Analysis - Scenario 1 (accounts for Reserves only) – Great Britain				
RSI Result	**0242-S-GB**	**0453-S-GB**	**1340-S-GB**	**1477-S-GB**
2003-05	1,167	527	461	364
% hrs< 110%	*4.4%*	*2.0%*	*1.8%*	*1.4%*
2003	515	181	194	0
% hrs< 110%	*5.9%*	*2.1%*	*2.2%*	*0.0%*
2004	239	125	126	123
% hrs< 110%	*2.7%*	*1.4%*	*1.4%*	*1.4%*
2005	413	221	141	241
% hrs< 110%	*4.7%*	*2.5%*	*1.6%*	*2.8%*

Table 8.22 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Great Britain (based on market share of total installed capacity).

Table 9.18: Summary Statistics on RSI - Scenario 1 (accounts for Reserves only) – Great Britain								
	0242-S-GB				**0453-S-GB**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.36	1.31	1.37	1.39	1.41	1.39	1.43	1.42
Min	0.98	0.98	1.02	0.99	1.00	1.01	1.04	1.00
Max	2.11	1.99	2.09	2.11	2.20	2.19	2.20	2.14

Table 8.23 presents the results of the threshold test when long-term contracts have been excluded from the calculation of available capacity. This second scenario offers no significant new insights. It confirms that the RSI measure does not raise concerns about market power in Britain.

Table 9.19: RSI Threshold Analysis - Scenario 2 (accounts for LTC only) – Great Britain				
RSI Result	**0242-S-GB**	**0453-S-GB**	**1340-S-GB**	**1477-S-GB**
2003-05	320	570	450	650
% hrs< 110%	*1.2%*	*2.2%*	*1.7%*	*2.5%*
2003	192	193	201	37
% hrs< 110%	*2.2%*	*2.2%*	*2.3%*	*0.4%*
2004	35	157	126	208
% hrs< 110%	*0.4%*	*1.8%*	*1.4%*	*2.4%*
2005	93	220	123	405
% hrs< 110%	*1.1%*	*2.5%*	*1.4%*	*4.6%*

Table 8.24 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Great Britain (based on market share of total installed capacity).

Table 9.20: Summary Statistics on RSI - Scenario 2 (accounts for LTC only) – Great Britain								
	0242-S-GB				**0453-S-GB**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.43	1.36	1.44	1.48	1.41	1.39	1.43	1.42
Min	1.01	1.01	1.07	1.03	1.00	1.01	1.04	1.00
Max	2.25	2.04	2.20	2.25	2.20	2.19	2.20	2.15

The tables above show that the qualitative conclusions that the RSI is not indicating a concentration problem in the British market is in general not sensitive to the impact of reserves and long term contracts.

PSI Results

The results of the PSI analysis for the large generation companies in Great Britain are presented in Table 8.25. 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. The results show that only in very few hours is any one large company pivotal.

Table 9.21: PSI Threshold Analysis – Great Britain

PSI Result	**0242-S-GB**	**0453-S-GB**	**1340-S-GB**	**1477-S-GB**
2003-05	0	0	0	7
% 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	1
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2005	0	0	0	6
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.1%*

Alternative PSI Scenarios

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenarios to test for sensitivity. Table 8.26 presents the results of the PSI threshold test having excluded long-term contracts from the analysis. The picture changes slightly though this change, but the conclusion that the PSI measure does not raise concerns about market power in Britain is not affected by this..

Table 9.22: PSI Threshold Analysis - Scenario 1 (accounts for Reserves only) - Great Britain				
PSI Result	**0242-S-GB**	**0453-S-GB**	**1340-S-GB**	**1477-S-GB**
2003-05	8	1	0	0
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2003	6	0	0	0
% hrs =1	*0.1%*	*0.0%*	*0.0%*	*0.0%*
2004	0	0	0	0
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2005	2	1	0	0
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*

Table 8.27 presents the results of the PSI threshold test - Scenario 2, whereby upward reserve commitments have been excluded from the calculation of available capacity. Despite small changes in the distribution of the PSI count between companies, the overall figures remain so low as to be negligible.

Table 9.23: PSI Threshold Analysis - Scenario 2 (accounts for LTC only) – Great Britain				
PSI Result	**0242-S-GB**	**0453-S-GB**	**1340-S-GB**	**1477-S-GB**
2003-05	0	1	0	9
% 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	3
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2005	0	1	0	6
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.1%*

The sensitivity analysis using long term contract and reserves shows the PSI measure is not sensitive to these factors in Great Britain.

9.3.4 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. Notwithstanding this feature, the British electricity market is, on average, a net importer of electricity and thus the results are somewhat more ambiguous.

9.3.5 Results (Interconnector allocated according to domestic market share)

RSI Results

Table 9.24 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. The presence of the interconnector slightly lowers the number of times the RSI exceeds the threshold, but the RSI results are not sensitive to the interconnector.

Table 9.24: RSI Threshold Analysis (+IC domestic) – Great Britain				
RSI Result	**0242-S-GB**	**0453-S-GB**	**1340-S-GB**	**1477-S-GB**
2003-05	199	332	236	428
% hrs< 110%	*0.8%*	*1.3%*	*0.9%*	*1.6%*
2003	109	93	88	14
% hrs< 110%	*1.2%*	*1.1%*	*1.0%*	*0.2%*
2004	31	85	73	135
% hrs< 110%	*0.4%*	*1.0%*	*0.8%*	*1.5%*
2005	59	154	75	279
% hrs< 110%	*0.7%*	*1.8%*	*0.9%*	*3.2%*

Table 9.25 presents summary statistics on the RSI for the two larges companies in Britain.

Table 9.25: Summary Statistics on RSI (+IC domestic) – Great Britain								
	0242-S-GB				**0453-S-GB**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.43	1.38	1.44	1.48	1.43	1.43	1.43	1.42
Min	1.00	1.00	1.07	1.04	1.02	1.02	1.04	1.02
Max	2.20	2.04	2.12	2.20	2.14	2.14	2.14	2.13

Alternative RSI Scenarios

Table 9.26 presents the results of the threshold test when long-term contracts have been excluded from the calculation of available capacity. The changes this produces are minute.

Table 9.26: RSI Threshold Analysis (+IC domestic) - Scenario 2 (accounts for LTC only) – Great Britain				
RSI Result	**0242-S-GB**	**0453-S-GB**	**1340-S-GB**	**1477-S-GB**
2003-05	199	407	308	446
% hrs< 110%	*0.8%*	*1.5%*	*1.2%*	*1.7%*
2003	109	123	111	19
% hrs< 110%	*1.2%*	*1.4%*	*1.3%*	*0.2%*
2004	31	115	101	141
% hrs< 110%	*0.4%*	*1.3%*	*1.1%*	*1.6%*
2005	59	169	96	286
% hrs< 110%	*0.7%*	*1.9%*	*1.1%*	*3.3%*

Table 9.27 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Great Britain (based on market share of total installed capacity).

Table 9.27: Summary Statistics on RSI (+IC domestic) - Scenario 2 (accounts for LTC only) – Great Britain								
	0242-S-GB				**0453-S-GB**			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.43	1.38	1.44	1.48	1.42	1.42	1.42	1.42
Min	1.00	1.00	1.07	1.04	1.01	1.01	1.03	1.01
Max	2.20	2.04	2.12	2.20	2.13	2.13	2.13	2.12

In general, the results from different allocation procedures for the interconnector flows are largely similar. There is little variation across companies too. We therefore conclude that there is little sensitivity of the measures to interconnector allocation procedure.

PSI Results

The results of the PSI analysis for the large generation companies in Great Britain are presented in Table 9.28. 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 can be seen in Table 9.28, none of the large companies in Great Britain comes near this threshold value.

Table 9.28: PSI Threshold Analysis (+IC domestic) – Great Britain

PSI Result	0242-S-GB	0453-S-GB	1340-S-GB	1477-S-GB
2003-05	0	0	0	3
% 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	2
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2005	0	0	0	1
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*

Alternative PSI Scenarios

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenario. Table 9.29 presents the results of the PSI threshold test having excluded long-term contracts from the analysis. There is no change in the PSI results under this scenario.

Table 9.29: PSI Threshold Analysis (+IC domestic) - Scenario 2 (accounts for LTC only) – Great Britain

PSI Result	**0242-S-GB**	**0453-S-GB**	**1340-S-GB**	**1477-S-GB**
2003-05	0	0	0	3
% 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	2
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2005	0	0	0	1
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*

9.3.6 Results (Interconnector allocated according to foreign market share)

RSI Results

Table 9.30 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. RSI values for all large companies are far from the threshold level.

Table 9.30: RSI Threshold Analysis (+IC foreign) – Great Britain

RSI Result	0242-S-GB	0453-S-GB	1340-S-GB	1477-S-GB
2003-05	167	285	197	393
% hrs< 110%	*0.6%*	*1.1%*	*0.7%*	*1.5%*
2003	93	80	71	12
% hrs< 110%	*1.1%*	*0.9%*	*0.8%*	*0.1%*
2004	24	71	61	117
% hrs< 110%	*0.3%*	*0.8%*	*0.7%*	*1.3%*
2005	50	134	65	264
% hrs< 110%	*0.6%*	*1.5%*	*0.7%*	*3.0%*

Table 9.31 presents summary statistics on the RSI.

Table 9.31: Summary Statistics on RSI (+IC foreign) – Great Britain

	0242-S-GB				0453-S-GB			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.44	1.39	1.44	1.48	1.44	1.44	1.44	1.43
Min	1.01	1.01	1.07	1.05	1.02	1.02	1.04	1.02
Max	2.21	2.06	2.13	2.21	2.15	2.15	2.15	2.13

The RSI results show that particular large suppliers are not pivotal in GB a significant number of hours. Some small increases to approximately 3% of hours is found for the upper bound of interconnection allocation, but the results are very general and the conclusions that one supplier is not often pivotal are generally unaffected.

Alternative RSI Scenario

Table 8.21 presents the results of the threshold test when long-term contracts have been excluded from the calculation of available capacity.

Table 9.32: RSI Threshold Analysis (+IC foreign) - Scenario 2 (accounts for LTC only)– Great Britain

RSI Result	0242-S-GB	0453-S-GB	1340-S-GB	1477-S-GB
2003-05	167	355	259	408
% hrs< 110%	*0.6%*	*1.3%*	*1.0%*	*1.6%*
2003	93	106	96	12
% hrs< 110%	*1.1%*	*1.2%*	*1.1%*	*0.1%*
2004	24	99	81	124
% hrs< 110%	*0.3%*	*1.1%*	*0.9%*	*1.4%*
2005	50	150	82	272
% hrs< 110%	*0.6%*	*1.7%*	*0.9%*	*3.1%*

Table 9.33 presents summary statistics on the RSI values calculated under this alternative scenario for the two largest companies in Great Britain (based on market share of total installed capacity).

Table 9.33: Summary Statistics on RSI (+IC foreign)- Scenario 2 (accounts for LTC only)– Great Britain

	0242-S-GB				0453-S-GB			
	2003-2005	**2003**	**2004**	**2005**	**2003-2005**	**2003**	**2004**	**2005**
Mean	1.44	1.39	1.44	1.48	1.43	1.43	1.43	1.42
Min	1.01	1.01	1.07	1.05	1.02	1.02	1.04	1.02
Max	2.21	2.06	2.13	2.21	2.14	2.14	2.14	2.13

PSI Results

The results of the PSI analysis for the large generation companies in Great Britain are presented in Table 9.34. 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 9.34: PSI Threshold Analysis (+IC foreign)– Great Britain

PSI Result	0242-S-GB	0453-S-GB	1340-S-GB	1477-S-GB
2003-05	0	0	0	2
% 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	1
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2005	0	0	0	1
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*

Alternative PSI Scenario

As with the RSI analysis above, the PSI analysis has been re-estimated under the same alternative scenario. Table 9.35 presents the results of the PSI threshold test having excluded long-term contracts from the analysis.

Table 9.35: PSI Threshold Analysis (+IC foreign) - Scenario 2 (accounts for LTC only)– Great Britain				
PSI Result	**0242-S-GB**	**0453-S-GB**	**1340-S-GB**	**1477-S-GB**
2003-05	0	0	0	2
% 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	1
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*
2005	0	0	0	1
% hrs =1	*0.0%*	*0.0%*	*0.0%*	*0.0%*

The PSI results accounting for long term contracts with and without are broadly similar to the results with and without interconnector under different allocation procedures. In addition, there is little change across company or over time. Thus we conclude that the PSI is not sensitive to the allocation of interconnectors or the inclusion of long term contracts.

Overall conclusion

Broadly speaking, the British market is best characterised as moderately unconcentrated, based on the results presented within this section. This conclusion is robust to choice of concentration measure, electricity specific market structure measure, and choice of market definition.

9.4 Contribution to UKPX 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 annual load weighted average UKPX price. Table 8.52 presents the load weighted average contribution of these three factors, to the load weighted average UKPX price. As evidenced from the table, the mark up is a much smaller factor in the price than the system marginal cost, and slightly smaller than carbon. One will notice the absence values for 2003, this is due to the unavailability of the data on the UKPX in this year. In fact, the UKPX only emerged in July 2004 and therefore the results for 2004 should only be considered to cover the final six months of this year.

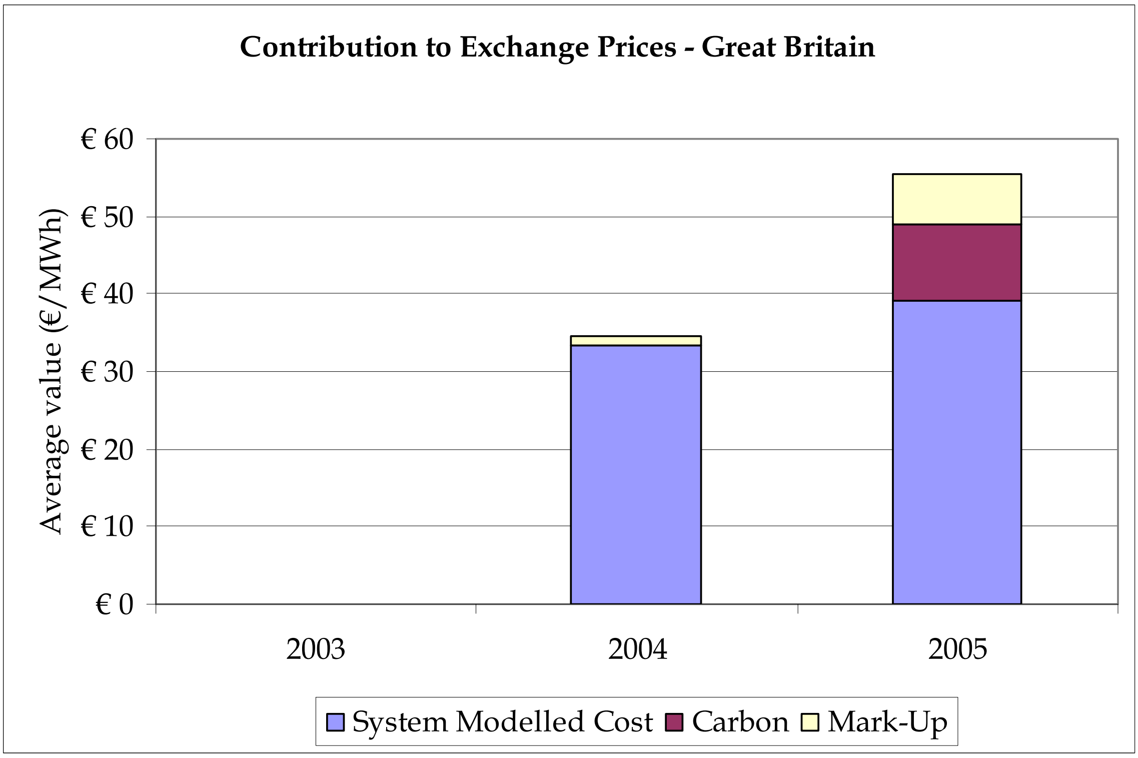
Table 9.36: Contribution of Cost, Carbon and Mark-up to UKPX Prices– Great Britain

	2003	2004	2005
Sys Modelled MC	-	€ 33.33	€ 39.06
Carbon	-	€ 0.00	€ 10.00
Mark-Up	-	€ 1.25	€ 6.35
Total	-	€ 34.58	€ 55.41
UKPX Price	-	€ 34.58	€ 55.41

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

Figure 9.11 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 UKPX price.

Figure 9.11: Contribution to Exchange Prices – Great Britain



Source: LE.

9.5 Outcome Measures

9.5.1 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.

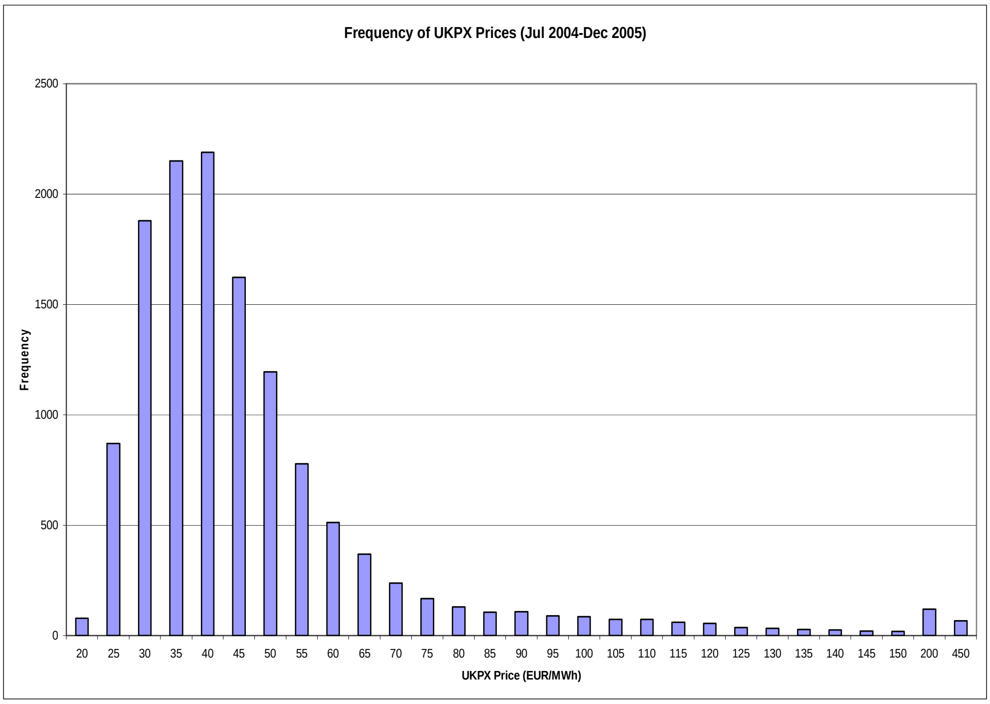
Two different sets of prices are used for this analysis;

3. The hourly day ahead prices published by the United Kingdom Power Exchange (UKPX). This half-hourly price series is only available from July 2004 and for the purposes of this study the observations have been adjusted to reflect hourly prices.

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 UKPX from July 2004 to December 2005 is presented in the histogram below (data was unavailable earlier in the period). The price exceeded €450 in 3 hours over this period, with a highest price of €964.

Figure 9.12: Frequency of UKPX Prices – Great Britain

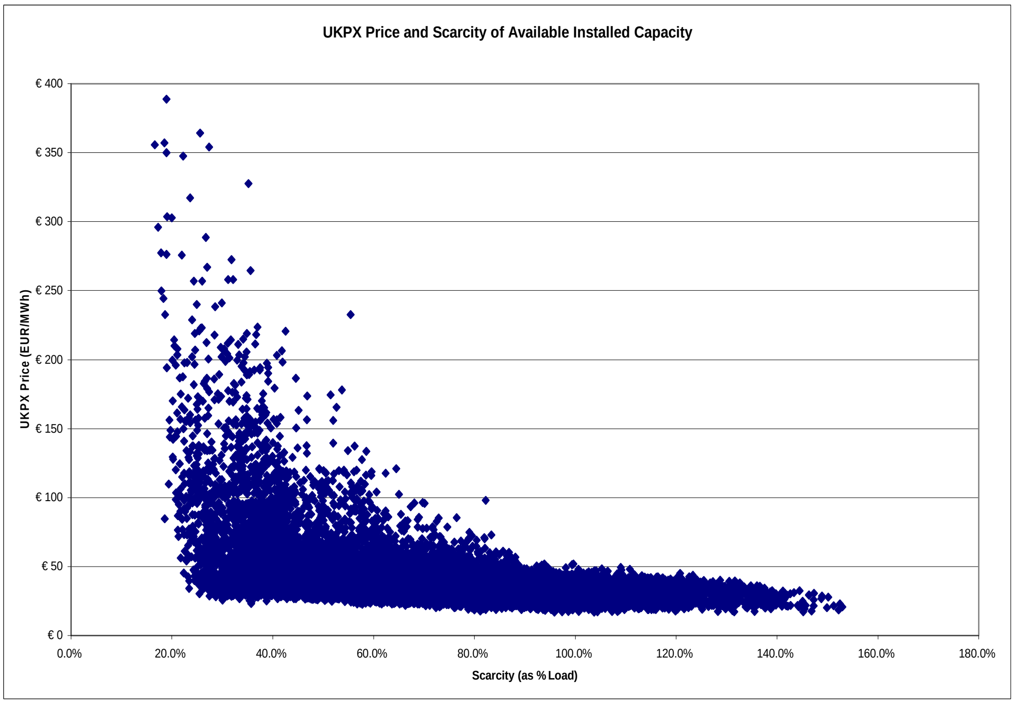


Source: LE.

In general, it is useful to consider the appropriatness of a candidate price for our margin analysis in every hour. For the UKPX price to be considered a relevant price for electricity in Great Britain it should be seen to reflect changing market dynamics within the British electricity market. 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 UKPX 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 9.13: UKPX & Scarcity of Available Generation Capacity – Great Britain



Source: LE.

One can see from this graphic that high UKPX prices correspond to times of relative scarcity of generation capacity, which is what one would expect given the natural convexity of the merit curve. The correlation coefficient of the two series over the entire sample period is -0.42.

The relationship between these two variables indicates that the UKPX price is an appropriate price to use in order to reflect the price of electricity in Great Britain. However as indicated above, the Platts assessment price of electricity in Great Britain shall also be used in calculations of the LI and mark ups. 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 Great Britain, a quantity considerably greater than that traded on a day ahead basis. Alternatively, the Platts price is not reflective of hourly fluctuations in scarcity. Finally, forward prices may contain forward premia for risk, or merely the risk free rate of interest which are natural and not indicative of market power use. We nonetheless include the Platts price analysis as an alternative price measure.

The analysis also considers two estimates of System Marginal Cost (SMC) for the system;

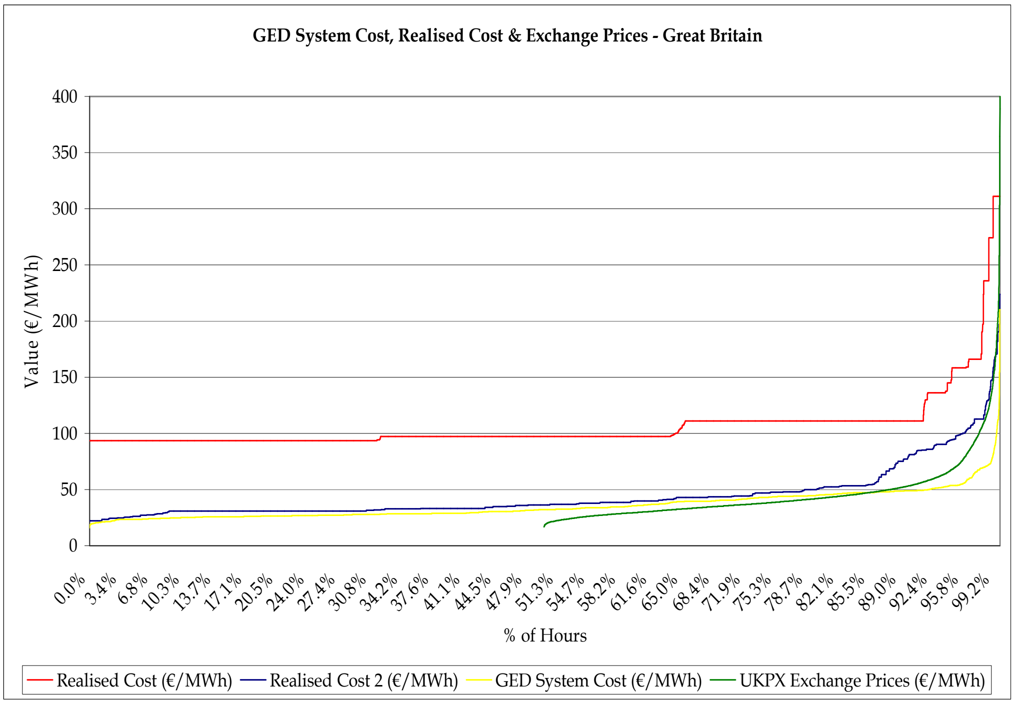
1. The System Marginal Cost estimated as part of GED's optimal dispatch run.

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 can be seen in the following graphic.

Figure 9.14: GED System Modelled Cost, Realised Cost and Exchange Prices – Great Britain



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 dispatch 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 reliability 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 UKPX 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 and the realised MC are provided in Table 8.53.

Table 9.37: Comparison of GED System Marginal Cost & Realised Marginal Cost– Great Britain					
		Average	**Minimum**	**Maximum**	**St Dev**
2003-2005	*GED System Cost*	€ 35.81	€ 16.00	€ 210.00	€ 12.40
	Realised Cost	€ 106.60	€ 93.48	€ 311.00	€ 28.07
	Realised Cost 2	€ 44.59	€ 22.02	€ 223.67	€ 23.76
2003	*GED System Cost*	€ 27.53	€ 18.32	€ 67.55	€ 4.77
	Realised Cost	€ 99.64	€ 97.18	€ 236.00	€ 17.68
	Realised Cost 2	€ 37.66	€ 22.02	€ 117.85	€ 18.03
2004	*GED System Cost*	€ 31.52	€ 23.02	€ 111.05	€ 5.61
	Realised Cost	€ 96.63	€ 93.48	€ 274.00	€ 22.14
	Realised Cost 2	€ 38.11	€ 24.40	€ 170.76	€ 17.48
2005	*GED System Cost*	€ 48.38	€ 16.00	€ 210.00	€ 12.75
	Realised Cost	€ 123.56	€ 111.24	€ 311.00	€ 33.55
	Realised Cost 2	€ 58.02	€ 31.48	€ 223.67	€ 28.18
Source: LE					

In general, the realised cost 2 is about €10 higher than the system marginal cost. The absolute realised cost is often double the modelled system marginal cost. Also, it can be seen that marginal costs have risen substantially from 2003 to 2005, regardless of the measure. This is in general due to rising fuel prices. Finally, the differences between the minimum and maximum costs are more stable, regardless of the, measure; for example, this range is about €200 in 2005.

9.5.2 Results

GED Modelled System Marginal Cost and UKPX Prices

Table 8.55 presents the Lerner Index values estimated for Great Britain based on the load weighted average system marginal cost returned by the GED optimal dispatch simulation and the UKPX price.

Table 9.38: Average LI based on GED System Marginal Cost & UKPX Prices (including carbon)– Great Britain

	2004-05	2003	2004	2005
Lerner Index	9.6%	-	3.6%	11.5%

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

Table 9.39: Average LI based on GED System Marginal Cost & UKPX Prices (excluding carbon)– Great Britain

	2004-05	2003	2004	2005
Lerner Index	23.5%	-	3.6%	29.5%

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

The tables indicate an apparent rise in margins from 2004 to 2005, with the impact of carbon in 2005 having a dampening effect on the realised margins. However, it is important to assess the 2005 figure in context, wherein the market in the UK displayed very high prices for gas, particularly nearing the end of this period. In so far as our approach cannot capture the potential for market players to sell back gas to the market during this period, there is a possibility that the market outcome figures presented overstate the true market outcome.

GED Modelled System Marginal Cost and Platts Assessment Prices

Table 8.57 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 9.40: Average LI based on GED System Marginal Cost & Platts Assessment Prices (Day-Ahead)– Great Britain				
	2003-05	**2003**	**2004**	**2005**
Lerner Index	21.5%	21.1%	15.6%	24.8%

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

Similarly, the Platts assessment prices show an apparent increase in margins in 2005. While the Platts margins appear higher than the UKPX calculated margins, again, some of this may be due to premia in forward sales, contract type, which may or may not have any basis in a market power related explanation.

9.5.3 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.

9.5.4 Results

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

Table 8.58 presents the PCMU values estimated for Great Britain based on the load weighted average system marginal cost returned by the GED optimal dispatch simulation and the UKPX price. Whether the cost of carbon is included or not, both tables show a marked increase in the average price-cost mark-up from 2004 to 2005, although the increase in is much higher in case where carbon is excluded from the calculation. However, once again one must consider the possibility that the 2005 figures are overstated due to the fact that our model did not factor in the possibility that firms could sell their gas back to the market during this period of high gas prices in the UK.

Table 9.41: Average PCMU based on GED System Marginal Cost & UKPX Prices (including carbon)– Great Britain

	2004-05	2003	2004	2005
Price-Cost Mark-Up	10.7%	-	3.8%	12.9%

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

Table 9.42: Average PCMU based on GED System Marginal Cost & UKPX Prices (excluding carbon)– Great Britain

	2004-05	2003	2004	2005
Price-Cost Mark-Up	30.7%	-	3.8%	41.9%

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

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

Table 8.60 presents the PCMU calculated using the load weighted average GED system marginal cost and the Platts Assessment prices.

Table 9.43: Average PCMU based on GED System Marginal Cost & Platts Assessment Prices (Day-Ahead)– Great Britain

	2003-05	2003	2004	2005
Price-Cost Mark-Up	27.5%	26.7%	18.5%	32.9%

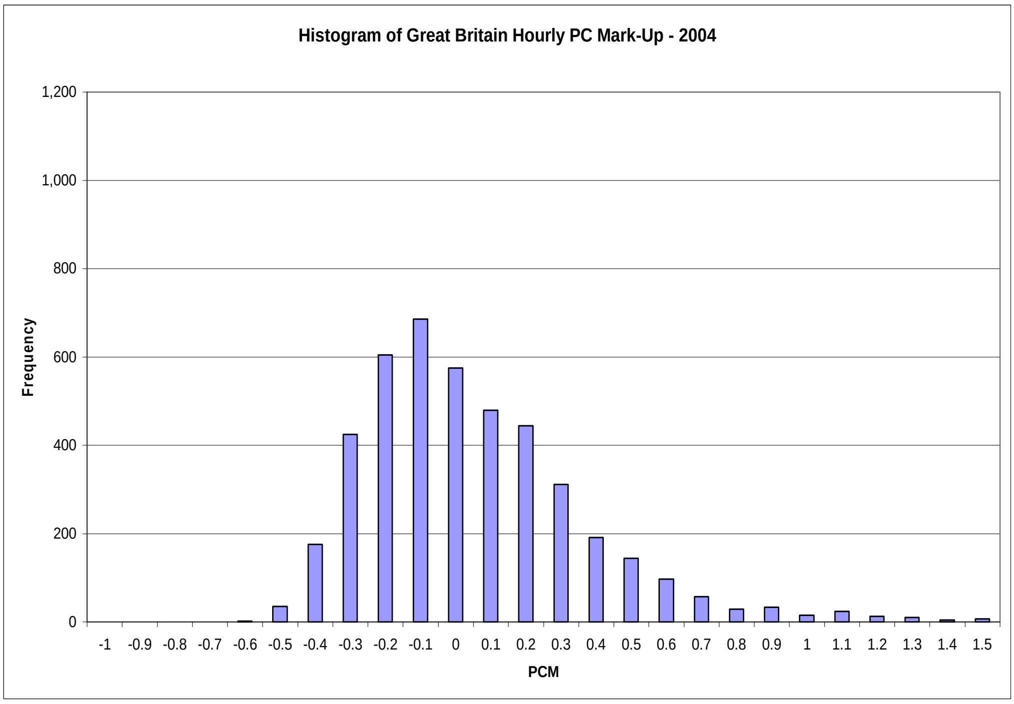
Note: Based on load weighted average prices and costs
Source: LE

Qualitatively, the price cost mark ups are similar to the LIs. There appears to have been an increase in margins in 2005, carbon seems to have increased margins, and the margins based on the Platts prices appear higher. Note that quantitatively, the price cost markups will be higher by construction since price is in general above cost.

9.5.5 Hourly PCMU Analysis

Histograms of the PCMU in 2004 and 2005 are shown below.

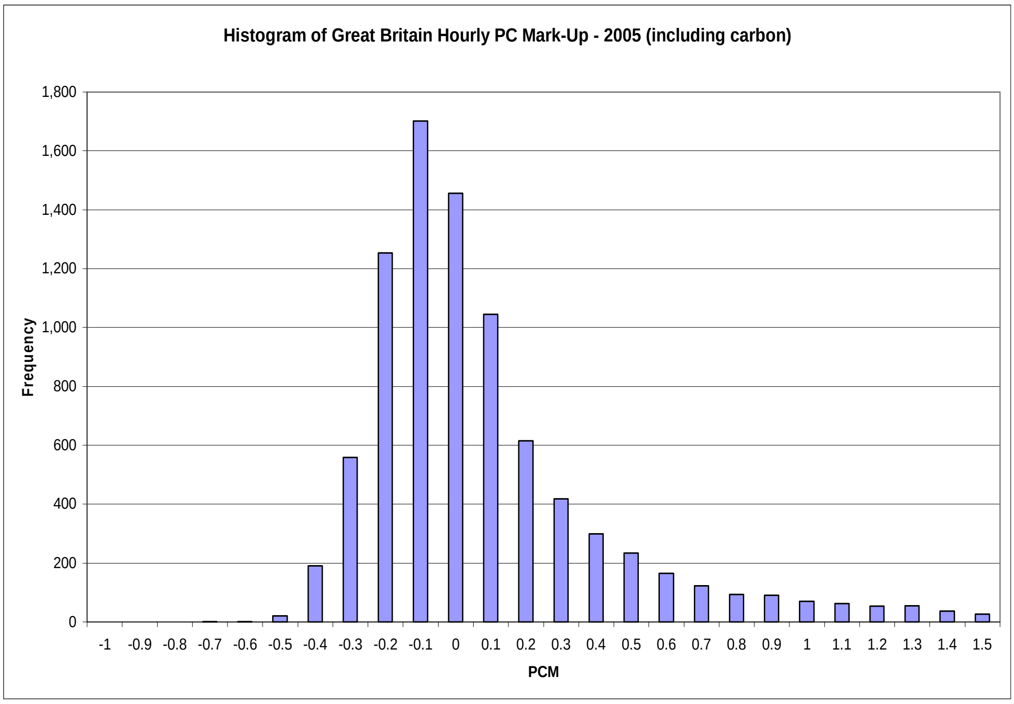
Figure 9.15: Histogram of Great Britain Hourly Price- Cost Mark-up - 2003– Great Britain



Note: N=4,362

Source: LE.

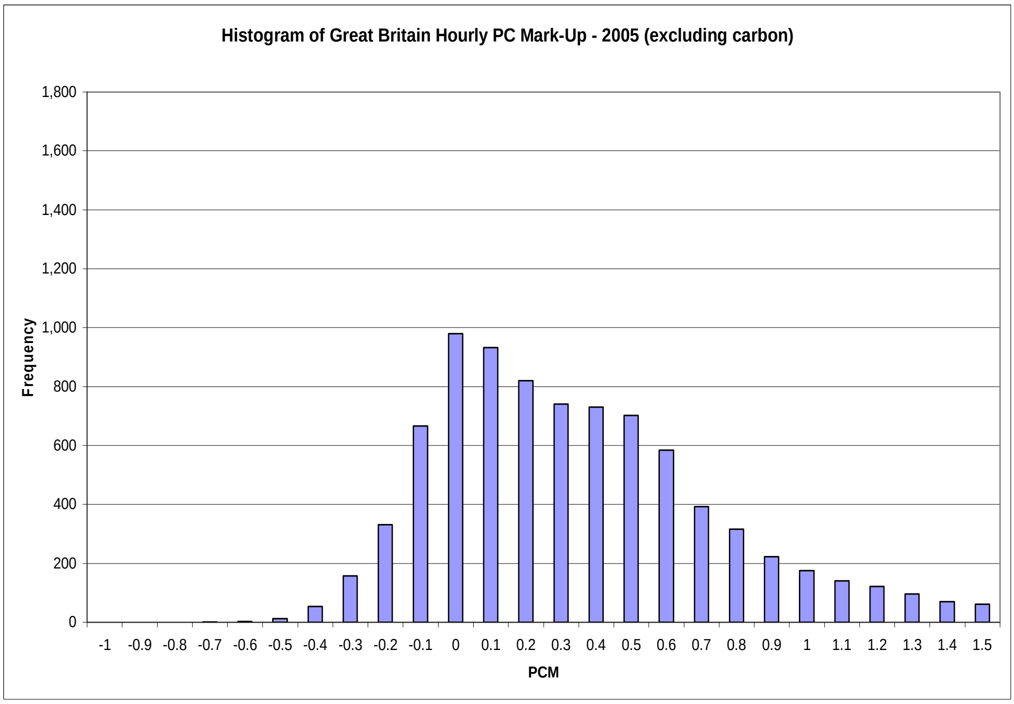
Figure 9.16: Histogram of Great Britain Hourly Price- Cost Mark-up – 2005 (incl. Carbon)– Great Britain



Note: N=8,575

Source: LE.

Figure 9.17: Histogram of Great Britain Hourly Price- Cost Mark-up – 2005 (excl. Carbon)– Great Britain



Note: N=8,314

Source: LE.

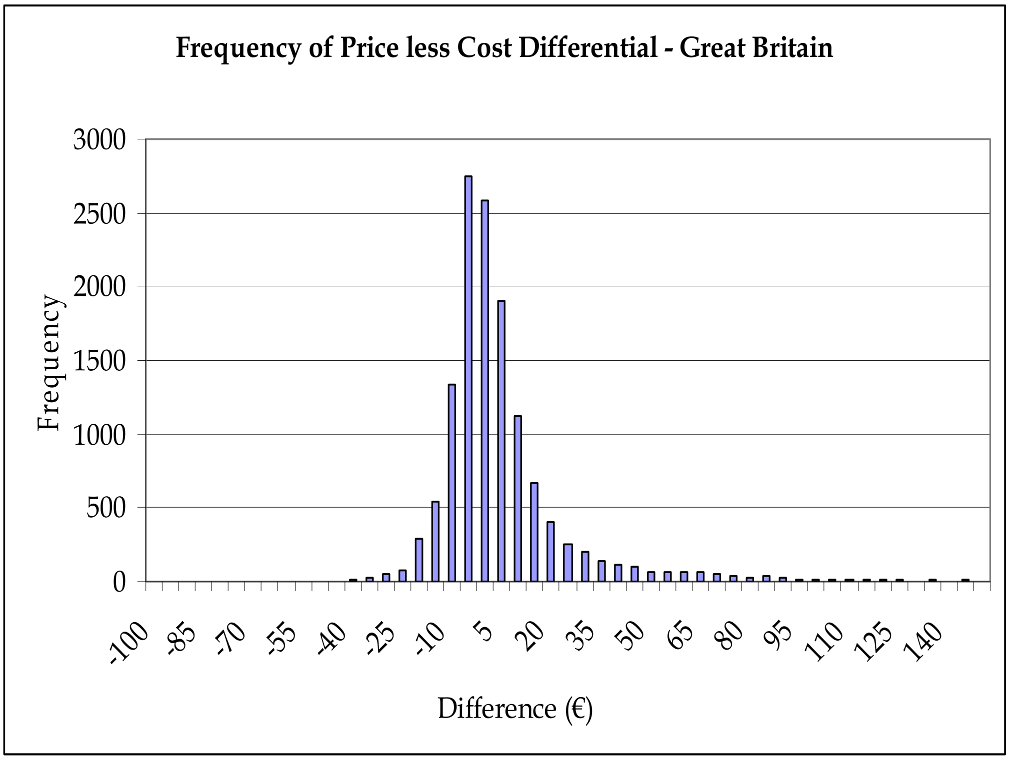
The histograms show the distribution of markups across hours in the year. A few points deserve mention. First, the number of hours is somewhat less than 8760 in some cases due to missing value mainly on price in 2004, however to the extent that values are not represented in 2005, these represent a small number of values to the right of the endpoint of the horizontal axis (with a PCMU greater than 1.5). Second, the distributions exhibit an expected amount of right skewness (large values to the right of the mean possible). This is common as price spikes are possible but prices themselves are bounded below by zero.

The markup measures themselves can be below zero, and in a significant number of hours this is the case. This is not too surprising for a number of reasons. First, a number of previous studies have found a similar finding. Second, it is likely that, given that a unit is running, it is rational to be willing to pay a premium (run at unit cost rather than purchasing at market) to avoid shutting down. This is due to many factors, including the fact of start costs and uncertainty of being redispatched. There also may be engineering or other reasons to avoid shutting the plant and restarting it frequently, such as risk of forced outage. Therefore, running at cost above the market price in certain hours is not surprising.

9.6 Price Cost Differential

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 UKPX price and the System Marginal Cost estimated by GED as a result of their optimal dispatch simulation.

Figure 9.18: Frequency of Price Cost Differential - Great Britain



Source: LE.

The price cost mark ups are absolute euro/MWh figures, whereas the PCMU and LI are alternatively unitless figures. The general shape of the distribution of absolute markups is the same. The usefulness of this measure is to put actual euro figures on the markups. From the distribution, again the distribution is skewed right, indicating some probability of very high mark ups. At the same time, the vast majority of mark ups are between about -10 and 10 €/MWh, with the most frequent ocurrances being between about -5 and 5 €/MWh. The mean, median and mode of the distribution is apparently greater than zero.

9.7 Carbon Impact in 2005

As is apparent from the previous analysis, the cost of carbon is included in the GED optimal dispatch 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 dispatch 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 dispatch. Table 9.44 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.

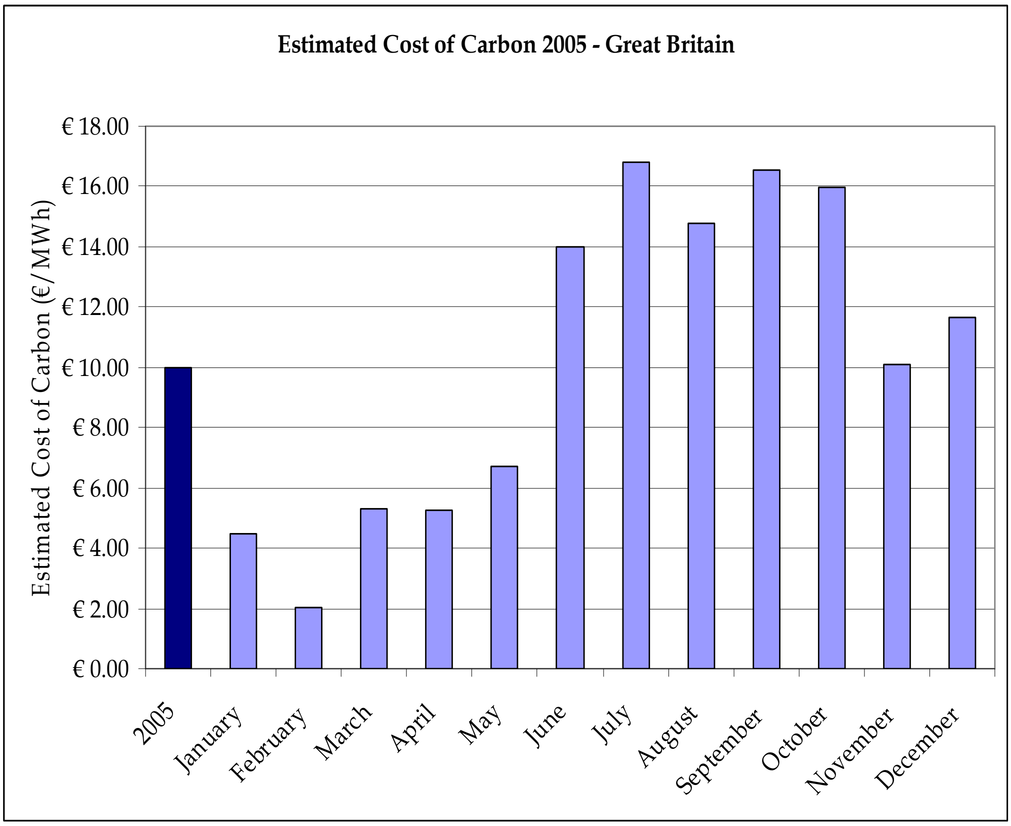
Table 9.44: Summary Statistics on the Modelled Impact of Carbon in 2005– Great Britain

	2005	January	April	August	October
Average	€ 10.00	€ 4.46	€ 5.25	€ 14.76	€ 15.98

Note: Based on load weighted average costs
Source: LE

Figure 9.19 presents the evolution of this differential over the year. During the first months of the Scheme there were steady increases in the cost of carbon up to July when the cost of carbon was in excess of €16/MWh. It remained at between €15/MWh and €16/MWh until October before the price moderated to approximately €10/MWh and €12/MWh in November and December, respectively.

Figure 9.19: Estimated Cost of Carbon 2005 – Great Britain



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.

9.8 Contribution to Fixed Costs

Our previous analysis analysed the impacts of RSI on margins. It is important to realize that regardless of the marginal cost and price setting plant, since generators most often own many plants that will be generating at cost below the system marginal cost or the price, that plants and thus generators will earn rents or contributions to fixed costs associated with running their plants which are more efficient than the plants at the margin. What was done was the quantity generated as a result of the optimal dispatch modelling was multiplied for each unit in each hour by the difference between the plant's reported generation unit cost and the estimated modelled system marginal cost. These figures were then summed over each company over each year.

This analysis, presented Table 9.45, shows on a company-by-company basis the total euro value of such rents. As can be seen in Table 9.45, the big companies, such as company 4 (C04) and company 9 (C09) would still earn a sufficient amount under this optimal scenario to contribute to fixed costs in the billions of euro annually.

Table 9.45: Contribution to FC (€'000)– Great Britain					
Company	**Company ID**	**2003**	**2004**	**2005**	**Total**
C01	**0047-S-GB**	0.0	0.0	0.0	*0.0*
C02	**0177-S-GB**	11,066.3	21,672.5	70,931.3	*103,670.1*
C03	**0234-S-GB**	39,060.2	33,555.1	22,034.3	*94,649.6*
C04	**0242-S-GB**	1,706,199.0	1,808,226.0	2,995,477.0	*6,509,902.0*
C05	**0244-S-GB**	422,153.5	448,385.1	732,872.3	*1,603,410.9*
C06	**0284-S-GB**	80,735.3	49,013.5	56,696.7	*186,445.5*
C07	**0378-S-GB**	845.1	17,306.4	17,737.6	*35,889.1*
C08	**0413-S-GB**	259,809.9	335,319.2	218,279.0	*813,408.1*
C09	**0453-S-GB**	606,512.1	643,986.9	685,716.3	*1,936,215.3*
C10	**0468-S-GB**	263,177.6	225,814.8	156,016.5	*645,008.9*
C11	**0763-S-GB**	37,134.1	51,380.1	121,839.5	*210,353.7*
C12	**0787-S-GB**	1,906.1	15,492.3	12,448.3	*29,846.7*
C13	**0891-S-GB**	0.0	5,988.7	38,429.8	*44,418.6*
C14	**1336-S-GB**	33,245.9	35,629.8	22,292.6	*91,168.3*
C15	**1340-S-GB**	275,285.6	301,754.6	282,985.8	*860,026.0*
C16	**1362-S-GB**	113,873.0	131,560.6	189,327.8	*434,761.4*
C17	**1387-S-GB**	326,060.2	451,280.3	375,499.3	*1,152,839.8*
C18	**1477-S-GB**	153,685.4	317,416.0	477,795.7	*948,897.1*
C19	**1567-S-GB**	50,853.0	92,597.5	199,087.8	*342,538.3*
C20	**1660-S-GB**	0.0	880.1	9,274.1	*10,154.3*
C21	**2000-S-GB**	81,646.5	99,548.5	143,201.2	*324,396.2*
C22	**2008-S-GB**	1,538.2	17,762.9	14,012.8	*33,313.9*
C23*	**0912-S-GB**	185,098.1	235,877.0	351,197.5	*772,172.5*

Source: LE

*Company 23 is a combination of four companies and the figures reported are the combined Contribution to Fixed Costs from its subsidiaries (0378, 0763, 1336, & 1362).

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[16]. 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.

[16] 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[17] 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[18]. 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[19]. 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.

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[17] The Commission for Energy Regulation, Ireland.

[18] 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.

[19] 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 9.46, we can see that even taking the generic new build (which we argue should be at the upper end of the investment cost scale), Great Britain'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 Great Britain, under a perfectly competitive market scenario, are, on average, at least sufficient to allow for new investment to take place. Considering the market outcomes in the market 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 British 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 operators in Great Britain, 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 Great Britain. As previously stated, we merely use this as a model check. There may be reasons that investment incentive hurdles are higher or lower.

Table 9.46: Comparison contribution to fixed cost and generic new build– Great Britain	
	€/MW/Year
Generic CCGT 400MW	67,980
Generic Coal 1000MW	61,911
	2003-05 Average
GB	109,102
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.

9.9 Regression Analysis

In order to relate our above market outcome/market performance measures to the structural indicators, we undertook a detailed regression analysis for selected countries. This is significant as it is likely that many stochastic factors may be influencing price cost margins, mark-ups, LI etc. A model that controls for random error is the classical linear regression model and related models correcting for possible violations of the standard classical regression model assumptions. We explored a number of models and assumptions about the error terms, the model specifications, and statistical significance. In general, we found that the models are robust to changes in these assumptions and that the qualitative conclusions, that electricity-specific indicators such as the RSI are significant explanatory determinants of mark ups in Great Britain and selected markets, were invariant to changes in the assumptions of the regression and model specification. In general, our method was to develop the models and explore the simple regression models, and progress on to more detailed specifications including more explanatory factors.[20]

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.

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[20] 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 capture simply this effect from what is designed to reflect, the impact of 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[21]. Table 8.64 provides a summary of the variables included in the regression analysis.

Table 9.47: Variables used in the Regression Analysis– Great Britain

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.

[21] 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 9.48: Variables used in the Regression Analysis– Great Britain	
Company Number	**Company Identification**
C04	0242-S-GB
C09	0453-S-GB
C15	1340-S-GB
C18	1477-S-GB
Source: LE	

9.9.1 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 British market, each are discussed in turn.

Lerner Index & RSI for 0242-S-GB

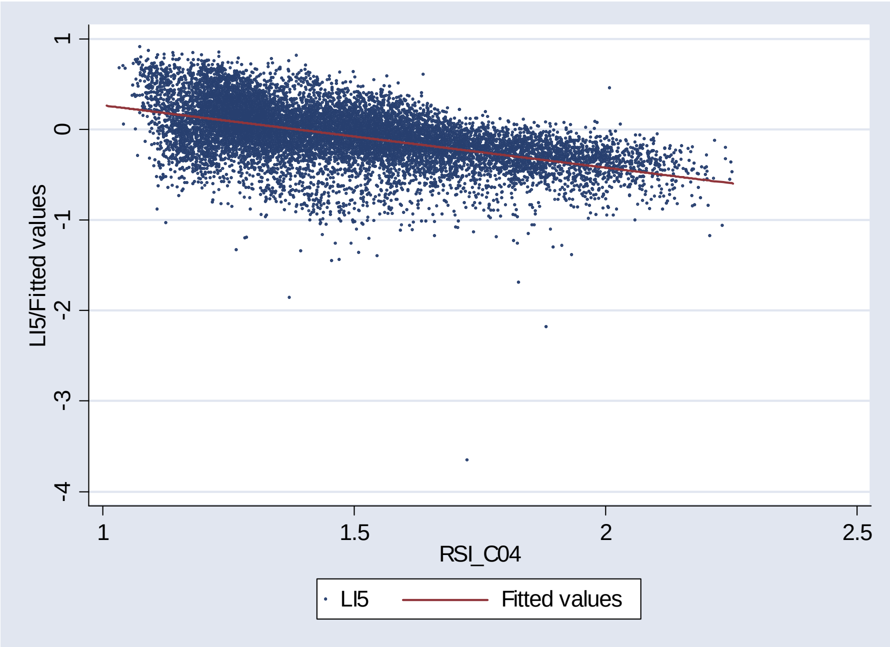
```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  1, 13174) = 5207.48
       Model |  365.311702     1  365.311702           Prob > F      =  0.0000
    Residual |   924.17436 13174  .070151386           R-squared     =  0.2833
-------------+------------------------------           Adj R-squared =  0.2832
       Total |  1289.48606 13175  .097873705           Root MSE      =  .26486

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -.6888778   .0095462   -72.16   0.000    -.7075897    -.670166
       _cons |   .9578882    .014297    67.00   0.000     .9298639    .9859124
```

The regression results show the expected negative sign on the RSI of company 0242-S-GB, and a highly significant t-value. The goodness-of-fit of the specification to the data, indicated by the R-squared, can be considered to be relatively high (28%) for a univariate regression of this type. It is noteworthy that Great Britain is the only country out of those contained in this report for whom the LI and PCMU regressions both report relatively good R-squared values for the type of regressions that are being estimated. Later in this section we persist with the regressions of PCMU on different explanatory variables for consistency with the other reports and to allow for comparisons across countries.

Figure 9.20 below shows the graphical depiction of the regression. The red line is the predicted value.

Figure 9.20: LI Regression on RSI for 0242-S-GB



Source: LE.

Regression with Robust Standard Errors - 0242-S-GB

Some evidence of non-spherical error terms is apparent from the above graphical analysis (more detailed analysis was carried out to confirm this). This suggests considering the sensitivity of the results to heteroskedastic errors (non constant variance in the error term). To correct for heteroskedasticity, we use the Huber-White sandwich estimator of variance[22] in place of the traditional calculation to ensure that our standard errors are robust.

22 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.

```
Regression with robust standard errors                 Number of obs =   13176
                                                       F(  1, 13174) = 5854.89
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2833
                                                       Root MSE      =  .26486

------------------------------------------------------------------------------
             |               Robust
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -.6888778   .0090029   -76.52   0.000    -.7065248   -.6712308
       _cons |   .9578882   .0140119    68.36   0.000     .9304228    .9853536
```

The coefficient estimates are unbiased in the presence of heterskedaticity, but the standard errors are not. The results above confirm that the statistical significance is not sensitive to the homoskedasticity assumption. 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 (see STATA manuals).

Prais-Winston Regression method to correct for AR(1) type disturbances - 0242-S-GB

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

      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  1, 13174) = 2193.67
       Model |  70.6218924     1  70.6218924           Prob > F      =  0.0000
    Residual |  424.116574 13174  .032193455           R-squared     =  0.1427
-------------+------------------------------           Adj R-squared =  0.1427
       Total |  494.738467 13175  .037551307           Root MSE      =  .17943

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -.8438973   .0180182   -46.84   0.000    -.8792156    -.808579
       _cons |   1.187004   .0273114    43.46   0.000      1.13347    1.240538
-------------+----------------------------------------------------------------
         rho |   .7416861

Durbin-Watson statistic (original)    0.532246
Durbin-Watson statistic (transformed) 2.227353
```

The Durbin-Watson statistic indicates a likely problem of serial correlation but the transformed Durbin Watson statistic is near 2 indicating the corrected model is better specified. The coefficient has increased and some explanatory power in the model has been lost as evidenced by the lower R-squared value, but the statistical significance remains robust.

Peak & Off-Peak Analysis - 0242-S-GB

We further refined the model to specify different values for a peak and off peak effect. A dummy variable was created for peak and this was included as an intercept shifter, as well as interacted with the slope coefficients. This essentially allows both the means and the slopes to vary by peak and off peak. Qualitatively, the results are not changed by this specification. The peak slope coefficient is larger and both are negative (expected sign) and significant. The R-squared has increased to 33%.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  3, 13172) = 2212.38
       Model |  432.048203     3  144.016068           Prob > F      =  0.0000
    Residual |  857.437859 13172  .065095495           R-squared     =  0.3351
-------------+------------------------------           Adj R-squared =  0.3349
       Total |  1289.48606 13175  .097873705           Root MSE      =  .25514

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   .5530894   .0393351    14.06   0.000      .475987    .6301919
   pk_RSI_C04 |   -.535791   .0167919   -31.91   0.000    -.5687055   -.5028765
  opk_RSI_C04 |  -.3055329   .0185231   -16.49   0.000    -.3418408    -.269225
       _cons |   .2317785   .0318758     7.27   0.000     .1692973    .2942597
```

Price-Cost Mark-Up & RSI for Company 0242-S-GB

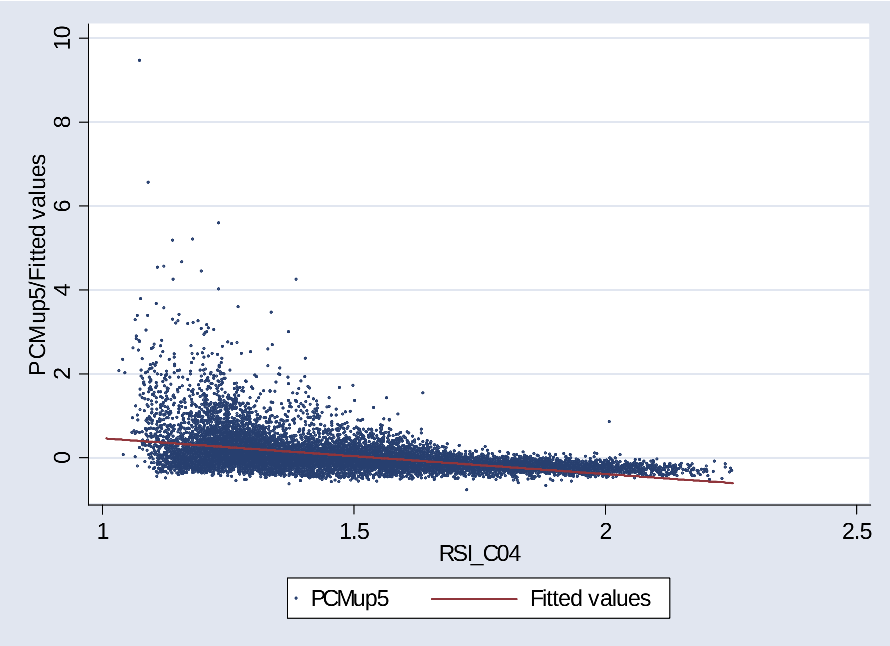
A similar set of regressions were estimated based on regressing the hourly PCMU on the RSI of Company 0242-S-GB. Qualitatively the results are very similar, the coefficients are of the expected sign, they are statistically significant and the values of the coefficients indicate similar responses to changes in the RSI variable. The R-squared of this simple regression model is approximately 20% indicating a relatively strong degree of explanatory power for a univariate regression of this nature.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  1, 13174) = 3345.85
       Model |  561.032781     1  561.032781           Prob > F      =  0.0000
    Residual |  2209.02167 13174  .167680406           R-squared     =  0.2025
-------------+------------------------------           Adj R-squared =  0.2025
       Total |  2770.05445 13175  .210250812           Root MSE      =  .40949

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -.8536985   .0147588   -57.84   0.000    -.8826279   -.8247691
       _cons |   1.316912   .0221039    59.58   0.000     1.273586    1.360239
```

Figure 9.21 presents the predicted regression line of the simple regression equation estimated in relation to company 0242-S-GB.

Figure 9.21:PCMU Regression on RSI for Company 0242-S-GB



Source: LE.

The scatter-plot 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 0242-S-GB. 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 - 0242-S-GB

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  2, 13173) = 1963.40
       Model |  636.116474     2  318.058237           Prob > F      =  0.0000
    Residual |  2133.93798 13173  .161993318           R-squared     =  0.2296
-------------+------------------------------           Adj R-squared =  0.2295
       Total |  2770.05445 13175  .210250812           Root MSE      =  .40248

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -4.462942    .168272   -26.52   0.000    -4.792779   -4.133105
   RSI_C04sq |   1.158067    .053791    21.53   0.000     1.052629    1.263505
       _cons |   4.053944   .1289752    31.43   0.000     3.801134    4.306754
------------------------------------------------------------------------------
```

Peak & Off-Peak Analysis - 0242-S-GB

This regression indicates that the likely relationship between the PCMU and RSI of company 0242-SGB 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 23.3% of the variation in the PCMU over the three years.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  3, 13172) = 1336.13
       Model |  646.284974     3  215.428325           Prob > F      =  0.0000
    Residual |  2123.76948 13172  .161233638           R-squared     =  0.2333
-------------+------------------------------           Adj R-squared =  0.2331
       Total |  2770.05445 13175  .210250812           Root MSE      =  .40154

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   1.257862    .061906    20.32   0.000     1.136517    1.379206
  pk_RSI_C04 |  -.9950474   .0264272   -37.65   0.000    -1.046849   -.9432462
 opk_RSI_C04 |  -.2748262   .0291518    -9.43   0.000    -.3319679   -.2176845
       _cons |   .2771454   .0501665     5.52   0.000     .1788118    .3754789
```

An almost identical approach has been applied to each of the three remaining big four companies in Britain 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 0242-S-GB. 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 0242-S-GB.

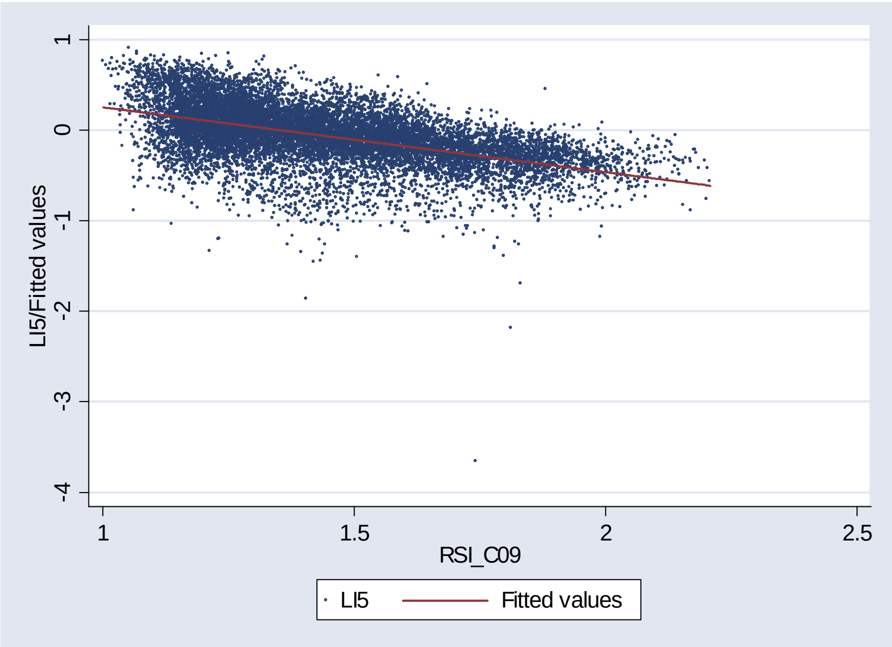
Lerner Index & RSI for Company 0453-S-GB

The simple regression analysis has been repeated for company 0453-S-GB, with almost identical results. The estimated coefficients are of the same sign and quantitatively are very similar to those estimated for company 0242-S-GB. This is similarly the case for the goodness-of fit measure. The estimated regression line is presented in Figure 9.22.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  1, 13174) = 5173.37
       Model |  363.593854     1  363.593854           Prob > F      =  0.0000
    Residual |  925.892208 13174  .070281783           R-squared     =  0.2820
-------------+------------------------------           Adj R-squared =  0.2819
       Total |  1289.48606 13175  .097873705           Root MSE      =  .26511

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C09 |  -.7170556   .0099693   -71.93   0.000    -.7365969   -.6975143
       _cons |   .9721261   .0145386    66.87   0.000     .9436283    1.000624
```

Figure 9.22: LI Regression on RSI for 0453-S-GB



Source: LE.

Peak & Off-Peak Analysis - 0453-S-GB

The regression based on the assumption of peak/off-peak differences equally yields the expected results. The dpeak dummy variable is highly significant, as are the negative coefficients on the RSI in both peak and off-peak periods.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  3, 13172) = 2211.54
       Model |  431.939456     3  143.979819           Prob > F      =  0.0000
    Residual |  857.546606 13172  .065103751           R-squared     =  0.3350
-------------+------------------------------           Adj R-squared =  0.3348
       Total |  1289.48606 13175  .097873705           Root MSE      =  .25515

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   .5388634   .0400488    13.46   0.000      .460362    .6173648
  pk_RSI_C09 |  -.5445649   .0170073   -32.02   0.000    -.5779016   -.5112282
 opk_RSI_C09 |  -.3198828   .0197211   -16.22   0.000     -.358539   -.2812266
       _cons |   .2403272   .0329307     7.30   0.000     .1757784    .3048761
```

Qualitatively, the results of the peak and off peak regressions are thus similar to the previous results. The statistical significance is high, the R-squares are very similar, and the signs are as expected. In addition, the impact on peak is larger than off peak.

Price-Cost Mark-Up & RSI for Company 0453-S-GB

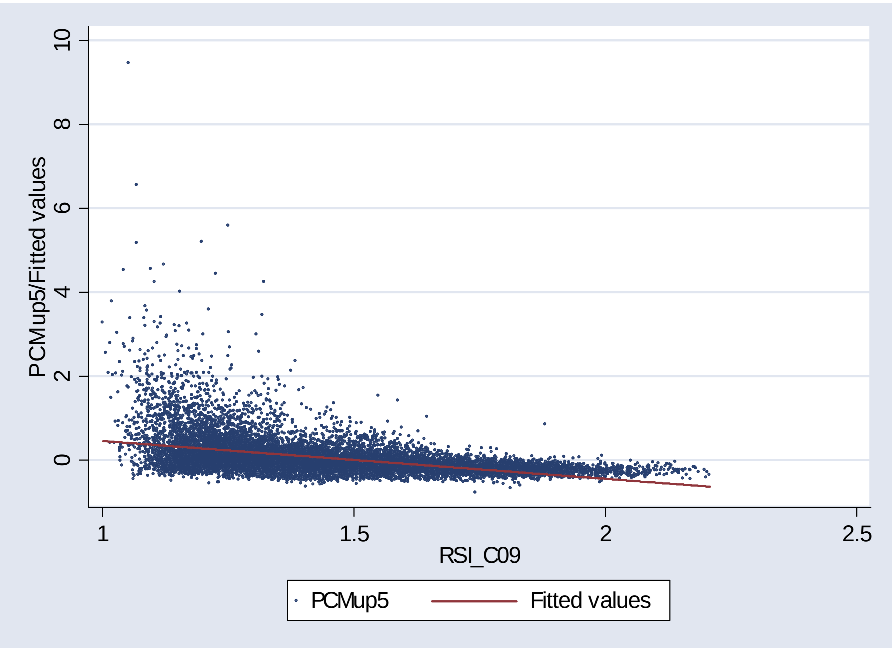
Repeating the regression analysis using the price cost mark up, similar to the LI, gives similar results.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  1, 13174) = 3452.67
       Model |  575.225192     1  575.225192           Prob > F      =  0.0000
    Residual |  2194.82926 13174  .166603101           R-squared     =  0.2077
-------------+------------------------------           Adj R-squared =  0.2076
       Total |  2770.05445 13175  .210250812           Root MSE      =  .40817

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C09 |  -.9019106   .0153492   -58.76   0.000    -.9319973    -.871824
       _cons |   1.353696   .0223843    60.48   0.000     1.309819    1.397572
```

The figure below shows the results of the mark-up regression graphically.

Figure 9.23: PCMU Regression on RSI for 0453-S-GB



Source: LE.

As with the company 0242-S-GB 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 0453-S-GB 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 - 0453-S-GB

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  2, 13173) = 2096.88
       Model |  668.919264     2  334.459632           Prob > F      =  0.0000
    Residual |  2101.13519 13173  .159503164           R-squared     =  0.2415
-------------+------------------------------           Adj R-squared =  0.2414
       Total |  2770.05445 13175  .210250812           Root MSE      =  .39938

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C09 |  -5.149696   .1759057   -29.28   0.000    -5.494496   -4.804895
   RSI_C09sq |   1.404872   .0579649    24.24   0.000     1.291253    1.518492
       _cons |   4.481927   .1309157    34.24   0.000     4.225313     4.73854
------------------------------------------------------------------------------
```

Peak & Off-Peak Analysis - 0453-S-GB

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 =   13176
-------------+------------------------------           F(  3, 13172) = 1364.15
       Model |   656.62725      3   218.87575           Prob > F      =  0.0000
    Residual |   2113.4272 13172  .160448466           R-squared     =  0.2370
-------------+------------------------------           Adj R-squared =  0.2369
       Total |  2770.05445 13175  .210250812           Root MSE      =  .40056

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   1.246464   .0628716    19.83   0.000     1.123227    1.369702
  pk_RSI_C09 |  -1.029159   .0266993   -38.55   0.000    -1.081494   -.9768248
 opk_RSI_C09 |  -.2979071   .0309596    -9.62   0.000    -.3585925   -.2372218
       _cons |   .3017059    .051697     5.84   0.000     .2003724    .4030395
```

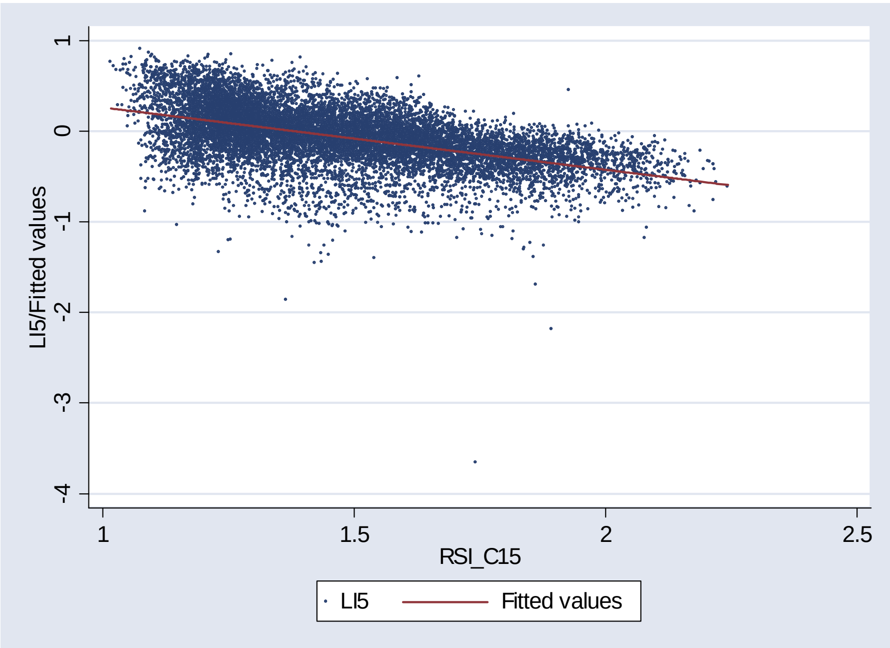
Lerner Index & RSI for Company 1340-S-GB

The estimation of the simple (univariate) regression for company 1340-S-GB results in a result that is qualitatively the same as that seen previously for companies 0242-S-GB and 0453-S-GB. The LI is predicted to increase with the indispensability of company 1340-S-GB. Figure 9.24 presents a graphical representation of the predicted regression line.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  1, 13174) = 5095.14
       Model |  359.629207     1  359.629207           Prob > F      =  0.0000
    Residual |  929.856855 13174  .070582728           R-squared     =  0.2789
-------------+------------------------------           Adj R-squared =  0.2788
       Total |  1289.48606 13175  .097873705           Root MSE      =  .26567

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C15 |  -.6881859   .0096411   -71.38   0.000    -.7070839   -.6692879
       _cons |   .9531608   .0143855    66.26   0.000     .9249632    .9813584
```

Figure 9.24: LI Regression on RSI for 1340-S-GB



Source: LE.

Peak & Off-Peak Analysis - 1340-S-GB

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 =   13176
-------------+------------------------------           F(  3, 13172) = 2200.42
       Model |  430.491604     3  143.497201           Prob > F      =  0.0000
    Residual |  858.994457 13172   .06521367           R-squared     =  0.3338
-------------+------------------------------           Adj R-squared =  0.3337
       Total |  1289.48606 13175  .097873705           Root MSE      =  .25537

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   .5613338   .0397296    14.13   0.000      .483458    .6392095
   pk_RSI_C15 |  -.5232214   .0162677   -32.16   0.000    -.5551084   -.4913343
  opk_RSI_C15 |  -.2913102   .0192291   -15.15   0.000    -.3290021   -.2536183
       _cons |   .2046875   .0328907     6.22   0.000     .1402171     .269158
```

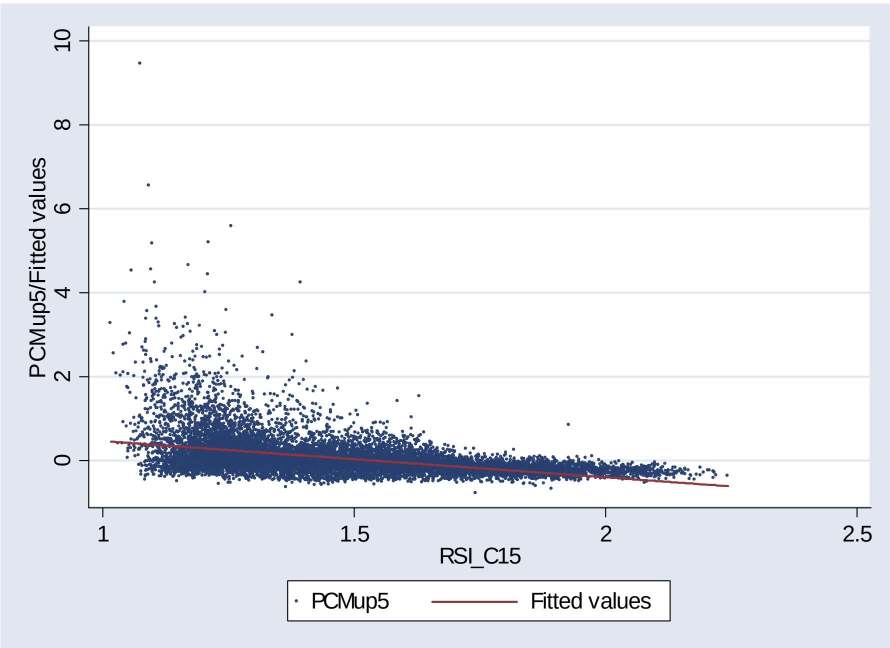
Price-Cost Mark-Up & RSI for Company 1340-S-GB

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, statistically significant coefficients on the RSI variables of the expected sign. Figure 9.25 presents the predicted regression line resulting from the estimation of this simple regression.

Source	SS	df	MS		
				Number of obs	= 13176
				F(1, 13174)	= 3412.72
Model	569.939177	1	569.939177	Prob > F	= 0.0000
Residual	2200.11527	13174	.167004347	R-squared	= 0.2058
				Adj R-squared	= 0.2057
Total	2770.05445	13175	.210250812	Root MSE	= .40866

PCMup5	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C15	-.8663483	.01483	-58.42	0.000	-.8954173	-.8372793
_cons	1.330946	.0221279	60.15	0.000	1.287572	1.374319

Figure 9.25: PCMU Regression on RSI for 1340-S-GB



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 only marginally improved by the inclusion of the quadratic term. 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 - 1340-S-GB

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  2, 13173) = 1841.79
       Model |  605.325682     2  302.662841           Prob > F      =  0.0000
    Residual |  2164.72877 13173  .164330735           R-squared     =  0.2185
-------------+------------------------------           Adj R-squared =  0.2184
       Total |  2770.05445 13175  .210250812           Root MSE      =  .40538

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C15 |  -2.023862     .08024   -25.22   0.000    -2.181144    -1.86658
   RSI_C15sq |    .409721   .0279209    14.67   0.000     .3549921    .4644499
       _cons |   2.197158   .0629779    34.89   0.000     2.073712    2.320603
```

Peak & Off-Peak Analysis - 1340-S-GB

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 1340-S-GB 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              Number of obs =   13176
-------------+------------------------------           F(  3, 13172) = 1351.63
       Model |   652.02072     3  217.34024            Prob > F      =  0.0000
    Residual |  2118.03373 13172  .160798188           R-squared     =  0.2354
-------------+------------------------------           Adj R-squared =  0.2352
       Total |  2770.05445 13175  .210250812           Root MSE      =    .401

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   1.231028   .0623858    19.73   0.000     1.108743    1.353313
   pk_RSI_C15 |  -.9770181   .0255445   -38.25   0.000    -1.027089   -.9269472
  opk_RSI_C15 |   -.275824   .0301947    -9.13   0.000      -.33501   -.216638
       _cons |   .2762037   .0516469     5.35   0.000     .1749684     .377439
```

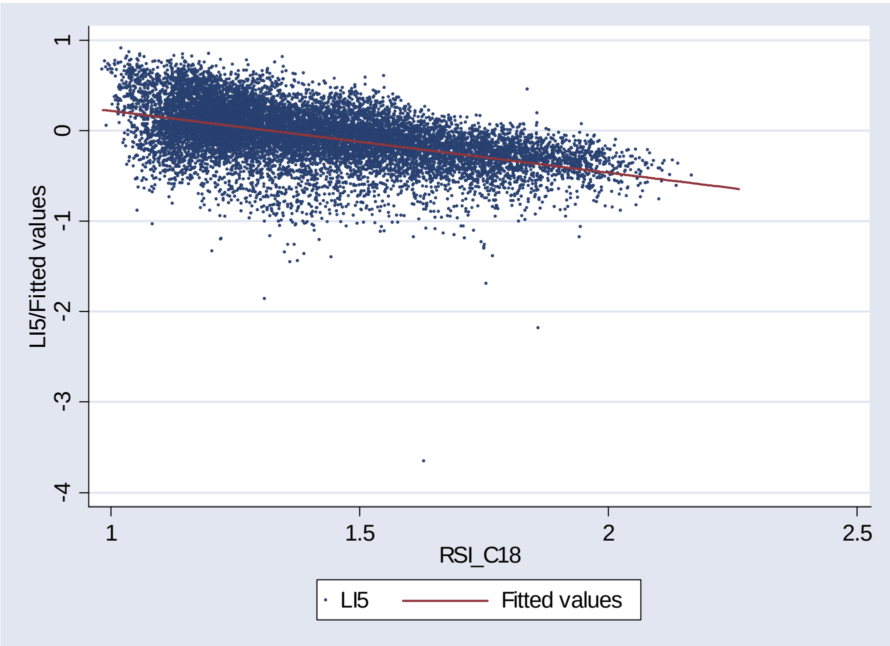
Lerner Index & RSI for Company 1477-S-GB

Finally, in this section a full suite of simple regressions is further carried out for Company 1477-S-GB. The simple regression equation of the LI on the RSI relative to company 1477-S-GB estimates a statistically significant relationship between the variables, of the expected sign. The predicted regression line is presented in Figure 9.26.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  1, 13174) = 4554.47
       Model |  331.271021     1  331.271021           Prob > F      =  0.0000
    Residual |  958.215041 13174  .072735315           R-squared     =  0.2569
-------------+------------------------------           Adj R-squared =  0.2568
       Total |  1289.48606 13175  .097873705           Root MSE      =  .26969

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C18 |  -.6836762   .0101305   -67.49   0.000    -.7035334   -.6638189
       _cons |   .9047493   .0144916    62.43   0.000     .8763438    .9331549
```

Figure 9.26: LI Regression on RSI for 1477-S-GB



Source: LE.

Peak & Off-Peak Analysis - 1477-S-GB

Considering a peak and off-peak distinction within the estimated regression of LI on RSI can be seen to significantly increase the goodness-of-fit of the regression, from approximately 26% to 32%. The estimated regression coefficients are statistically significant and of the expected sign, supporting previous findings of a premium in peak hours.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  3, 13172) = 2079.83
       Model |  414.482569     3  138.160856           Prob > F      =  0.0000
    Residual |  875.003493 13172  .066429053           R-squared     =  0.3214
-------------+------------------------------           Adj R-squared =  0.3213
       Total |  1289.48606 13175  .097873705           Root MSE      =  .25774

------------------------------------------------------------------------------
         LI5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   .5484887   .0391786    14.00   0.000     .4716929    .6252845
   pk_RSI_C18 |  -.4882959   .0170995   -28.56   0.000    -.5218134   -.4547783
  opk_RSI_C18 |  -.2658375   .0195763   -13.58   0.000    -.3042099    -.227465
       _cons |   .1425889   .0321039     4.44   0.000     .0796607    .2055171
------------------------------------------------------------------------------
```

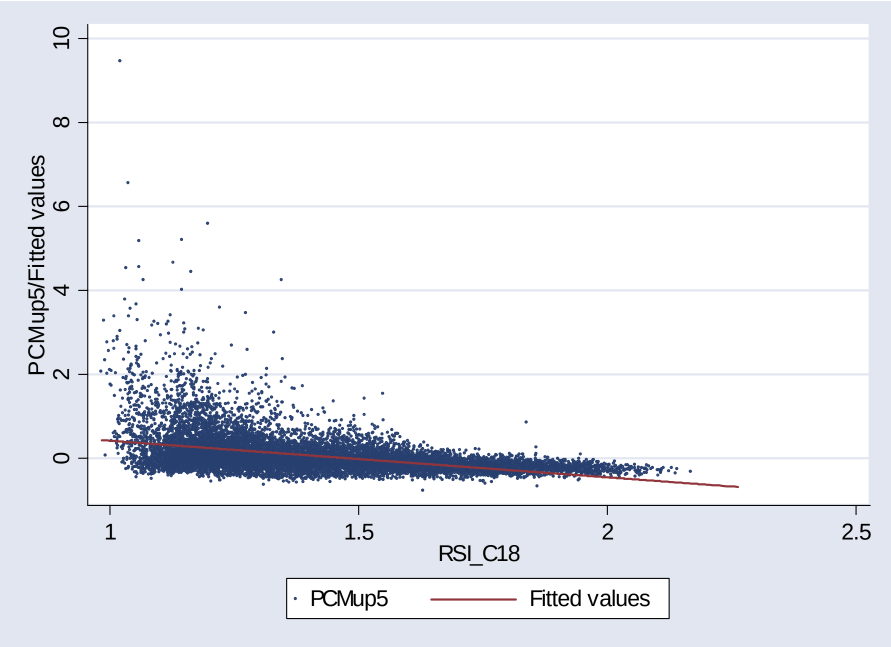
Price-Cost Mark-Up & RSI for Company 1477-S-GB

Replacing LI with PCMU as the dependent variable in the regression equations one can see a result common to the analysis of all four companies in the British 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 9.27.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  1, 13174) = 3180.26
       Model |  538.667133     1  538.667133           Prob > F      =  0.0000
    Residual |  2231.38732 13174  .169378117           R-squared     =  0.1945
-------------+------------------------------           Adj R-squared =  0.1944
       Total |  2770.05445 13175  .210250812           Root MSE      =  .41156

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C18 |  -.8718042   .0154592   -56.39   0.000    -.9021065   -.8415019
       _cons |   1.285716   .0221142    58.14   0.000     1.242369    1.329063
```

Figure 9.27: PCMU Regression on RSI 1477-S-GB



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.

Quadratic Specification - 1477-S-GB

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  2, 13173) = 1874.62
       Model |  613.726001     2     306.863           Prob > F      =  0.0000
    Residual |  2156.32845 13173  .163693043           R-squared     =  0.2216
-------------+------------------------------           Adj R-squared =  0.2214
       Total |  2770.05445 13175  .210250812           Root MSE      =  .40459

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C18 |  -4.641921    .176718   -26.27   0.000    -4.988314   -4.295528
   RSI_C18sq |   1.272108   .0594071    21.41   0.000     1.155662    1.388555
       _cons |   4.004359   .1288077    31.09   0.000     3.751877     4.25684
```

Peak & Off-Peak Analysis - 1477-S-GB

Allowing for peak and off-peak differences in the relationship between the PCMU and the RSI of company 1477-S-GB, one can see that the estimated coefficients of this regression equation are all statistically significant and of the expected sign.

```
      Source |       SS       df       MS              Number of obs =   13176
-------------+------------------------------           F(  3, 13172) = 1286.93
       Model |  627.881313     3  209.293771           Prob > F      =  0.0000
    Residual |  2142.17314 13172  .162630818           R-squared     =  0.2267
-------------+------------------------------           Adj R-squared =  0.2265
       Total |  2770.05445 13175  .210250812           Root MSE      =  .40328

------------------------------------------------------------------------------
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       dpeak |   1.204203   .0613016    19.64   0.000     1.084043    1.324363
  pk_RSI_C18 |  -.9672286   .0267551   -36.15   0.000    -1.019672   -.9147848
 opk_RSI_C18 |  -.2627163   .0306305    -8.58   0.000    -.3227564   -.2026761
       _cons |   .2353305   .0502319     4.68   0.000     .1368687    .3337922
```

9.9.2 Regression Analysis – Part 2

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.

Price-Cost Mark-Up & RSI for Company 0242-S-GB (including a Scarcity variable)

The result of adding the scarcity variable to the simple regression of PCMU on the RSI of company 0242-S-GB is presented in the following regression. The estimated coefficient on the RSI is no longer statistically significant, however, the estimated coefficient on the scarcity variable is of the expected sign and is statistically significant. This result indicates that in fact scarcity is the factor explaining what we previously saw to be the market power of company 0242-S-GB. However, one must be somewhat careful in over interpreting this result, there are potentially a number of other factors that could explain this behaviour that are not included in the specified model. If these variables are correlated with the independent variables of the model then this is likely to bring about what is referred to as omitted variable bias which will bias the estimated regression coefficients of the estimated model.

To investigate this 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.

```
Regression with robust standard errors                 Number of obs =   13176
                                                       F(  2, 13173) = 1321.97
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2064
                                                       Root MSE      =  .40852

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |   .0049823   .0819473     0.06   0.952    -.1556463    .1656109
        Scar |  -.7733456   .0760416   -10.17   0.000    -.9223981   -.6242931
       _cons |   .5619515   .0723883     7.76   0.000     .4200599     .703843
```

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 25.5%, indicating an improved goodness-of-fit measure as one might expect given that many of the dummy variables are statistically significant. Apart from the peak hours dummy the remainder of the dummy variables added are statistically significant. The dummy for 2005 is dropped as in the absence of price data for 2003, its inclusion would bring about perfect collinearity in annual dummy variables thus not allowing for a relative comparison. 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 0242-S-GB and/or in times of relative scarcity of available installed capacity.

Price-Cost Mark-Up & RSI for Company 0242-S-GB (including a Scarcity and dummy variables)

```
Regression with robust standard errors                 Number of obs =   13176
                                                       F(  7, 13168) =  655.93
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2552
                                                       Root MSE      =  .39583

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |   -.386315   .0935408    -4.13   0.000    -.5696685   -.2029616
        Scar |  -.6104474   .0864496    -7.06   0.000    -.7799011   -.4409937
       d2004 |  -.0558908   .0074066    -7.55   0.000    -.0704087   -.0413728
       d2005 |  (dropped)
       dpeak |   .0006707   .0082797     0.08   0.935    -.0155587    .0169001
     dsummer |   .1012018   .0073233    13.82   0.000      .086847    .1155565
     dwinter |  -.1618322    .011239   -14.40   0.000    -.1838624   -.1398021
      dwkday |  -.1424565   .0086503   -16.47   0.000    -.1594124   -.1255006
       _cons |   1.159275   .0889883    13.03   0.000      .984845    1.333705
------------------------------------------------------------------------------
```

Price-Cost Mark-Up & RSI for Company 0453-S-GB (including a Scarcity variable)

Including the scarcity variable and using robust standard errors was also repeated for this next company. Differently, this time in the simple model it is the scarcity variable that is not significant and the RSI variable that is significant. The sensitivity of this is likely due to collinearity of scarcity with RSI. However, if collinearity were a significant problem, neither variable would be significant.

```
Regression with robust standard errors                Number of obs =   13176
                                                      F(  2, 13173) = 1309.10
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.2077
                                                      Root MSE      =  .40818

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C09 |  -.7907946   .1341926    -5.89   0.000    -1.053831   -.5277578
        Scar |  -.0954185   .1119876    -0.85   0.394    -.3149303    .1240932
       _cons |   1.257154   .1205367    10.43   0.000     1.020884    1.493423
```

The inclusion of annual, seasonal, weekday, and peak hours, dummy variables in the regression bring about a qualitatively different result in relation to the estimated coefficient on the RSI variable. It is statistically significant but has a positive sign indicating that outcomes in the market are negatively correlated with increases in the company's market power. Intuitively, this result appears unusual but nevertheless the estimated coefficient on scarcity is both statistically significant and of the expected sign while a number of the dummy variables similarly have estimated coefficients that do not appear consistent with our priors.

Price-Cost Mark-Up & RSI for Company 0453-S-GB (including a Scarcity and dummy variables)

Regression with robust standard errors

Number of obs	= 13176
F(7, 13168)	= 660.65
Prob > F	= 0.0000
R-squared	= 0.2550
Root MSE	= .39587

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C09	.6619443	.1865485	3.55	0.000	.2962824	1.027606
Scar	-1.525845	.1634077	-9.34	0.000	-1.846147	-1.205542
d2004	-.0666572	.0098167	-6.79	0.000	-.0858994	-.0474151
d2005	(dropped)					
dpeak	-.0044272	.0085085	-0.52	0.603	-.021105	.0122507
dsummer	.1083618	.0071989	15.05	0.000	.0942508	.1224727
dwinter	-.1595731	.0111404	-14.32	0.000	-.1814099	-.1377363
dwkday	-.1468064	.0086195	-17.03	0.000	-.1637019	-.1299109
_cons	.2514706	.1591419	1.58	0.114	-.0604704	.5634116

Price-Cost Mark-Up & RSI for Company 1340-S-GB (including a Scarcity variable)

Again a scarcity variable is included with the RSI for company 1340-S-GB as independent variables in the specified regression. The estimated coefficient on the scarcity variable is statistically significant and of the expected sign, while the estimated coefficient on the RSI variable is significant only at the 10% level but is of the expected sign.

Regression with robust standard errors

Number of obs	= 13176
F(2, 13173)	= 1300.19
Prob > F	= 0.0000
R-squared	= 0.2065
Root MSE	= .40849

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C15	-.2185876	.1337859	-1.63	0.102	-.4808273	.043652
Scar	-.5758195	.1179227	-4.88	0.000	-.8069651	-.3446739
_cons	.7598834	.1201554	6.32	0.000	.5243614	.9954053

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 and both variables are now statistically significant at 5% level. All of the other estimated coefficients, with the exception of the peak hour dummy variable, are statistically significant and are largely of the expected sign.

Price-Cost Mark-Up & RSI for Company 1340-S-GB (including a Scarcity and dummy variables)

Regression with robust standard errors

Number of obs	= 13176
F(7, 13168)	= 648.37
Prob > F	= 0.0000
R-squared	= 0.2549
Root MSE	= .3959

PCMup5	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
RSI_C15	-.5860178	.2125339	-2.76	0.006	-1.002615	-.1694208
Scar	-.422666	.1895559	-2.23	0.026	-.7942229	-.0511091
d2004	-.0594201	.0095867	-6.20	0.000	-.0782114	-.0406289
d2005	(dropped)					
dpeak	.0083333	.0083842	0.99	0.320	-.0081008	.0247675
dsummer	.1001023	.0077381	12.94	0.000	.0849346	.1152701
dwinter	-.1512426	.0107397	-14.08	0.000	-.1722939	-.1301912
dwkday	-.1453791	.0087119	-16.69	0.000	-.1624557	-.1283024
_cons	1.322567	.1930944	6.85	0.000	.9440744	1.70106

Price-Cost Mark-Up & RSI for Company 1477-S-GB (including a Scarcity variable)

The result of adding the scarcity variable to the simple regression of PCMU on the RSI of company 1477-S-GB is presented in the following regression. The estimated coefficients on both the scarcity and RSI variables are statistically significant, indicating the presence of two separate effects and not just that brought about by scarcity. However, the sign of the estimated coefficient on RSI variable is not in accordance with our priors. In light of the potential problem of omitted variable bias, this regression equation is re-specified to include a series of dummy variables, analogous to the approach previously adopted in relation to the other countries in the market.

```
Regression with robust standard errors                 Number of obs =   13176
                                                       F(  2, 13173) = 1573.27
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2131
                                                       Root MSE      =  .40678

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C18 |   1.334839   .0783715    17.03   0.000      1.18122    1.488459
        Scar |  -1.903332   .0663445   -28.69   0.000    -2.033377   -1.773287
       _cons |  -.5635535   .0695889    -8.10   0.000    -.6999577   -.4271493
```

The inclusion of annual, seasonal, weekday, and peak hours, dummy variables has a significant impact on the statistical significance of the RSI variable. Under this specification the estimated coefficient on the RSI variable is no longer statistically significant thus indicating that the effects observed previously in relation to this company and their perceived power to influence the price in the market in times of indispensability are now unlikely to be the case. The estimated coefficient on the scarcity variable is statistically significant and of the expected sign.

Price-Cost Mark-Up & RSI for Company 1477-S-GB (including a Scarcity and dummy variables)

```
Regression with robust standard errors                Number of obs =   13176
                                                      F(  7, 13168) =  665.85
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.2546
                                                      Root MSE      =  .39599

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C18 |   .0433226   .0929426     0.47   0.641    -.1388582    .2255035
        Scar |  -.9855075   .0769852   -12.80   0.000     -1.13641   -.8346054
       d2004 |   -.046243    .007189    -6.43   0.000    -.0603344   -.0321516
       d2005 |  (dropped)
       dpeak |   .0024774   .0082407     0.30   0.764    -.0136756    .0186304
     dsummer |   .1051703   .0086497    12.16   0.000     .0882156     .122125
     dwinter |  -.1525783   .0107181   -14.24   0.000    -.1735872   -.1315693
      dwkday |  -.1429123   .0086247   -16.57   0.000     -.159818   -.1260066
       _cons |   .7692485   .0880511     8.74   0.000     .5966557    .9418412
```

9.9.3 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 in many cases, 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 broad similarity of the results on the estimated coefficients on the RSI values for the largest companies in Great Britain 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 two of the 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 0242-S-GB and 1477-S-GB 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 dispatch, the under-utilisation of coal increases the PCMU while the over-utilisation of gas increases the PCMU.

Price-Cost Mark-Up & RSI for Companies 0242-S-GB and 1477-S-GB (including a Competition, a Scarcity, Withholding and dummy variables)

```
Regression with robust standard errors                Number of obs =   13176
                                                      F( 11, 13164) =  555.28
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.2980
                                                      Root MSE      =  .38434

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -3.211374   .1846482   -17.39   0.000    -3.573311   -2.849437
     RSI_C18 |  -2.272733   .1627043   -13.97   0.000    -2.591657   -1.953809
 RSI_C18_C04 |   1.538111   .0761332    20.20   0.000     1.388879    1.687344
        Scar |  -.3248961   .1466892    -2.21   0.027     -.612428   -.0373641
      C0_gas |   .0000222   3.86e-06     5.75   0.000     .0000146    .0000298
     C0_coal |  -8.19e-06   2.58e-06    -3.18   0.001    -.0000132   -3.14e-06
       d2004 |  -.0948248   .0092436   -10.26   0.000    -.1129437   -.0767059
       d2005 |  (dropped)
       dpeak |  -.0165038    .008294    -1.99   0.047    -.0327613   -.0002463
     dsummer |   .1093081   .0082372    13.27   0.000      .093162    .1254542
     dwinter |   -.220097   .0129813   -16.95   0.000    -.2455423   -.1946517
      dwkday |   -.186715   .0089301   -20.91   0.000    -.2042192   -.1692108
       _cons |   5.140984   .2822737    18.21   0.000     4.587686    5.694281
------------------------------------------------------------------------------
```

As a further sensitivity check on the results already presented another regression has been estimated which includes the RSI variables of all four of the largest companies in the British 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 & RSI for the 4 largest Companies (including a Scarcity and dummy variables)

```
Regression with robust standard errors                 Number of obs =   13176
                                                       F( 10, 13165) =  481.78
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.2561
                                                       Root MSE      =  .39562

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     RSI_C04 |  -.5184297   .1310514    -3.96   0.000    -.7753093   -.2615501
     RSI_C09 |   .2457587   .2455964     1.00   0.317    -.2356456     .727163
     RSI_C15 |  -1.047295   .2473132    -4.23   0.000    -1.532065   -.5625254
     RSI_C18 |  -.1299695    .134023    -0.97   0.332     -.392674    .1327349
        Scar |   .3412346   .5114863     0.67   0.505    -.6613522    1.343821
       d2004 |  -.0905093   .0125739    -7.20   0.000    -.1151559   -.0658627
       d2005 |  (dropped)
       dpeak |   .0079811   .0085701     0.93   0.352    -.0088175    .0247797
     dsummer |   .0926982   .0088151    10.52   0.000     .0754194     .109977
     dwinter |  -.1653333   .0114048   -14.50   0.000    -.1876884   -.1429782
      dwkday |  -.1481077   .0087961   -16.84   0.000    -.1653494    -.130866
       _cons |   2.107605   .5175524     4.07   0.000     1.093127    3.122082
------------------------------------------------------------------------------
```

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 two of the companies, 0242-S-GB and 1340-S-GB, are capable of independently affecting the PCMU in the market. This result is statistically significant and independent of the likely impact of scarcity given the estimated coefficient on this variable is not statistically significant. This is similarly the case for the estimated RSI coefficients for companies 0453-S-GB and 1477-S-GB.

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 estimated peak and off-peak coefficients on the RSI variables for companies 0242-S-GB and 1340-S-GB are independently statistically significant and of the expected sign. The estimated coefficients on the RSI variables of the two remaining companies are not statistically significant, with the exception of the off-peak RSI of company 1477-S-GB. The estimated coefficient on the scarcity variable is statistically significant but no of the expected sign. This coefficient on this variable predicts a reduction in the PCMU of the market at times of increasing tightness on the system. The estimated coefficients on the dummy variables are once again largely consistent over specifications, however one notices the estimated coefficient on the *dpeak* dummy variable is statistically significant and of the expected sign under this specification.

Peak and Off-Peak Analysis for the 4 largest Companies (including Scarcity and dummy variables)

```
Regression with robust standard errors               Number of obs =   13176
                                                      F( 14, 13161) =  499.87
                                                      Prob > F      =  0.0000
                                                      R-squared     =  0.2811
                                                      Root MSE      =  .38898

------------------------------------------------------------------------------
             |               Robust
      PCMup5 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   pk_RSI_C04 |  -1.196779   .1849775    -6.47   0.000    -1.559361    -.834196
  opk_RSI_C04 |  -.7868977   .1213557    -6.48   0.000    -1.024772    -.549023
   pk_RSI_C09 |  -.1136617   .2776605    -0.41   0.682    -.6579163    .4305929
  opk_RSI_C09 |  -.0938566   .2396294    -0.39   0.695    -.5635647    .3758515
   pk_RSI_C15 |  -1.553419   .2979706    -5.21   0.000    -2.137484   -.9693539
  opk_RSI_C15 |  -.7959601   .2298045    -3.46   0.001     -1.24641   -.3455102
   pk_RSI_C18 |  -.0898155   .1588228    -0.57   0.572    -.4011311       .2215
  opk_RSI_C18 |  -.4316095   .1336376    -3.23   0.001    -.6935584   -.1696606
         Scar |   1.295948   .5196902     2.49   0.013     .2772805    2.314616
        d2004 |  -.0964167   .0125537    -7.68   0.000    -.1210238   -.0718096
        d2005 |  (dropped)
        dpeak |   1.331428   .0643112    20.70   0.000     1.205369    1.457487
      dsummer |   .0837428   .0088071     9.51   0.000     .0664797    .1010059
      dwinter |  -.1653646   .0114219   -14.48   0.000    -.1877531   -.1429761
       dwkday |  -.1917968   .0092244   -20.79   0.000     -.209878   -.1737156
        _cons |   2.347223   .5173006     4.54   0.000     1.333239    3.361206
------------------------------------------------------------------------------
```

Overall the results of the regression analysis indicates that, in general, there is a significant statistical relationship between the RSI and outcome measures in the British electricity market, with company specific indispensability a factor in the resulting Price-Cost Mark-Ups observed in the market. This is particularly true for two companies in the British electricity market, 0242-S-GB and 1340-S-GB, the estimated coefficients for which were robust to a number of different specifications.

9.10 Withholding

The GED model of optimal system dispatch 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. 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.

Table 9.49 presents the total amount of installed capacity of the units modelled by GED for the optimal system dispatch by generation technology.

Table 9.49: Total Installed Capacity of modelled Units, by Technology – Great Britain

Gas	Coal	Nuclear	Pump storage	Other
26,175	28,997	12,517	1,045	19,578

Source: LE

Table 8.67 below present the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis, and the actual average MW differential between actual and modelled generation for company 0242-S-GB. The differential is very high in the case of nuclear generation and still considerable in the case of coal generation.

Table 9.50: Potential Withholding, by Technology, for 0242-S-GB, (Number of hours where modelled is greater than actual generation) – Great Britain					
	Gas	**Coal**	**Nuclear**	**Pump Storage**	**Other**
2003-05	0	9,817	26,110	0	0
% hrs<0	*0.0%*	*37.3%*	*99.3%*	*0.0%*	*0.0%*
2003	0	4,280	8,671	0	0
% hrs<0	*0.0%*	*48.9%*	*99.0%*	*0.0%*	*0.0%*
2004	0	3,518	8,680	0	0
% hrs<0	*0.0%*	*40.1%*	*98.8%*	*0.0%*	*0.0%*
2005	0	2,019	8,759	0	0
% hrs<0	*0.0%*	*23.0%*	*100.0%*	*0.0%*	*0.0%*
Source: LE					

Table 8.68 presents evidence of potential withholding for Company 0242-S-GB in MW.

Table 9.51: Potential Withholding, by Technology, for 0242-S-GB						
	Gas (MW)	**Coal (MW)**	**Nuclear (MW)**	**Pump Storage**	**Other (MW)**	**Total (MW)**
2003-05	0	102	-1288	0	0	-1186
2003	0	-99	-1082	0	0	-1181
2004	0	93	-1407	0	0	-1315
2005	0	312	-1374	0	0	-1062
Source: LE						

Table 9.52 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis. Company 0453-S-GB's coal and gas plants generated less than hour model predicted for up to three quarters of the time.

Table 9.52: Potential Withholding, by Technology, for 0453-S-GB, (Number of hours where modelled is greater than actual generation)					
	Gas	**Coal**	**Nuclear**	**Pump Storage**	**Other**
2003-05	20,055	15,268	0	0	4,806
% hrs<0	*76.2%*	*58.0%*	*0.0%*	*0.0%*	*18.3%*
2003	5,717	4,837	0	0	1,225
% hrs<0	*65.3%*	*55.2%*	*0.0%*	*0.0%*	*14.0%*
2004	6,051	5,455	0	0	1,817
% hrs<0	*68.9%*	*62.1%*	*0.0%*	*0.0%*	*20.7%*
2005	8,287	4,976	0	0	1,764
% hrs<0	*94.6%*	*56.8%*	*0.0%*	*0.0%*	*20.1%*
Source: LE					

Table 9.53 presents evidence of potential withholding for Company 0453-S-GB in MW.

Table 9.53: Potential Withholding, by Technology, for 0453-S-GB						
	Gas (MW)	**Coal (MW)**	**Nuclear (MW)**	**Pump Storage (MW)**	**Other (MW)**	**Total (MW)**
2003-05	-336	-206	0	0	3	-539
2003	-124	-113	0	0	4	-233
2004	-194	-346	0	0	6	-534
2005	-689	-159	0	0	-2	-851
Source: LE						

Table 9.54 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis. For company 1340-S-GB the differentials are comparatively small.

Table 9.54: Potential Withholding, by Technology, for 1340-S-GB, (Number of hours where modelled is greater than actual generation)					
	Gas	Coal	Nuclear	Pump Storage	Other
2003-05	9,274	8,462	0	0	442
% hrs<0	*35.3%*	*32.2%*	*0.0%*	*0.0%*	*1.7%*
2003	2,593	3,110	0	0	105
% hrs<0	*29.6%*	*35.5%*	*0.0%*	*0.0%*	*1.2%*
2004	4,041	2,320	0	0	83
% hrs<0	*46.0%*	*26.4%*	*0.0%*	*0.0%*	*0.9%*
2005	2,640	3,032	0	0	254
% hrs<0	*30.1%*	*34.6%*	*0.0%*	*0.0%*	*2.9%*
Source: LE					

Table 9.55 presents evidence of potential withholding for Company 1340-S-GB in MW.

Table 9.55: Potential Withholding, by Technology, for 1340-S-GB						
	Gas (MW)	Coal (MW)	Nuclear (MW)	Pump Storage (MW)	Other (MW)	Total (MW)
2003-05	422	506	0	0	17	945
2003	595	562	0	0	15	1173
2004	328	648	0	0	6	981
2005	344	306	0	0	31	681
Source: LE						

Table 9.56 presents the number of hours and the percentage of time that modelled generation exceeded actual generation, on an hourly basis for company 1477-S-GB. Again, the difference between modelled generation and the generation reported by the company is considerable, albeit lower than for some of the other companies.

Table 9.56: Potential Withholding, by Technology, for 1477-S-GB, (Number of hours where modelled is greater than actual generation)					
	Gas	**Coal**	**Nuclear**	**Pump Storage**	**Other**
2003-05	9,534	1,352	0	4,248	10,140
% hrs<0	*36.2%*	*5.1%*	*0.0%*	*16.1%*	*38.5%*
2003	1,974	0	0	1,332	2,859
% hrs<0	*22.5%*	*0.0%*	*0.0%*	*15.2%*	*32.6%*
2004	2,247	1,153	0	1,412	3,767
% hrs<0	*25.6%*	*13.1%*	*0.0%*	*16.1%*	*42.9%*
2005	5,313	199	0	1,504	3,514
% hrs<0	*60.7%*	*2.3%*	*0.0%*	*17.2%*	*40.1%*
Source: LE					

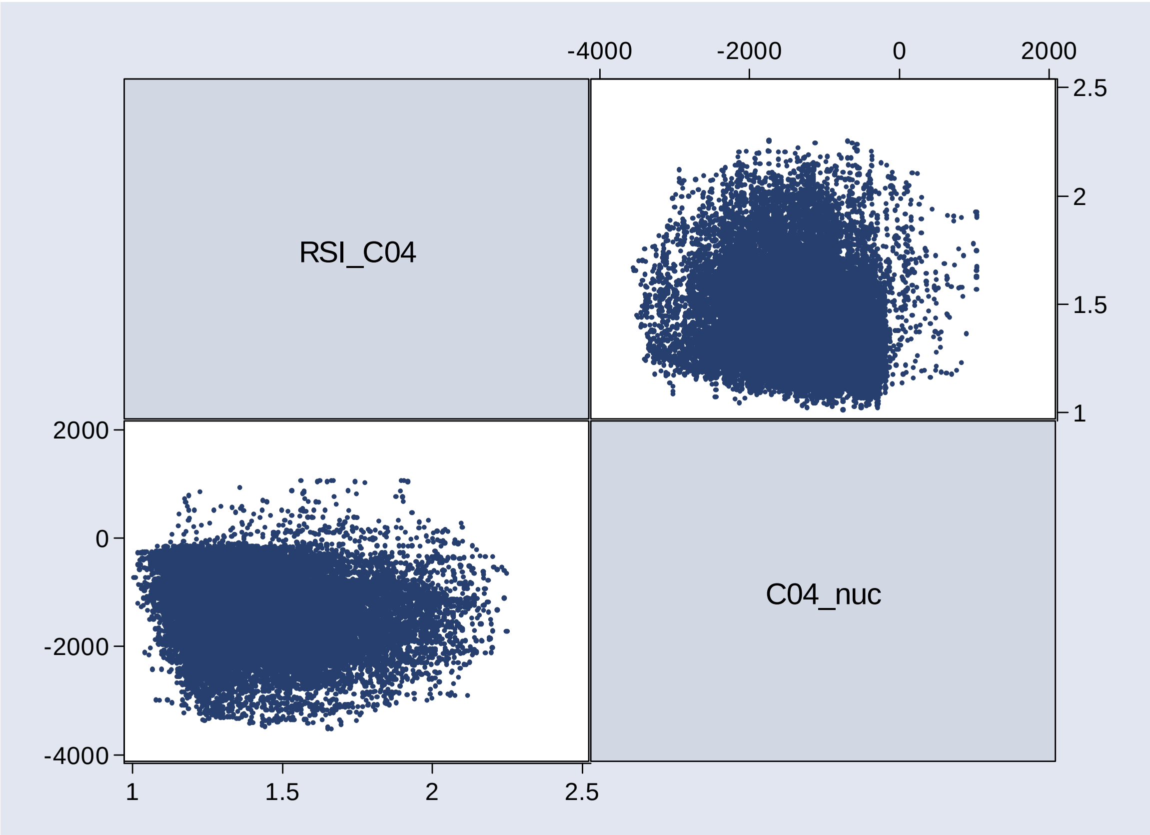
Table 9.57 presents evidence of potential withholding for Company 1477-S-GB in MW.

Table 9.57: Potential Withholding, by Technology, for 1477-S-GB						
	Gas (MW)	**Coal (MW)**	**Nuclear (MW)**	**Pump Storage (MW)**	**Other (MW)**	**Total (MW)**
2003-05	269	515	0	5	16	805
2003	485	0	0	11	15	511
2004	418	119	0	6	16	559
2005	-96	1427	0	-2	17	1346
Source: LE						

Analysis of Company 0242-S-GB and Withholding

The figure below shows a graphical depiction of withholding by company 04 for the nuclear technology. It is not apparent that any particular trend emerges from this graphical analysis.

Figure 9.28: Comparison of the use of nuclear technology and the hourly RSI of Company 0242-S-GB

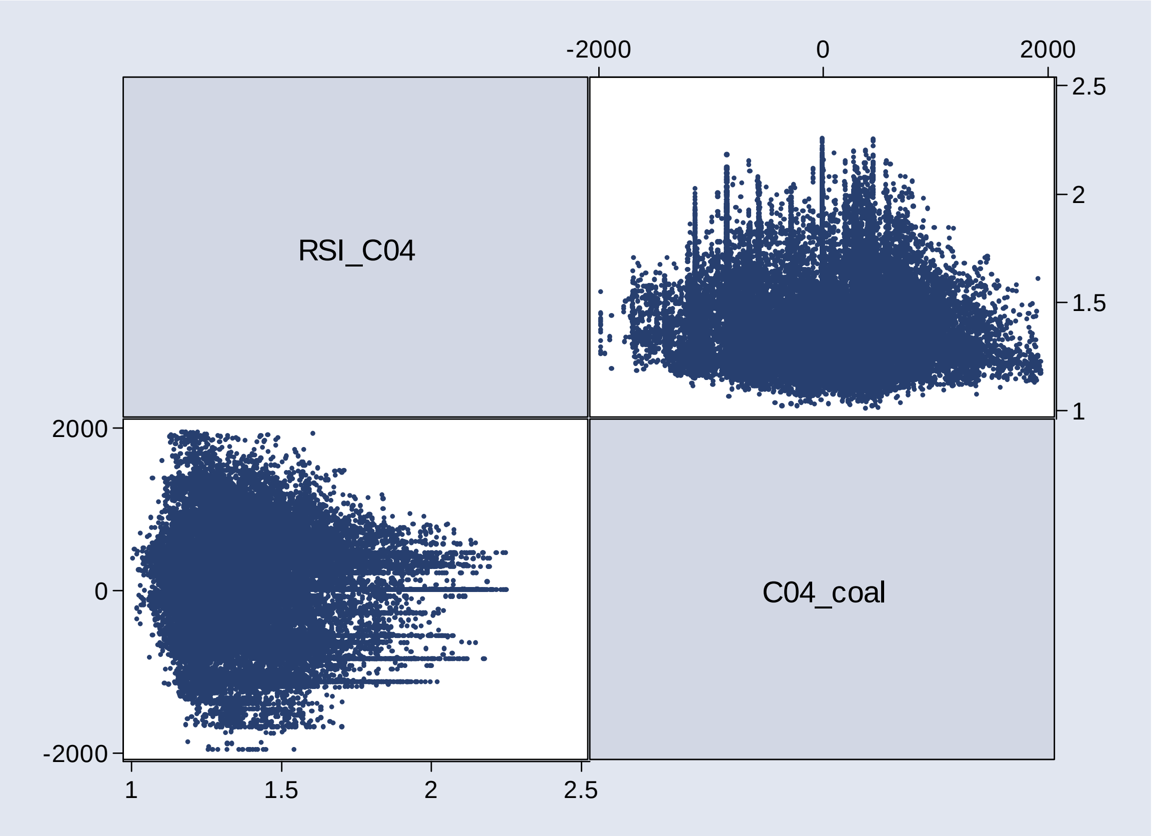


Source: LE.

Comparison of the use of coal fired technology and the hourly RSI of Company 0242-S-GB

Coal fired technology is similarly presented in the figure below. Again a trend does not appear obviously from the graphical depiction.

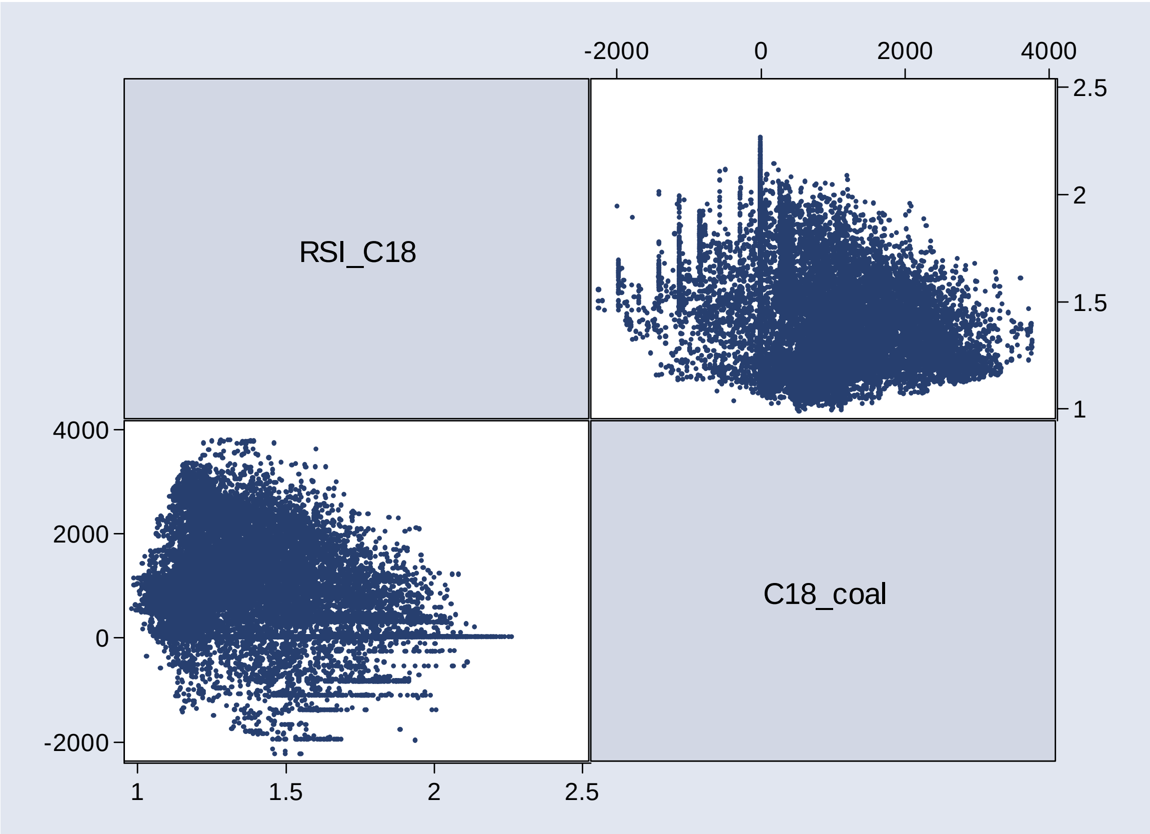
Figure 9.29: ***Comparison of the use of coal fired technology and the hourly RSI of Company 0242-S-GB***



Source: LE.

Comparison of the use of coal technology and the hourly RSI of Company 1477-S-GB

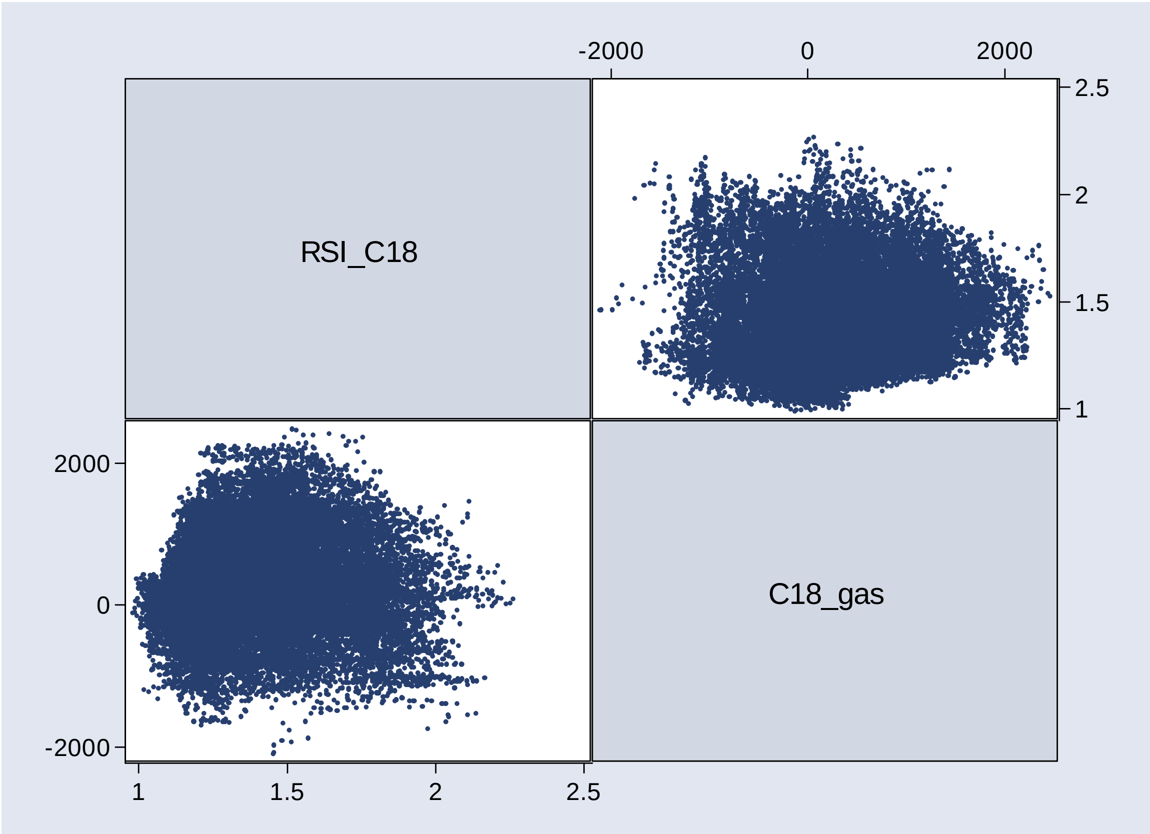
Figure 9.30: Comparison of the Use of Coal Technology and the hourly RSI of 1477-S-GB



Source: LE.

Comparison of the use of gas technology and the hourly RSI of Company 1477-S-GB

Figure 9.31: Comparison of the Use of Gas Technology and the hourly RSI of 1477-S-GB



Source

The graphical depictions of the 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.

9.11 Conclusions

In conclusion, the British market was in general found to be borderline unconcentrated and the market structure was found to be generally conducive to competitive outcomes using the RSI and PSI threshold analysis.

Market structure as measured by traditional concentration measures ranges from unconcentrated to borderline moderately concentrated. Based on available capacity, the HHI for Great Britain was found to be 1,072 on average through the sample period, and the CR(2) was found to be 31.2%. Allocating the interconnectors led to a range from 1,004 to 1,189 for HHI and 31.6% to 36.8% for CR(2)[23].

We note that threshold values such as 1800 for the HHI and 33% for CR(*n*) are somewhat arbitrary.

The electricity-specific measures of market structure confirmed the qualitative conclusions of the HHI and CR(2) for the British market. In general, the largest companies' RSIs passed the proposed screening test with RSI>110% more than 95% of hours. Similar results were found for the PSI in Britain, with PSI finding no single company was pivotal often in more than 7 hours out of a total of 26,304.

[23] There are variations in the 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.

Price cost margins in Great Britain were lower than in other countries, with an average price cost margin over the full sample period of 21.5%for the LI and 27.5%, and 30.7% price-cost mark-up (using UKPX prices 2004-05) and for the price cost mark-up using Platts prices.[24] There was some variation over time with 2004 showing some low margins relative to 2005, with PCMU respectively at 3.8% and 41.9% (UKPX data). However, it is important for one to assess the 2005 figure in context, wherein the market in the UK displayed very high prices for gas, particularly nearing the end of this period. In so far as our approach cannot capture the potential for market players to sell back gas to the market during this period, there is a possibility that the market outcome figures presented overstate the true market outcome.

Relating the RSI to the price cost margins via regression analysis for the British market showed similar results as to other countries. 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 British 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.

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 Great Britain 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.

[24] Based on Platts assessment price 2003-05. UKPX prices were not available for the full period.

Estimates of withholding were significant in British market. 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 Great Britain are that the British market seems borderline unconcentrated by both traditional and new electricity-specific market structure measures. In spite of its unconcentrated structure, price cost margins (LI and PCMU) were significantly related to market structure. 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.