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Final Report

Department of Trade and Industry
Research project on “The Case for Liberalisation”

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10 January 2006

Research project for the Department of Trade and Industry on "The Case for Liberalisation"

Dear Ms Allas,

In accordance with our engagement letter dated 7 October 2005, we enclose our report in relation to the analysis of "the case for liberalisation". Our report focuses on a quantitative and qualitative analysis of energy market liberalisation in Europe, focusing on an evaluation of the key issues arising from the liberalisation process and whether liberalisation is working.

Scope of our work

This scope sets out our understanding, based on discussions with you, of your objectives, the issues that are relevant to those objectives and the work we have agreed to perform. These Services are based on your Terms of Reference dated 1 September 2005.

In undertaking our work we have based our analysis and views on publicly available information, that provided to us by the Department of Trade and Industry (DTI) and our own information sources. The scope of our work has focused on three areas:

1. An examination of the broad benefits of liberalisation. We have presented a discussion of the theoretical arguments for moving from monopolistic to competitive markets, and the benefits that, in theory and practice, can be derived from such a movement to a liberalised market.
2. Detailed analysis of five topics, which are frequently cited as challenges to the case for liberalisation. These five topics are:
   a. Does liberalisation lower prices?
   b. Do liberalised markets drive volatility, is this necessary?
   c. Do liberalised markets deliver investment?
   d. Does liberalisation deliver reliable and secure energy supplies?
   e. How do liberalised markets effectively interact with other aspects of public policy?

   In each case, we have gathered relevant statistical evidence, including consumer prices, spot market prices, production and technology costs, energy consumption, income and investment data, and have performed (as far as possible) statistical analysis to evaluate the linkages in each case between the data. Where robust statistical data is not available, we have relied on case studies to demonstrate linkages.

   In the case of examining prices (topics a and b) we have performed regression and other descriptive statistical analysis to examine the relationship between market opening and prices. The details and formulation of the analysis are presented in the report and also in Annex A.

   In the case of investment (topic c) we have prepared case studies on four European markets to determine whether investment has followed market signals in an orderly fashion. This analysis has focused on electricity where sufficient evidence is available. It has not been undertaken for gas. The formulation of the data is presented in the report.

   In the case of reliability and security of supply (topic d), we have presented data on interruptions, plant availability and also on fuel diversity. The examination of fuel diversity is based on statistical analysis, other data is presented from alternate sources with interpretation.

Finally, in terms of public policies (topic e), we have presented data on emissions of SO_2 and NOx, energy intensity and proportions of income spent on energy. This is reporting other analysis with interpretation.

3. A review of transitional issues. In this review we have considered the importance of transitional issues which face the energy sectors in moving to a liberalised market. These are issues which while important, are not fundamental beyond the initial phases of market opening. The transitional issues we have examined include:
   a. Stranded costs;
   b. Unemployment;
   c. The demise of small companies and the emergence of a small number of "European Champions";
   d. Short term rises in prices (particularly where prices are supported or subsidised); and
   e. Cost-efficiency of liberalisation.

   In each case we have outlined the nature of the issue, and presented a discussion of evolution. This evolution is backed up where possible with data and information, much of which is used elsewhere in the report to assess other challenges.

For the analysis within the above areas, the focus is on industrial and commercial customers only.

Purpose of our report and restrictions on its use

The Report has been prepared on the specific instructions of the DTI. It is our understanding that the DTI wishes to use the Report as an independent assessment of the Case for Liberalisation. The Report should not be relied upon for any other purpose.

It is important to recognise that our work is limited to the scope described herein and has been carried out over a limited period of time, and is based on publicly available industry data, information supplied by the DTI, and Ernst & Young proprietary information. It is possible that the Report, which does not constitute an audit, may not reveal all those matters which would have been identified by a full scope report. As a consequence, further and analysis will be required prior to relying on the information in the Report.

Although we consent to the publication of parts of the Report we would wish to review what is intended to be published and in any event it is for the DTI to ensure that an appropriate disclaimer is included in any publication which makes it clear that in carrying out our work and preparing the Report, we have worked solely on the instructions of the DTI and for the DTI's purposes. Also our Report may not have considered issues relevant to any third parties. Any use such third parties may choose to make of our Report or extracts from it is entirely at their own risk and we shall have no responsibility whatsoever in relation to any such use.

Structure of report

The report is structured as follows: Section 1 is the executive summary, Section 2 contains an introduction to the report, Section 3 presents our discussion of the broad benefits of liberalisation. Sections 4 to 8 presents our analysis and findings for each of the five frequently cited challenges to liberalisation. Section 9 provides the assessment of transitional issues. Section 10 presents our conclusions.

Yours faithfully

Ernst & Young LLP

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Disclaimer

The Report was prepared solely for the use of the Department of Trade and Industry and addressed issues specific to them. Accordingly, we may not have addressed issues of relevance to any other party. Further, the Report was concluded on 10 January 2006, and we have not undertaken any further work since that time. Material events may therefore have occurred which will not be reflected in the Report. The analysis has been based on information provided by the DTI and on other publicly available sources.

Whilst we are prepared to provide access to the Report, it is only on the basis that it is acknowledged and agree that

1. Ernst & Young LLP (including its partners, employees, agents, subcontractors and employees of its wholly owned company, Ernst & Young Services Limited) accepts no responsibility and shall have no liability in contract, tort or otherwise to you or any other third party in relation to the contents of the Report,

2. any use you make of the Report, is entirely at your own risk,

3. the terms of this disclaimer shall be governed by and construed in accordance with English law and any dispute regarding these terms shall be subject to the exclusive jurisdiction of the English courts.

1. Executive summary

In this report on our research project for the Department of Trade and Industry (DTI) we explore the benefits of liberalisation and also examine the basis for five frequently cited challenges.

The case for liberalisation is a strong one, both theoretically and practically. The evidence suggests that the benefits outweigh the costs and that some of the frequently cited challenges to liberalisation may be overstated.

In undertaking our work, we have based our analysis and views on publicly available information that was provided to us by the Department of Trade and Industry (DTI) and our own information sources. We have performed statistical analysis relying on regression techniques and descriptive statistics. This statistical analysis has been backed up by case studies. The scope of our work has focused on three areas:

1. An examination of the broad benefits of liberalisation.
2. Detailed analysis of five topics, which are frequently cited as challenges to the case for liberalisation. These five topics are:
    a. Does liberalisation lower prices?
    b. Are liberalised markets more volatile?
    c. Do liberalised markets deliver investment?
    d. Does liberalisation deliver reliable and secure energy supplies?
    e. How do liberalised markets effectively interact with other aspects of public policy?
3. A review of transitional issues. The transitional issues we have examined include:
    a. Stranded costs
    b. Unemployment
    c. The demise of small companies and the emergence of a small number of "European Champions"
    d. Short term rises in prices (particularly where prices used to be supported or subsidised)
    e. Cost-efficiency of liberalisation

Our analysis has focused on industrial and commercial customers for reasons of data availability, completeness and consistency.

1.1. Does liberalisation lower prices?

The report has shown that there are two elements to the analysis of whether liberalisation lowers prices. The first is whether competition per se reduces prices and the second is whether competitive tensions in energy markets provide incentive to reduce the cost base and drive lower margins.

Overall, the report has found a number of statistically significant relationships between indicators of competition and prices. These demonstrate a statistical linkage between increasing competition and both lowering prices and lowering costs and margins.

1.1.1. Does Liberalisation Lower Prices?

The analysis performed in the report has focused on electricity and gas prices for small and average industrial and commercial customers for electricity and for small, average and large industrial and commercial gas customers. The study has been conducted using regression analysis, which investigates the relationship between prices (the dependant variable) and a range of competition indicators (the independent variables).

The competition indicators that have been used are:

1. The degree of market opening (ie: the proportion of the electricity and gas markets that are open for customers to choose supplier)
2. The percentage of market not covered by the three largest companies (for both electricity and gas)
3. The unbundling of a market in the case of gas (particularly the presence of a Transmission System Operator (TSO) for gas)

Further analysis has been completed based on a composite indicator of competition combining the above indicators.

The key conclusions for electricity are that:

- Electricity prices are lower under liberalisation.
  - The price of electricity falls by 0.035€/kWh for every unit increase in the competition indicator. This is equivalent to a 0.1€/kWh reduction from no liberalisation to full liberalisation
  - The elasticity of price (which is a measure of the responsiveness of prices to changes in the degree of competition) with respect to the competition indicator is between –0.21 and –0.25. This means that for every one per cent change in the competition indicator, prices reduce between 0.21 and 0.25 per cent.
- Correlation does not necessarily imply causation and the statistical results, after rough control for external events and the internal resource endowment of countries, are difficult to interpret. But these results still show a strongly significant association between liberalisation and falling prices.

The key conclusions for gas are that:

- Gas prices are lower under liberalisation.
  - The price of gas falls by approximately 0.8€/GJ from no liberalisation to full liberalisation
  - There is a strong correlation or linkage between border and consumer prices and the degree of liberalisation, particularly unbundling and the creation of an independent TSO
  - Where the TSO is unbundled, prices in all groups have fallen with the price difference being estimated at around 15% for data points with and without TSO unbundling.

1.1.2. Does liberalisation lower costs and margins?

A competitive market creates a strong incentive to reduce costs. The analysis performed in this report has focused on four aspects of reducing costs and margins, which are:

1. The cost of comparable equipment under competitive procurement
2. Plant utilisation
3. Reserve margin
4. Labour productivity

The report further undertakes an analysis of margins, using spark spreads (the difference between the cost of gas and the price of electricity) as an approximation.

The report finds that:

- There has been a strong decline in the cost of new electricity generation plant over the period of liberalisation. The decline in technology costs for Combined Cycle Gas Turbines (CCGTs) has been around 40% in the UK between 1990 and 2005; this has been concurrent with technological advances, improving generation efficiency.
- There has been an improvement in plant utilisation through liberalisation. The analysis shows an improvement in utilisation of approximately 0.1% per year for the EU 15 between 1990 and 2003 which also covers the period of increasing liberalisation and coincides with the implementation of the Electricity Directive.
- There has been a reduction in reserve margin. The analysis shows a reduction in reserve margin of 1.5% per year from 1990 to 2003[1]. This is partly a consequence of a more efficient use of resources under liberalisation.
- There has been an improvement in labour productivity. Analysis performed by the European Commission shows an improvement in utility labour productivity of around 5.9% per year on average in the EU 15 between 1995 and 2001. This is also the period of increasing liberalisation and coincides with the implementation of the Electricity Directive.

With regards to a reduction in profit margins, the report finds that:

- Competition has delivered a reduction in spark spread, which in this report has been used as an indicator of reducing margins.
- There is good circumstantial evidence for an association between competition and a reduction in margins.

1.2. Do liberalised markets increase price volatility?

The report has found that price volatility has reduced over time, with no suggestion of linkage between spot market volatility and consumer prices (except potentially for the largest of consumers). These findings however, need to be viewed against the backdrop of limited data availability.

[1] The number of data points is limited after 1997.

Overall the findings are that:

- Liberalisation, through the establishment of wholesale markets, is attendant with the creation of volatility.
- Volatility is a necessary facet of liberalisation and essential for incentivising investment.
- Long-term movements appear to follow border prices closely.
- In electricity the volatility on wholesale markets appears to be decreasing with time, possibly as a consequence of greater familiarity with the functions of wholesale markets.
- Relative volatility is lower in gas than electricity markets.

1.3. Does liberalisation inhibit investment?

The report has shown that investment levels have been maintained in liberalised markets (when compared to non-liberalised). The report has used four case studies for the UK, Spain, France and Germany for electricity only.

Overall, the findings are that:

- The market has broadly responded to price signals (and capacity margins indicators) providing appropriate levels of investment.
- There are instances where market incentives have been inhibited by regulation or government policy which have had unintended consequences, eg Spain.

Some caution is sensible when interpreting the findings as data are quite scarce and have been used over a relatively short period of time.

1.4. Do liberalised markets provide reliable and secure supply?

The report has shown that reliability and security of supply have not deteriorated and indeed have improved marginally during liberalisation. The report has looked at evidence for reliability in measures of outages for electricity networks, as well as measures of diversity (in both electricity and gas supply) and gas storage.

The conclusions of this analysis are that:

- There is no evidence to suggest that the quality and continuity of electricity supply have fallen since liberalisation.
- Reliability in generation is apparently provided through investment induced by price excursions on the wholesale and balancing markets.
- The maintenance of standards of reliability in generation has been achieved with falling reserve margins as a consequence of higher utilisation of plant and better interconnection.
- There has been a strong association between liberalisation and diversity over the recent past. There are also theoretical reasons to believe that markets will produce diversity. This is not to state that liberalised energy markets will always produce diverse solutions, but it does show that liberalised markets are certainly not inhibiting diversity.

Quality of supply on electricity networks is essentially a consequence of operational controls and can be achieved in either an administered or liberalised market structure.

1.5. Do liberalised markets effectively interact with other public policies?

The report has shown that liberalised markets can perpetuate other public policies and indeed increase the efficiency of implementation. The report has looked at evidence regarding costs of energy as a proportion of incomes (as an indicator of social policy), reductions in energy intensity in the economy (as an indicator of industrial policy) and environmental emissions.

The report has found that:

- Social policies are maintained with liberalisation. As liberalisation encourages lower prices and as incomes in the EU rise, the proportion of income spent on energy has fallen.
- Industrial policies are maintained by liberalisation. We have found some evidence of a reduction in energy intensity through efficiency and energy conservation. However there are important structural changes to the economy to consider, particularly the change towards a service-based economy with lower energy intensity.
- The costs of compliance for environmental legislation have been reduced in liberalised markets. Analysis suggests that earlier assessments of complying with emissions standards may have been over-estimated by 600%, implying competitive business has found a lower cost solution.

1.6. Transitional issues

The report has considered transitional issues with regards to liberalising markets. Transitional issues have been considered as those issues that have a measurable but short term impact as part of the liberalisation process. Under transitional issues we have considered:

- Stranded costs
- Unemployment
- The demise of small companies and the emergence of a small number of "European Champions"
- Short term rises in prices (particularly where prices are supported or subsidised)
- Cost-efficiency of liberalisation

Under each of these issues, the following conclusions have been drawn:

- That stranded costs are inevitable in some markets and are important in smoothing transition to a liberalised market in gaining industrial support for a political process. The critical issue is in ensuring how these costs are compensated and that compensation is designed to work with liberalised markets.
- Unemployment has occurred as part of the liberalisation process, however it has been limited and has not been achieved (generally) through compulsory redundancies. Overall employment in the EU has risen over the period and it is likely that those leaving the energy

industry have found gainful employment and added to overall economic growth (due to a rise in productivity).

- There has been a rise in the number of national and multinational champions. This is however an indirect consequence of liberalisation as this is more to do with ownership rather than liberalisation and is a matter for competition policy.
- There have been price rises during and in advance of liberalisation particularly in the Accession countries. This is a consequence of the ending of subsidies.
- There have been some considerable costs incurred in the liberalisation of energy markets. In the UK alone these amount to close to £1 billion. However, when calculated per customer, the costs are quite low and when compared to the benefits, particularly lower prices, the costs are easily justified.

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2. Introduction

This report has been prepared by Ernst & Young LLP, consequent to our analysis as part of the research project on "*the case for liberalisation*". The report contains our research, and quantitative and qualitative findings.

The case for liberalisation is a strong one, both theoretically and practically. The evidence suggests that the benefits of liberalisation outweigh the costs, and indeed that some of the frequently stated challenges to liberalisation may be overstated. In this report we explore the benefits of liberalisation and examine the basis for challenges.

2.1. Scope and overview of our approach

This scope sets out our understanding, based on discussions with you, of your objectives, the issues that are relevant to those objectives and the work we have agreed to perform. These Services are based on your Terms of Reference dated 1 September 2005.

In undertaking our work, we have based our analysis and views on publicly available information that was provided to us by the Department of Trade and Industry (DTI) and our own information sources. The focus of the analysis is on industrial and commercial customers only and the scope of our work has focused on three areas:

1. An examination of the broad benefits of liberalisation. We have presented the benefits that, in theory and practice, can be derived from moving from a monopolistic to a liberalised market setting.
2. Detailed analysis of five topics, which are frequently cited as challenges to the case for liberalisation. These five topics are:
    a. Does liberalisation lower prices?
    b. Are liberalised markets more volatile?
    c. Do liberalised markets deliver investment?
    d. Does liberalisation deliver reliable and secure energy supplies?
    e. How do liberalised markets interact with other aspects of public policy?

    In each case, we have gathered relevant statistical evidence (i.e. industrial and commercial (I&C) consumer prices, spot market prices, production and technology costs, energy consumption, income and investment data) and have performed (as far as possible) statistical analysis to evaluate the linkages between each case and the data the data. Where robust statistical data is not available, we have relied on case studies to demonstrate relationships.
3. A review of transitional issues. These issues are important but not fundamental beyond the initial phases of market opening. The transitional issues we have examined include:
    a. Stranded costs;
    b. Unemployment;

c. The demise of small companies and the emergence of "European Champions";

d. Short term rises in prices (due to the fact that prices were supported or subsidised); and

e. Cost-efficiency of liberalisation.

In each case we have outlined the nature of the issue, and presented a discussion of evolution. This evolution is backed up where possible with data and information, much of which is used elsewhere in the report to assess other challenges.

2.2. Limitations

The findings of this report reflect the data that are available. However, there are a number of limitations that should be considered when reading this report. We raise particular limitations where appropriate in the text, but overall, it is important to bear in mind the following:

- The availability and completeness of publicly available data. Data in some countries covers the period from the early 1990s to 2005. However in some countries, the data sets either do not cover the period, or only contain points over the period.
- The consistency of data. Some of the measures that we have used in our analysis have not been consistently gathered or have been re-defined over time. This is particularly the case for indicators of competition.
- The definitions of data. Some of the data appears to be on the same basis but may not have been gathered on a comparable basis. This is relevant for spot market prices which reflect local market circumstance, and which also have different contracts which under-pin the prices, eg time of delivery etc, and on some elements of contracts, eg settlement and force majure. There is a degree of commonality in these contract terms, but they are not always wholly consistent.
- The analysis showing correlation does not always show causation. Much of the analysis that we have conducted has been done using regression analysis. This type of analysis is good at determining and estimating relationships and testing hypotheses, however, it is important to remember that correlation does not mean causation. With the limitations of data, it has not always been possible to say that factor x has directly contributed to lower prices.

2.3. Report Structure

The remainder of this report is structured as follows:

- Section 3 presents the theoretical basis of liberalisation in energy markets;
- Sections 4 to 8 examine each of the five frequently posed challenges;
- Section 9 presents our assessment of transitional issues; and
- Section 10 presents our conclusions.

3. The benefits of liberalisation

Historically, gas and electricity companies developed in local and profitable centres of demand and then expanded outwards, generally with concessions to protect them against the perceived threats of competition. After the Second World War they were consolidated and often nationalised on the grounds that it was necessary to create large entities that could fully exploit economies of scale in generating technology and that were capable of funding the high voltage national grids.

This process created the classic utility. Large, vertically integrated entities that enjoyed monopoly rights from generation to supply which could create monopoly rents, which could be passed onto consumers albeit within politically acceptable limits.

European energy markets have undergone considerable change through liberalisation in the last decade, albeit the pace and direction of change is not homogenous. During the process of liberalisation, regional/national monopolies have been dismantled through a process of unbundling - the competitive parts of the electricity and gas sectors (generation and supply) have been separated from the natural monopoly business, namely the transmission and distribution networks. The natural monopolies are then regulated and generation and supply have been assumed under a competitive environment.

Evidence from the European Commission and other institutions have demonstrated clear benefits from liberalisation, and this report further reinforces these claims.

This section presents an initial discussion of the benefits of liberalisation in energy markets, focusing on:

- Definitions of liberalisation, competition and privatisation;
- The process of price-formation under monopoly and competitive market structures
- The case put forward by the European Commission with regards to energy market liberalisation; and
- A reconciliation of the theory and the case with some preliminary indicators of successes.

3.1. Liberalisation, competition and privatisation

The three terms of liberalisation, competition and privatisation are frequently confused. The definitions that we will use in this report are as follows:

- Liberalisation refers to the creation of an industrial structure wherein competitive forces can work and to the adoption of processes to ensure that a competitive ethos can be fostered. The key elements of liberalisation are:
  - The separation of business functions into production/generation, transmission, distribution and supply;
  - The enabling of fairly priced third party access to networks for production, energy transportation and for competition to supply customers;

  - Fostering of competition where it is possible (e.g. generation and supply); and
  - Effective regulation of businesses where competition is not possible (e.g. transmission and distribution).

- Competition refers to a market structure where consumers have choice and therefore economic power. This means that the participants in that market are obliged to respond to the needs of consumers in terms of price and quality of service.
- Privatisation refers to ownership; for nationalised industries, privatisation means the vesting of state-owned entities into private companies. The European Commission has no power to change ownership and there is no requirement for privatisation under the Directives. Privatisation has occurred in some countries along with liberalisation, because although privatisation is not a prerequisite for liberalisation, there is a common logic. A liberal and competitive market depends on the effectiveness of shareholder return as a driver of efficiency and the state is not always a demanding shareholder. Also, the tendency to move assets into private hands has been assisted by concerns over state-aid and competition law, and the increasing burden placed on public finances by ongoing energy market investment requirements.

With these definitions in mind, we now consider the underlying theory of monopolistic and competitive markets, and show why the consumer will (and does already) benefit from liberalisation.

3.2. The Theory of Monopolies

Monopolistic markets are characterised by a structure in which one entity supplies an entire market. These markets can be national or regional, and for a good or service that has limited or no substitutes.

3.2.1. Price formation by monopolies

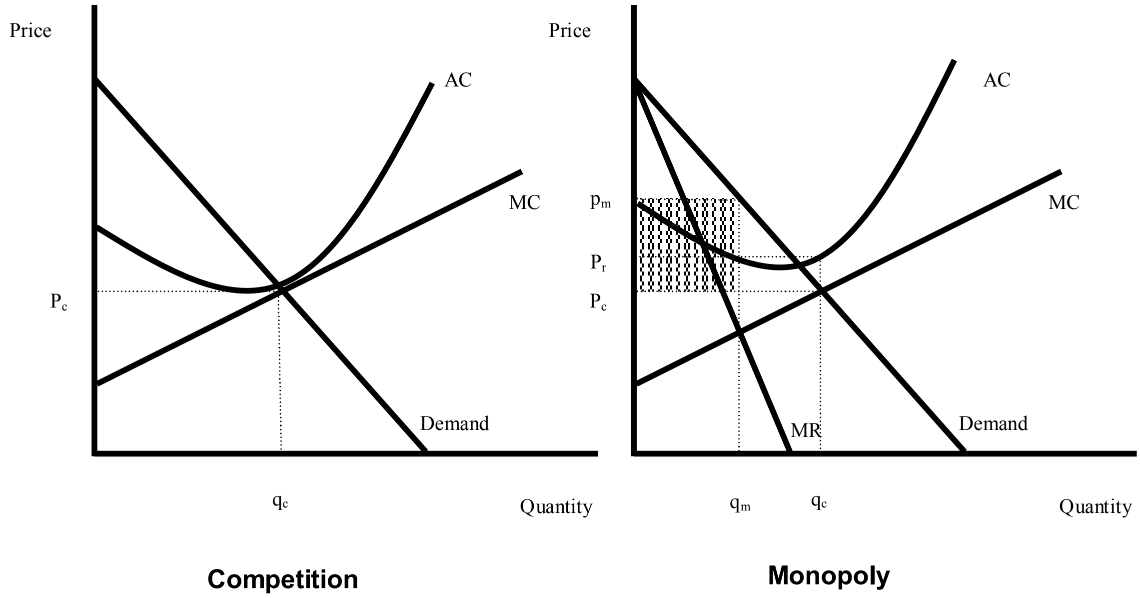
Left unconstrained, monopolists select a price that maximises their profit. This is achieved by producing up to the point where the extra revenue obtained from selling a unit of output is equal to the extra cost of producing that last unit of output. This is different from a situation under a competitive market. While the same is true of competitive markets the way of deriving the extra revenue is different, and, in most cases where markets are unregulated, results in monopolists charging higher prices.

Figure 3.1 presents the situation under the two different market models. Under a competitive structure, price and quantity is determined based on the willingness to pay for a good or service. Willingness to pay is represented by the demand curve which also presents the extra revenue obtained from selling an extra unit of output. Competitive businesses will produce where their costs of producing an extra unit of output (Marginal Cost, or MC) is equal to price. This gives us an output quantity of q_c and a price of p_c.

A monopolist will produce where the cost of producing an extra unit of output is equal to the revenue received from that extra unit of output (Marginal Revenue, or MR). This gives an output quantity of q_m and a price of p_m. We know that the curve MR descends faster than the demand curve because the marginal revenue achieved by the monopoly producer is equal to the willingness to pay at that production level less the fall in the margin on the other products that were sold at a slightly higher price before the marginal increment of output was made.

It is evident that a monopoly will restrict volume (ie it will produce at the point where marginal revenue equals marginal cost) and will price the output above the average cost because it can. This conduct leads to the creation of a monopoly rent (i.e. a difference between the cost of output and the price). This is the extra profit and is shown by the shaded area. It is inefficient because potential productive consumption is deterred.

Figure 3.1 – Theoretical derivation of prices under competition and monopoly



3.2.2. The case of the natural monopoly

Natural monopolies usually occur where for technical or social reasons there cannot be more than one efficient provider or a good or service. This is the case for Transmission and Distribution where it is not efficient to replicate networks. Natural monopolies are identical to the form of monopoly presented in Figure 3.1, however because moving to a competitive market is not possible regulation seeks to control rents. Under natural monopoly it is frequently the case the at the competitive market equilibrium (the point denoted at p_c q_c) a natural monopoly would make negative profits average costs are above marginal cost therefore is loss making. This results in two options, firstly to set prices based on average costs (allowing costs to be covered for a business – defined in the Figure as AC) or secondly to subsidise energy production and delivery (which may not be desirable) by forcing the operator to price at MC, and usually results in inefficient decisions

Figure 3.1 demonstrates the impact of this form of regulation. In Figure 3.1, we have set the quantity to be produced at q_c, and can see (using the average cost curve, or AC) that this equates to a price of p_r. This price is above the competitive position, but below the monopolist's position to maximise profit. It is important to note that the Average Cost will also reduce under competition.

This discussion confirms the first order disadvantage of monopolies as compared to competitive markets: irrespective of whether prices are determined by pure monopoly or regulated monopoly, prices remain higher than in a competitive market.

3.2.3. Efficiency

Monopolists have little incentive to reduce operating costs or invest efficiently in equipment to meet demands. As they are not subject to competition they can pass costs directly through to (captive) customers with little loss of revenue. Rate-of-return regulation (ie RPI-X regulation, where the X is an adjustment to reflect the rate of return on capital) on the capital asset base may also create an incentive not to select low cost supply options, but to potentially over-invest and "gold-plate" investments. Good regulation will monitor the company to try to ensure this does not happen, but the subject of the pitfalls of regulation is not the object of this report.

3.3. The Theory of Competitive Markets

Liberalisation implies the opening to competition of the generation and supply sectors. A competitive market is characterised by a certain number of firms are price-takers, i.e. they do not exercise market power. Again, it is the process of price formation that is crucial to understanding behaviour and other market challenges.

3.3.1. Price Formation

As shown above, price in a competitive market is set on the basis of willingness to pay for the supply of a certain level of a good or service. Consumers show their willingness to pay through the demand curve. Each firm in a competitive market cannot (by its nature) influence price and as such is a price-taker. Therefore the decision facing each firm is whether the cost of producing an extra unit of output will be less than or equal to the price determined by consumers. The sum of outputs from all firms in the sector will be the supply of goods and services, and as such will provide the derivation of price for the supply of a good (or in this case energy).

Figure 3.1 shows this relationship clearly using p_c, q_c. As shown above, this will normally be at a price less than the monopoly price (if a firm prices above the MC then it will not sell anything) and importantly the competitive process will drive down average cost, such that profit on a portfolio can be made at or around the marginal cost.

3.3.2. Other Competitive Market Issues

Businesses in a competitive market have a constant incentive to reduce costs in order to increase their margin on their sales and/or extend their market share. Improvements in efficiency and changes in comparative competitive advantage are the only ways in which businesses can increase market share, and generate more profit for themselves (in the short term because supernormal profits will attract new entrants).

Extra profits are obtained by:

1. Reducing technology costs – driving the selection of low cost technologies, and providing in turn pressure on suppliers of equipment to lower prices (as they too operate in competitive markets!)
2. Reducing operating costs – particularly on labour productivity and in sourcing low cost energy supplies.
3. Improving performance and productive efficiency.

Overall, in terms of theory, the benefits of moving to a competitive market are substantial, particularly in terms of the likely impact on prices.

3.4. Aims of Liberalisation

Against this theoretical background, the European Commission and its Member States have recognised the potential benefits and have set a path for liberalisation. The European Commission, in its original brochure on energy market liberalisation[2] states the case, picking up on many of the points raised above, as follows:

- *"To increase efficiency by introducing competitive forces into the electricity market.*
- *Electricity price levels, at present, vary enormously between Member States. This causes unacceptable, and unnecessary, distortions in competitive conditions across the single market. In addition increased efficiency leads to lower prices. This is essential; electricity in the European Union is more expensive than in many countries with which European industry trades, such as the United States and Australia.*
- *Essential public services such as ensuring electricity supply to all customers, protecting the old and disadvantaged, and protecting the environment, can be achieved in the competitive single market. Indeed, competition can improve these services if appropriate measures are taken.*
- *An interconnected market requires less reserve capacity, and reserve capacity is expensive.*
- *The introduction of competition means that electricity producers will have to make better use of resources in the electricity production process to avoid waste of resources; wasting resources is both expensive and polluting.*
- *The introduction of competition gives customers the right to choose their supplier of electricity. They can choose for example the nearest one, the cheapest one, the cleanest one, or the one that offers the best service.*
- *The introduction of competition means that electricity companies will have to improve their service to maintain their customers or to gain new ones.*
- *The lower prices for electricity result in lower production prices for European industry, which in turn will be translated into lower prices for products."*

The essence of these points can be reduced to five indicators: customer switching; market structure (as defined by new entrants and market share); changes to prices; unbundling; and

[2] European Commission (1999) Opening up to Choice

regulated Third Party Access.. The Commission monitors these (and other) indicators regularly. The findings of this monitoring exercise are used elsewhere in this report.

The five indicators are consistent and intended as objective measure of liberalisation and competition. They divide into two groups – those that measure success in achieving competitive markets and those that measure crucial pre-cursors to competitive markets.

In this regard, the following indicators relate to the functioning of the competitive market (with comments drawn from the most recent monitoring report[3]):

1. Customer switching identifies the ability of consumers to set (or at least shape) price. The indicators from the 2005 monitoring report indicate that good progress is being made in this regard, although there are still a number of countries for which further progress is required to move effectively from a monopolistic market to one of competition.
2. Market structure is another important indicator of whether the market is moving to competitive supply side pressures, and away from monopoly. As with customer switching there remain some markets where the supply side is dominated by one or two large entities.
3. Price change is a consequence of the structural changes measured by the previous indicators. We would expect costs and margins – and hence prices – to reduce as we move to competitive markets. In most countries, there has been a downward trend in real prices from 1995 (although there have been some recent upward movement as a consequence of rising input energy costs).

The following indicators relate to the precursors of competition:

1. Unbundling is a precursor for competitive markets, and is the basis of liberalisation. Greater degrees of unbundling will (or should) encourage competition by reducing market power, and separating the degree of vertical monopoly. In most cases, unbundling of transmission (from generation and supply) is near complete, the picture is not the same for distribution (from supply).
2. Regulated third party access is a similar argument as for unbundling. Providing a clear and regulated basis for new entrants to be granted use of the energy networks is crucial to removing barriers to entry. Like for unbundling, of the transmission system, third party access seems fair with a narrowing of charges for use and connection.

[3] European Commission (2005) Fourth Benchmarking Report: Annual Report on the Implementation of the Gas and Electricity Internal Market (COM(2004 863))

4. Does Liberalisation lower prices?

This section sets out the theoretical principles (and the evidence) underpinning the expectation that market-driven energy companies should deliver lower prices to consumers than monopolies. This section presents:

- The theoretical benefits of liberalisation regarding prices
- The evidence as to whether gas and electricity prices to various classes of industrial consumers can be associated in a systematic manner with degrees of market liberalisation; and
- The evidence as to whether competitive tensions in electricity and gas markets create identifiable movements in production costs and company margins that underlie the price movements.

4.1. Theory

The traditional form of the energy industry comprises monopoly businesses with a concession to operate over all, or part, of the industry or all, or part, of the country. These monopolies will seek monopoly rents through prices that are above their marginal costs (as discussed in Section 3). Public (or private) monopolies may not seek rents in the strict sense, but they may have high costs as a consequence of low labour and capital productivity.

For this reason, the energy industry has traditionally been subject to statutory control or forms of regulation to ensure that monopoly rents are not created and that companies function efficiently. Indeed when liberalised, elements of the market (particularly transmission and distribution) are still subject to regulation and supervision – although prices are not controlled in generation or supply.

Competition offers a more effective tool than regulation for controlling rents and reducing prices. In a competitive market, any rent derived from a position of market power will attract other producers who are able to sell at lower cost, forcing the incumbent producer to reduce prices. Such behaviour continues until competition brings prices down to the lowest level that covers operating costs and provides a return on capital that reflects supply conditions and demand.

Competition is more effective than regulation because it is sustained and dynamic. There are of course some limits to the process; market power can reassert itself even without overt collusion and local monopolies can be created by congestion constraints. Regulators and competition authorities therefore do have a role in the competitive market in monitoring its operation and correcting any deficiency as it appears.

The principle of a liberalised market is to regulate where competition cannot be introduced and to allow competition to operate freely where it can. The advantages of competition are:

- Monopoly rents are eliminated; and
- Companies are driven to reduce their production costs and margins

If this process is working then it should be possible to show that:

- Prices fall as liberalisation develops; and
- Costs and margins fall.

Empirical evidence that liberalisation leads to lower prices has been sought from time series and cross-sectional analysis of electricity and gas prices to industrial consumers across the EU15 as a function of: competition, movements in the international price for fuels; national endowments of resource and technological advantage.

Evidence for falling production costs in the liberalised environment has been sought from changes in:

- The cost of comparable equipment under competitive procurement;
- Plant utilisation;
- Reserve margin; and
- Labour productivity.

Evidence for lower profit margins has been examined by study of the difference between the price of electricity and the price of the fuel required to generate the electricity (spark spread). A convergence between the price of electricity and the price of the fuel inputs could indicate falling margins for generators. It might also reflect the higher production efficiencies noted above or shifts in the underlying supply-demand balance and therefore the market-clearing price for electricity. To detect genuine evidence of falling margins might therefore be difficult. To determine the relationship, time-series and cross-sectional analysis of spark-spreads across the Member States of the EU15 as a function of competition has been conducted.

4.2. Empirical Evidence from Consumer Prices

The objective of this analysis is to determine whether the impact of competition can be detected in a systematic manner in prices to industrial consumers.

The main analytical tool used for this study was regression analysis. A note on the scope, assumptions and limitations of regression analysis along with details of the specific applications made here is given in Annex A. However, it is important to note that regression analysis is a tool that permits us to estimate the likelihood that certain hypotheses are true.

4.2.1. Electricity

Industrial electricity prices have been obtained from Eurostat. Measures of competition have been taken from the four Benchmarking Reports produced by DGTREN[4]. The analysis is confined to EU 15, and Norway when appropriate.

There are nine (one for each consumer group) data series for industrial electricity prices. The series run on an annual basis from 1985 and become six-monthly from 1991 onwards. These

[4] The latest benchmarking reports cite a wide range of indicators of competition, but relatively few have been collected throughout the series.

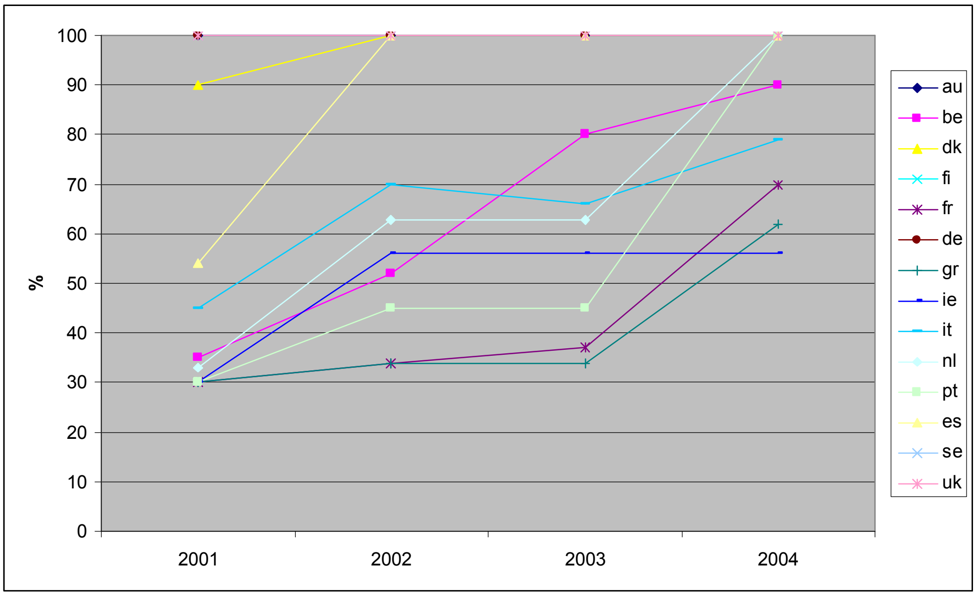
series are not complete and poorly populated up to 1990. This study has analysed two groups of consumers:

- Class Ia: the smallest industrial consumers, with an annual consumption of 30MWH and a maximum demand of 30kW. This group was chosen because it includes SMEs and commercial customers; and
- Class Ie: the median group of industrial consumers with an annual consumption of 2000MWh and a maximum demand of 500kW. This group was chosen because it has the most populated data set.

The only quantitative indicators measuring competition that are available from all of the Benchmarking Reports are the degree of market opening and the extent of the market not covered by the three largest generators. Preliminary cross-sectional analysis on individual years showed that these indicators were also the most useful for statistical work and were the strongest determinants of price movements.

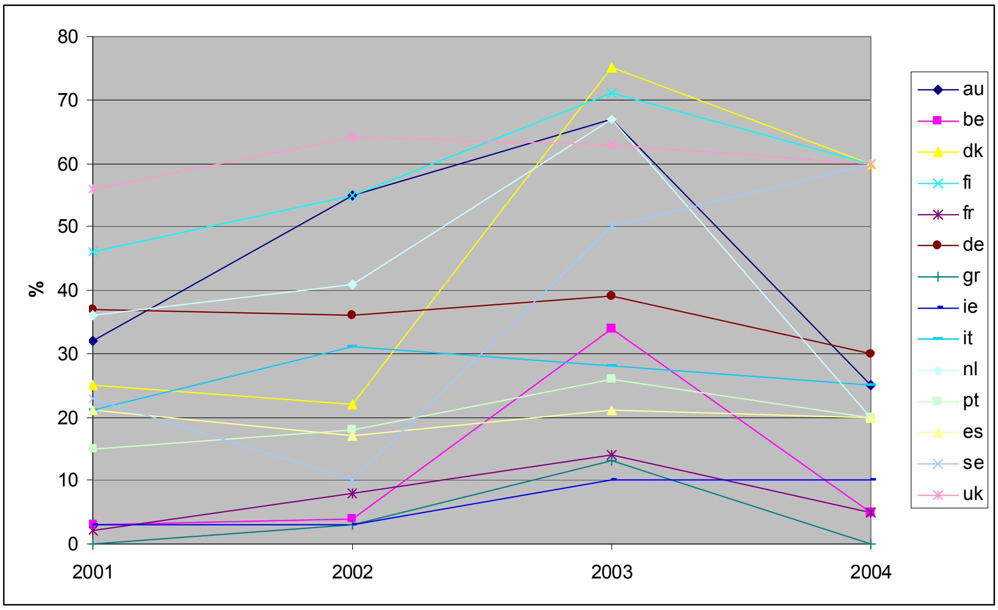
Market opening is defined as the share of the market represented by consumers that are permitted to choose a supplier; Figure 4.1 shows how market opening has developed in the period from 2001 to 2004. Figure 4.2 shows the extent of the market not covered by the three largest generators over the same period.

Figure 4.1 Development of market opening



Source: 1st to 4th Benchmarking Reports, EU Commission

Figure 4.2 Percentage of market not supplied by 3 largest generators



Source: 1st to 4th Benchmarking Reports, EU Commission

Figure 4.1 shows that market opening tends to increase with time. This is a consequence of sustained administrative decision and is not a market-determined event.

Figure 4.2 shows that the proportion of the market not met by the three largest generators is more variable, with some sign of consolidation towards the end of the period.

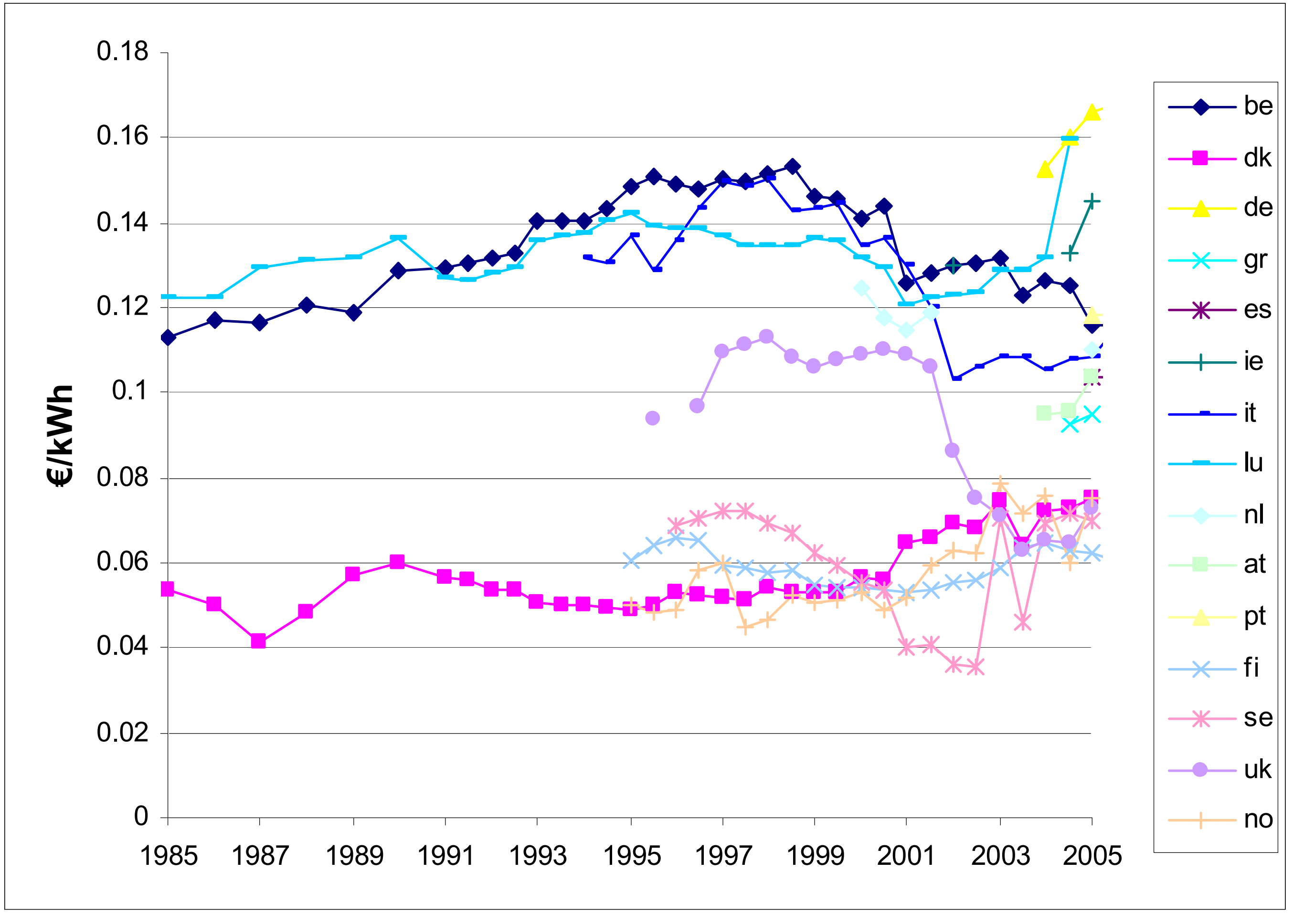
For simplicity these indicators are now referred to as MO (Market Opening) and 3G (market share not covered by the 3 largest generators). It is finally worth noting that the correlation coefficient between the two indicators is 0.59, which while high, is not statistically limiting[5].

4.2.1.1. Class Ia

Figure 4.3 shows the price data for Class Ia since 1985. There is a general upward trend. The trend is evident towards the end of the period, reflecting the recent increase in the price of fuels. The countries divide into a group of low price countries, mainly from Scandinavia, and a group of countries from central Europe with generally higher prices. The UK makes an interesting transition from the higher to lower price group perhaps as a consequence of liberalisation. Denmark moves away from the lower price group, probably as a consequence of the large share in generation of high cost coal and wind. Not all countries make returns to Eurostat for this class of consumers so there are some notable omissions from the Figure, e.g. France.

[5] The measure of correlation is important as it shows the degree of association between MO and 3G. When two independent variables are highly correlated then it is hard to distinguish their separate impacts on the data, although their combined impact can be assessed.

Figure 4.3: Time series of price data for Class Ia consumers



Source: Eurostat

Based on the price data, and the two competition indicators (MO and 3G), preliminary cross-sectional analysis among countries indicated a modest association between price and competition, i.e. that the more competitive countries tended to have lower prices.

To confirm this hypothesis the four-year data set from the second half of 2001 to the first half of 2004 was pooled to try to determine whether price movements in time and across countries could be associated with increasing competition. The price series were lagged slightly on the competition indicators, for example the indicators from the fourth benchmarking report (showing progress to 2004) were associated for prices in the latter half of 2004 and the first half of 2005.

The regression analysis indicates that prices on average reduce by 0.00074€/kWh for each percentage of MO and 0.000335€/kWh for each percentage of 3G. This relationship between MO and 3G explains 68% of the price data variance, a good statistical explanation, and each of the indicators' coefficients are statistically significant at the 95% level, i.e. that the chances of such a relationship occurring by chance is in each case less than 5%.

If we adopt the view that practically it would be difficult to have more than 70% of the market belonging to other than the three largest generators then this formulation gives a maximum reduction in electricity price of a 0.074€/kWh from MO and 0.023€/kWh from 3G.

The sum of around 0.1€/kWh is considerable; taken at face value it implies a fall from 0.16€/kWh with no competition to around 0.06 €/kWh with full competition – a fall of about 60%.

As a means of testing these conclusions, we have developed a composite Competition Indicator (CI) equal to (MO +3G)/100[6]. The regression analysis on CI suggests that the price of electricity falls by 0.053 €/kWh for every point of CI. The estimate has a statistical significance greater than 99.9%. The maximum range of the CI[7] is from 0 to about 1.7, which again suggests a reduction in price from the extremes of about 0.1 €/kWh.

Figure 4.4 then presents a scatter diagram (with trendline) of the price to consumers in the Class Ia against CI. The fall of around 0.1 €/kWh from the extreme values of CI is visually evident.

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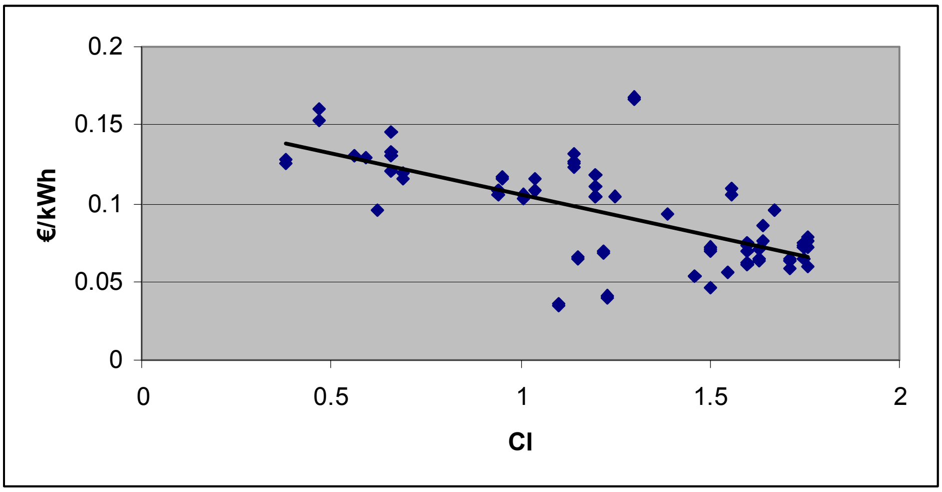
[6] The composite indicator of competition has no theoretical significance. It is an empirical finding of the analysis that the price variation is correlated with this indicator and it allows for a convenient presentation of the results

[7] On the basis of the foregoing assumptions that all of the market is open, and that a maximum of 70% of the market will be owned by operators other than the three largest electricity

Figure 4.4 Price to Class Ia consumers against composite indicator of competition



Source: Eurostat, Benchmarking Reports and E&Y calculations

A logarithmic formulation has also been estimated, because it corresponds to the well-known economic concept of price elasticity[8]. In this formulation price is assumed to depend on MO and 3G as follows:

$$p = p_0 \, MO^{\alpha} \, 3G^{\beta}$$

Where p is the price of electricity to the members of the Class Ia group of consumers for the countries over the period considered; p_0 is a constant; α and β are the price elasticities with respect to MO and 3G respectively.

The coefficients are estimated by multiple regression of the log-linear form:

$$\log(p) = \log(p_0) + \alpha.\log(MO) + \beta.\log(3G)$$

The results from the log-linear formulation are similar in general nature to those described earlier. The elasticities of MO and 3G are -0.57 and -0.06 (ie for every percentage change in MO, prices decrease by 0.57%). That of MO is statistically significant and that of 3G is not. The elasticity with respect to CI is -0.63 and is statistically highly significant.

It is more satisfactory to use the CI measure in some respects than the joint regression on MO and 3G. The fairly strong correlation between MO and 3G means that small changes in the data may shift the coefficients of MO and 3G considerably, whereas the coefficient of CI is stable to such change. This observation applies both to the linear and log linear forms.

4.2.1.2. Class Ie

Figure 4.5 shows the price data for Class Ie since 1985. The main visual impression is of a slight convergence from a range of 0.03 to 0.10 €/kWh at the beginning of the period to 0.05 to 0.09 €/kWh towards the end. Visually there is not much sign of a systematic movement, but statistically there is an overall tendency to fall in the period. The trend line for the EU 15 is shown and that of the UK also. Prices in the UK have fallen faster than the average.

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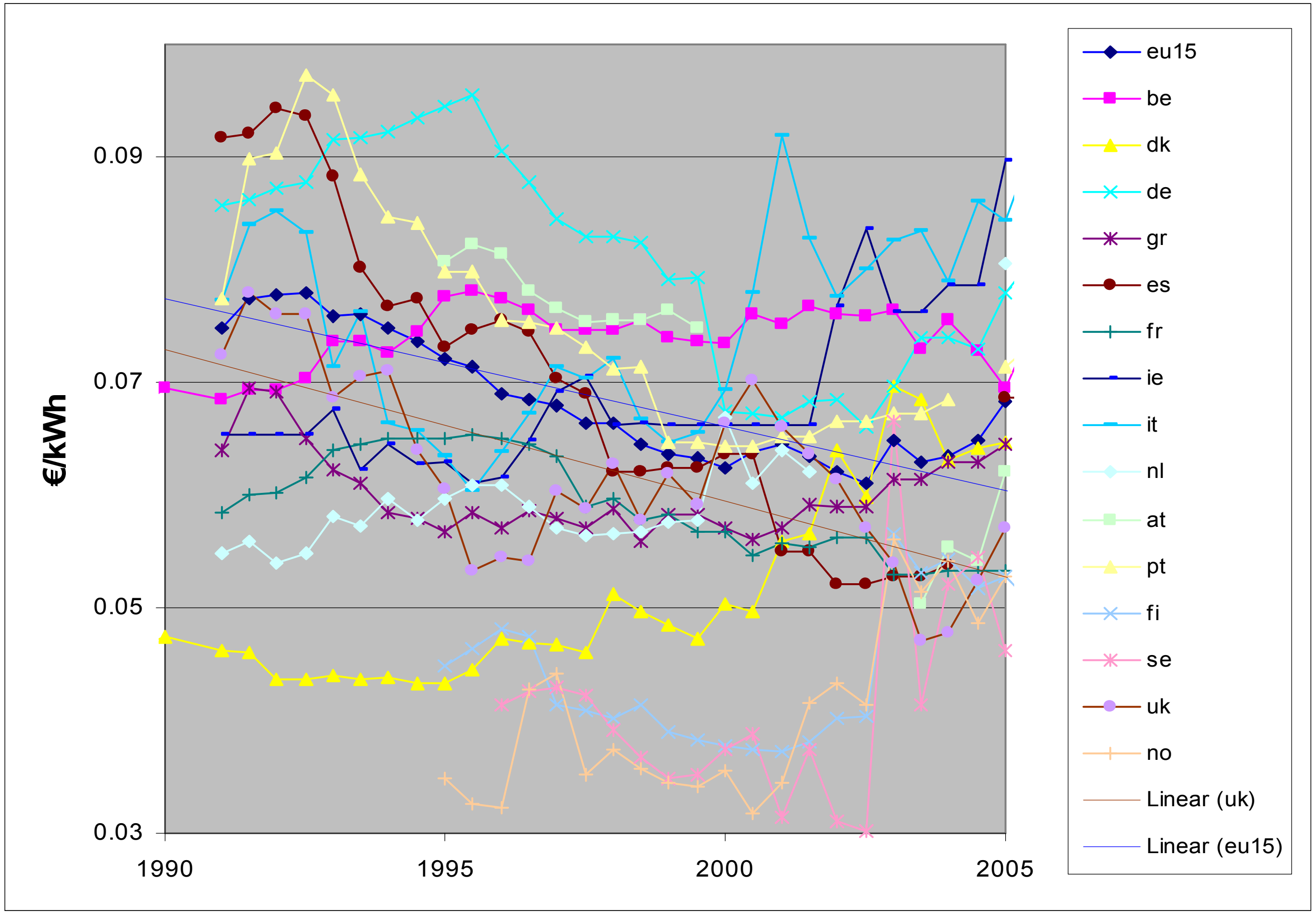
[8] An elasticity is an expression of a relationship between factors driving demand and the price.

Figure 4.5 Time series of price data for Class Ie consumers (1990-2005)



Source: Eurostat

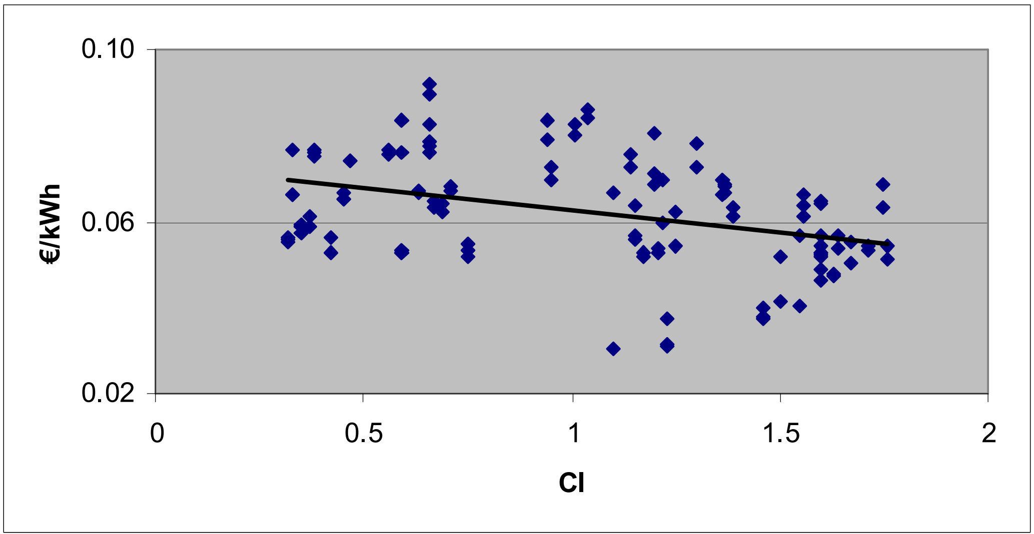
A pooled four-year time series and cross-sectional regression analysis was conducted as described for the consumer Class Ia. The results with both MO and 3G included as dependent variables suggest that price falls 0.0001€/kWh for every percentage point of MO and about the same for every percentage point of 3G.

The regression explains 15% of the variance in the original data, which indicates a lower association of price and competition than for Class Ia. However, the value for MO is significant at the 95% level and that for 3G is almost so; this is because of the large number of data points for this class of consumers.

Regression on either MO or 3G individually gave statistically more significant results for the individual coefficients (in each separate case the association is significant at the 99.9% level). This behaviour is due to the high correlation between MO and 3G that hinders their joint estimation; the correlation coefficient is 0.68; this is higher than for consumer Class Ia for which fewer countries reported data.

Regression on the composite indicator, CI = (MO+3G)/100, indicates that price falls 0.010€/kWh for every percentage point change in CI and is highly significant.

Figure 4.6 Price for industrial consumers (Ie) against composite indicator of competition



Source: Eurostat, Benchmarking Reports and E&Y calculations

Figure 4.6 shows a scatter diagram of price against this composite CI. The visual impression from the chart is consistent with the statistical analysis. There is a distinct negative association of price with competition, but there is much variance that remains unexplained.

A logarithmic formulation was also examined as for Class 1a. The elasticity for the composite indicator was estimated at -0.14 (ie for every percentage increase in CI, prices decrease by 0.14%) and is significant at the 95% level.

The implication is that competition has less impact on prices for larger consumers than on the smaller consumers in Class Ia. It appears from inspection that the difference between the two elasticities is significant, but we cannot be entirely sure. This is examined in more detail below.

4.2.1.3. Pooled Ia and Ie

An analysis has also been made of the pooled data for the two classes (Class Ia and Ie). Based on what should be expected, smaller consumers should have higher costs of supply and pay more. The formulation should reflect this, and the one adopted is:

$$p = p_0 + \alpha.MO + \beta.3G + \gamma.Class$$

where p is the price to the consumers in the pooled classes and p_0 is a constant. "Class" is a dummy variable that takes the value 0 for Class Ia and 1 for Class Ie.

The estimates from a regression on all three independent variables are:

$$\alpha = -0.00025; \beta = -0.00025 \text{ and } \gamma = -0.035$$

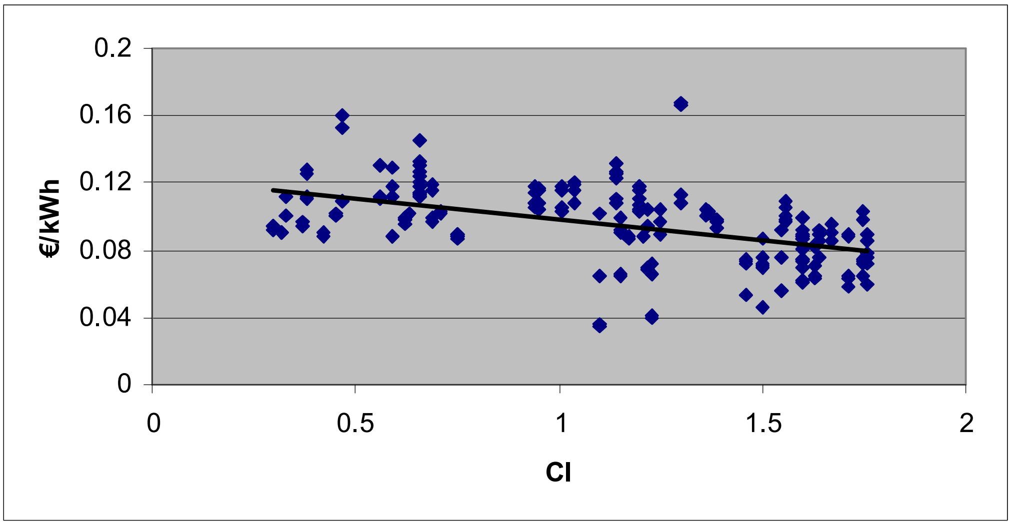
All the estimates are significant at the 95% level, which are a good statistical fit.

The interpretation of these results is that Class Ie consumers pay on average 0.035 €/kWh less than Class Ia consumers and that prices decrease by 0.00025 €/kWh for each unit change in MO and each unit change in 3G. The regression explains 46% of the variance.

Regression against CI gives virtually identical results, with good statistical significance.

To allow visual representation of the relationship, an "adjusted price" has been calculated, which is defined as the price paid by Class Ia consumers or the price paid by Class Ie consumers plus the estimated differential of 0.035 €/kWh.

Figure 4.7 Adjusted price against composite CI for pooled Class Ia and Ie consumers



Source: Eurostat, Benchmarking Reports and E&Y calculations

Figure 4.7 shows a plot of "adjusted prices" against the composite CI. The visual impression bears out the strong association of competition with lower prices.

A logarithmic estimation of the pooled Ia and Ie data against CI to further test the impact of prices for the different classes has also been developed. The following formulation has been estimated:

$$\log(p) = \log(p_0) + (\alpha + \beta.Class).\log(CI)$$

This formulation tests the proposition that the price elasticity (α) with respect to CI differs by the amount β between the two groups. “Class” is again the dummy variable. This formulation is equivalent to the linear form:

$$\log(p) = \log(p_0) + \alpha.\ \log(CI) + \beta.\ Class.\log(CI)$$

The elasticities have been estimated as:

$$-0.25 + 0.04.Class$$

Both coefficients α.and β are statistically significant.

These elasticities can be interpreted as the price elasticity with respect to competition is -0.25 for the consumers of class Ia (ie for each percentage increase in CI, prices reduces by 0.25%) and -0.21 for the consumers of class Ie and that the difference is statistically significant.

The hypothesis of differential behavioural impacts of competition is confirmed. It may indicate that prices to the larger consumers were closer to cost and that therefore the impacts of competition were less than for smaller consumers.

4.2.1.4. Is this a false association?

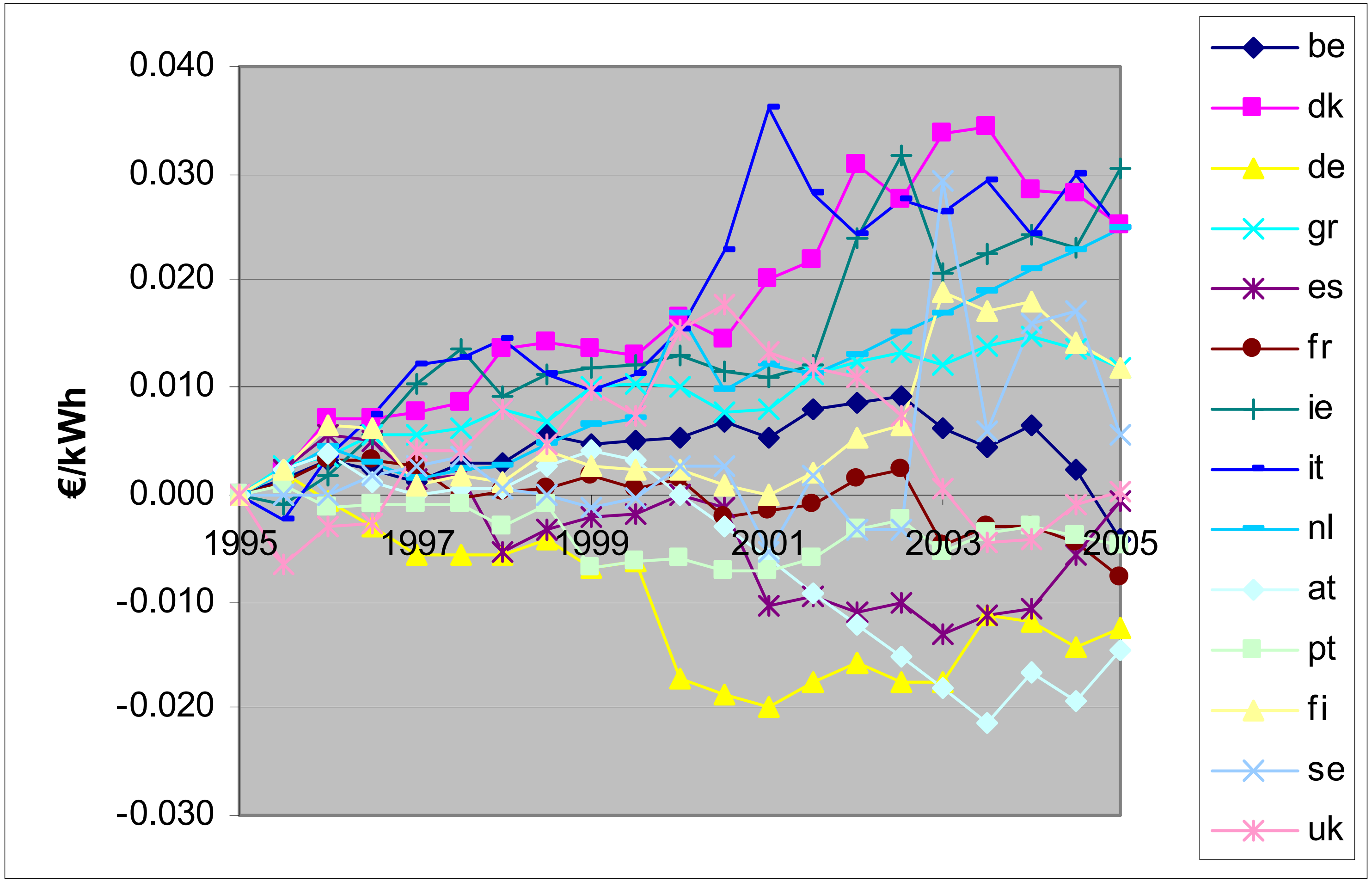
Regression analysis can never prove causality. There is the possibility of a contingent correlation between competition and some other factor that determines price and that appears to indicate a correlation between competition and price. The most obvious possibility is that liberalisation is strongest in the Northern European countries with indigenous gas and hydro plants that permit generation at lower cost than in the non-liberalised countries.

A second concern with the analysis might be how general trends in energy prices might affect comparisons. This objection is less serious than the first, because although it will affect the regression it should primarily just increase the unexplained variance and cannot plausibly lead to the deduction of a false association.

To deal with these concerns an analysis has been conducted using doubly differenced time series. The analysis was conducted on the Class Ie data as this is the best populated set. Two base years were chosen (1991 and 1995) to reduce the possibility that the conclusions are determined by the choice of base year. First the differences of national prices have been calculated from the EU 15 average. Then the difference of prices in each year has been calculated relative to a base year. The first of these operations should correct for general fluctuations that may be reflected in the EU average price and the second operation should broadly correct for natural differences in resource endowments that may influence the absolute level of prices.

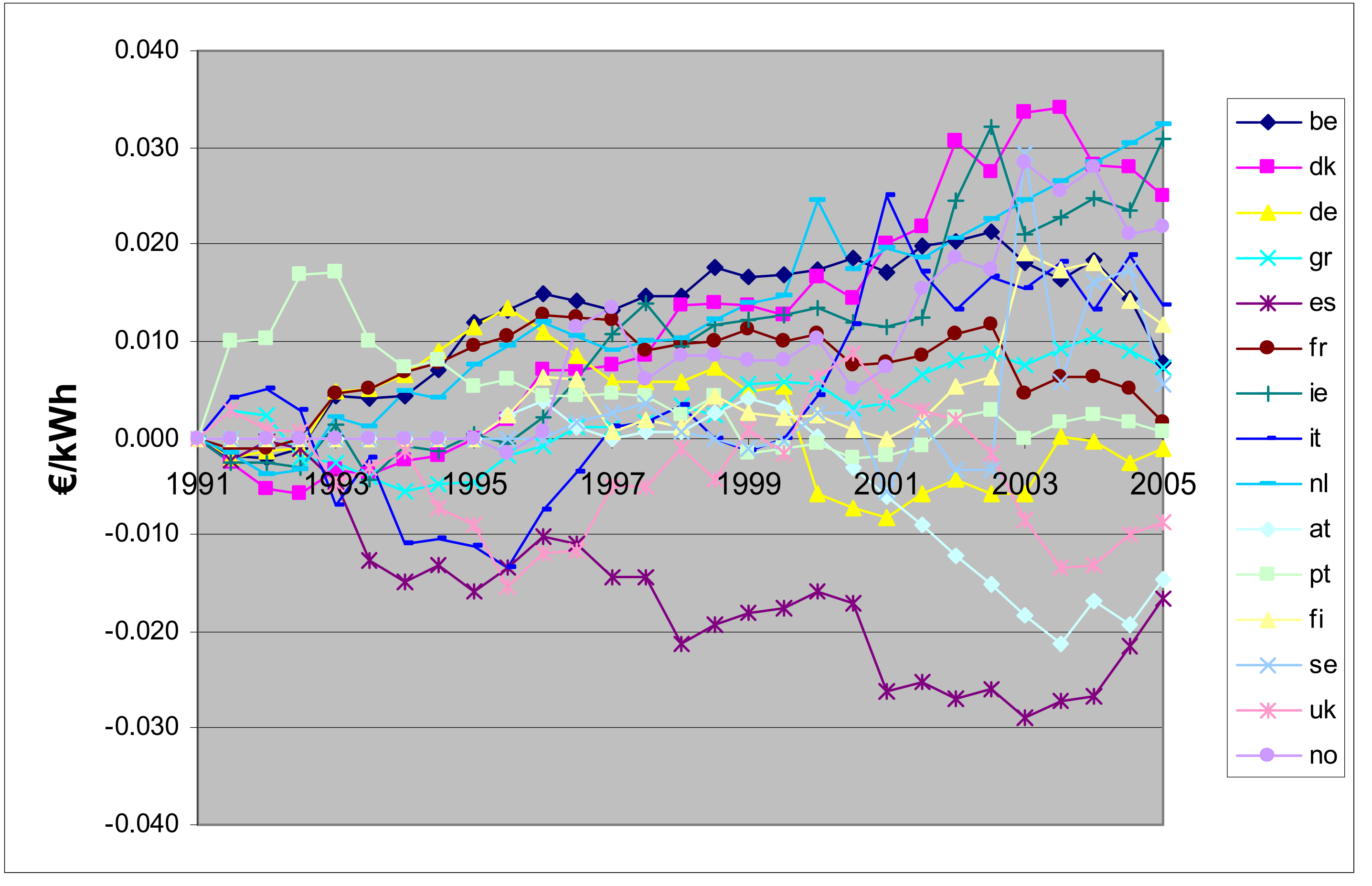
Figures 4.8 and 4.9 show the movement of these price differentials with time. The visual impression is of a significant divergence between Member States over the period. To some extent some divergence is normal, but there is some sign of stability in the behaviour from around 2001. The hypothesis to test is that the differences are associated with competition.

Figure 4.8 Prices to Class Ie consumers relative to EU mean and 1995



Source: Eurostat and E&Y calculations

Figure 4.9 Prices to Class Ie consumers relative to EU mean and 1991



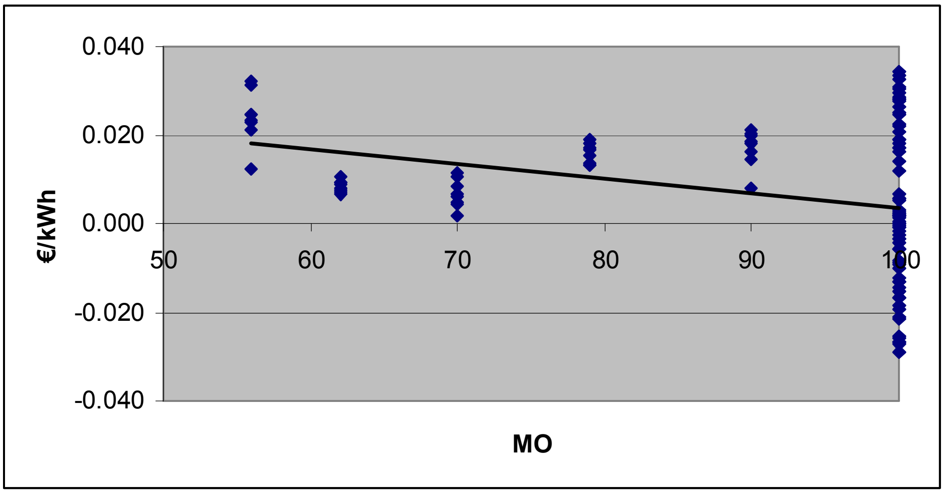
Source: Eurostat and E&Y calculation

To test the hypothesis, we have regressed the double differenced prices against MO. This has produced a statistically significant negative association of prices with MO using the two base year cases (1991 & 1995), but it is a statistically weak explanation, explaining between 10% and 12% of the variance in the original data. Regression against 3G gives a poorer result.

Joint regression against MO and 3G gives a better fit, but with the coefficient of 3G being positive (which suggests that prices move up as more generators enter the market). Examination of residuals indicates that this is in large part a consequence of the data from France. Because of the large nuclear programme French prices to this class of consumers have been rather stable; the regression against MO indicates that prices in France should have risen because of the low market opening. In the regression analysis the 3G variable artificially compensates for this effect because the value of this variable in France is very low and can be used to account for this price stability. If the French data is removed from the regression then the 3G variable becomes negative, although still not statistically significant.

Figure 4.10 shows a scatter plot of the double differenced data against MO for the 1991 base year. The interesting feature is that although the markets with 100% opening show a broadly even distribution of positive and negative values relative to the EU mean and the base year, in general, all the markets with an opening of less than 100% show positive values, indicating that relative to the EU mean and to the chosen base year, prices have risen.

Figure 4.10 Scatter plot of double differenced data against MO for the 1991 base year



Source: Eurostat and E&Y calculations

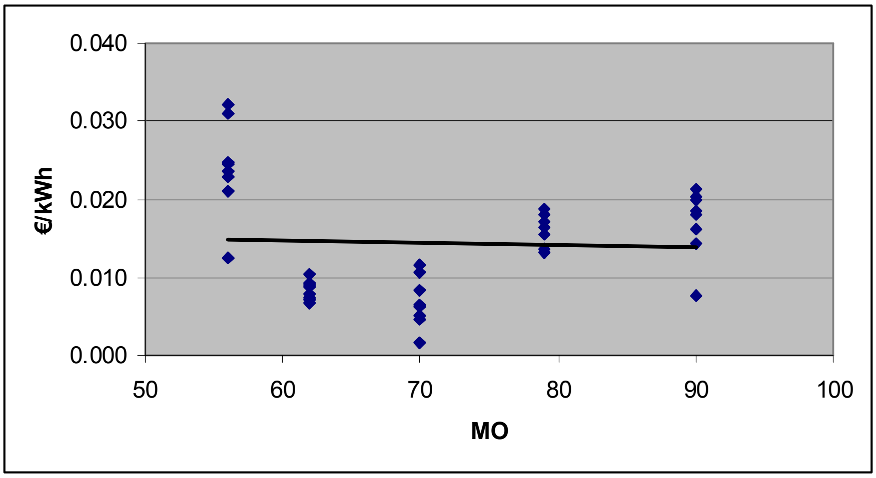
This observation can be given statistical form by a test that examines for the probability that the two samples (MO<100% and MO=100%) are from different populations. The results of this test show that relative to the EU mean and to the base year, the average price in both groups has risen[9]. The differential price in the group with 100% market liberalisation has on average risen by 0.003 €/kWh. The differential price in the remaining countries has risen by 0.014 €/kWh. The probability of this result happening by chance is less than 5 in a million. One should bear in mind

[9] Note that the EU mean is volume weighted so this result is possible.

that the main confounding factors of different resource endowment and the influence of international energy prices have been approximately removed.

We note that even if the points corresponding to 100% market-opening are removed, there is still a weak (and statistically insignificant) tendency for prices to fall with MO. This is shown in Figure 4.11; the trendline has been added, but it is not statistically significant.

Figure 4.11 Industrial consumer prices for incomplete market-opening



Source: Eurostat and E&Y calculations

4.2.1.5. Conclusions for electricity

We can conclude from this analysis that:

- There is a strong association between liberalisation and the price of electricity to industrial consumers.
- A competition indicator of (MO+3G)/100 is a useful measure of competition.
- The price of electricity to the pooled Class Ia and Class Ie group of consumers falls by 0.035€/kWh for every unit increase in this indicator. The theoretical range of the indicator is 0 to 2, but in practice it would be hard to achieve a value greater than 1.7.
- The price elasticity for industrial consumers with respect to the CI is between -0.21 and -0.25 depending on their size. This means that if competition were to rise by 10% then prices would fall by between 2 and 2.5%. We note that because the theoretical range of CI is from 0 to 2, the elasticity concept cannot be applied over the entire range and the linear form should be used for wide excursions in CI.
- The proposition of a false association between price decrease and competition was examined. The statistical results, after rough control for external events and the internal resource endowment of countries, are difficult to interpret, but still show significant association between liberalisation and falling prices.

4.2.2. Gas

Gas prices, compiled by Eurostat, have been obtained for industrial customers classified by size of consumer. Measures of competition have been taken from the four Benchmarking Reports produced by DGTREN[10]. The analysis is confined to EU 15.

The six monthly series of prices for industry divide the sector into five categories by size. The series run on an annual basis from 1992. Many countries have not returned complete series of data, especially for the very large and very small consumers. This study has looked at the most highly populated set for the consumer class I3. This is the central class characterised by consumers with an annual consumption of 41 860 GJ (equivalent to 11.6 GWh, and 4.4 million therms) and a load factor of 200 days (ie consuming gas for 200 out of 365 days).

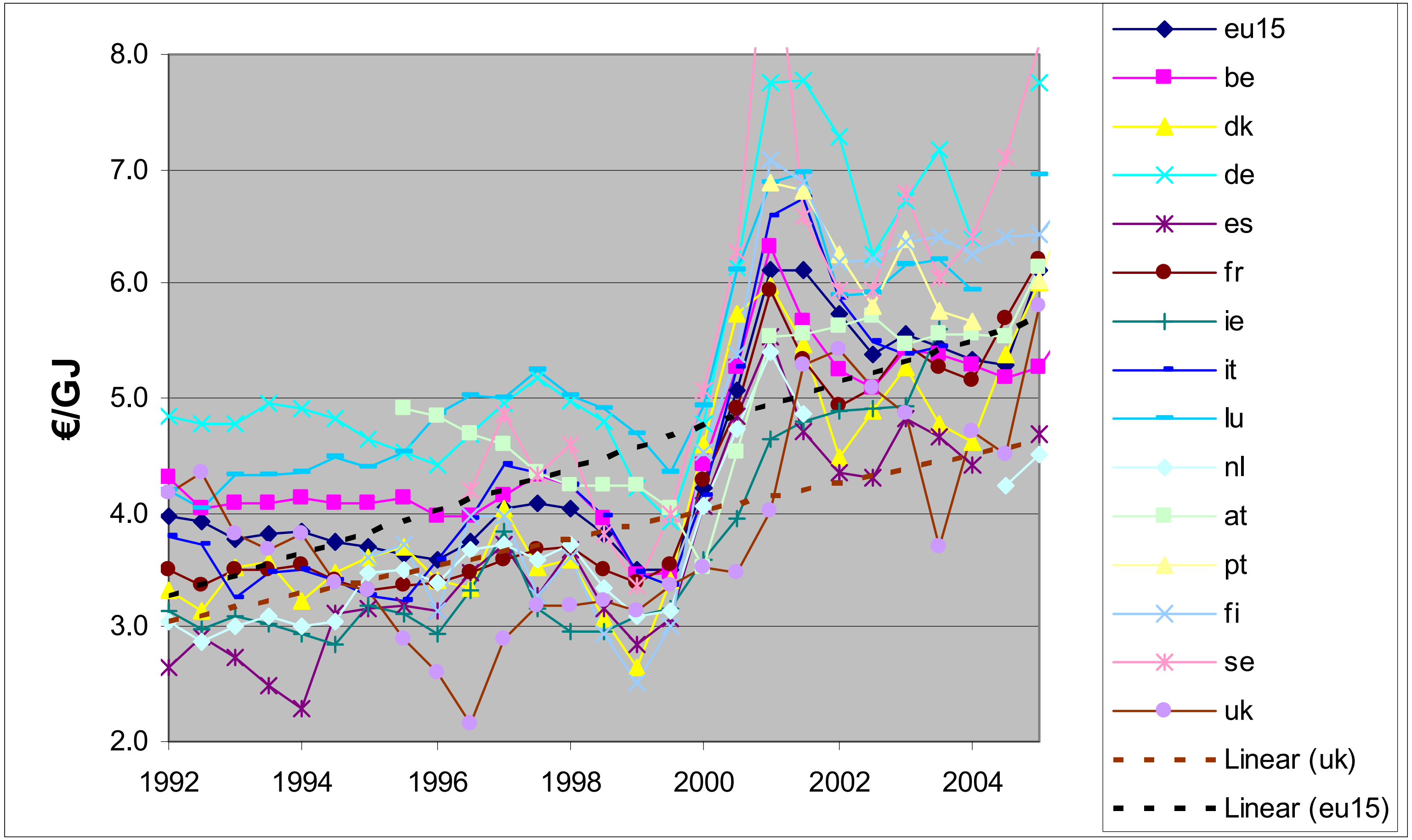
Consideration is also given for classes I1, I2, I4 and I5, albeit in less detail, and also as a means of testing hypotheses.

4.2.2.1. Class I3

Figure 4.12 shows the plot of gas prices to the Class I3 of consumers in most countries of the EU15 along with trends lines for the EU average and the UK. Gas prices have increased over the period, but more slowly in the UK than elsewhere. The visual impression suggests some increase in volatility over the period, and this is borne out by analysis.

[10] The latest benchmarking reports cite a wide range of indicators of competition, but relatively few have been collected throughout the series.

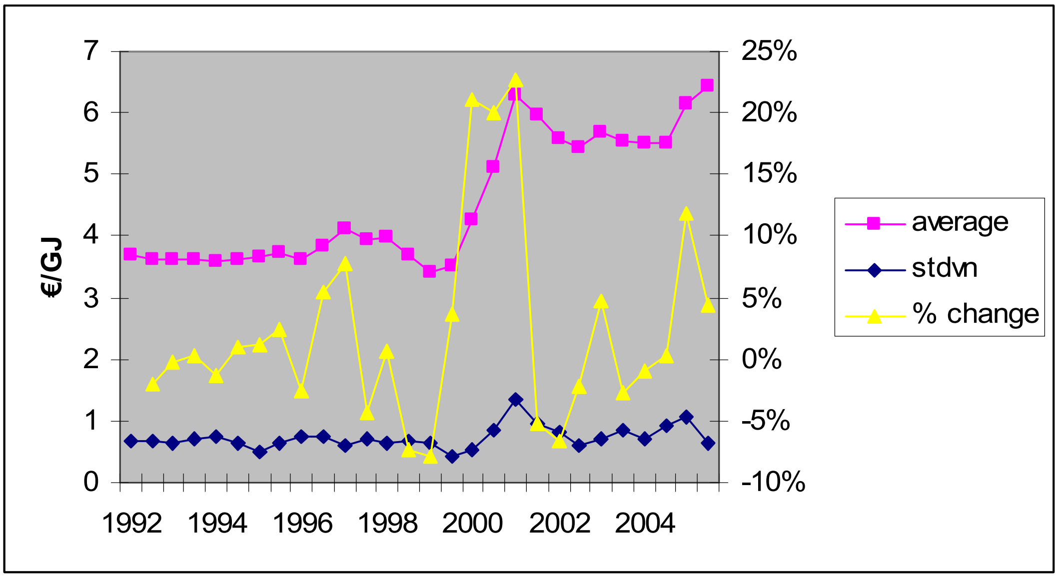
Figure 4.12 Time series of price data for Class I3 consumers



Source: Eurostat

Figure 4.13 shows the development over time of the average EU gas price, the standard deviation of the gas price among countries (in €/GJ) and the percentage change year on year of the average.

Figure 4.13 Measures of volatility over time



Source: Eurostat and E&Y calculations

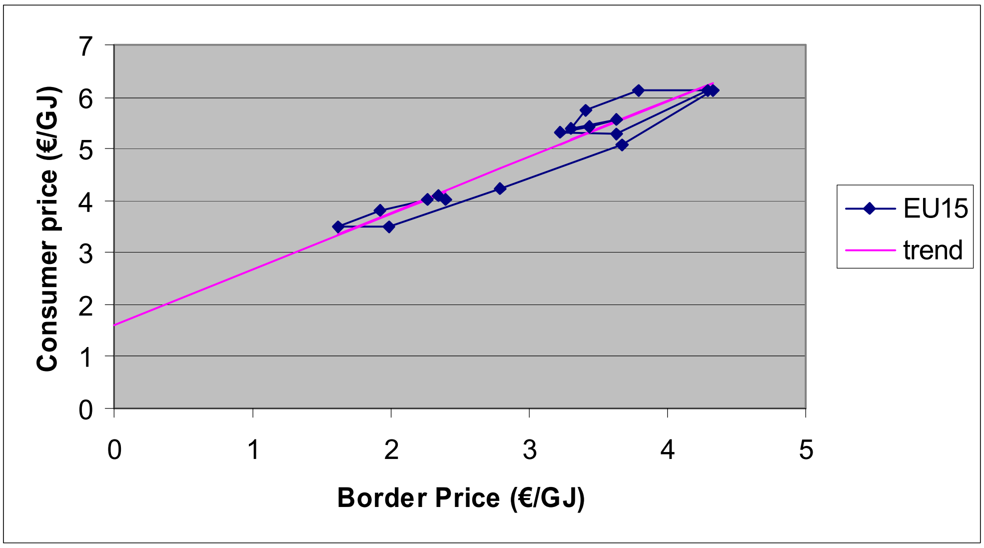
The gas price varies over time, but the variation among countries (measured as the standard deviation) increases little in comparison and if measured as a percentage of the gas price it falls. There are large percentage changes in average price, mainly up, but occasionally down.

4.2.2.2. The impact of international gas prices

The main question is to what extent the variation is due to international circumstances and whether the impact has been modified by liberalisation.

Figure 4.14 shows the average EU gas price against a measure of German border prices since 1997. The earlier dates are at the bottom left of the trajectory along with the lower gas prices. German border prices are taken simply as a measure of the general level of gas prices in Europe. They are calculated as a simple average of the prices at the four border points.

Figure 4.14 Average EU and German border prices



Source: Eurostat and Gas Strategies

The trendline shown on the figure expresses the following relationship

Average EU price (€/GJ) = 1.596 +1.08*Border Price

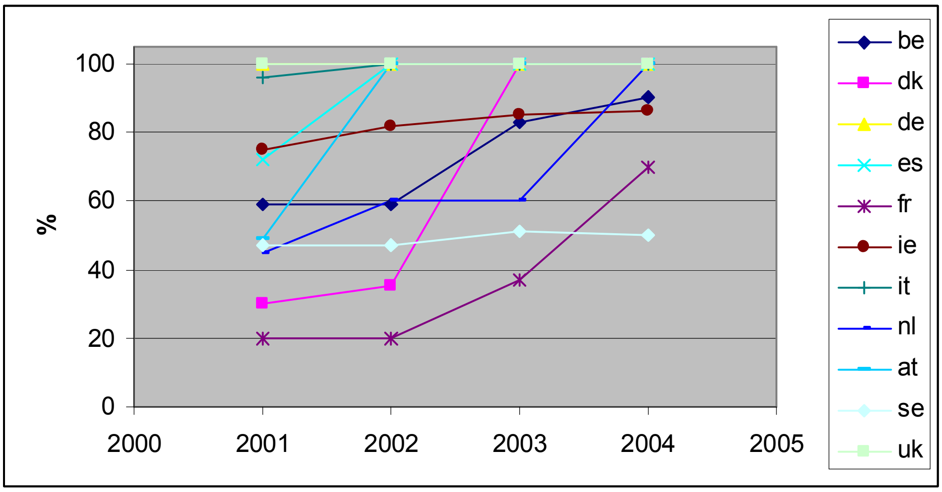
This relationship can be explained as the price of gas to this class of consumers is equal to a fixed amount of 1.596 €/GJ plus a variable quantity equal to the Border Price plus 8%. The fixed payment represents the margins for transmission. The border-price related component suggests a margin of 8% on purchases, which seems a fair return to compensate financing of working capital and losses. This formulation represents a good statistical fit. Importantly, it is convincing support for the proposition that the main source of observed long-term volatility in consumer prices is the impact of variations in border prices.

Points beneath the trend line in the Figure 4.14 indicate a consumer price somewhat less than would be expected from the formulation. It can be seen that over a long period this was the case, suggesting that liberalisation was bringing consumer prices down below the level that would be expected from the long-run relationship with border prices. In recent years the consumer prices have moved a little above the long-term trend. The explanation for this behaviour is not obvious.

The previous discussion examines the EU 15 average. The next step is to examine whether there are systematic variations across countries that relate to competition. There are several measures of competition available. The most convenient and the most accessible measures over a period are: Market Opening (MO), the presence of an unbundled TSO (TSO) and the amount of market not met by the largest supplier, which we will call the contestable market (CM).

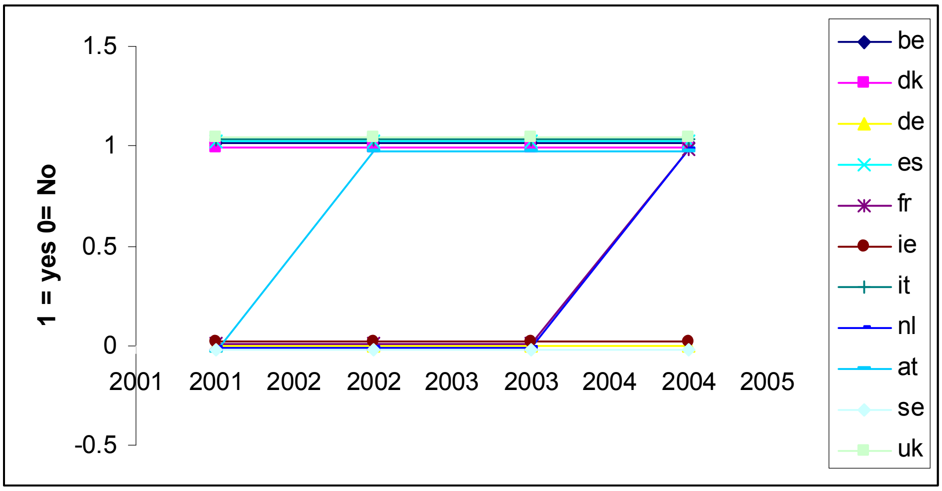
The evolution of these parameters within Member States is shown in Figures 4.15 to 4.17. Data is from the Benchmarking Reports (one to four). The variable TSO takes the value 1 if unbundling is complete and zero otherwise.

Figure 4.15 Development of market opening



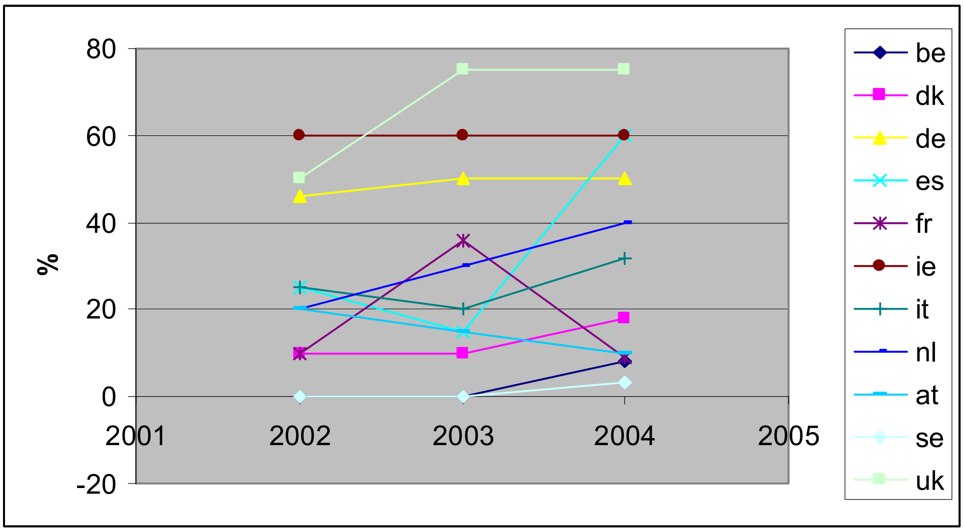
Source: 1st to 4th Bench Marking reports

Figure 4.16 Unbundling of TSO



Source: 1st to 4th Bench Marking reports

Figure 4.17 Contestable market (%)



Source: 1st to 4th Bench Marking reports

The general impression given by Figure 4.16 is of increasing competition[11].

The six monthly price data for the consumers in Class I3 over the past four years have been regressed against the three indicators (MO, TSO and CM) in a pooled time-series, cross-sectional analysis. The most acceptable formulation determined was between price, TSO and CM[12]. The regression formula derived was:

Price (€/GJ) = 6.23 - 0.87*TSO - 0.0074*CM

The coefficient of TSO is highly significant; that of CM is not so significant, but it increases the amount of the variance explained by the data from 22% to 26%, so it has been included.

The interpretation of these values is that there is a fixed charge to the class I3 of consumers of 6.23, but that where the market is unbundled, prices reduce by 0.87€/GJ and by 0.0074€/GJ for each percentage change in CM.

As for electricity, if we consider a competition index (CI) equal to TSO + CM/100. The coefficients of TSO and 100 x CM in the formula are roughly comparable in size; consequently this composite indicator approximates the regression equation. If we used a composite indicator that exactly reproduced the ratio of the coefficients in the regression equation then we would get a better fit to the composite indicator[13].

The scatter diagram of price against this index is shown in Figure 4.18. Two groups of points are observable. Those on the right represent those with fully legally unbundled TSOs, and those to

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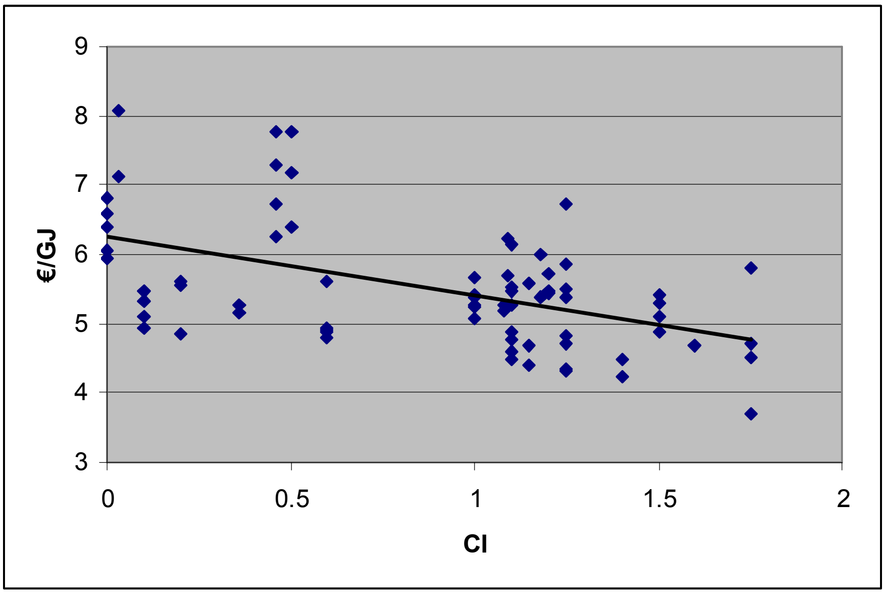
[11] There is one potentially erroneous result for the value of the gas controlled by the largest company in France.

[12] MO is not included for reason of low statistical significance, and when considered with the other variables, it did not add to the explanatory power of the formulation.

[13] The equal combination is chosen because it is simple; it is not specified by any one particular regression and it can be used throughout the study to present results on a common basis.

the left of the figure represent those without fully legally unbundled TSOs. The association of price to consumers in this class with properly completed unbundling is highly apparent.

Figure 4.18 Industrial price of gas (Class I3) against competition indicator



Source: E&Y analysis

To confirm this impression a Student-t test[14] was conducted on the two populations with bundled and unbundled TSOs[15]. The means of the two groups are 5.99 and 5.16 €/GJ, i.e. a difference of about 0.83 €/GJ or about 15%. The chance of this happening by accident is 5 in 100,000. This is compelling further evidence of a significant benefit on consumer prices from completing the full unbundling of the TSO.

Estimation of a logarithmic formulation gives a price elasticity with respect to this competition indicator of -0.053 (ie for every percentage increase in CI, price reduces by 0.053%) with high statistical significance.

Border prices (BP) can also be introduced into the cross-sectional analysis. This gives the following estimation:

Price (€/GJ) = 3.06 + 0.90*BP - 0.92*TSO - 0.008*CM

The formula explains 37% of the observed variance; all coefficients are statistically significant.

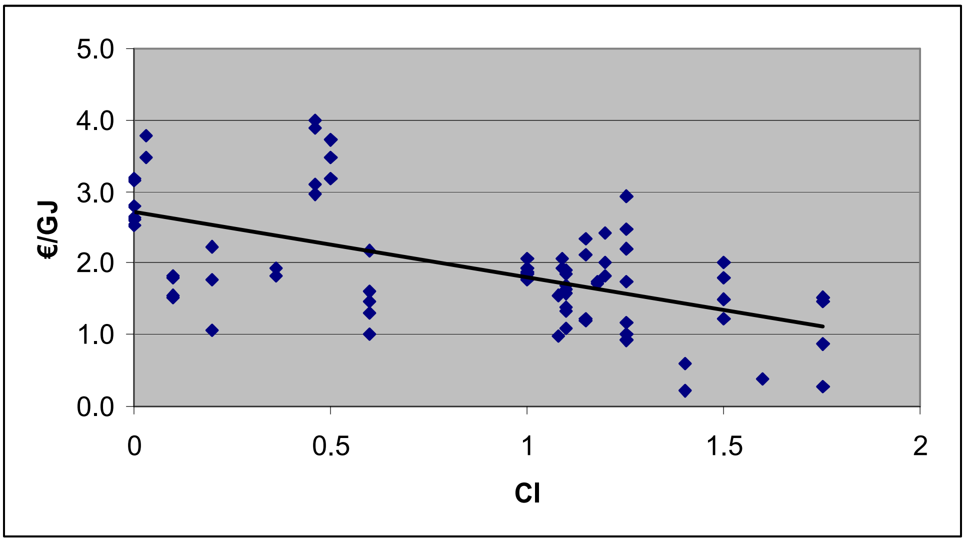
The interpretation is that the industrial price of gas can be approximated as 3.06 €/GJ plus 90% of the border price less 0.92 €/GJ if the TSO is properly unbundled and 0.008 €/GJ for each percentage point change in the contestable market.

[14] A student-t test is a measure of independence within the data sets and is a rough control for auto-correlation.

[15] This test is designed to estimate the probability that the two groups come from the same population, i.e. that the unbundling of the TSO has no relationship to price.

Figure 4.19 shows a plot of the margin against CI; the visual impression of falling prices with increased competition is apparent.

Figure 4.19 The margin of consumer prices (class I3) over the border price against competition



Source: E&Y analysis

4.2.2.3. Small consumers

The data series for smaller consumers are rather thin, because many countries did not report data, (especially for earlier years). The time series for the Classes I1 and I2 representing smaller consumers have consequently been pooled. Class I1 is defined as consumers using 418.6 GJ/yr (0.17 GWh or 0.04 million therms) with a load factor of 200 days (ie they demand gas for 200 out of 365 days) and Class I2 comprises consumers using 4,186 GJ/yr (1.7 GWh or 0.4 million terms) with a load factor of 200 days.

Regression of gas price data for the last four years against TSO and CM was performed, introducing a dummy variable to represent the two classes (Class I1 using 0 and Class I2 using 1). The formulation is as follows:

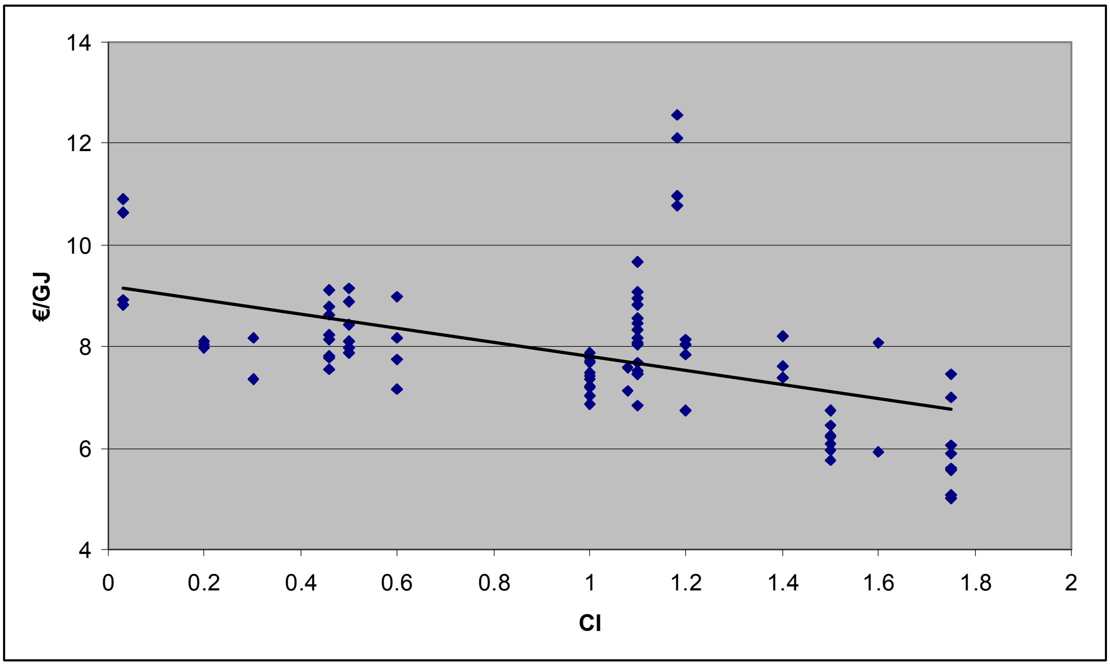
Price (€/GJ) = 9.43 - 0.99*Class - 1.15*TSO - 0.027*CM

This formulation can be interpreted as the price of gas being equal to 9.43 €/GJ, with a reduction of 0.99 €/GJ for the Class I2 of consumers and 1.15 €/GJ for countries with fully unbundled TSOs; the price falls by another 0.027 €/GJ for every percent of contestable market. All the coefficients are highly significant; 39% of the variance in the data can be explained by this regression.

It is interesting that the percentage of contestable market enters so strongly into the formulation, when it is only weakly present for the Class I3. This may be because the smaller consumers are affected by a more competitive supply as they will not have benefited from low cost provision as larger users would have done prior to liberalisation, whereas the larger consumers will seek out lower cost supplies if the opportunity is there and are less dependent upon an intensely competitive market.

The fit can be presented approximately using the CI indicator. Figure 4.19 shows the scatter and trend line for gas prices for the pooled data against CI. (The high price outliers are from Denmark; without these the fit would be even better.[16])

Figure 4.20 Gas prices to small industrial consumers and competition



Source: E&Y analysis

A further addition to the formulation can be made representing average prices at the German border as a proxy for international prices. The formulation in this case becomes:

$$\text{Price } (€/GJ) = 4.04 + 1.69*BP - 0.99*Class - 1.12*TSO - 0.030*CM$$

This formulation explains 52% of the variance in the data; all the coefficients are highly statistically significant.

The formulation tells us that the price of gas to small industrial consumers is equal 4.04 €/GJ plus 1.69 times the border price but that this can be reduced by 0.99 €/GJ for the larger customers in the sample and by 1.12 €/GJ if the TSO is fully unbundled and by 0.03 €/GJ for every percentage point in the contestable market.

4.2.2.4. Large Consumers

The same analytical problems encountered for small consumers have been found for large consumers. In this examination, data from the two largest consuming classes have been pooled. The two Classes involved are:

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[16] Note that the indicator CI so defined gives a good fit to the price data even though the unconstrained regression on TSO and CM gives coefficients in a ratio closer to 1:2.5; the reason for this is that TSO and CM are fairly strongly correlated so it is rather difficult to determine the individual coefficients with confidence. Any linear combination in approximately the right proportions will give a good fit.

- Class I4, which typically have annual consumption of 418,600GJ; and
- Class I5, which typically have annual consumption of 4,186 000GJ.

The regression has produced the following formulation (where Class is defined as 0 for I4 and 1 for I5):

$$\text{Price (€/GJ)} = 3.54 + 0.55*BP - 1.04*Class - 0.95*TSO - 0.007*CM$$

The regression accounts for 59% of the variance; all coefficients are statistically significant.

In this case the price paid by large consumers of gas is a fixed amount equal to 3.54€/GJ, plus 55% of the border price, but that this can be reduced by a further 0.95€/GJ for an unbundled TSO and a further 0.007€/GJ for each percentage change in the contestable market. The formulation also reveals that Class I5 customers earn a 4% discount when compared to Class I4 customers.

4.2.2.5. Conclusions for gas

- The analysis provides strong empirical evidence for the proposition that competition reduces consumer prices for gas. The evidence is compelling in all sizes of market.
- The analysis shows an 8% margin on consumer prices, on average, across the EU above border prices
- The proper unbundling of the TSO is a key element, with a clear relationship shown to exist, resulting in the strong separation of data points between markets with an unbundled TSO and without. The price difference between the two groups is estimated at around 15%

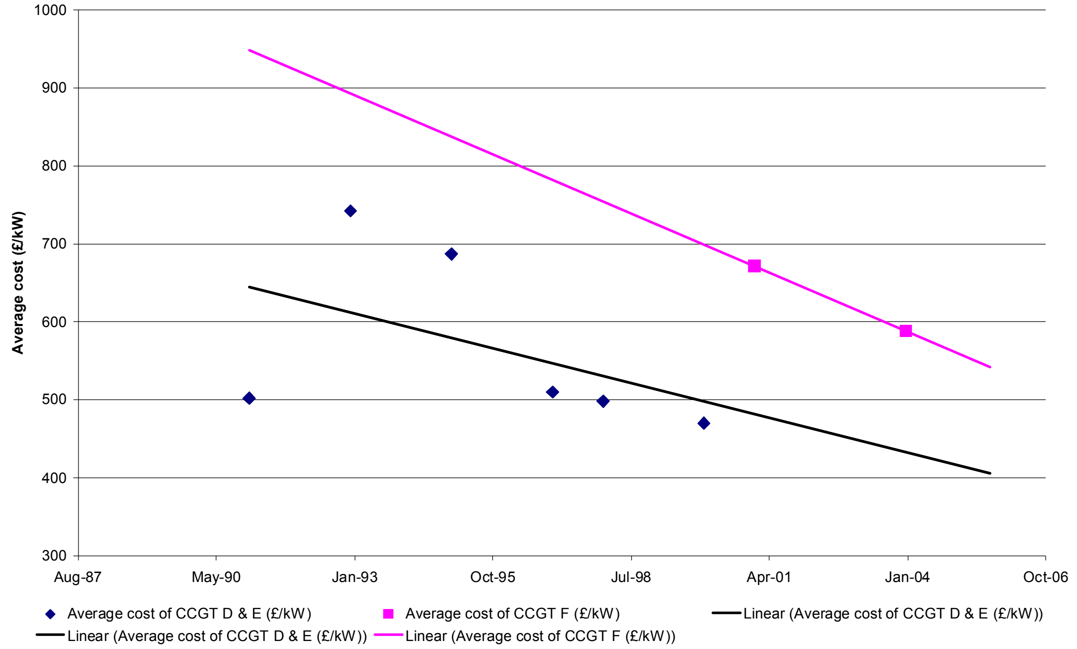
4.3. Evidence of falling costs

A competitive market creates a strong incentive to reduce costs in order to increase either the volume of sales or the margin on sales or both. The sustained pressure on the cost-base will operate at every level of activity from procurement of plant to the costs of metering and billing. Evidence for falling costs in various aspects of the industry is given below.

4.3.1. Capital costs of plant

Figure 4.22 shows the specific capital cost of Combined Cycle Gas Turbine (CCGT) plant in the UK over the period from 1990 to 2005. It suggests that on average there has been a fall in the specific capital costs of around 40% in the period.

Figure 4.22 Specific capital costs of CCGT plant in the UK from 1990 to 2005.



Source: Platts

The figure shows that the combination of competitive tensions to supply low cost technology and the requirements of purchasers has driven the cost of new CCGTs downwards. This is made even more apparent when it is considered against improvements in electrical efficiency. Over the period, the average efficiency of new CCGTs has also increased from 42% to 52%. The scale of the reductions is in cost and the improvements in efficiency may not have occurred without competition.

4.3.2. Reserve margin

A margin of electrical generating capacity over the simultaneous maximum demand is necessary to ensure reliable supply when there are unexpected breakdowns in plant or at times of unusually high demand. It is costly to construct and maintain plant for this purpose. In a monopoly, there is encouragement for higher reserve margins than are strictly needed. In these systems the investor can pass investment costs on to consumers so there is no commercial disincentive to provide this margin of reserve.

In competitive markets, there is strong asymmetry in the risks associated with the decision because possible interruptions in supply can attract political reaction and possible sanctions, whereas overinvestment will go unnoticed and risks going unrewarded.

In competitive markets, producers will try to reduce reserve margins whilst maintaining a reliable supply. They can do this by:

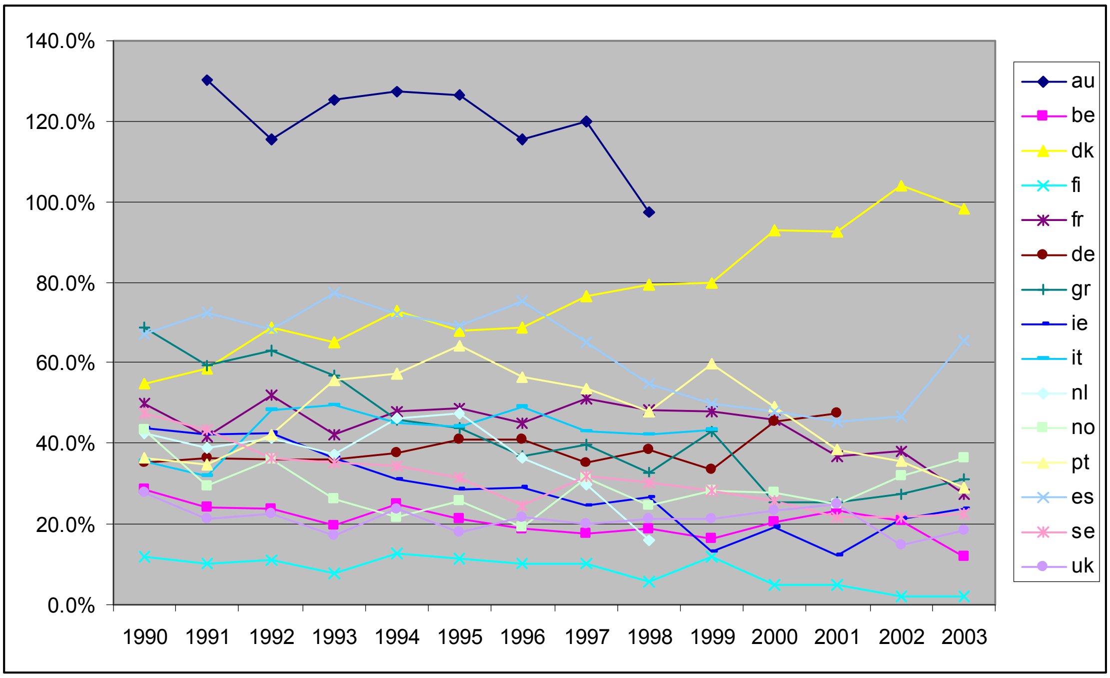
- Better maintenance of plant;
- Better planning of outages;

- Sharing of margins with interconnected systems; and
- Demand side management (ie opportunities to reduce energy consumption in the short or medium term), include demand side bidding (ie companies offering to halt production in return for payment).

All these are activities for which private ownership and competition provide incentives.

The reserve margin can be defined in several ways. A widely used definition is the percentage of installed capacity in excess of peak demand over a given period, normally a year. Figure 4.23 shows how reserve margins have evolved since 1990 for the EU Member States.

Figure 4.23 Reserve capacity in EU Member States (1990 – 2005)



Source IEA Electricity Information

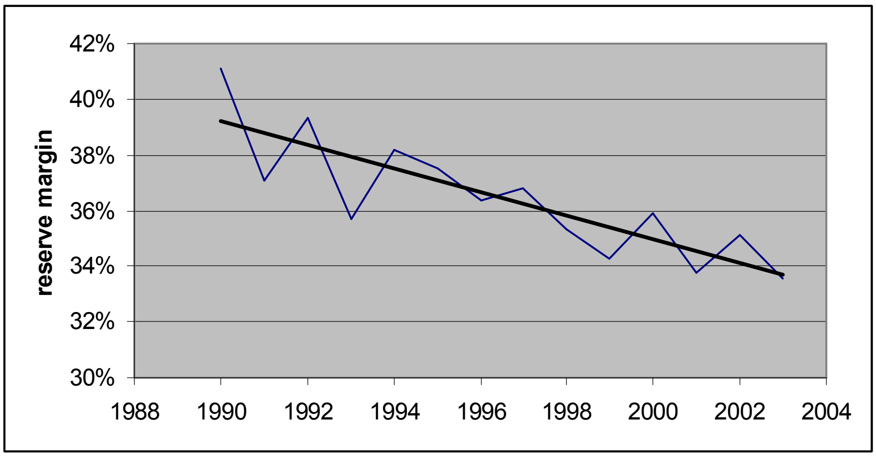
The figures for Austria related to the installed capacity of hydro plants, which is not necessarily available at times of peak demand, does not fully contribute to capacity. The rapidly growing margin for Denmark relates to the large wind capacity, which also makes a poor contribution to reliability. In most other countries there is a slight drift downwards towards a median value of around 20%. This downward drift may reflect several factors:

- More efficient use of available capacity; there is some evidence for improved availability of plant under liberalisation;
- Better sharing of reserve margins between countries as a consequence of new investment in interconnection and provision of effective cross-border trading mechanisms; and
- Adjustment from excessive demand forecasts of the past.

There is no evidence that this reduction in reserve margin has lead to lower levels of reliability and it should be seen rather as an indication of the greater efficiency of the liberalized industry.

The Figure 4.24 shows the total reserve margin for the group of countries for which data was available throughout the period (excluding Denmark and Austria because of the discounting problems for wind and hydro); they are Belgium, Finland, France, Germany, Greece, Ireland, Norway, Portugal, Spain, Sweden and the United Kingdom.

Figure 4.24 Total reserve capacity for most large European countries

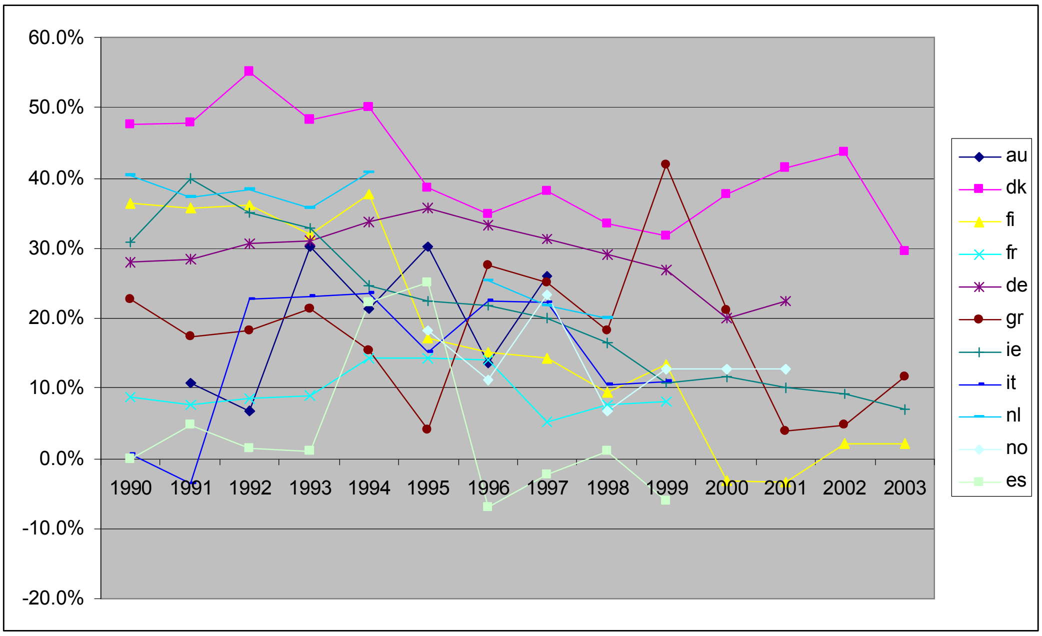


Source IEA Electricity Information and E&Y calculations

A regression of the total reserve margin against time explains 70% of the observed variance in the data and gives a very significant statistical fit. It shows that the margin has decreased over the period by 0.04% per year. This reduction has not been accompanied by any detectable fall in reliability so it can be interpreted as a success of the liberalised environment.

The simple reserve capacity can be adjusted in several ways: import transmission capacity may be added; nameplate capacity may be discounted to allow for degradation of plant or other operating constraints including low availability of water at the peak (hydropower) or intermittency (wind). The real availability of capacity is less widely published. Some countries make assessments and these are shown in the Figure 4.25.

Figure 4.25 Capacity at peak compared to peak demand



Source IEA Electricity Information

The extreme figures for Austria and Denmark are reduced in this treatment (for reasons given previously). The drift downwards in reserve margin is still evident. Regression analysis shows a highly significant downward trend from an average of about 25% in 1990 by around 1% a year to 2003. This analysis may exaggerate the real trend, because the data series thins out towards the end of the range. Regression from 1990 to 1997 shows a fall of about 0.5% a year on average which is comparable to the rate of increased productivity calculated for the nameplate reserve capacity and is probably more realistic. Unless there is indication of a declining tend in direct measures of reliability, which there is not, then this fall should be seen as a measure of the more efficient use of resources under liberalisation.

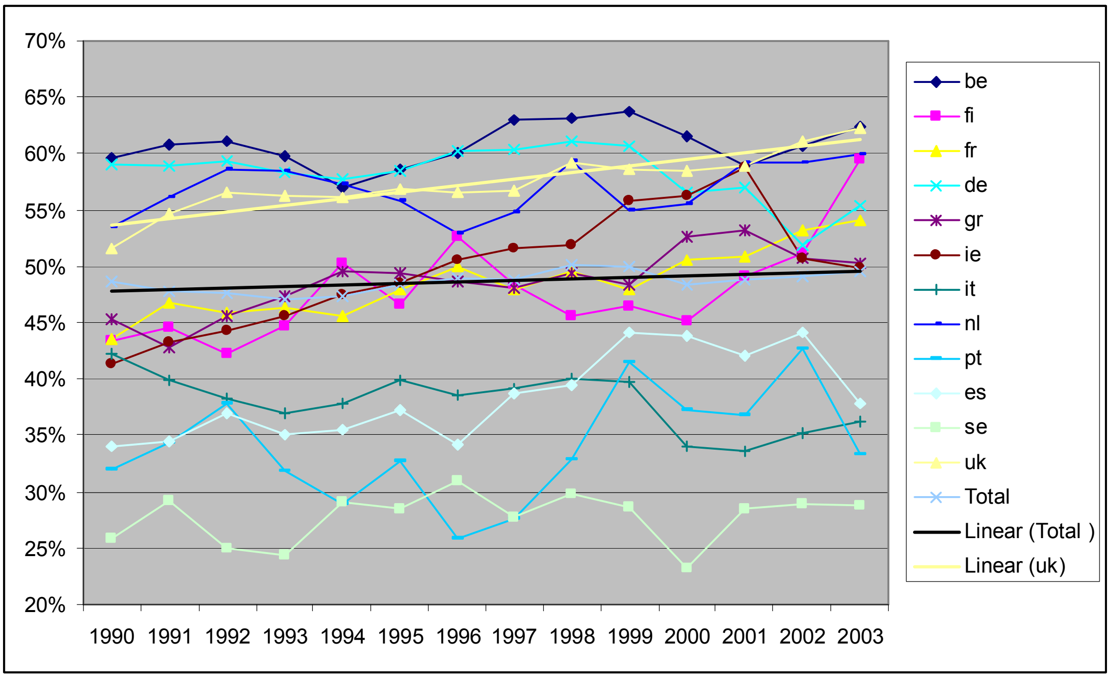
Some countries have negative values of reserve margin by this definition; they are supported at peak by the interconnected European network.

4.3.3. Plant utilisation

The possibility to maintain good reliability with lower reserve margins may arise to some extent from the improved utilisation of plant. Figure 4.26 shows the utilisation of plant defined by the total output in GWh divided by the capacity in MW and then converted to the equivalent percentage for the year in which plant runs on average. Trend lines have been added for the EU15 and for the UK. It can be seen that there is a marked improvement in the UK – one of the most liberal of markets. There is a small positive trend for the EU 15. The trend is actually statistically significant at the 95% level shows an improvement at around 0.1% per year. That for the UK is statistically extremely significant and is estimated at 0.6% per year.

The figure shows a generally tendency to significantly higher utilisation. The main exception is Germany and because of its weight in the total it tends to pull down average EU performance.

Figure 4.26 Plant utilisation 1990 - 2003 (%)



Source IEA Electricity Information and E&Y calculations

4.3.4. Labour Productivity

A recent report of DG Enterprise on the competitiveness of the EU economy provides statistics on the productivity improvements that have been achieved in the utility sector over the period 1990 to 2001. The Table 4.1 shows the annual labour productivity growth in the electricity, gas and water industries in the two halves of the period for the EU15 countries. Productivity growth has been good in both periods. With some evident exceptions, especially Ireland, the growth is generally stronger in the second half as liberalisation has got underway. The average growth in the first half of the period was 5.0% per year and in the second half was 5.9% per year.

Table 4.1 Productivity improvements in the utility sector (%/year)

	1990-95	**1995-2001**
Austria	3.5	3.5
Belgium	4.4	6.3
Denmark	5.4	n.k.
Finland	7.9	5.4
France	2.2	3.6
Germany	3.5	6.2
Greece	2.0	5.5

	1990-95	1995-2001
Ireland	18.2	7.9
Italy	3.2	3.6
Luxembourg	5.2	5.4
Netherlands	1.9	4.5
Portugal	8.7	14.4
Spain	1.7	5.5
Sweden	1.6	0.6
UK	5.2	10.4

Source: DG ENTR report, EU productivity and competitiveness: An industry perspective, http://europa.eu.int/comm/enterprise/library/lib-competitiveness/series_competitiveness.htm

4.4. Evidence of falling margins

4.4.1. Spark Spread

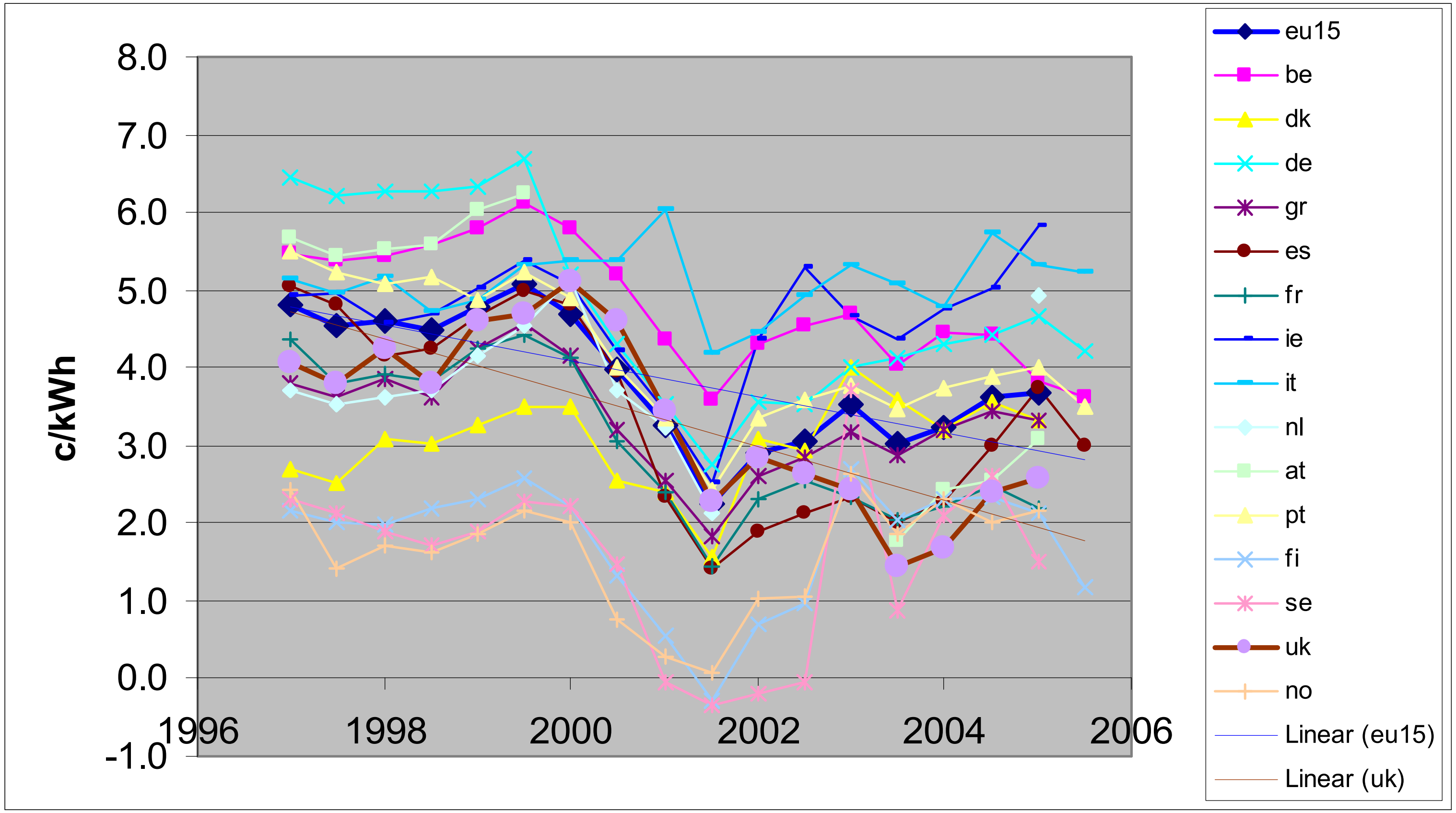
4.4.1.1. Time series

The spark spread is a measure of the difference between the price of electricity and the price of the gas required to make the electricity. The precise detail of the definition varies among authors depending on what efficiency is assumed for the generator and whether the capital cost of conversion is taken into account. We can use the spark spread as an approximate measure of the margin achieved by electricity generators on the production of electricity from gas. Some care must be taken in the interpretation because other factors will affect the spark-spread; in particular a rise in spark-spread is normally thought to indicate a scarcity in generating capacity. Nevertheless over a long period, a decline in spark-spread can be seen as an indication of a decline in the margins achieved by the generator.

The spark spread (in this context) is calculated as the price of electricity minus the price of gas for generation valued at in German border prices and assuming a generation efficiency of 40%. No allowance need be made for capital cost as this is similar for all countries. The border price in other gas-using continental countries tracks the German price closely, so a greater differentiation adds little to the analysis.

Figure 4.27 shows the spark spread calculated for the best populated data set of industrial consumers (Class Ie) on a six monthly basis since 1997. The interpretation of the spark-spread is less obviously relevant to non-gas using countries, but they are included in the Figure, because a decline in this “virtual” spark-spread can indicate a general tendency for prices to move towards the costs of the most effective widely available technology.

Figure 4.27 Spark spread across Europe (€c/kWh)

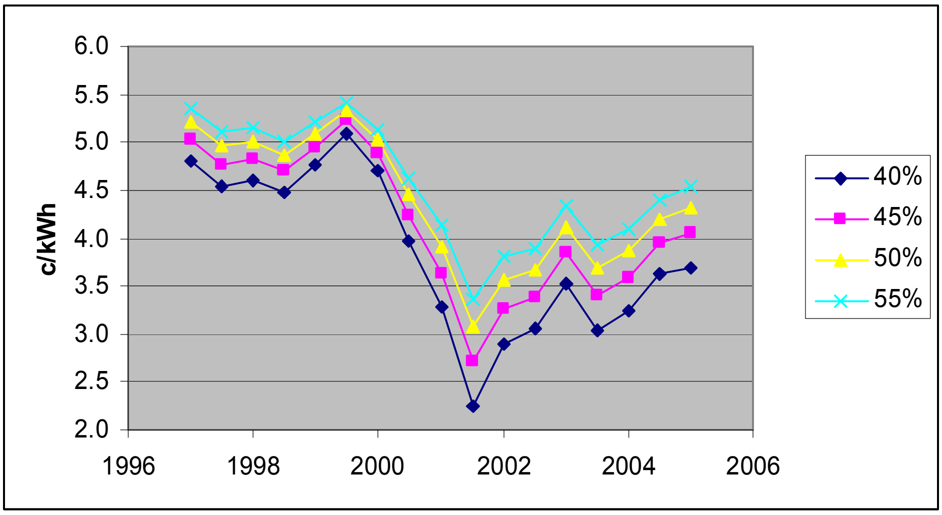


Source: Eurostat and E&Y calculations

There is considerable variation over the period, but the trend is downwards. Trends lines have been indicated for the EU15 and for the UK. Over the period, the EU average has fallen, but that in the UK has fallen faster.

Other authors assume different efficiencies for the gas-turbine plant. The results of this analysis are insensitive to that choice as can be seen in Figure 4.28 that shows the spark-spread averaged over EU15 for various efficiencies between 40% and 55%.

Figure 4.28 "Spark Spreads" for EU15 Class Ie consumer prices; various assumptions on turbine efficiency



Source: E&Y Calculations

4.4.1.2. Relationship to liberalisation

The Table shows the average annual rate of reduction in €c/kWh over the period by country, with some comments on the factors that may have an influence.

Table 4.2 Average annual rate of reduction in spark spread from 1997-2005 (€c/kWh/yr)

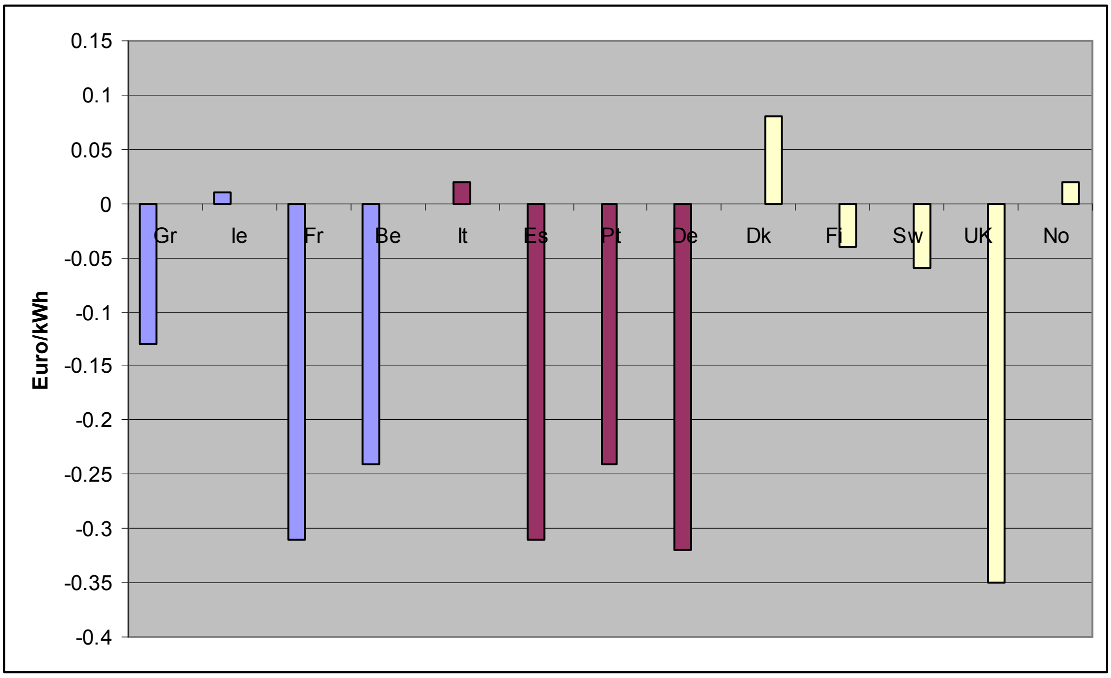
Country	€c/kWh/yr	Comment
EU15	-0.23	Falling margins across the Community
Belgium	-0.24	Essentially open, but concentrated market
Denmark	0.08	Highly liberalized; trend to costly wind and coal
Finland	-0.04	Fully open; competitive market, shift from hydro
France	-0.31	Incomplete market opening; highly concentrated market; large nuclear endowment
Germany	-0.32	Open market; moderate contestability
Greece	-0.13	Low market opening; highly concentrated market

Country	€c/kWh/yr	Comment
Ireland	0.01	Low market opening; highly concentrated market
Italy	0.02	Incomplete market opening; concentrated market
Portugal	-0.24	Open market; moderate contestability
Spain	-0.31	Open market; moderate contestability
Sweden	-0.06	Fully open; competitive market, shift from hydro
UK	-0.35	Fully open; competitive market
Norway	0.02	Fully open; competitive market, shift from hydro

Source: E&Y Calculations

Figure 4.29 shows the same data as ordered according market competitiveness as estimated by the composite indicator (MO+3G)/100 calculated for 2004. Bars in red are countries with a CI less than 1, amber indicates a CI between 1 and 1.5, and green indicates a CI greater than 1.5.

Figure 4.29 "Spark-spreads" for Member States ranked by competitiveness



Source: E&Y Calculations

There is little structure in the data. The UK shows the fastest rate of improvement (-0.35 € c/kWh) and it is the most liberalised country. The other fairly liberal systems in Germany, Spain and Portugal have also done well (-0.32, -0.31 and -0.24 euro c/kWh). The rather little liberalised systems in Greece, Ireland and Italy show slower rates of improvement, even though in Greece the system is sheltered from external cost increases by the domestic lignite. These countries exhibit a fairly consistent story with regards to liberalisation and technical progress. The remaining countries do not fit the pattern, but it is not hard to see the contingent reasons why.

France shows an apparently strong rate of improvement although it is not strongly liberalised, this may be because conditions in Germany determine the opportunity cost for French generators that can trade freely on the German market. Finland, Sweden and Norway show poor rates of progress even though they are highly liberal. This is because the Nordic countries are coming to the limits of the hydro resource and have over the period shifted to more costly sources. In Denmark, also highly liberalised, the spark spread has risen rather fast. This is a consequence of the dependence of that country on costly wind and coal.

4.4.1.3. Conclusion

There is strong evidence across Europe of falling margins after liberalisation as measured by the rate of decrease of electricity prices with respect to gas. This measure has some significance even when gas is not a major source of fuel because it provides a reference for other technologies.

4.5. Overall Conclusion

The analyses described here have weaknesses, both in terms of data reliability and statistical methodology, but they provide cumulative evidence for a strong association between competition and lower consumer prices.

- The behaviour of the gas market is especially well described and the big advantages in price enjoyed by countries that have successfully and fully implemented competition are well identified by the analysis.
- The evidence in the case of electricity prices is less clear, but still shows consistent association of competition with significant benefits in price. There is no evidence to suggest that this is a false correlation between liberalised Northern economies and low-cost fuels.
- There is strong evidence of the falling costs that underlie the falling prices in terms of specific capital costs, lower reserve margins, higher utilisation of plant and better labour productivity.
- There is strong evidence for a sustained and significant fall in electricity prices relative to gas over the period of liberalisation. This can be seen in the spark-spread (notional for some countries). There is some evidence that the highest rates of improvement are found in the most liberalised countries.

5. Does Liberalisation increase Price volatility?

This section explains why liberalised energy markets require large price excursions in wholesale markets to ensure timely investment and high levels of reliability. In our view, volatility in wholesale markets is normal and wholesale market participants must be prepared to accept it.

The section has examined wholesale price data from several exchanges in Europe to determine the extent of volatility and whether there is evidence of it increasing over time. The analysis has determined whether there are signs of volatility feeding through into consumer prices and finally attempts to determine whether the observed level of volatility is commensurate with the need for price signals for capacity shortages.

The section concludes that the wholesale markets are functioning properly, that volatility is not excessive and does not feed through in the short-term to end-use consumer prices.

5.1. Theory

Very high prices for small quantities of energy delivered over short periods are necessary in a liberalised market to reward the marginal investments in peaking capacity which are essential to ensure reliability. In a gas market the reasons for and solutions to volatility are similar to those of an electricity market, but the latter are more complex and are our focus in this section.

The fundamental relationship that governs the socially optimal level of reliability is that the cost of the marginal plant should equal the Probability of Loss of Load (LOLP) multiplied by the Value of Loss of Load (VOLL).

$$\text{Cost (€/kW/yr)} = \text{LOLP (hrs/yr)} \times \text{VOLL (€/kWh)}$$

Very high values of the VOLL have been estimated. For example, a contingent valuation study in the City of London estimated VOLL at £200/kWh. This seems high, but if the cost of plant were £50/kW/yr then this value of VOLL in the above formula would give a LOLP equivalent to 15 minutes per year. In the context of the City of London, it is quite likely that financial service companies would require at least this level of reliability.

The fundamental relationship between socially optimal reliability and VOLL x LOLP is the same in a liberalised as in an administered market. However, there is no parallel to the planning process that determines the appropriate level of investment to provide socially optimal reliability in an administered market and the wholesale market for power (and in some extreme circumstances, regulation) in a liberalised market.

In a liberalised market, if generators are to make the same level of investment as that determined by the planning process on the basis of VOLL x LOLP then they must receive prices of a comparable magnitude to VOLL x LOLP. So if the marginal plant in the planned system is justified by VOLL x LOLP then in the liberalised system spot prices must be allowed to rise to that level.

Price volatility in spot markets is therefore essential to ensuring reliability. But of course only a very small amount of electricity changes hands at this price and the price will not be paid for long. As such, there should be no perceptible impact on consumer prices.

The issue can also be analysed from the perspective of a generator. A generator has contracts with suppliers. If they are unable to meet those contracts then the generator is forced into the balancing markets, generally at high prices. In order to avoid that, the generator has an incentive to build new plant(s) to maintain its portfolio reliability. Effectively the generator will invest in order to maintain a level of reliability of its portfolio that reflects perceptions of the future prices in the balancing market. It follows once again that these must be allowed to reach very high levels approximating to VOLL or the generator will have no incentive to invest.

Liberalisation does not introduce these high costs; the marginal cost of reliability is simply high, reflecting the high valuation placed by consumers on loss-of-load. The only difference is in a liberalised market the costs are transparent and future capacity constraints are well signalled.

5.2. Evidence

5.2.1. Electricity

The data used in this analysis is the daily average day-ahead prices on the following exchanges[17]:

- EEX: the European Energy Exchange;
- Powernext (France);
- OMEL (mandatory Spanish pool)[18];
- EXAA (the Austrian Power Exchange);
- APX (Amsterdam Power Exchange);
- UKPX (the UK business of APX); and
- NordPool.

The raw data from the various exchanges are plotted in the Figure 5.1. The y-axis has been truncated – there are some excursions up to 700 €/MWh. Interpreting the data from Figure 5.1 is difficult, so further analysis of weekly moving averages, standard deviations and averages over all exchanges are presented in Figures 5.2, 5.3 and 5.4.

Figure 5.2 (showing weekly moving averages) shows a modest upward trend over the period with occasional dramatic excursion. The upward trend is more evident in the plot of the average price over the exchanges shown in Figure 5.4. This tendency for wholesale electricity prices to rise over the rather short period covered by the data is not in conflict with the long-term trend. Figure

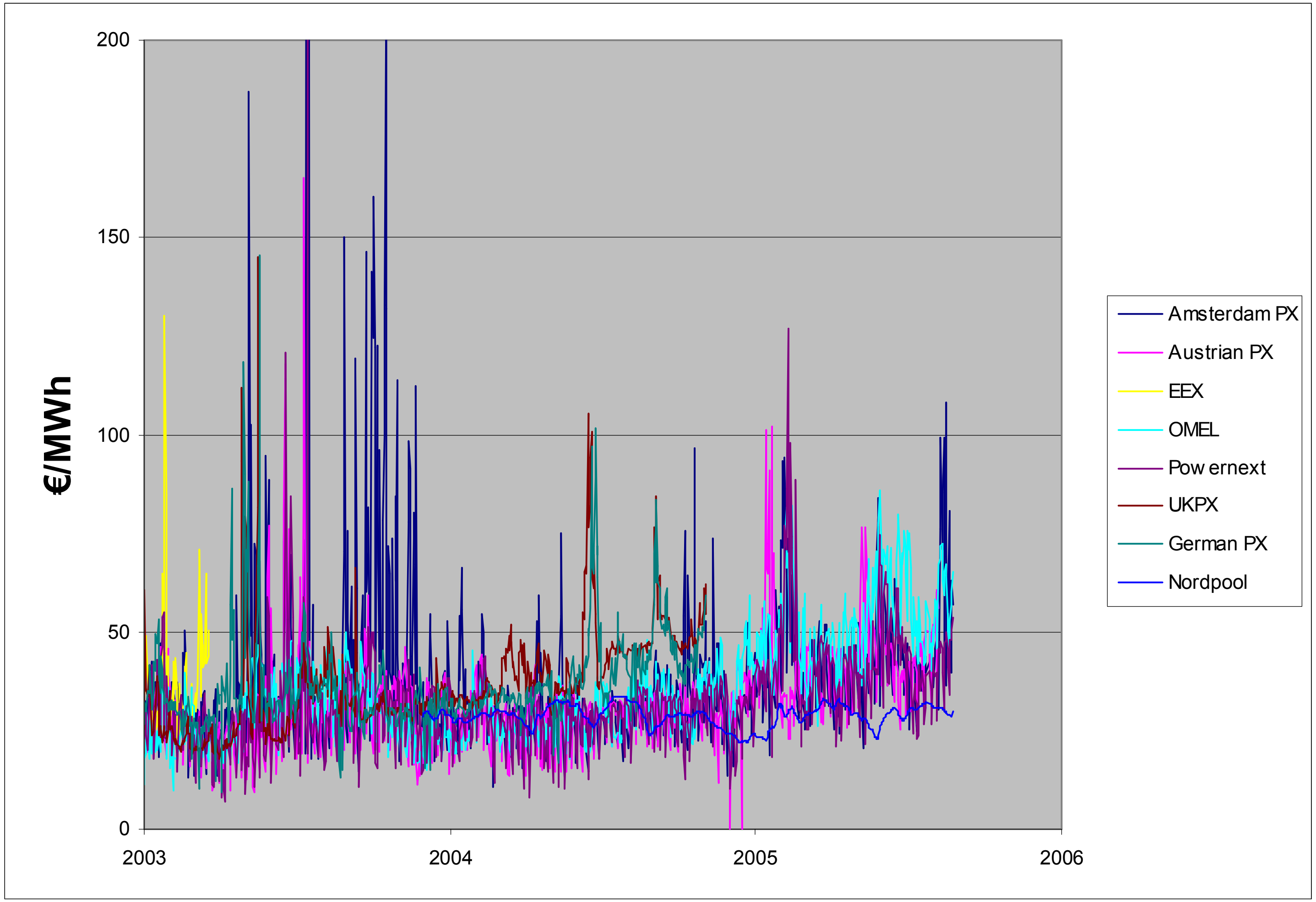
[17] A good account of the origins, performance and trading rules of these exchanges is given in *Power exchange spot market trading in Europe: theoretical considerations and empirical evidence*, (Reinhard Madlener, Markus Kaufmann, OSCOGEN, Project co-funded by the European Community under the 5th Framework Programme, March 2002).

[18] We note that OMEL is not strictly comparable with the other exchanges, because it is a mandatory pool with far larger volumes of trade than the others. The data is included in the study, but this difference should be borne in mind.

4.5 shows the long term downward trend, and include the recent short term up-turn in power prices.

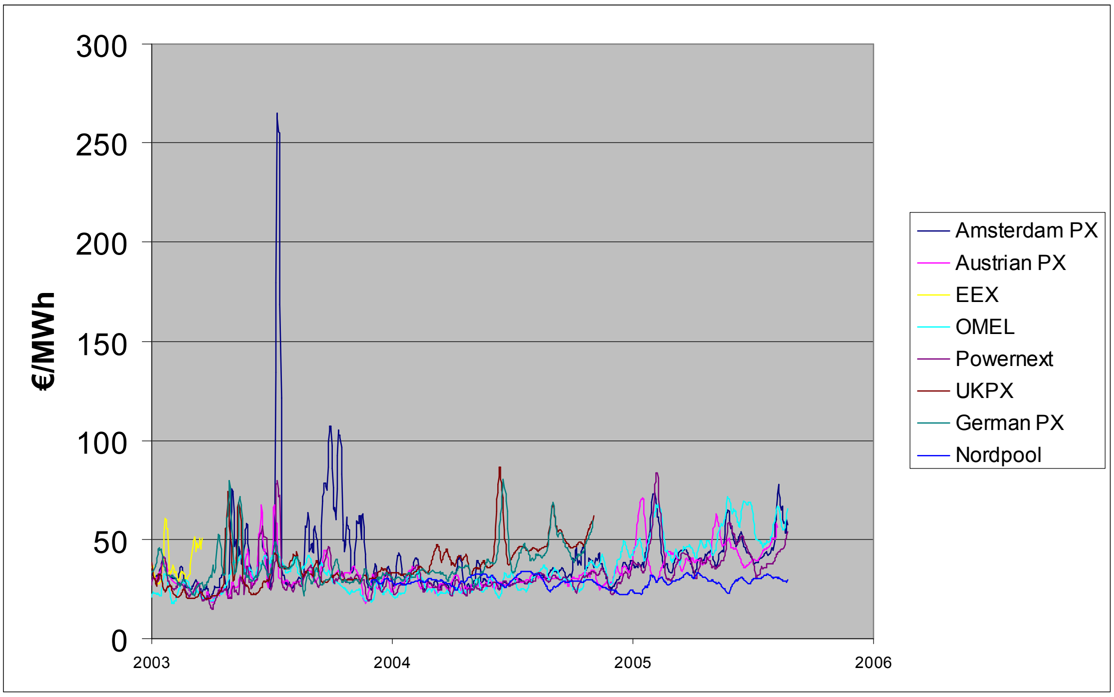
Figure 5.3 shows the weekly standard deviation of prices. This is distorted by a few extreme points and is hard to interpret.

Figure 5.1 Day ahead prices on European Exchanges



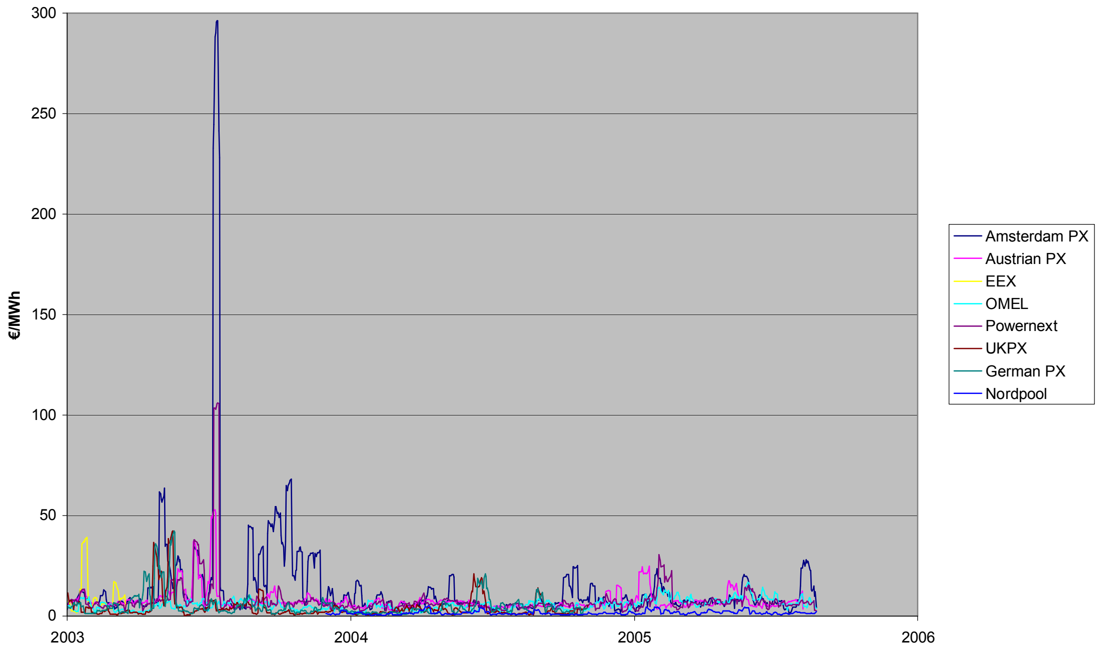
Source: Bloomberg

Figure 5.2 Weekly moving-average of day-ahead prices



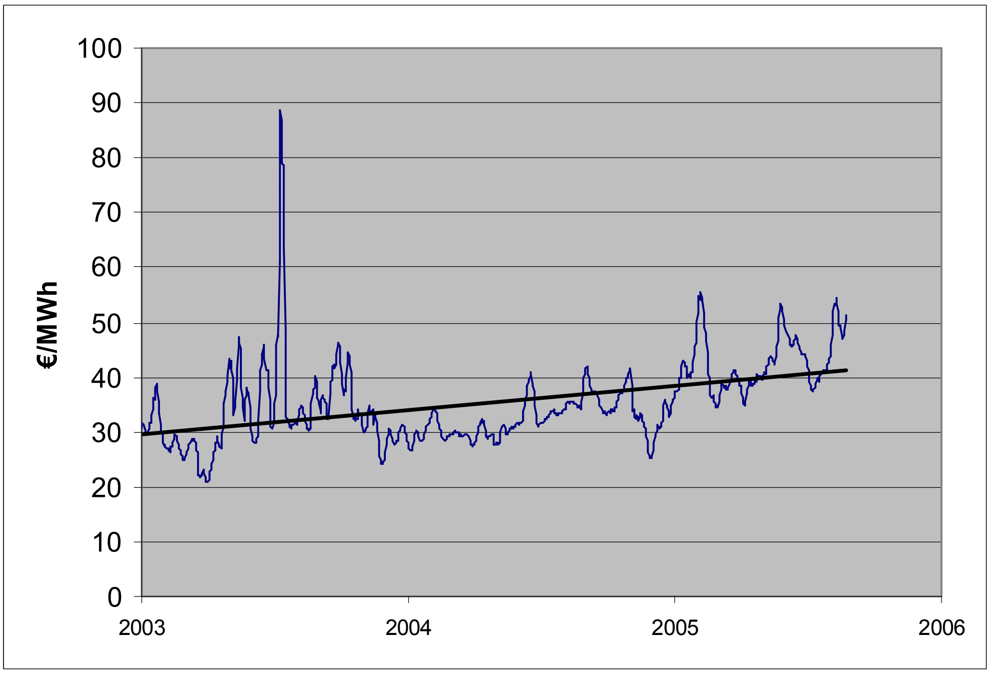
Source: Bloomberg and E&Y calculations

Figure 5.3 Weekly moving standard deviations of day-ahead prices



Source: Bloomberg and E&Y calculations

Figure 5.4 Weekly moving average wholesale prices averaged over the exchanges with trend line



Source: Bloomberg and E&Y calculations

Figure 5.5 shows monthly standard deviations and the extreme values have been removed by truncating the y-axis.

It is clear from inspection that some exchanges are more volatile than others. The least volatile is Nordpool. There is then a group of exchanges (the Austrian PX, OMEL, Powernext, UKPX and the German PX) that show roughly similar volatility with monthly standard deviations in the range 5-10 €/MWh. EEX is the second most volatile exchange, characteristically between 10 and 15€/MWh and the Amsterdam PX is the most volatile with standard deviations over the month regularly exceeding 20€/MWh.

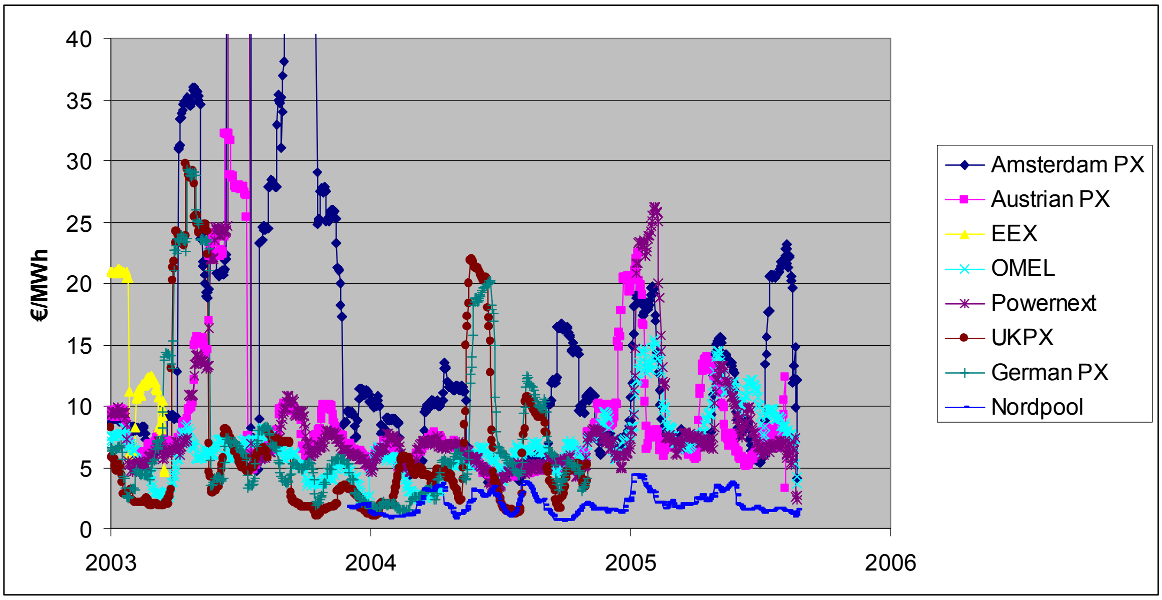
No attempt has been made here to assess why some exchanges show more volatility than others. However, it has been argued by some[19] that certain forms of market rules are more prone to volatility than others.

It is also apparent from the data that there has been no increase in the general volatility of prices over the period and the large excursions appear to have been controlled. This is confirmed by the weekly moving standard deviation averaged across the exchange as shown in Figure 5.6. There is no significant trend with time. A more reasonable measure of volatility is the weekly standard deviation divided by the average prevailing price. This measure is shown in Figure 5.7, along with the trend-line. There is a clear and significant long-term trend to lower volatility by this measure. It is not clear why this should be; it may be that market participants have come to

[19] Market Power and Price Volatility in Restructured Markets for Electricity, T. Mount, Hawaii International Conference on System Sciences, January, 1999

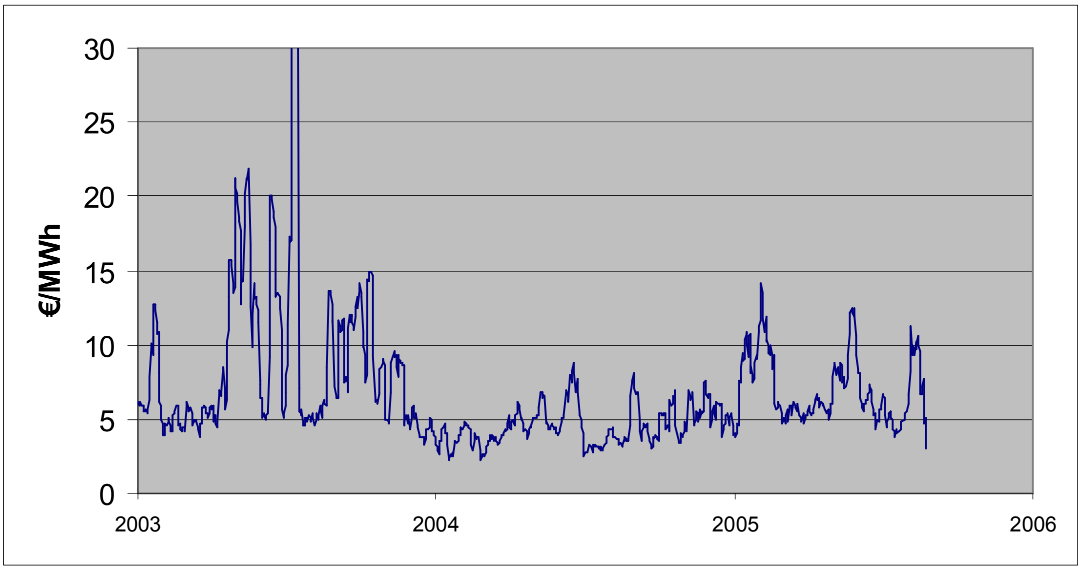
understand how to use wholesale markets more efficiently, so reducing large imbalances and high prices. It may also be that regulators have developed better means of monitoring markets and eliminating price movements that arise out of the exercise of market power.

Figure 5.5 Moving monthly standard deviations of wholesale electricity prices with extreme values removed



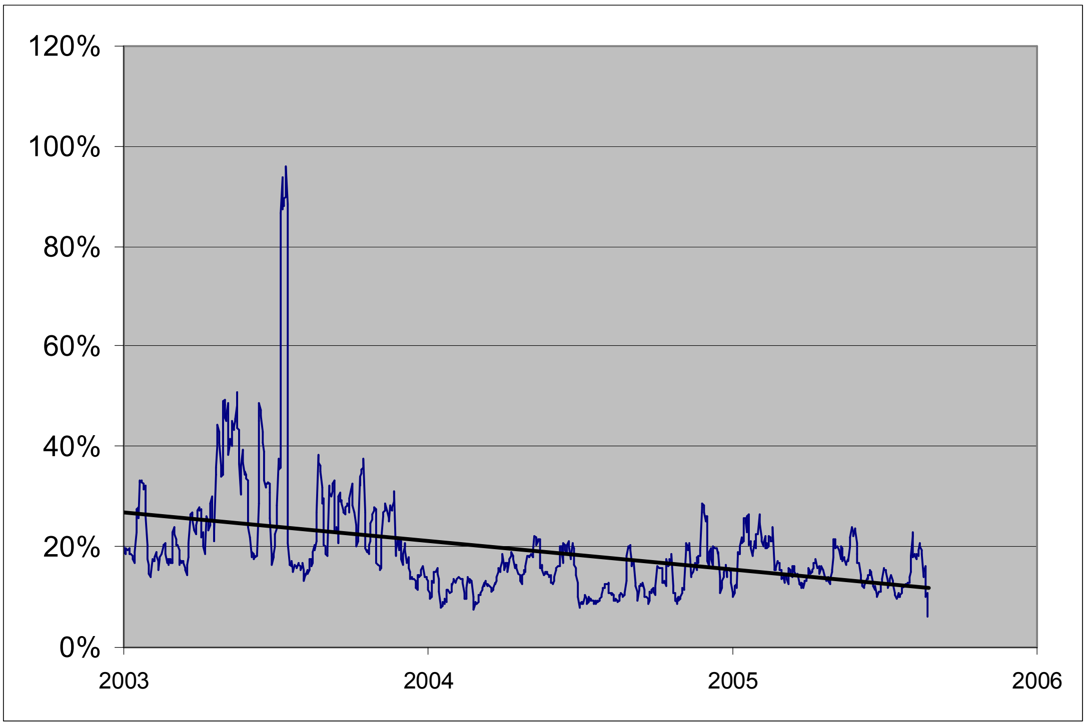
Source: Bloomberg and E&Y calculations

Figure 5.6 Weekly standard deviation averaged across exchanges



Source: Bloomberg and E&Y calculations

Figure 5.7 Weekly standard deviations as a percentage of the average



Source: Bloomberg and E&Y calculations

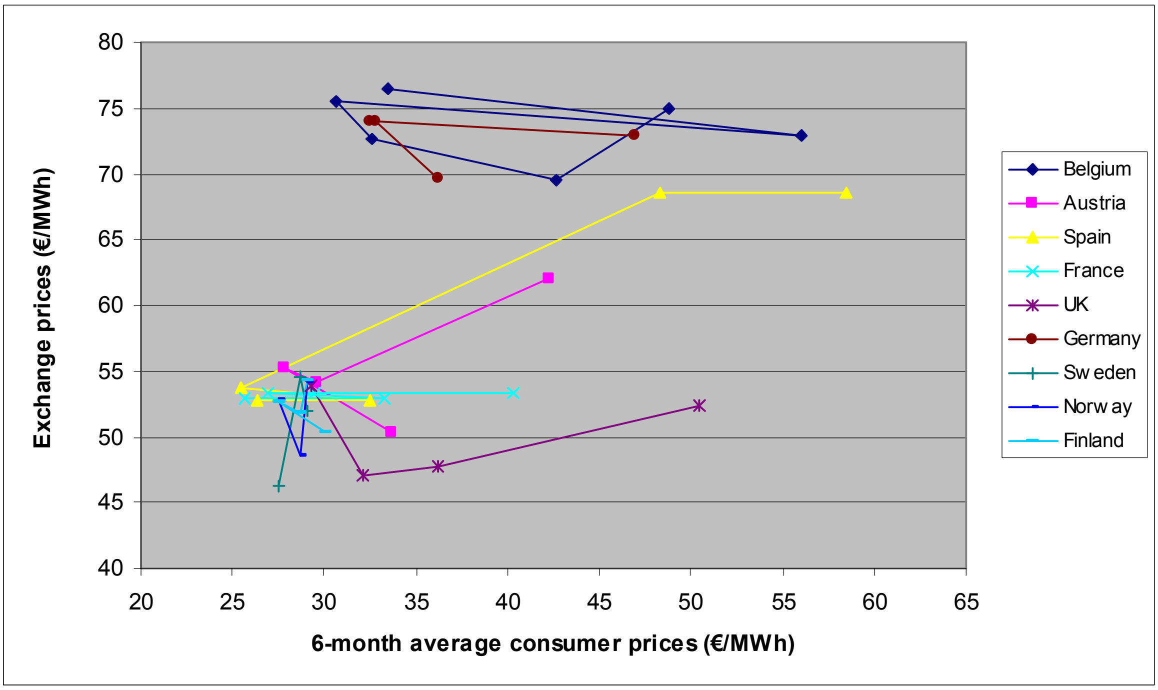
5.2.1.1. Relation to consumer prices

It has not been possible to identify the extent to which short-term volatility in wholesale prices feeds through into industrial consumer prices and contracts. It seems unlikely that daily (or shorter) variations could have any direct pass-through into long-term contracts to most groups of consumers (excepting potentially the largest). It is possible that short-term contracts might be affected, but the shorter the term of the contract the less proportion of consumption it will normally represent and the smaller the influence on average price. Without detailed information on the prices prevailing in the short-term contracts offered to industrial consumers it is not possible to relate them to short-term wholesale prices. The most detailed data series on consumer prices that are reasonably complete are the six month series published by Eurostat. The IEA compiles quarterly statistics, but the response from countries is so poor that the series cannot be used in comparative analysis.

Six monthly averages of exchange prices were constructed to compare with the six monthly Eurostat series of industrial consumer prices in the countries where the exchanges are located. Trajectories were then constructed by country showing the relationship between six monthly average prices to industrial consumers of Class Ie and the spot prices[20]. No consumer prices were available for the period from Eurostat for the Netherlands so Belgium was chosen as a proxy for consumer prices to link to the Amsterdam exchange. The trajectories are shown in the Figure 5.8.

[20] Class Ie includes consumers typically with an annual consumption of 2,000MWh and a maximum demand 500kW.

Figure 5.8 Trajectories of six monthly average exchange prices and consumer prices (2003-2005)



Source: Eurostat, Bloomberg and E&Y calculations

On the German and Amsterdam exchanges prices are rather high and do not seem to correlate with consumer prices. On the French exchange and in Nordpool there are lower exchange prices and again little correlation. On the Spanish, UK and Austrian exchanges there seems to be some tendency for the two sets of prices to move together.

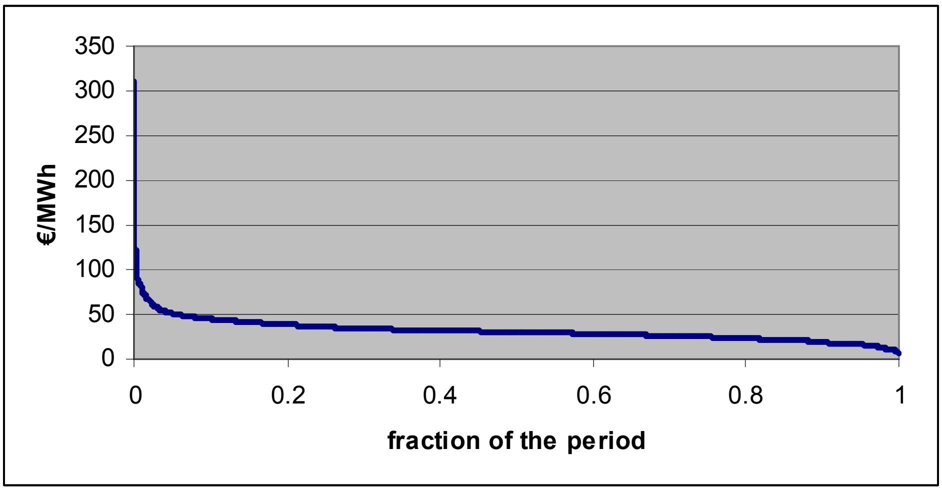
Regression on the pooled cross-sectional and time series gives a strongly significant statistical relationship between the exchange price and the consumer price, but this is driven by the cross-sectional effect, not by any real transmission of wholesale prices through to consumer prices within the country. Analysis of substantial time series on a more frequent basis might help elucidate the relationship. The necessary data does not seem to be available. Given the importance of understanding better the behaviour of liberalised markets it is desirable that more attention be given to the reporting of good quality price data on at least a quarterly basis.

5.2.1.2. Are spot markets volatile enough?

Volatility in the spot market is the market mechanism to reward the marginal investment that sustain reliability. The question arises as to whether markets are sufficiently volatile to ensure adequate reliability. Figure 5.9 shows the cumulative probability distribution of prices on the Powernext exchange for the period from January 2003 to September 2005. The x-axis shows the fraction of the period for which wholesale prices exceeded the value shown on the y-axis.

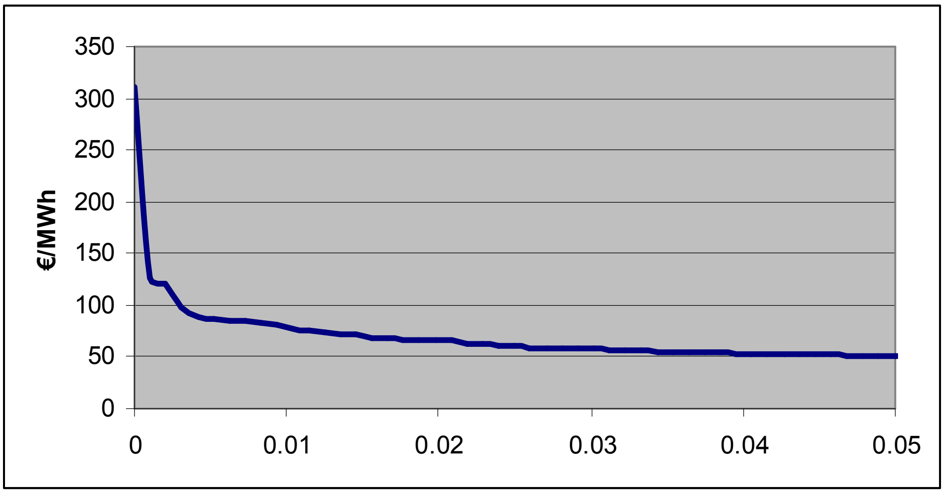
To achieve high system reliability, the marginal plant that operates for very few hours a year must be rewarded when it does operate by high prices. The part of the graph of interest therefore relates to the distribution of high prices, shown more clearly in the Figure 5.10.

Figure 5.9 Probability distribution of day-ahead electricity prices (Powernext)



Source: Bloomberg and E&Y calculations

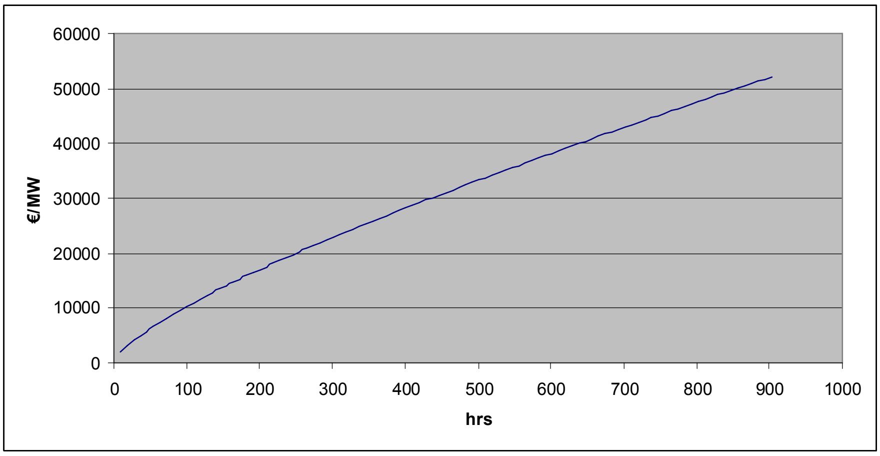
Figure 5.10 Probability distribution of high day-ahead electricity prices (Powernext)



Source: Bloomberg and E&Y calculations

From the probability distribution in Figure 5.10, we can see that for the perhaps one hour in the year prices rise to €300/MWh. Using this, we can calculate the annual revenues for a marginal addition of plant according to the running hours it achieves. This is shown in Figure 5.11. In Figure 5.11 the y-axis shows the revenues that will be achieved by a plant running for the number of hours indicated on the x-axis. If we compare this to a new Open Cycle Gas Turbine (OCGT) which would represent the cheapest means of new peak capacity, with an annual cost of €40,000/MW then the plant needs to run during the 600 to 700 hours a year of highest prices in order to pay back the annual cost. In some circumstances this will incentivise new build and will be complemented by other generation sources such as pump-storage.

Figure 5.11 Annual revenues per MW of plant as a function of running hours



Source: Bloomberg and E&Y calculations

5.2.1.3. Conclusion

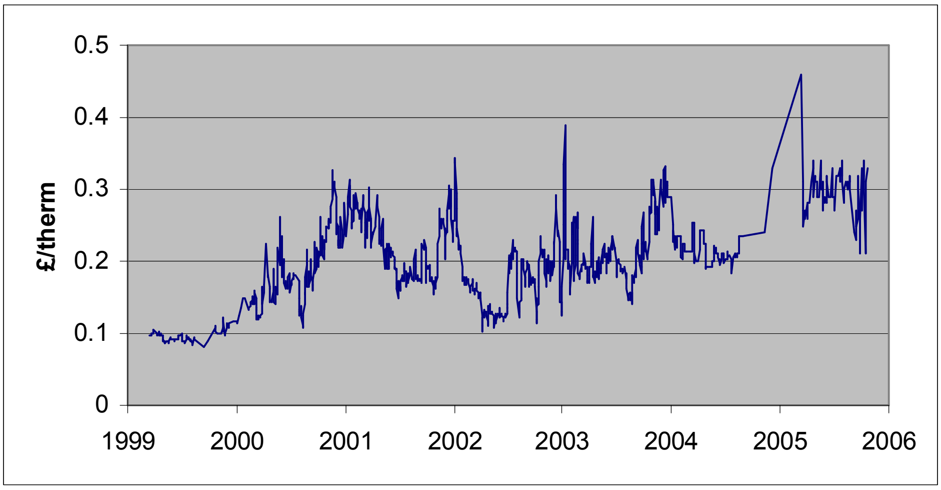
One can conclude from this analysis that:

- Wholesale markets are working well
- On a daily time-scale some exchanges have been very volatile;
- The level of volatility is not excessive compared to the prices that are necessary to reward the investment needed for adequate reliability;
- There is a clear difference in the volatility of different exchanges which may be due to different market rules and should be studied further;
- Volatility appears to be decreasing as a proportion of average wholesale prices; the reason for this is unclear but may be linked to better use of wholesale markets by participants and better understanding and control by regulators of market power; and
- The evidence for the manner in which wholesale prices influence consumer prices is poor and no clear conclusion can be drawn.

5.2.2. Gas

The data for this analysis is the day-ahead spot price at Zeebrugge, and is presented in Figure 5.12.

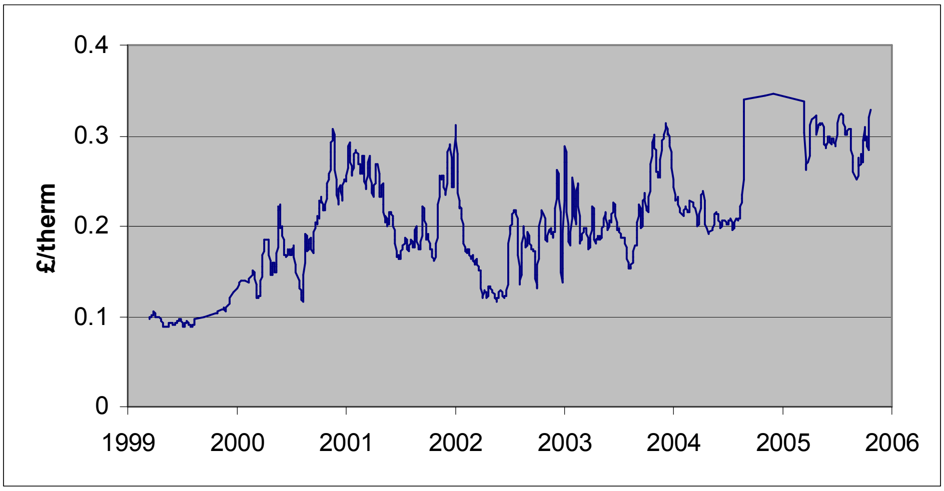
Figure 5.12 Time series of Zeebrugge spot prices



Source: Bloomberg and E&Y calculations

It is clear that prices have been increasing over the period, but this reflects the general international trend and is not a consequence of the design or operation of the wholesale market. Weekly standard deviations were calculated as a measure of short-term volatility. These are shown in Figure 5.13.

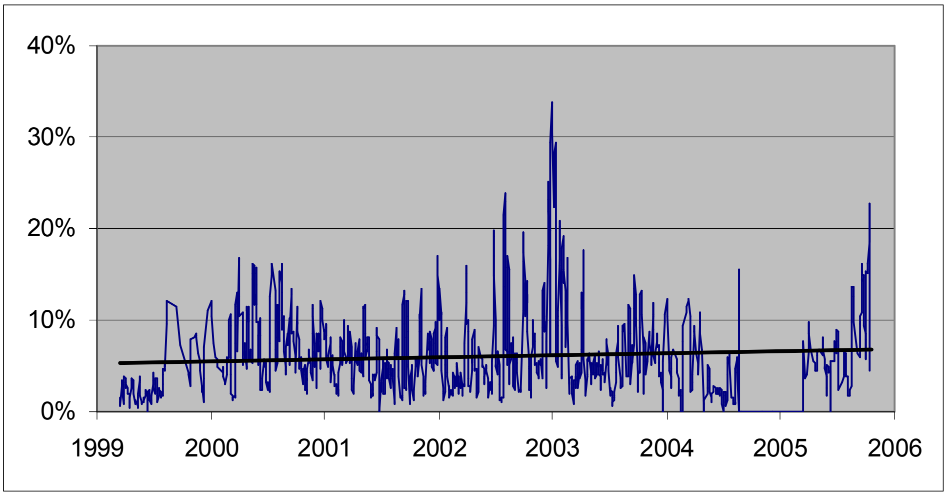
Figure 5.13 Weekly standard deviations of day-ahead prices



Source: Bloomberg and E&Y calculations

Figure 5.13 suggests an increase in volatility over the period, but it is more reasonable to judge volatility with respect to the prevailing price. Figure 5.14 shows the weekly standard deviations expressed as a percentage of the weekly average.

Figure 5.14 Weekly standard deviations as a % of the average



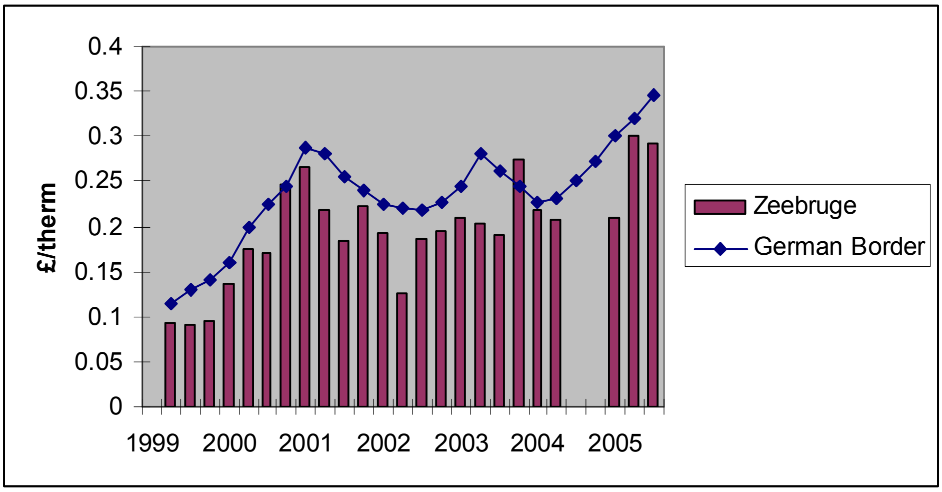
Source: Bloomberg and E&Y calculations

According to Figure 5.14, there is little increase in volatility over time. Regression shows the apparent trend to be statistically significant, but that the analysis explains less than 1% of the variance, so for practical purposes it is not significant. The volatility, which is typically around 7-8% of the average day-ahead price, is significantly less than for electricity markets, which are up to 20%.

5.2.2.1. Impacts of the international market

The quarterly price at the German border is taken as an indication of the prevailing international market prices. Figure 5.15 shows the quarterly average of the spot market price at Zeebrugge and the quarterly German Border prices averaged over the four entry points. It is evident that the average spot market price mirrors the prices in the long-term contracts at the border. In the short-term the spot market may move a long way from the prevailing price, but averaged over the longer term it closely follows border prices. A regression of the quarterly average spot market price against the German border price gives statistically very significant fit that explains 75% of the observed variance in the spot market averages. This implies that volatility is in the market at the border, but is generally passed onto consumers providing appropriate signals but in the short term.

Figure 5.15 Price for gas on the Zeebruge day-ahead market and German border prices

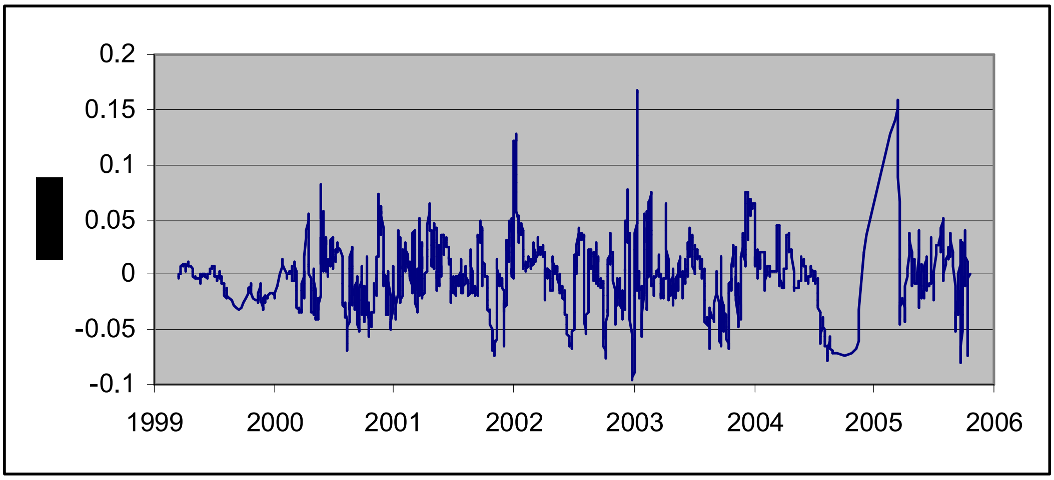


Source: Bloomberg and E&Y calculations

5.2.2.2. Are spot markets volatile enough?

It is more difficult to relate wholesale prices to peaking capacity for gas than it is for electricity because gas can be easily stored and therefore the analysis depends on the operating regime of storage. Figure 5.16 shows the volatility in wholesale prices around the monthly moving average.

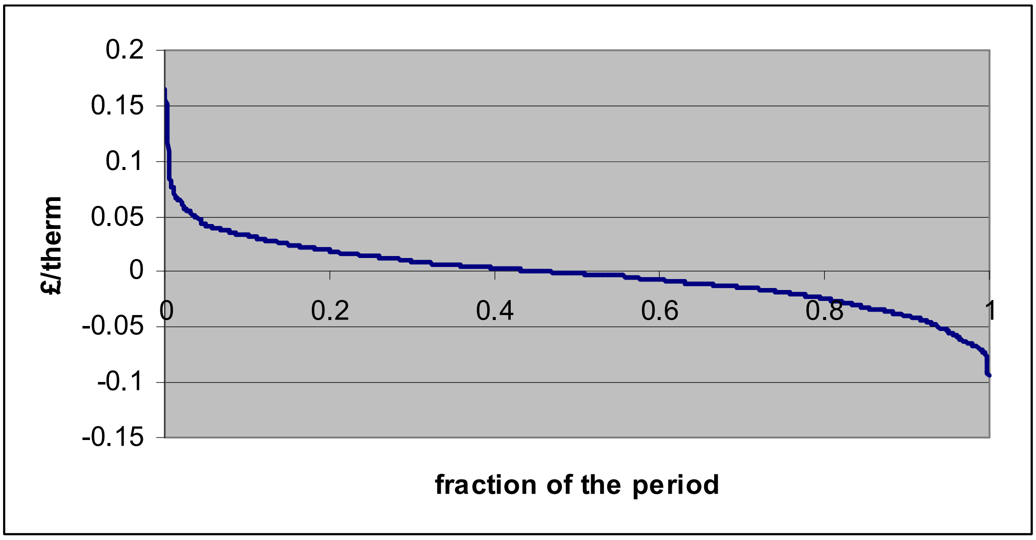
Figure 5.16 Volatility of gas wholesale prices with respect to the monthly moving average



Source: Bloomberg and E&Y calculations

In Figure 5.16, excursions above the axis represent times when wholesale prices are high and present an opportunity to an owner of storage. This can be converted into a cumulative probability distribution as shown in Figure 5.17.

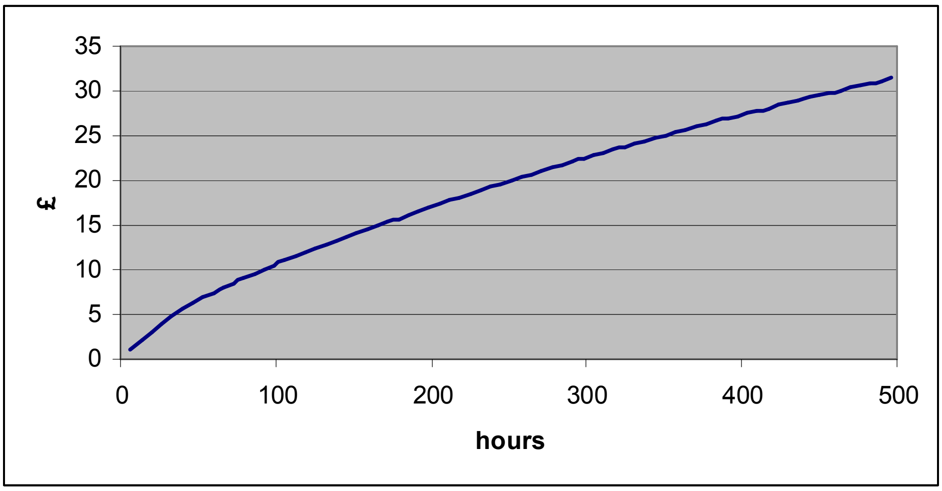
Figure 5.17 Probability distribution of price excursions from the moving monthly average



Source: E&Y Calculations

The x-value of any point on the curve represents the probability that the differential from the monthly moving average price exceeds the value on the y-axis. From this distribution we can calculate the reward to an owner of storage releasing 1 therm per hour of gas at the most favourable times; the reward is shown in Figure 5.18.

Figure 5.18 Reward for the release of 1 therm per hour of gas as a function of release hours



Source: E&Y Calculations

The annual cost of cavern storage might be in the order of £150 for deliverability of 1 therm/hour so the owner could not recover costs on the basis of the above wholesale price variations. It maybe that shorter timescales would reveal larger price excursions and a stronger case, but we can conclude that at present there is no indication that volatility exceeds the levels necessary to provide appropriate signals for investment in facilities to provide reliable supply.

5.2.2.3. Conclusions for gas

We can conclude:

- Short-term volatility in the wholesale markets does not exceed the level necessary to provide correct price signals;
- The long-term trends in wholesale market movements follow border prices; there is no sign that they are manipulated relative to border prices by the exercise of market power; and
- There is no evidence to suggest a practically significant trend to a long-term increase in volatility of spot markets.

5.3. Overall Conclusions

We can conclude from this analysis that:

- There is no evidence to suggest that short-term volatility in electricity and gas wholesale markets is greater than is necessary to provide appropriate price signals.
- There is no obvious evidence of any major exploitation through market power of the general level of wholesale prices for gas; long-term movements follow border prices closely.
- In electricity the volatility on wholesale markets appears to be decreasing with time, possibly as a consequence of greater familiarity with the functions and character of wholesale markets.
- In wholesale markets for gas the volatility of prices appears to be stable at a lower percentage level relative to the average prices than for electricity.

6. Does liberalisation inhibit investment?

This section examines whether liberalisation inhibits or encourages investment. The basis for the examination is that wholesale prices reveal underlying supply-demand imbalances which act as drivers for new investment.

In examining the issues of liberalised markets with regard to investments, we have considered:

- How wholesale price and capacity margin changes are transmitted from the market into investment decisions by commercial entities; and
- The extent to which investment decisions are made based purely on price signals.

In exploring these relationships, we have focused on case studies for electricity in the UK, Spain, France and Germany. Analysis of gas is not conducted as there is insufficient evidence.

6.1. Theory

In competitive markets, price and the expectation of future prices are the fundamental drivers for investment (within the usual confines of regulation and other business objectives). Where business is responsive to prices, competitive markets will drive:

- Investment to meet real capacity requirements and consumer demand patterns (albeit on a potentially just-in-time basis); and
- Efficient, low cost investment in new capacity (considered in Section 4.3).

Markets that are not liberalised or competitive have a tendency to over invest and these investments tend to be costly. This higher cost in monopoly markets is driven by a differing basis for decision making and pricing which reflects the pass-through of average costs (rather than marginal costs).

In liberalised markets the clear focus is on a combination of signals to encourage investment. These responses are driven by complex processes and dictated by spot and forward wholesale prices in varying market segments (eg baseload and peak markets), by future expectations (and potentially long term contracts), by the design and implementation of market mechanisms (eg capacity payments) and other fuel and resource markets.

Crucially new capacity is developed in a well planned fashion, usually just-in-time. For example:

- Limits on generation capacity in Spain are currently being satisfied by investment in new CCGT capacity.
- Growing gas demand in Europe and a lack of indigenous gas production, is spurring investment in LNG capacity in the UK, Spain and France.

6.2. Evidence

6.2.1. United Kingdom Electricity Generation

Figure 6.1 presents average electricity wholesale prices, costs of capacity additions, capacity margins and the new build profile. Figure 6.1, is presented vertically to aid comparison.

The top chart in Figure 6.1, shows:

- The pattern of wholesale prices in the UK from 1990 (the start of the liberalised market) to 2005. The price curve at a high level can be shown in three segments – the initial arrangements for trading power (up to 1994), the Electricity Pool system (from 1994 to 2001) and then the New Electricity Trading Arrangements (from 2001).
- The cost of adding new plant to the electricity system (related to the right hand y-axis). A trendline has been added for these capacity additions. Average construction costs have been compiled for three types of CCGT technology: D and E frame which have been grouped as they were constructed over the same time period and F frame technology[21].

The middle chart in Figure 6.1 shows the capacity margin from 1990 to 2005 from National Grid Transco.

The bottom chart in Figure 6.1 shows the new build capacity over the period from 1990 to 2005.

The figure shows:

- In the early years of liberalisation, prices were low on the back of robust capacity margins (almost 35% (compared to National Grid's planning margin of around 20%)). Together with a less than dynamic early market, this resulted in the commissioning of a few plant, which were an effective hangover from the earlier un-liberalised market.
- A slow reduction in capacity margins over the period however to 1993 (which were based on planned plant shutdowns), a number of new plant were built and commissioned. These plant were the first of the new breed of CCGT technologies.
- With capacity additions, the margins improved and electricity prices, which had been on an upward trend, softened. However with a number of very large retirements of capacity in 1995 (through the run down of oil firing plant, eg Tilbury), causing a drastic reduction in margin (down to 16%), prices began an upward trend, encouraging new investment in capacity (again mainly CCGTs).
- In the late 1990's, plant were also heavily incentivised by the existence of capacity payments within the electricity Pool market.
- With the return of healthy capacity margins in 2000 / 2001, plants started to be mothballed, to protect plant margin and sustain price levels. This mothballed capacity has been returned to service in several instances, usually for winter service, again to protect capacity margins and responding to short term pricing signals.

The recent upward trend in prices, has not come on the back of changes to capacity margins, but more as an exogenous shock to the system – particularly rises in gas prices.

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[21] The construction data was largely sourced from Power Finance Infrastructure and Platts.

The critical element for consideration in drawing conclusions is whether investment decisions were made on the basis of price response and foresight.

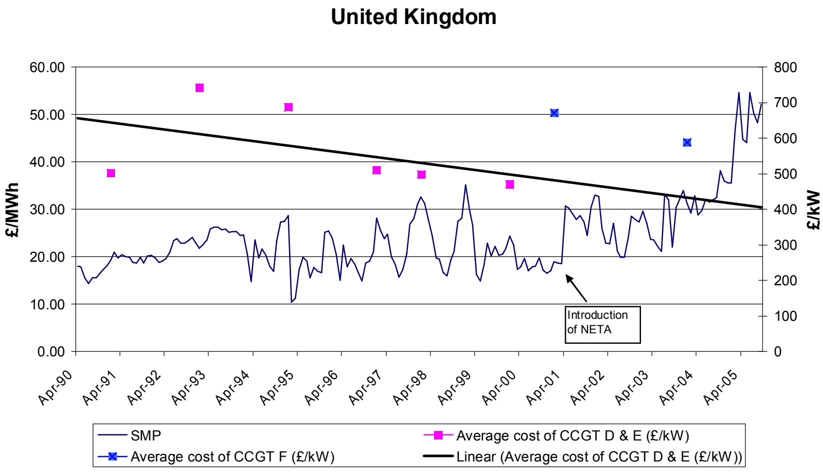
The early capacity additions suggest price responsiveness and foresight with considerable additions being made as prices increase and the prospect of further rises in prices as capacity margins reduce. However, there is a good visual relationship, because as prices softened, fewer plant were brought onto the system.

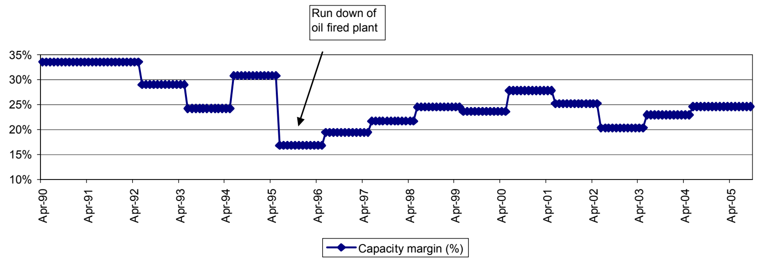
However, there is a dislocation of this experience starting in 1998, where new capacity was added based on current high prices and their expected continuance. This is also however the coincidence of low gas prices and long term gas contracts, providing sufficient financial margin to encourage new build.

In conclusion:

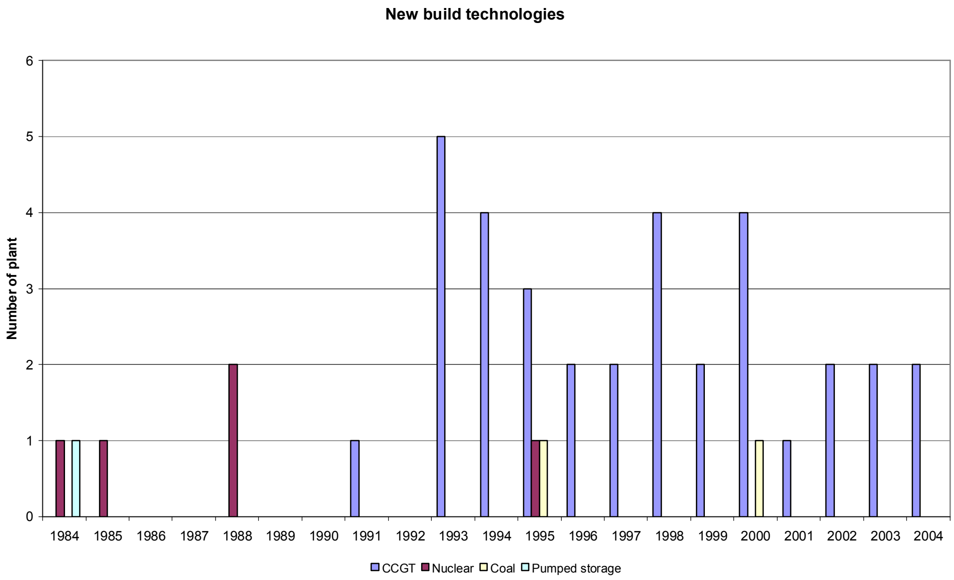
1. The market has responded to price signals (and capacity margins) over time, and has prevented capacity squeezes;
2. Price has clearly been a strong influence, but this must be balanced against other factors, particularly focusing on gas availability, and a generally healthy set of plant economics (particularly spark spreads) which are explored in Section 4.4.1.

Figure 6.1 – Price, Margin and Capacity Profile for UK (1990 to 2005)





Sources: Platts, National Grid, Bloomberg, Electrica Services



6.2.2. Spain Electricity Generation

The Spanish market has some parallels to the UK in that together with Portugal, it is seen as an 'energy island' due to limited interconnection with other EU Countries. The Spanish liberalisation process is however, behind that of the UK, but it is still interesting to see whether the same early trends in the UK market are repeated in Spain.

Figure 6.2 contains the evidence for our Spanish case-study. Electricity prices, costs of capacity additions, capacity margins and the new build profile are presented in three charts which are vertically comparable.

The top chart in Figure 6.2, shows:

- The pattern of wholesale prices in Spain from 1998 (the start of the liberalised market and the introduction of the pool system) to 2005; and
- The number of plant built from 1996 to 2005 (coal, hydro and CCGT technologies.)

The middle chart in Figure 6.2 shows capacity margin from 1990 to 2004 from IEA data.

The bottom chart shows the new build capacity over the period from 1984 to 2005 and the cost of adding new CCGT plant to the electricity system (related to the right hand y-axis[22].

The figure shows that:

- At the start of liberalisation, prices were low on the back of robust capacity margins (over 70%).
- A steady decline in capacity margins from 1998 was the result of a step rise in demand (primarily driven by a sequence of cold winters and droughts and the increased rate of installation of air conditioning systems) coupled with a lack of new generation capacity. The lack of new investment is largely attributed to the uncertainty over the future of 'Competition Transition Costs' payments agreed in 1996 to be made to incumbents over the transition period. Furthermore a condition in the Royal Decree 6/2000 did not allow incumbents to construct new plants if they had market share of over 30%.
- The result of the reduction in capacity led to rolling blackouts in central Spain in the end of 2001 and led to a sharp rise in prices. The regulator encouraged incumbents to implement their construction plans and a surge in new build resulted from 2002 with a consequent improvement in capacity margins in 2003.

Again the recent upward trend in prices, has not come on the back of changes to capacity margins, but more as an exogenous shock to the system – particularly rises in gas prices.

In conclusion:

1. the market has responded to price signals (and capacity margins indicators) over time when unrestricted by the regulator/law;
2. Price has clearly been a strong influence, however as mentioned above the restrictions applied to the incumbents overrode the price signals in the early years of liberalisation.

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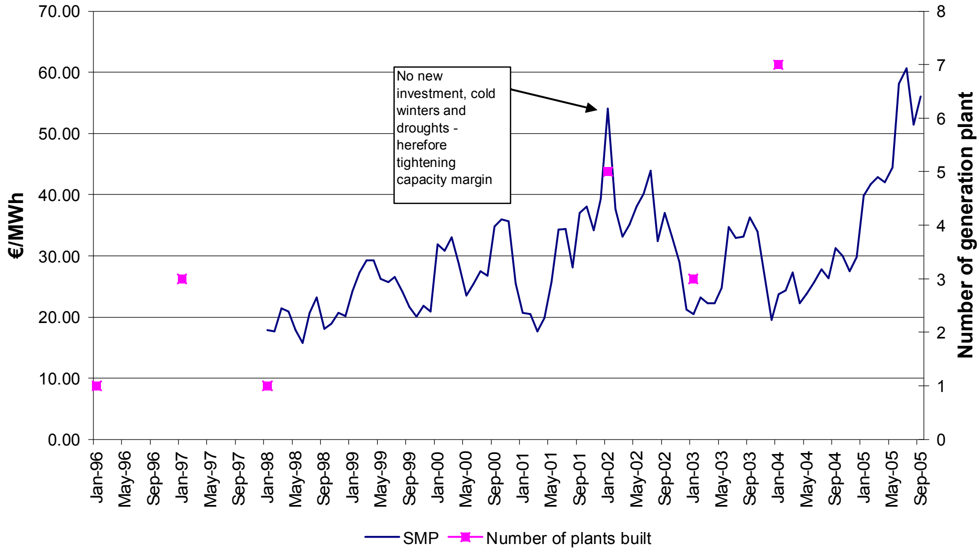
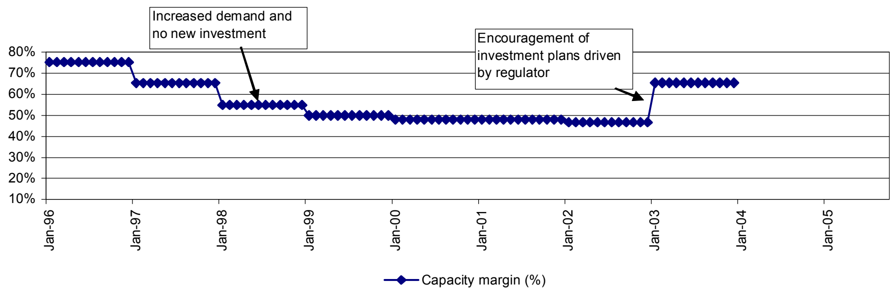
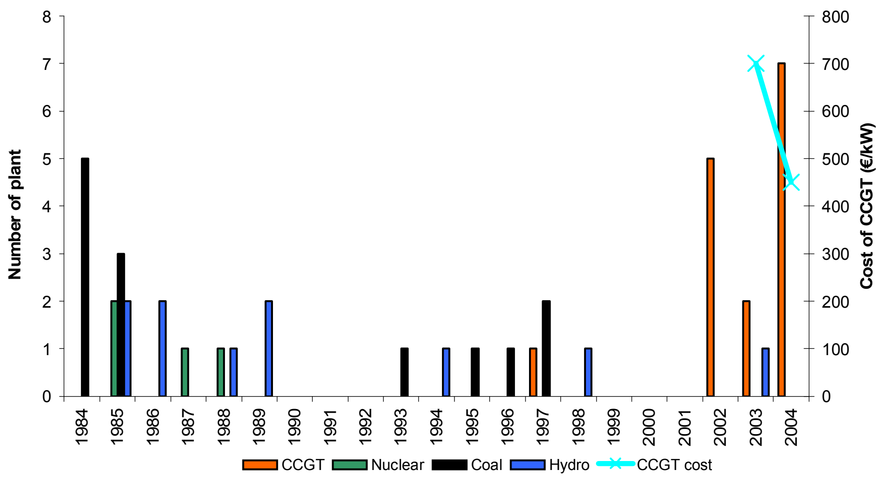
[22] The construction data was largely sourced from Power Finance Infrastructure and Platts and is somewhat limited due to the incumbents (Endesa and Iberdrola) building the majority of plants and not publishing cost data.

Figure 6.2 – Price, Margin and Capacity Profile for Spain (various dates due to data availability)





Sources: Platts, IEA, OMEL



Source: Platts

6.2.3. France Electricity Generation

The French market offers a converse picture given that liberalisation of the generation market is still in its infancy and the predominance of nuclear technology in the generation mix.

Figure 6.3 contains the data for the case-study: electricity prices, costs of capacity additions, capacity margins and the new build profile are presented in three charts which are vertically comparable.

The top chart in Figure 6.3 shows:

- The pattern of wholesale prices in France from 2001 (the start of the liberalised market and the introduction of the pool system) to 2005. The electricity spot price has been used for the duration of the time series; and
- The number of plant built from 2000 to 2005 (nuclear and CCGT technologies).

The middle chart in Figure 6.3 shows capacity margin from 2000 to 2004 compiled from IEA data.

The bottom chart shows the new build capacity over the period from 1984 to 2005. The cost of construction has not been analysed due to the lack of available data.

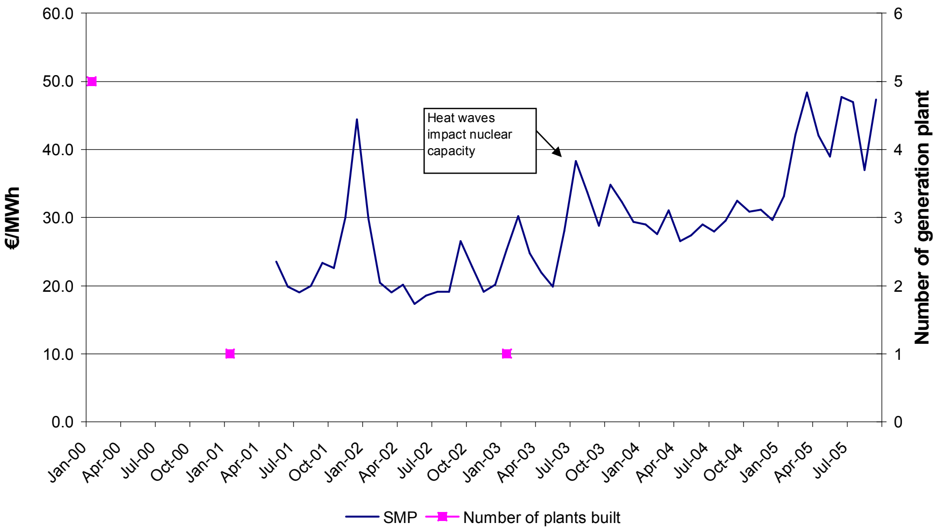
The Figure 6.3 shows:

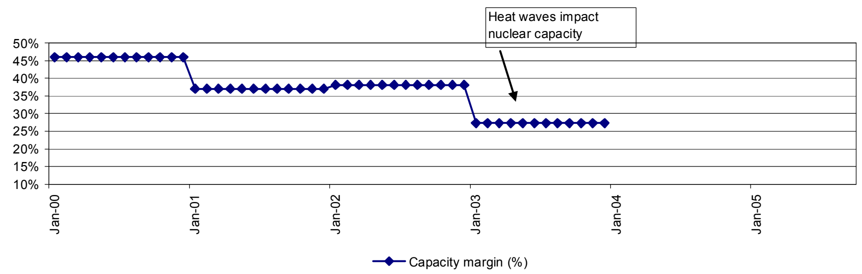
- At the start of liberalisation, prices were low on the back of robust capacity margins (over 40%). In part due to an abundance of nuclear capacity, but also continued use and availability of "load following" capacity, particularly aging coal and hydro assets.
- A decline in capacity margins in 2003 was the result of a long hot summer reducing the capacity of the nuclear fleet, some of which was withdrawn from service as they relied on cooling water drawn from rivers, which had a combination of low flows and also high inlet temperatures. These capacity withdrawls resulted in a short term spike in prices.

As mentioned in the UK case study, the recent upward trend in prices, has not come on the back of changes to capacity margins, but more as an exogenous shock to the system – particularly rises in gas prices which in the French system will be the marginal supplier.

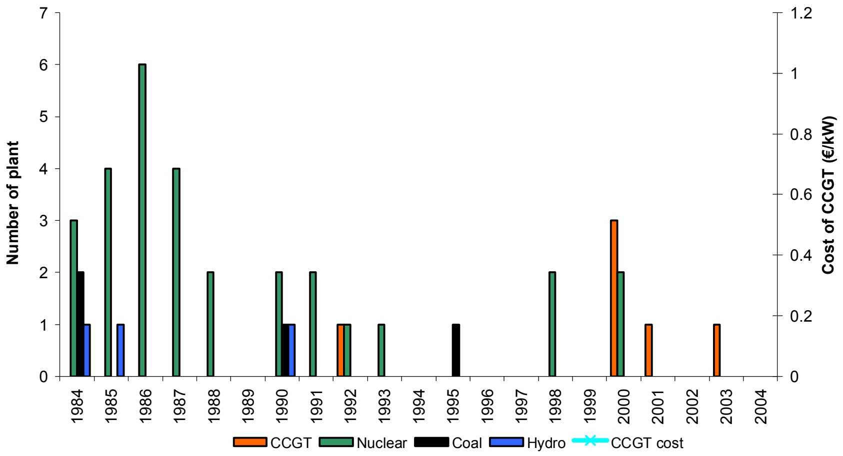
Crucially there is now a commitment to construct new capacity in this market, with a joint venture to build new CCGT capacity between EdF and ENEL (of Italy). It is expected that this is a consequence of capacity margin declines, and also current and expected rises in wholesale prices.

Figure 6.3 – Price, Margin and Capacity Profile for France (various dates due to data availability)





Sources: Platts, IEA



Source: Platts

6.2.4. Germany Electricity Generation

Figure 6.4 contains the data for Germany including electricity prices, costs of capacity additions, capacity margins and the new build profile.

The top chart in Figure 6.4, shows:

- The pattern of wholesale prices in Germany from 1999 (the introduction of the pool system) to 2005; and
- The number of plant built from 1998 to 2005 (nuclear, coal, hydro and CCGT technologies).

The middle chart in Figure 6.5 shows the capacity margin from 1998 to 2001 compiled from IEA data.

The bottom chart shows the new build capacity over the period from 1984 to 2005.

Figure 6.4 shows that:

- Again, at the start of liberalisation, prices were low on the back of robust capacity margins (over 30%).
- A decline in capacity margins in 2002 was the result of ageing plant retirement particularly that from eastern Germany which resulted in a sharp rise in prices.

As mentioned in the UK case study, the recent upward trend in prices, has not come on the back of changes to capacity margins, but more as an exogenous shock to the system – particularly rises in gas prices.

It is also known that there are a number of plant currently under construction in the German market. It is known that these are being built in response to an expectation of rising power prices and also reducing capacity margins. Table 6.1 shows the expected current capacity additions. These are substantial, and when compared to retirements will approximate a net gain to increase reserve margin towards historic levels.

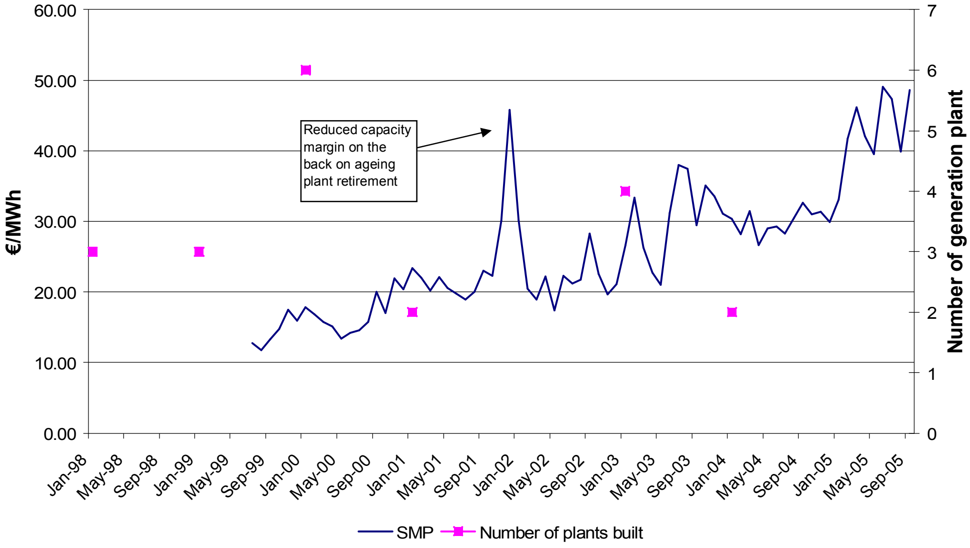
Table 6.1 – Planned Power Plant Capacity Additions in Germany

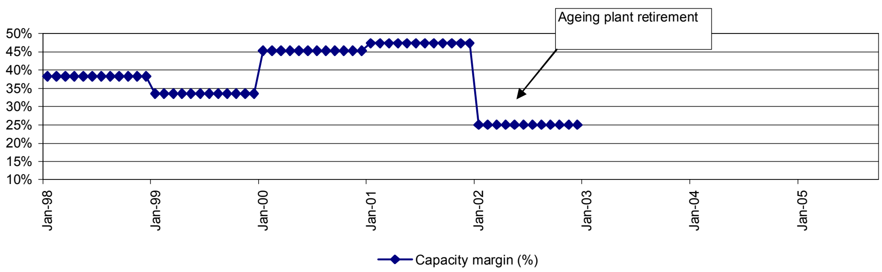
Plant	**Company**	**Capacity (MW)**	**Commissioning Date**
Hard Coal			
Hamm	RWE	2*750	2011/12
Dattelm	E.ON	1100	2011
Moorburg	Vattenfall Europe	2*750	2010/11
Spremberg	Vattenfall Europe	30	2008
Kahlsruhe	EnBW	750	
Walsum	Steag/EVN	750	2010
Lignite			

Plant	Company	Capacity (MW)	Commissioning Date
Neurath	RWE	2*1050	2009
Boberg	Vattenfall Europe	660	2010/11

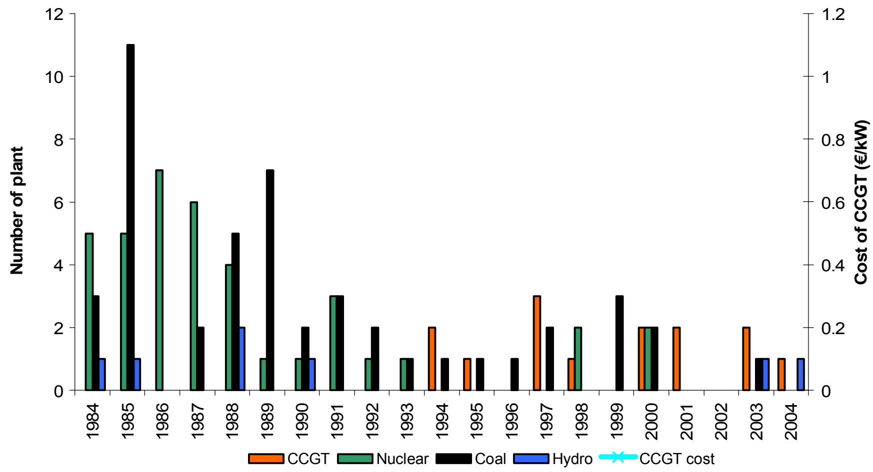
Source: UDI Power Plant Database: press

Figure 6.5 – Price, Margin and Capacity Profile for Germany (various dates due to data availability)





Sources: Platts, IEA



Source: Platts

6.3. Conclusions

From the limited liberalised market experience that is available, it is possible to draw some tentative conclusions on whether investment is encouraged in liberalised markets. The clearest evidence can be drawn from the UK market, but to some extent some of the findings are starting to be repeated in other European markets.

The key conclusion is that: the market has broadly responded to price signals (and capacity margins indicators) over time when unrestricted by the regulator/law, and indeed in some markets has seen the use of “mothballing” (ie temporary retirement of plant, usually in times of unfavourable market conditions) to manage market margins and prices.

As has been shown, the liberalised market has also generally driven low cost investment – particularly CCGT capacity (more discussion of these conclusions are contained in Section 4.3).

7. Do liberalised markets provide a reliable and secure supply?

The concern is sometimes expressed that private companies operating in a liberalised market will have less concern with reliability and security of supply than is appropriate and in the national interest. This section explores that proposition in theoretical terms then seeks to identify some objectively verifiable indicators of reliability and security and then examines the historical record to see whether there is any evidence that liberalisation has compromised either attribute.

7.1. Theory

The terms reliability and security are used often interchangeably. Here, we define reliability to mean resistance to events that are reasonably likely and for which the probability of occurrence can be confidently assessed. By security we mean resistance to events of low probability and high consequence that we can easily formulate conceptually but for which it is difficult to estimate a probability.

7.1.1. Reliability

Physical failures in energy supply can occur as a consequence of failures in production, transmission or distribution. Generation and transmission events are normally rare, but if they occur then they affect many people; in the limit the entire country can be without power. Distribution events are common, but affect a few people. Analytically, generation failure events are the easiest to model and distribution events are the most difficult. It is relatively easy to know what improvement in reliability can be obtained by an incremental investment in generation or transmission, but the relationship between investment and improved reliability in distribution is much less clear.

There is another aspect to the distinction between generation and network failures. Generation is a competitive business whereas the network businesses are regulated. The available mechanisms for ensuring reliability are therefore different.

In generation the priority is to determine what level of reliability the market will deliver and then to decide whether policy intervention is required and what form it should take. This is different from the regulation of generation in an administered system. In the network businesses the provision of reliability stems fundamentally from proper regulation and in this respect there is little difference between administered and liberalised systems although the unbundling of the network businesses in the liberalised system may facilitate precise regulation.

7.1.1.1. Generation

In the traditional, monopoly model of energy supply it was generally assumed that the electricity industry would not spontaneously provide the socially optimal level of reliability. The basis for this belief was that the private cost to the unliberalised industry of a loss of load was simply the revenue foregone, which would only be a few € cents per kWh, whereas the social cost was a great deal higher. Therefore the balance between incremental investment and loss of load would be different from the two perspectives; industry would prefer low investment and high outage whereas from a social perspective higher investment and lower outages would be better.

Probabilistic simulation techniques have been developed to determine the socially optimal level of investment necessary to ensure a reliable supply, assuming probability distributions of plant performance and demand; these techniques have been especially influential in electricity supply. The probabilistic simulation methodology is fairly robust, but the numerical results depend strongly on the assumed values for the social cost of outage or Value of Loss of Load, which can be contentious. To deal with this divergent perception of private and public costs of outage it was normal to provide in the statutes of state industries or in the concessions of private companies that they should achieve an externally specified level of reliability.

As experience with liberalised markets has developed it has become apparent that they also have the capacity in theory to deliver high levels of reliability. Most models of a liberalised market include a balancing mechanism where the operator of the balancing market buys energy at whatever may be the clearing price to meet shortfalls in the positions of suppliers. Prices in the balancing market may rise well beyond long-run marginal costs of production. The imposition of forced interruptions is determined by the TSO. So, there is not the direct link between supplier and consumer that would allow the consumer to pay more for a reliable supply, but there is a mechanism that allows prices to rise to levels to reflect shortage and that provides an incentive to generators to invest to supply this market or for integrated generator-suppliers to invest to avoid having to buy in this expensive and problematic market.

If this degree of price volatility in spot markets is considered unacceptable then administered mechanisms are needed to achieve reliability. In this case, the marginal plant necessary to achieve the socially optimal reliability still needs to be rewarded which will not be achievable through wholesale prices. If the plant is not rewarded by extreme prices in a wholesale market then it must get its reward from administered payments, probably determined by the availability of capacity.

7.1.1.2. Networks

Similar probabilistic principles are used to calculate the appropriate levels of investment in networks necessary to achieve good reliability. Accurate probabilistic models exist for high voltage networks, but increasingly approximate methods are used for medium voltage and distribution networks.

In this context the managerial principles for achieving reliable performance are exactly the same in a liberalised and a centrally planned industry. The main difference is that in the liberalised industry the eventual decisions are the result of a dialogue between the industry and the regulator whereas in the centrally planned industry the industry tends to dominate the decision making process through asymmetry of knowledge and information. The unbundling of the businesses in the liberalised model also helps make the regulation of the networks more transparent.

Normally the network business would discuss with the regulator the network extensions necessary to cope with incremental demand and to maintain reliability. The regulator would sanction the investments and the revenues according to the regulatory principles in force. This procedure may be accompanied by a regime of financial incentives and penalties according to whether the network operator is successful in maintaining acceptable reliability. The details of these schemes vary from country to country. In the UK, for example, Ofgem has recently proposed a revision of the scheme of control for the National Grid that would make revenues dependent on an annual performance target for energy not supplied. The target is based upon average historic performance since 1991/92. Under the scheme the operator would not be penalised or rewarded if the performance fell within 5% of the target. Performance that improved upon the average by more than 5% would attract a bonus and worse performance would attract a penalty.

Ofgem has also set out similar mechanisms for improving the performance of distribution companies in terms of losses and quality of service. A target level of losses is established over five years based on the historic performance of the distribution network operator, as measured by the average proportion of electricity lost between 1994/95 and 2003/04. Revenue from savings above that level can be kept by the company. Ofgem has also set reliability targets for distribution network operators based on historic performance. An incentive is then applied to measures of the number of customers interrupted and the number of customer minutes lost.

Similar schemes exist elsewhere, in varying degrees of detail.

7.1.2. Security of Supply

We have argued that markets can assure reliable systems because the consumer willingness to pay feeds back into prices and can be assessed by a potential investor. The same does not necessarily apply to low probability high damage events and it is not obvious to what extent markets alone can cope.

Among the type of events that might be of concern here are the following:

- Common failure in a technological design on which the system depended (e.g. generic failure in a nuclear reactor design or an unexpected loss of capacity as a consequence of inadequate cooling as in France in the summer 2003 or the discovery that the power system could not be made stable to very large volumes of intermittent generation);
- Extreme weather events which impact on both the ability to supply electricity and the level of demand, for example, low rainfall years impact on the ability of hydro stations, and hot summers increase the potential demand for electricity for air conditioning;
- Terrorist attack on facilities or civil war in a major supplier of gas (or potentially coal);
- Unilateral termination of supply as a consequence of political opposition; and
- Very large rises in price of a particular fuel and no available substitute.

These are of course events that could happen to liberalised and non-liberalised markets and the question is not whether liberalised markets are secure but whether they can be made secure more or less easily than non-liberalised markets.

The actions that could mitigate the consequences of such events are:

- Diversity of technology, of fuel or of country of origin for the fuel;
- Storage; and
- Emergency procedures.

7.1.2.1. Diversity

Markets generally produce diversity. In competitive markets players back their own ideas and, providing the underlying conditions permit, they will offer a range of solutions. Centrally planned systems have a tendency to single solutions often founded in economies of scale and series; the dominant actors impose their will; dissenting voices are eventually suppressed and never get to market.

A large generator of electricity or shipper of gas will have a corporate interest in diversity that might not be shared by a centralised system; if underlying fuel and technology markets turn against the company in a competitive system there is the threat of loss and so a player in a competitive market will have some internal drive to diversify. So, there seems to be no good argument that liberalised markets will provide less diversity than centrally planned systems. Indeed, the balance of the argument suggests the reverse.

But the fact that markets are likely to produce at least as much diversity as centrally planned systems does not mean that they necessarily produce as much as is socially desirable. In this case government has a range of instruments that could be used to intervene. These include: a refusal to licence more of a given technology than determined by policy statements and imposition of constraints on the volume of fuel from a specific source. It is somewhat more difficult to impose high cost technologies that bring diversity, but it has been done for renewable energy through instruments such as feed-in tariffs and obligations on suppliers and given the appropriate agreements within the EU such instruments could be developed for the purpose of diversity also.

7.1.2.2. Storage

Storage is the classical response to managing supply shortages and has precedents in the stock-piling programmes for crude oil and products within the IEA and EU. Within the overall discussion of security (as discussed in Section 7.1.1.1), market players will seek to provide a reliable supply as long as they are rewarded for it (and penalised otherwise). Therefore to ensure reliability we would expect storage capacity to respond to market signals.

7.1.2.3. Emergency procedures

The stockpiling programmes for crude oil and products within the IEA and EU are associated with emergency procedures for the allocation and sharing of the resources. The proposal of the Commission for a Directive concerning measures to safeguard security of natural gas supply is predicated on the assertion that in order to ensure the continued well-functioning of the internal market for gas, it is necessary to ensure that appropriate measures are implemented to deal with an extraordinary supply situation. The Directive would require that in the event of extraordinary gas supply situations, the Commission might take action to ensure solidarity amongst member states. The Directive has made rather little progress.

7.2. Evidence

7.2.1. Reliability

7.2.1.1. Networks

Performance indicators for networks are not readily available in public sources. The best analysis of the standards in place across Europe and the impact of liberalisation upon them is that conducted by the Council of European Regulators[23]. The Council notes in its report that it is difficult to make systematic comparisons across countries or over time because of different

[23] Second Bench marking report on quality of electricity supply, Council of European Regulators, September 2003

indicators, changing indicators and different methods of calculating indicators. The Council circulated a questionnaire among its members relating to the continuity of supply over the period 1999-2001. Seven countries reported time-series data for unplanned interruptions. The data is shown in Tables 7.1 and 7.2.

Table 7.1 Unplanned interruptions: minutes lost per customer per year

	1999	**2000**	**2001**
Finland	188	161	199
France	55	46	59
Great Britain	70	63	78
Italy	228	209	171
Ireland	254	256	197
Netherlands	26	27	34
Norway	186	234	234
Portugal	n.a.	n.a.	531
Spain	n.a.	n.a.	179

Source: Council of European Regulators

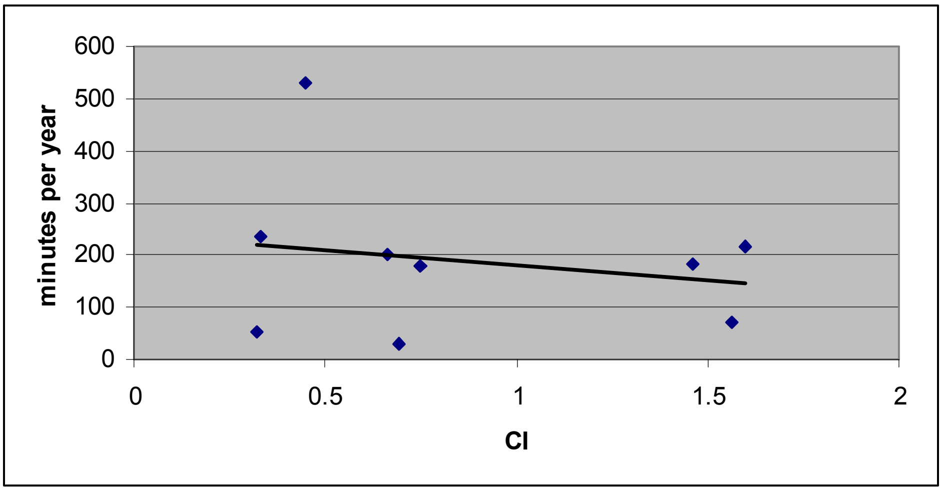
Table 7.2 Unplanned interruptions: interruptions per customer per year

	1999	2000	2001
Finland	3.3	4.2	4.69
France	1.22	1.2	1.2
Great Britain	0.729	0.775	0.806
Italy	4.21	3.81	3.46
Ireland	1.13	1.54	1.35
Netherlands	0.44	0.41	0.67
Norway	2.5	2.7	3
Portugal	n.a.	n.a.	7.51
Spain	n.a.	n.a.	3.3

Source: Council of European Regulators

There is little real structure in this data. Figure 7.1 shows the average minutes of interruption over the three years against the competition index (CI) that was used earlier[24]. The trend-line is added; it shows a very weak and statistically quite insignificant decrease in minutes lost as a consequence of increased competition. It can be deduced that on the basis of the limited data available that there is no evidence that liberalised systems are systematically less reliable.

Figure 7.1 Minutes lost from unplanned outages against competition index



Source: Council of European Regulators

The same countries reported the same indicators for planned interruptions. These are shown in Tables 7.3 and 7.4.

Table 7.3 Planned interruptions: minutes lost per customer per year

	1999	2000	2001
Finland	103	38	32
France	4	6	6
Great Britain	11	8	8
Italy	n.a.	127	127
Ireland	170	172	188
Norway	109	106	70
Portugal	n.a.	n.a.	57
Spain	n.a.	n.a.	37

Source: Council of European Regulators

[24] i.e. market opening plus market not supplied by the three largest generators

Table 7.4 Planned interruptions: interruptions per customer per year

	1999	2000	2001
Finland	1.8	1.3	0.6
France	0.03	0.04	0.04
Great Britain	0.05	0.04	0.04
Italy	n.a.	0.83	0.79
Ireland	0.46	0.44	0.51
Norway	0.64	0.63	0.52
Portugal	n.a.	n.a.	0.32
Spain	n.a.	n.a.	0.42

Source: Council of European Regulators

A plot of minutes lost through planned interruptions against the competition index again yields a weakly negative association of no statistical significance. The best performing systems are the UK, which is strongly liberalized, the Netherlands, which is weakly liberalized and France which is little liberalized. It appears that good continuity of supply can be achieved under any regime; confirming that the achievement of good reliability in the networks is more a question of effective regulation than of market structure.

The Council of European Regulators itself, recognizing the difficulties of the analysis and based more on qualitative than quantitative analysis concluded in its report that, "*On the whole, no relevant signals of quality of supply decrease are emerging in European countries even after utilities privatization, increasing supply competition, price-cap regulation for monopolistic activities and legal unbundling of businesses, if any. Rather, many positive results have been achieved in terms of quality increase when appropriate policy instruments are put in place. Quality of supply regulation is becoming more and more important in all European countries, and regulation is working positively, even if different approaches and methodologies may be used in different countries. A mix of moral suasion, comparative publication of companies' performance, standards for worse-served customers and incentive/penalties mechanisms is used in most countries*."

7.2.1.2. Generation

A commonly used proxy for direct measures of reliability arising out of the generation business is the reserve margin. This is not a entirely satisfactory measure, because the reserve margin is the tool for achieving reliability not reliability itself. As described in Section 3 on the falling cost-base; a falling reserve margin can be achieved by:

- Better maintenance of plant;
- Better planning of outages;
- Sharing of margins with interconnected systems; and
- Demand side management, include demand side bidding.

Despite these objections to the use of reserve margin as a primary measure of efficiency it remains the case that it is the easiest indicator to obtain from public records. The earlier discussion has presented evidence to show how reserve margin has fallen and plant utilisation has increased in the period of liberalisation. This has been achieved with no clear evidence that the reliability of the generating system has been compromised. There has been no major outage in Europe within the last ten years that has been caused by a deficiency in generating capacity.

7.2.2. Security of Supply

Security of supply we have defined as the robustness of the system to events that can be foreseen in principle, but for which there is not the quantitative information needed to provide analytically optimal solutions. Principal policy instruments to achieve security are:

- Diversity of technologies and suppliers so that a failure of one component cannot jeopardise the whole
- Storage, especially of gas, so that failure events can be compensated by withdrawals from storage

7.2.2.1. Diversity

Markets generally produce diversity. Diversity is a desirable, but not a necessary characteristic of a secure system. Diversity helps manage the risks that are associated with individual energy technologies or sources. The French electricity supply system based on nuclear energy is little diversified. There is a strong focus on one fuel, one technology and a small number of related plant designs. In some respects it is secure; being robust to external political events and economic changes. In other respects it could be argued to be insecure to; generic technical faults, terrorist threats, or a serious nuclear accident. At the other extreme, the old UK coal-based system was also apparently secure, based on indigenous coal and again a limited range of technologies. Ironically it showed itself insecure because of its exposure to the actions of monopolies of labour. It was a non-diversified system, with a single vulnerability that turned out to be critical.

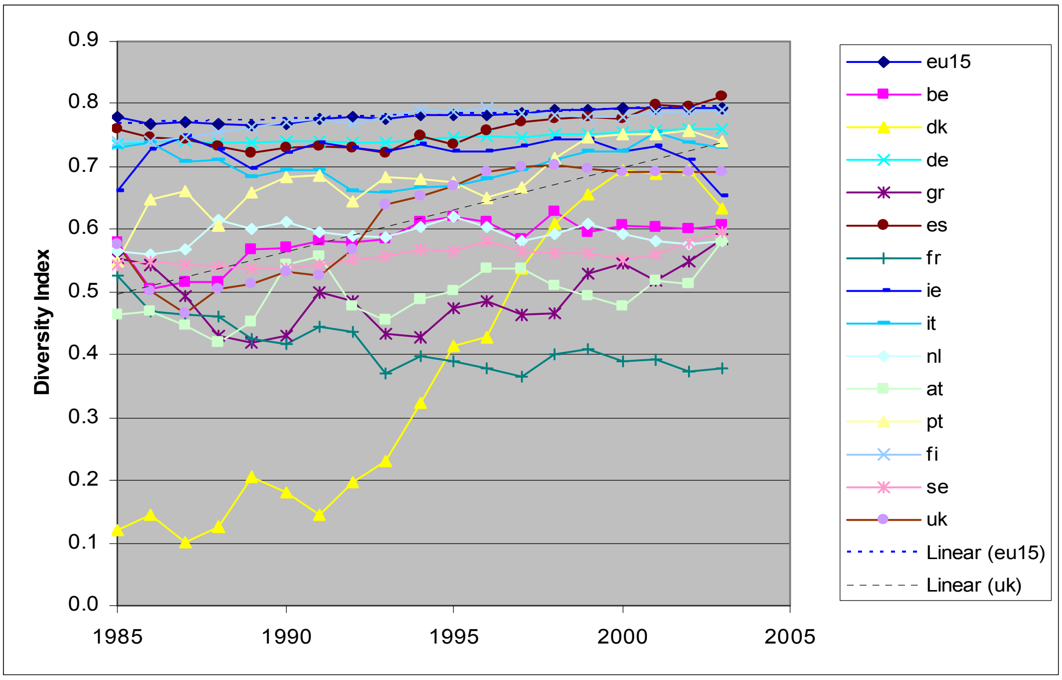
Several measures of diversity are in common use in the life sciences to describe biodiversity. The simplest and quite appropriate here is Simpson's Index, which we define as:

$$1 - \sum (p_i)^2$$

where p_i is the proportion of fuel i in the generating mix. The theoretical limits of this index are from 0 (if the system is dependent upon a single resource) to 1 (if the system is equally dependent upon many resources). Strictly the upper limit for the index is $1 - N/N^2$ where N is the number of possible resources.

We have calculated this index for electricity generation by dividing the fuel-burn into seven categories: gas, coal, nuclear, petroleum products, hydro, renewable energy and others (mainly lignite). The value of the index over the period 1985 to 2003 (calculated for the Member States and the EU15) is shown in Figure 7.2. Trend lines are shown for the EU15 and the UK.

Figure 7.2 Diversity index for EU15 and Member States



Source: Eurostat and E&Y calculations

The Figure shows a tendency in most countries for diversity (based on this measure) to increase over the period. This is confirmed by the regression against time, which gives the following annual growth rates of the diversity index by country.

Table 7.5 Annual growth rate of diversity index (% per year)

Country	**Annual growth of diversity (%)**
EU15	0.2%
Belgium	0.5%
Denmark	3.9%
Germany	0.1%
Greece	0.3%
Spain	0.4%
France	-0.6%
Ireland	0.0%
Italy	0.1%
Netherlands	0.0%
Austria	0.4%
Portugal	0.8%
Finland	0.3%

Country	Annual growth of diversity (%)
Sweden	0.2%
United Kingdom	1.3%

Source: Eurostat and E&Y calculations

The UK, a country that has been liberalised for a long time, shows a strong and sustained increase in diversity. Denmark has diversified even more as a consequence of the replacement of coal by wind and gas. Only France shows a decrease in diversity and this is a consequence of the large nuclear component; the rather small increase in the nuclear share over the period has a significant effect on the index because of the underlying large share.

There is therefore compelling evidence that liberalisation has not been associated with a reduction in diversity, but rather with a strong increase in diversity sustained over the period and across almost all Member States. This finding does not prove that liberalisation causes diversity, but it is strong evidence that liberalisation does not impede diversity. It might be argued that recent trends in diversity have been much influenced by the entry of natural gas and that this if continued will eventually reduce diversity. Of course such a development is possible. All that one can say with certainty that diversity on a national level has increased since liberalisation.

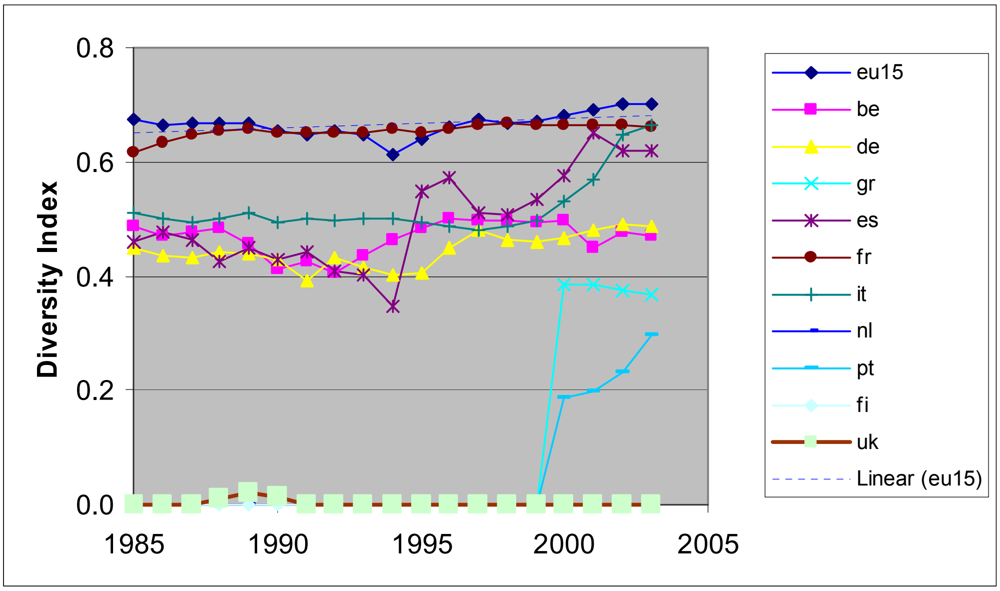
Despite the trend in Member States to higher diversity, the diversity index for the EU15 changes relatively little. With seven categories the highest theoretical level of the diversity index is achieved when each fuel has an equal share and the value is then 1 – 7*(1/49) = 0.86. The value for the EU fluctuates at around 0.77 to 0.79. The explanation for this apparent paradox is that aggregating historic non-diverse national systems to the EU level gives the impression of a diverse EU system. In an extreme case if six countries were all 100% dependent on a single fuel, different from all the others, then they would have completely non-diverse national systems, but sum to a diverse EU system. Figure 7.2 illustrates rather nicely that within the liberalised context the EU Member States have diversified supply at national level, but that process has had relatively little impact on the relatively diverse EU as a whole. This is still a big step forward, because the perils of dependency are more to be found locally than across the board. Diverse national systems with strong capabilities to support each other are actually the lynch-pin of security of supply.

7.2.2.2. Diversity of gas imports

Concern has been expressed in many quarters about the security of gas imports. Diversity indices were calculated for gas imports on the same basis as for power generation, recognising nine significant sources: Norway, Algeria, the FSU, Libya, Nigeria, Trinidad and Tobago, the United Arab Emirates, Oman and Qatar.

The results are shown in Figure 7.3. There has been a trend to more diverse supplies, although it is uneven across the EU. There has been strong diversification in the Southern Mediterranean countries as Nigeria, Libya and Qatar have begun to supply Spain. The entry of Egypt into the market will further diversify supply. This diversification is the consequence in part of state policy, but it shows the capability of the market to respond to such perceived national priorities.

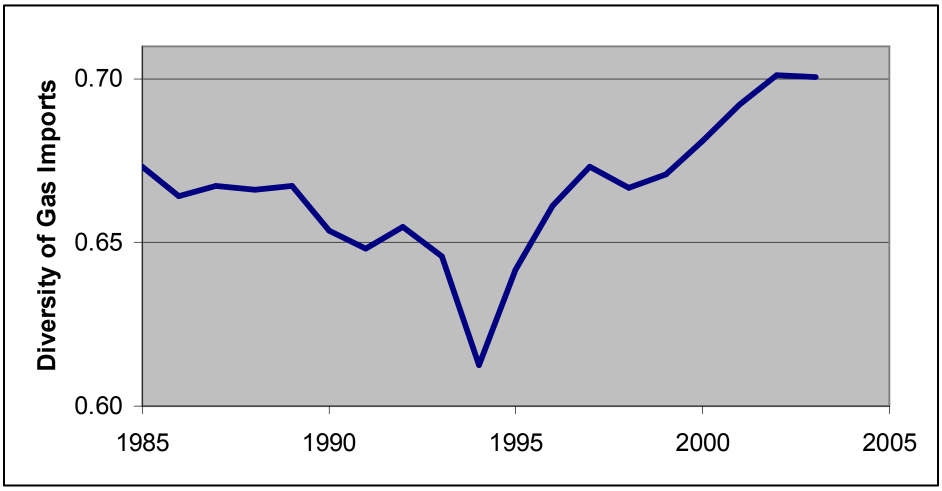
Figure 7.3 Diversity indices for gas imports 1985 to 2003 by country



Source: Eurostat and E&Y calculations

The diversity index for the EU has increased a little over the period. Figure 7.4 shows its development on this larger scale.

Figure 7.4 Diversity indices for EU gas imports



Source: Eurostat and E&Y calculations

The Figure 7.4 shows a sharp decline in diversity in the mid-90s and then as security of supply and potential dependence became a more prominent political issue it has slowly climbed. The implication is one of recognition; it is not easy to determined whether the reaction is driven by market recognition of the need for diversity or by market reaction to national priorities, but either way it show the capability of the liberalised system to react to the issue.

This is not to suggest that security of supply polices are not needed; this may or may not be the case. The point to retain is that the liberalised market can seemingly provide security of supply.

7.2.2.3. Gas Storage

A critical element in the reliability of supply for natural gas is the provision of storage; this may be short-term to cope with daily fluctuations in demand; annual to cope with seasonal fluctuations or strategic to cope with unforeseen events. The volume of working gas storage available by country is shown in Table 4.6 in bcm and as the equivalent days of imports and consumption.

Table 7.6 Working gas storage capacity in the EU15

Country	Working Capacity (bcm)	Imports (bcm)	Days equiv	Consumption (bcm)	Days equiv
Austria	2.5	0.0		9.3	98.4
Belgium	0.7	8.9	28.8	17.7	14.4
Denmark	0.8	0.0		5.7	51.0
Finland		5.0		5.0	
France	11.0	35.7	112.4	48.4	83.0
Germany	19.1	63.0	110.7	97.3	71.7
Greece		2.5		2.5	
Ireland					
Italy	12.8	55.0	84.9	77.8	60.0
Netherlands	5.0	7.5	244.8	44.2	41.3
Portugal		3.2		3.2	
Spain	2.1	25.9	29.6	26.2	29.2
Sweden					
UK	3.5	6.8	187.3	105.5	12.1
Total	68.3	180.8	137.9	449.6	55.4

Sources: Report on Monitoring Guidelines for Good TPA Practice for Storage System Operators, Energy regulators Group for Electricity and Gas, 7th September, 2005. Eurostat.

There is considerable variability in the storage capacities of Member States. The storage capacity roughly reflects the dependence of countries on imports. Large importing countries are well provided for in terms of days-equivalent of imports. The UK has many fewer days relative to consumption than other countries, but of course it is a major producer.

It is hard to draw conclusions from this data pertinent to liberalisation. The obvious relationship is between storage capacity and import dependence. There is no other perceptible theme.

7.3. Conclusions

The conclusions of this analysis are that:

- There is no evidence to suggest that the quality and continuity of electricity supply have fallen since liberalisation.
- Reliability in generation is apparently provided through investment induced by price excursions on the wholesale and balancing markets.

- Quality of supply on electricity networks is essentially a consequence of close regulation and can be achieved in either an administered or liberalised market structure. There are some theoretical advantages to the liberalised model, but there is no empirical evidence to confirm the theory.
- The maintenance of standards of reliability in generation has been achieved with falling reserve margins as a consequence of higher utilisation of plant and better interconnection
- There has been a strong association between liberalisation and diversity over the recent past. There are also theoretical reasons to believe that markets will produce diversity. This does not add up to a case that liberalised energy markets will always produce diverse solutions, but it does show that liberalised markets are certainly not inimical to diversity.

Market operators share with the state a common interest in reliability and security of supply. If there are cases where public costs do diverge from private costs then policy instruments are required. The market can operate satisfactorily within policy constraints as long as the implementation is clear, prompt and stable. If public and private costs diverge then policy instruments are required in both administered and liberal markets. In the liberal market there is greater transparency; a greater range of instruments (including market-based instruments) and clearer responsibility (as a consequence of unbundling).

8. How do liberalised markets effectively interact with other public policies?

This section analyses whether businesses operating in a liberalised environment have improved the implementation of broader public policies that impact on energy industries. The section considers whether implementation has become more difficult, but focuses on whether implementation is more efficient, specifically examining whether:

- Tariffs continue to support social and industrial policies;
- Other policies are better incentivised in liberalised markets – particularly around the promotion of renewables; and
- Environmental performance has improved.

Overall the analysis finds that there has been no noticeable degradation of implementation of public policies, and indeed in some circumstances, implementation has been made more efficient.

8.1. Theory

Traditionally state owned monopoly energy companies have been used by governments not only to provide energy but as an agent to implement a diverse range of policies. These include:

- National solidarity through universal tariffs;
- Income redistribution through concessions for small consumers;
- Industrial policy through relations with equipment suppliers;
- Social and regional policy through overt or veiled obligations to burn domestic fuel; and
- Environmental and security of supply policies through constraints on fuel and technology choice.

As markets have moved to more liberalised structures, the market has sustained some of these policies (eg lower prices assists with social policy through reducing the proportion of income spent on energy by low income households). These have however been bolstered through complementary regulatory approaches, particularly through Public Service Obligations (PSO) and other policies outside of the energy markets on environmental protection.

The question at the centre of the debate is whether market liberalisation makes it more difficult to achieve public policy goals, and whether liberalised markets are more efficient in implementation.

8.1.1. Implementation becomes more difficult?

At a high level, liberalisation makes implementation more difficult. Considered on a purely logistical basis, instead of dealing with one large entity, governments now have to consult with multiple organisations with varying views and objectives. This is made worse by the old state monopolies in effect being an adjunct of government who are more compliant with government requirements than private companies.

Despite the addition of transaction costs in working with more organisations in developing and implementing public policy, there is no evidence that effectiveness is impacted. The critical issue now is are the objectives of public policy better and more efficiently achieved through competitive markets?

8.1.2. Markets work to implement public policy more efficiently?

The critical argument in favour of liberalisation relates to gains in economic efficiency. The competitive dynamic, will always drive organisations to strive for low and least cost solutions. This is relevant to indirect achievement of social goals, and to the interaction of liberalised markets with other policy instruments.

Public policies will impose costs on the sector that in a state owned monopoly context can then be passed on to customers in full. At a theoretical level this is certainly true as state owned (natural) monopolies set their prices in one of two ways (or in combination) – willingness to pay or based on long run average costs. Under either pricing approach, the full costs of policy compliance can be recognised and charged based on an increase in the long run average cost, or through an increase in government subsidy. As such any public policy impacts or costs, can be passed onto the consumer.

Public policy costs however under a monopoly are not efficient as a consequence. As the full costs can simply be passed on (or subsidised) , there is no need to focus on achieving these at least cost – hence an inefficiency.

Imposing public policy on competitive businesses results in a more efficient solution (although overall efficiency gain depends on the regulated approach). In competitive markets, increases in cost bases are to be avoided as a first rule (as it impacts on marginal costs) and where they cannot be avoided they must be minimised to maximise competitive advantage, to maximise profitability and maintain market share. It is this competitive element that drives efficiency.

In the following discussion, we break down the key areas of public policy to examine the role of competitive markets in implementation, focusing on:

- Tariffs to look at social and industrial policies;
- The growth of renewables and other energy sources to consider socially acceptable security of supply; and
- the implementation of environmental policy

8.1.2.1. Tariffs as instruments of social and industrial policy

Governments through monopolies, effectively set acceptable tariffs to consumer groups on an annual (or regular) basis. These tariffs consider the total costs of operation, and are translated into charges reflecting either long run average cost or willingness to pay (or a combination of both). As an instrument of public policy, tariffs were generally reduced to domestic consumers, and to some extent cross-subsidised, or subsidised directly. In this way, governments were able to benefit distinct consumer groups and ensure social policy objectives were met.

Overall, tariffs, while being to some extent cost reflective, were set to protect domestic consumers from high prices, and provide a reasonable and stable cost base for commercial and industrial consumers.

8.1.2.2. Security of Supply

State owned monopolies made investment decisions based on social need. Electricity and gas transmission capacity was built on the basis of social provision, aiming for all users to have access (except for gas). Monopolies also aimed for a socially acceptable level of security of supply, with electricity generation capacity being added on the basis of capacity margin, central planning and the need for a diversity of plant. Similarly, gas supply came from reliable and in some cases indigenous supplies, or utilising alternate sources, eg synthesised gas.

In competitive markets, the investment in wires and pipes has continued, albeit now reflecting differing signals. In some cases, where locational transmission pricing has been put in place, be that through transmission pricing or through entry exit regimes, the signals for investment have got stronger, and made investment more orderly (albeit on a "just in time" basis).

Working with the energy markets, there has also been parallel policies to encourage security of supply. We have discussed these before and will not repeat these here.

8.1.2.3. Environmental Issues

The same is true for achieving environmental goals (although investment in these goals was limited until during the liberalisation process). For example the CLRTP only began in the early 1990's and indeed environmental constraints only started to bite through the LCPD in 1996/7, and even then only on new plant.

Environmental goals have been achieved as an indirect result (eg the increased use of gas in electricity generation). These have been complimented through parallel policies. The critical element here is that the process of liberalisation has in fact fostered an ethos of discovering least cost solutions. The imposition of targets on SO_2, NOx and CO_2 has resulted in concerted activity and effectiveness, but in a lower cost way than may have been envisaged by a state owned monopoly. Under a monopoly, investments and additions would have uniformly been made to all plants to make them all compliant rather than selecting the best and ordering improvements.

8.2. Evidence

There is a wide spectrum of evidence to support the theory available. To examine the evidence, we focus on each of the key areas of efficiency, prices, security of supply and finally the environment.

8.2.1. Prices

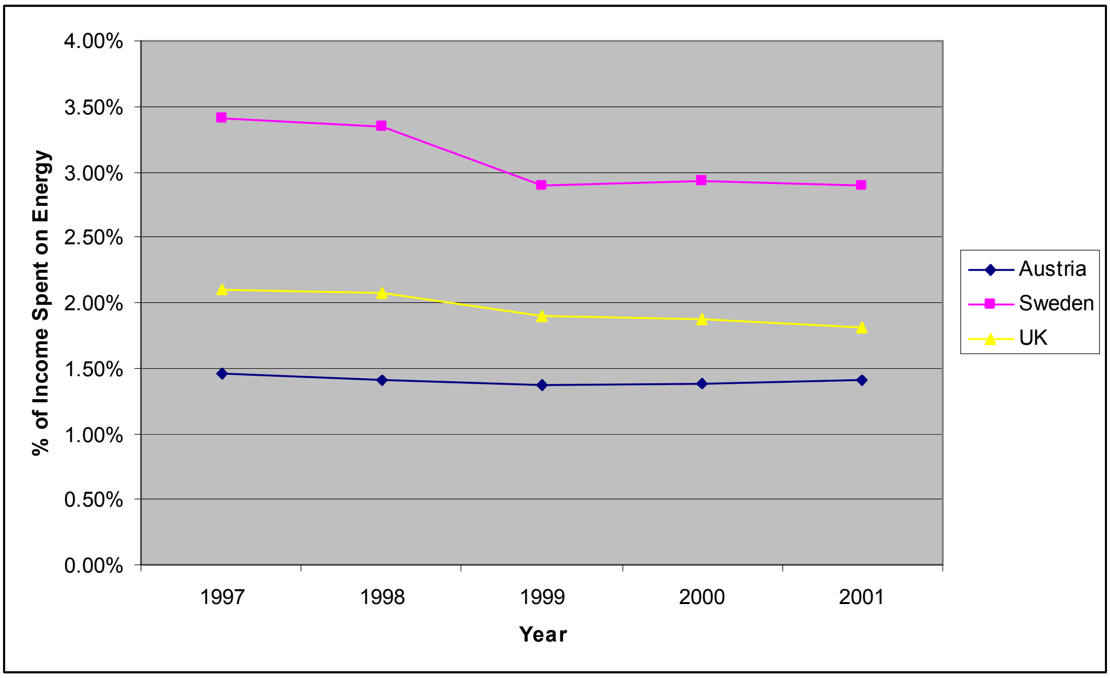
8.2.1.1. Price reductions achieve social objectives.

As we have expounded earlier in this report, prices have generally reduced under liberalised markets. These clearly have an impact on the proportion of income or turnover spent on procuring energy. In the most vulnerable domestic consumer categories, liberalisation has made energy costs constitute a smaller (and shrinking) proportion of income – clearly a winner in the context of social objectives.

In examining this relationship, we draw on consumer prices, and also the average national incomes and incomes for the bottom quartile of consumers. We have conducted some simple analysis to determine whether over time the proportion of incomes spent on energy has increased or decreased as liberalisation has proceeded.

Figure 8.1 plots for each EU country the proportion of income spent in 1997 to 2002. The figure focuses on those countries that have developed domestic competition (UK and Sweden) and one country which is a laggard (Austria) We have not performed further statistical tests on these values as first inspection shows a clear relationship.

Figure 8.1 – Consumer prices



Source: Eurostat, Economist Intelligence Unit and E&Y Calculations

The figure shows that:

- Over time the proportion of incomes spent on energy has reduced, this is as a combination of reductions in prices for energy products and rising average incomes.
- In the two most liberalised markets – the UK and Sweden – the reduction in the proportions has been around 20%, which on the face of it suggests liberalisation drives lower proportions of income spent on energy

While we have only been able to gather information for a small number of markets (limited by the availability of income data, we can in the case of two liberalised markets demonstrate a relationship, which is one that we would expect.

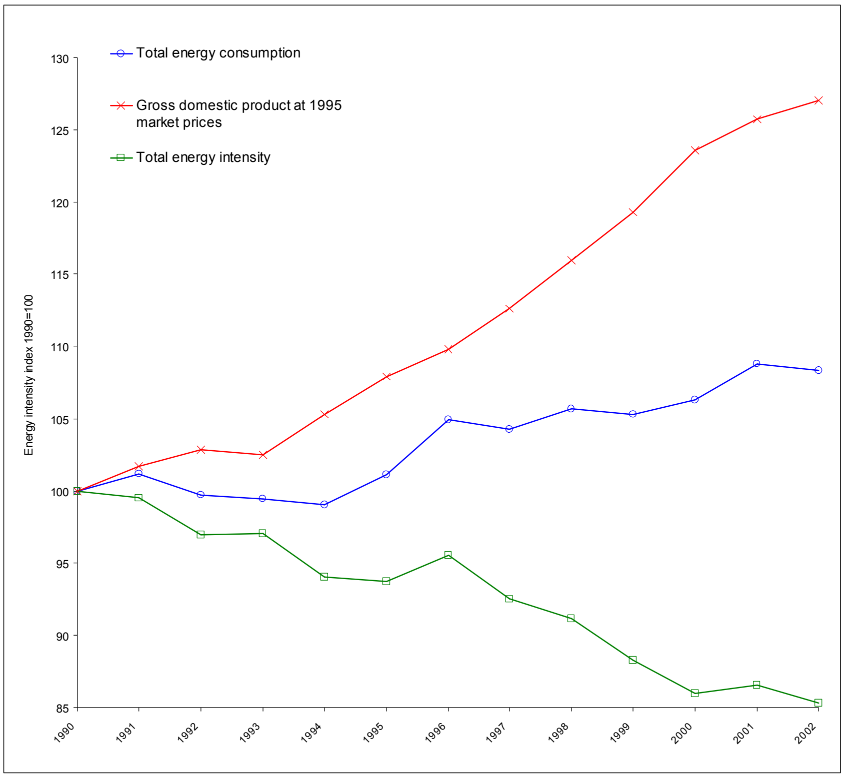
8.2.1.2. Liberalised markets improve energy management

Liberalised markets have generally lowered prices for industrial users. With regards to industrial users, prices have also reduced, but the stability has been taken away. However, in most circumstances these can be managed through hedging and effective contracting. One interesting consequence of increased volatility has been better energy management, and reducing consumption. This has meant more businesses proactively managing their demand profile, particularly around peak demand (and high price) periods, and overall seeking to minimise energy use.

In examining whether this is the case we have gathered data on the changes to energy intensity over time. It has not been possible to gather data on changes specifically in industry, but we have gathered information on changes in energy intensity as measured against GDP. This is a suitable proxy for changes in energy intensity, however it is important to bear in mind that there are some structural economic shifts over the time period studied which may drive lower energy consumption, particularly the growth of the service sector.

Figure 8.2 contains the time series on changes in energy intensity with time for the EU as a whole. It is indexed to 1995, and shows the growth in energy demand and GDP becoming disconnected. Importantly in the green line it shows that on average annually energy intensity has reduced at a rate of around 1% per annum.

Figure 8.2 – EU Energy Intensity Indicator



Source: European Environment Agency

A comparison with prices over this period reveals that this change in economy wide energy intensity has been achieved against falling energy prices. This is counter to the theoretical premise where we would expect demand to rise as prices fall. However, as markets have liberalised and volatility increased and as companies now have a choice, it is likely that they are doing more to reduce energy consumption overall.

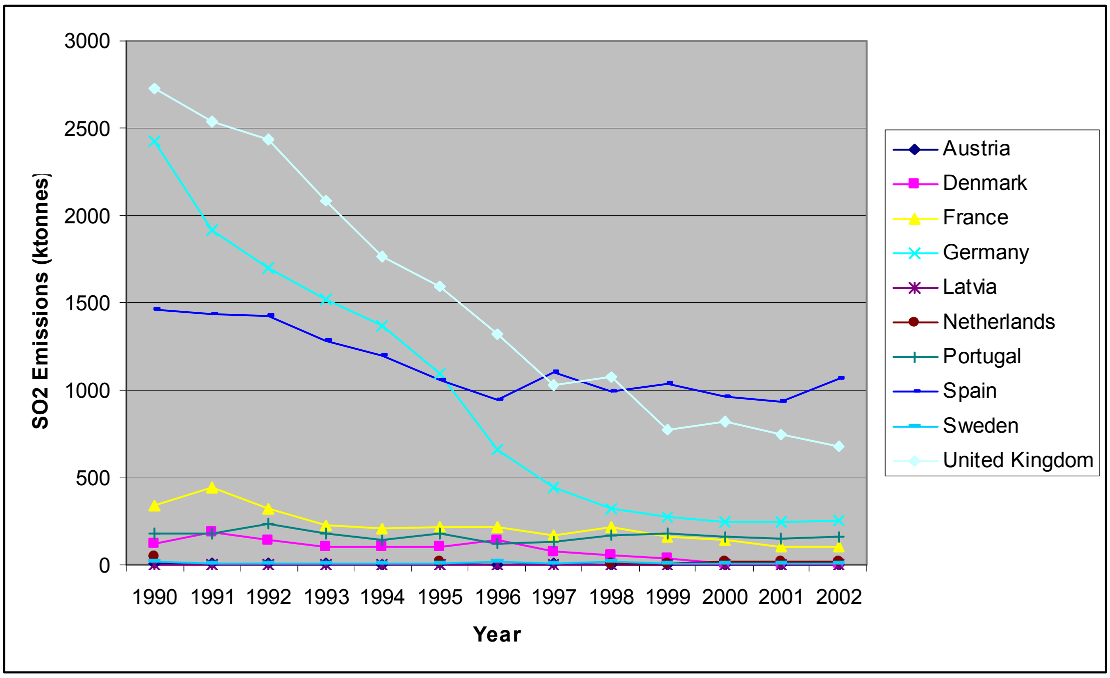
8.2.2. Environment

There are two elements that are worthy of exploration – long term trends in environmental indicators from power plant and secondly reductions in the costs of compliance. As presented in the discussion of theory, liberalised markets will drive out some improvements in environmental performance, particularly in countries where there has already been a switch to natural gas. As such we could postulate that emissions intensity and total emissions should be reducing over time.

It is important to recognise though that these reductions have been complemented by other policy instruments – particularly the Large Combustion Plant Directive (LCPD), both in its original form as set out in 1988 and the more recent revision.

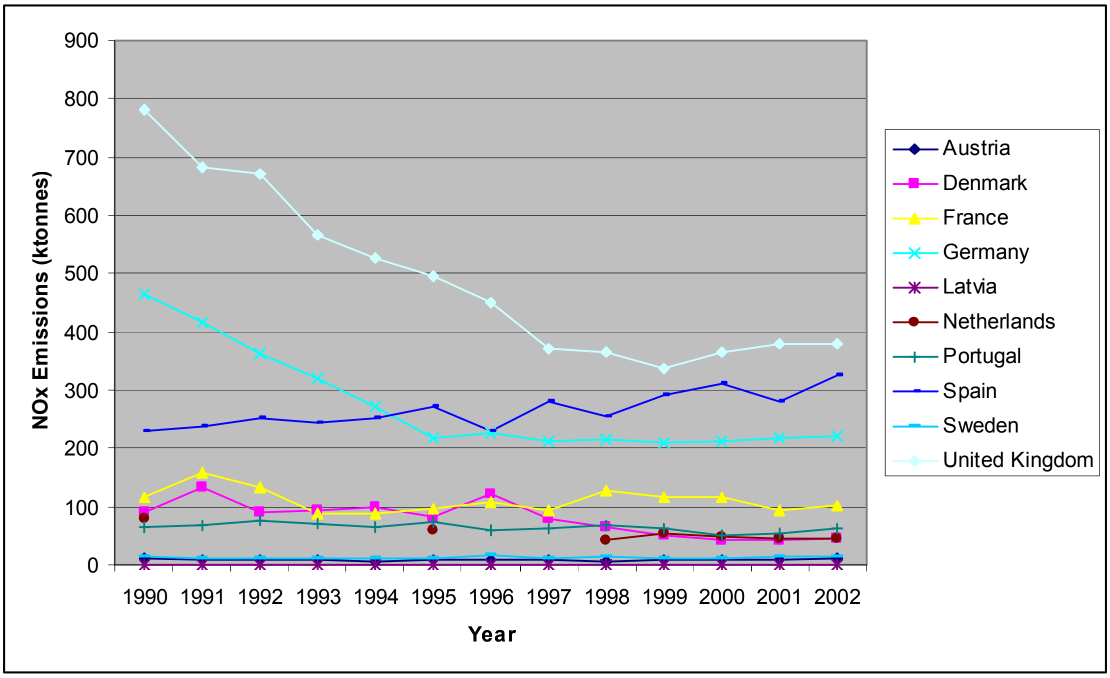
Figure 8.3 and 8.4show the long term trends in emissions of SO_2, and NOx. These are for a selection of countries which have available long term data series.

Figure 8.3 – SO2 Emissions



Source: European Environment Agency

Figure 8.4 – NOx emissions



Source: European Environment Agency

By examining the figures it is possible to see some clear trends, and that overall the emissions of both SO_2 and NOx have drastically reduced over time. In both cases the biggest reducers are the UK and Germany. In the UK context, the reductions will have in part been attributable to the switch to gas, but this is not the entire picture – part of the improvement is a consequence of the LCPD.

It is the latter that is also important for Germany, with only a limited fuel switch over the period, it is investments in pollution reduction technologies – low NOx burners and flue gas desulphurisation (FGD) that is important.

Critically in this context for both SO_2 and NOx, key targets in the LCPD had to be met in 1993, 1998 and 2003. These targets related to existing power plants, and in both the cases of Germany and the UK account for a substantial reduction in emissions of both. Indeed it is possible to see, particularly in the case of the UK a steep decline in 1993 emissions of both SO_2 and NOx, and that emissions levelled off at 1998.

Interestingly the levelling off of emissions in 1998 is a result of early achievement of the 2003 goals. This is an interesting result, but equally logical. In plants where investment decisions have been made for pollution abatement equipment, there has been analogous decisions on upgrading and improving the underlying plant. In these cases, the sooner the investment is undertaken the better (within usually maintenance cycles). Hence in pretty much all cases, the investment has been made early.

An interesting set of results also comes from this exercise, in that ex-ante policy costs and ex-post reveal a large difference. In the original policy analyses, it was the assumption that companies would fit FGD to their plant at huge cost (but equally huge benefit). Cost estimates produced by the UK monopoly electricity company in 1988 suggested a potential total cost of around £28 billion, adding 30% to generation costs[25]. The out turn is completely different, with only 3 plants in the UK being fitted with FGD to comply with the LCPD, and most companies turning to low sulphur coal as an alternative. Out turn costs have been in the range of 0-5% of generation costs, up to a maximum of £4.8 billion.

The difference in outturns provides robust support for the idea that competitive markets drives lower compliance costs.

8.3. Conclusions

It is possible to conclude that broader social, industrial and environmental objectives are being met by companies operating in liberalised markets, either as a consequence of usual market functioning or through more efficient implementation of PSOs.

Specifically, we can conclude:

- The PSOs can co-exist and be effective within a liberalised market environment either through regulatory or market mechanisms;
- That innovative pressures on businesses operating in a liberalised market forces lower cost solutions.

[25] AEA Technology plc (2004) An evaluation of the air quality strategy http://www.defra.gov.uk/environment/airquality/strategy/evaluation/pdf/chapter3.pdf

9. Transition

This section of the report discusses a number of additional consequences of liberalisation. Discussion in the previous sections has focused on more structural changes and challenges to liberalisation. There are number of other issues that are important to discuss, but are considered to be transitional rather than structural.

In this section we discuss:

1. Stranded costs;
2. Unemployment;
3. The demise of small companies and the emergence of a small number of "European Champions";
4. Short term rises in prices (particularly where prices had been supported or subsidised pre-liberalisation); and
5. Cost-efficiency of liberalisation.

Where possible we present analysis around these issues, and discuss findings.

9.1. Stranded Costs

A principal objective in liberalizing energy industries is to reduce electricity prices. When prices fall then consumers gain, but the incumbent utilities lose revenues. If revenues fall then the assets of the industry will be less valuable; and part of the costs of the utility may not be recovered – these are known as stranded costs. Sometimes there are particular assets that are especially visible, for example Independent Power Producers (IPP) contracts represent commitments to purchase electricity at a certain price and it may not be possible to sell this electricity in a competitive market. This is very clearly a stranded asset and becomes so under restructuring.

The practical problem arises mainly with generation; there can be stranded costs in transmission, but as these are generally regulated the old practice of allowing their costs to be recovered by average cost pricing can be maintained.

The question arises as to whether utilities should be compensated for stranded costs. Utility management obviously thinks they should be and this is not a negligible consideration because the cooperation of utilities can be helpful in industrial restructuring and in liberalisation. Consumer groups may disagree on the grounds that stranded costs are just mistakes of the utilities and that there is no need to arrange transfer payments from consumers (or taxpayers) to utilities to compensate them. It is important to note that restructuring does not create stranded costs it simply makes them visible. There is no increase in the cost-base of the utilities the question is only whether it is right to arrange transfer payments to moderate the revenue flows from consumers to utilities as determined by the competitive market to compensate utilities for the consequences of past decisions that have proved to be bad. The issue with stranded costs is purely one of distribution – there is no other significance. Stranded costs are not in any way an economic loss to the community as a consequence of restructuring, despite the rather ominous name that the phenomenon has attracted.

General opinion across the world is that utilities should be compensated. The basic argument is that the decisions made were sanctioned by the regulator or the line Ministry and therefore were implicitly prudent or politically motivated and deserve compensation. If the authorities were effectively to repudiate the implied sanctions then it would cast doubt on the value of future undertakings and would heighten the perception of regulatory risk that is already present among investors.

The next question is how to compensate utilities. There are definite economic issues: some forms of compensation may distort the operation of the competitive market and some may amount to unfair state-aid. The question as to whether compensation represents state-aid has been important within European debate and is treated first here. We return to the question of what constitutes the economically most efficient process subsequently.

The classic arrangement to compensate utilities for stranded costs is by a levy on customers. This was proposed at an early stage in the liberalisation process in Spain and the intent to create such a scheme seems to have contributed to the acceptance by the utilities of restructuring. At the time it was believed that any state-aid implications of this arrangement were sanctioned by Article 24 of the electricity Directive. The Commission after examining many submissions from Member States requesting derogation from state-aid legislation under Article 24 concluded that in many cases the provisions of Article 24 were not applicable. It issued a Communication relating to the methodology for analyzing state aid linked to stranded costs.

The basic position established in this Communication is that if designed to offset stranded costs normally qualifies for derogation under Article 87(3) if it "*facilitates the development of certain economic activities without adversely affecting trading conditions to an extent contrary to the common interest*." The Communication then sets out sensible principles for whether aid might be approved. The exact mechanism for financing the aid is left to the Member State.

In the case of Spain the Commission ruled that an amended proposal by the Spanish government, which took into account the methodology set out in the Communication, could benefit from derogation under Article 87(3) of the EC Treaty. In July 2001 the Commission approved schemes for Spain, Austria and the Netherlands.

Interpretation of the Communication of the Commission is still contentious. Recently DG Competition, the Directorate General responsible for state-aid legislation with respect to gas and electricity has opened an enquiry into a draft law in Poland that is designed to manage the stranded costs of PPAs. Details are given in the Box.

Stranded costs in Poland

In the mid-90s, Poland introduced a system of Power Purchase Agreements (PPAs) as an incentive for power generators to invest in Poland. Under these agreements, which have been signed between 1994 and 1998 and will expire between 2005 and 2027, the transmission system operator has the obligation to buy a fixed quantity of electricity at a fixed price. The PPAs thereby guarantee the generators a return on investment without any risk as well as a profit element. In the view of the Commission, PPAs strengthen the position of PPA-bound generators in comparison with others.

The European Commission has launched a formal investigation under EC Treaty state-aid into the long term power purchase agreements (PPAs) in force in Poland and into a draft law compensating for the cancellation of these agreements. The PPAs, concluded between the state-owned network operator and various generators cover about half of the generation market. The Commission doubts whether the arrangements put in place for the cancellation of the PPAs is compatible with state-aids legislation. The investigation seeks to determine whether state compensation is proportionate and does not deter new competitors from entering the market.

The last concern is what mechanisms for delivery of aid are efficient. It is important to avoid incentives that lead to inefficiencies in the energy market. If compensation is tied to the amount of power produced this may encourage high-cost generators to operate rather than to close. A guarantee of recovery of stranded costs discourages utilities from seeking mechanisms to minimize their costs. Stranded cost recovery should also be designed to avoid distortions in the decisions of consumers. This means in practice a non-avoidable charge. If the charge is avoidable then consumer will make decisions to avoid it that may be financially justified but economically unsound. It should also be independent of the supplier otherwise it can easily be avoided by switching supplier. Whatever mechanism is used it should be transitional preferably strongly digressive so that the achievement of a competitive market is not delayed more than necessary. These principles are largely present in the Communication of the Commission.

9.1.1. Conclusions

- The issue with stranded costs is purely one of distribution. Stranded costs are not in any way an economic loss to the community as a consequence of restructuring although we should also recognise that these investments may have been made inefficiently in the first instance.
- There are acceptable ways of compensating utilities that are permitted under state aids legislation and do not introduce significant economic distortion. The interpretation of the legislation is still in dispute, but that is normal in an issue of such complexity.
- There are examples of these schemes at work in the Community.

9.2. Unemployment

Any industry undergoing structural change is likely to see its employment structure change. The energy sector is no different. The much posited opinion is that in moving from a position of monopoly to one of competition, results in unemployment.

Referring back to Section 2 of this report, there was a lengthy discussion of the need to improve productivity to increase margin and market share in competitive markets – an important aspect of this will be improving labour productivity.

Is this necessarily a bad thing? There are two key questions that we need to address:

1. has liberalisation resulted in a large scale shift in employment? and
2. is such a shift detrimental?

9.2.1. Has liberalisation resulted in widescale unemployment?

In understanding this question, we have gathered information on sectoral employment for the EU15 from annual employment activity reports produced by the European Commission[26]. Overall total employment has risen over the period from 1994 to 2004 by around 5 million full time equivalents, or around 1% of population. Over the same period there have been changes (as you would expect) in the sectoral make-up of this employment.

In the Electricity Sector, employment declined by 2.5% from 1994 to 1997, with a share of employment at 0.7% of total. This is further reinforced by an estimate made by the European Commission that from 1990 to 1998 250,000 jobs were lost in both electricity and gas sectors[27]. This decline occurred before liberalisation began in earnest in most European countries, and reflects significant change either in anticipation of liberalisation, or in recognition of inefficiencies even within monopolies.

The European Commission has highlighted in its reports that employment reductions have generally been achieved through natural wastage (ie not replacing leavers) and also through encouragement of early retirement. This has driven improvements in labour productivity.

Since 1998 employment in the electricity sector (as a share of total) has remained relatively constant, with perhaps the hint of an upward trend. In 2004, the share of employment was 0.7%[26]. This constant share indicates that liberalisation has not (in aggregate) impacted employment in the electricity sector.

There are reasonable explanations as to why this has occurred. It is conceivable that during liberalisation and the progress of competition, the drive for labour productivity has seen a re-allocation of individuals from incumbents to new entrants, leaving the aggregate level of employment constant, while seeing labour movement. Again this is quite plausible and indeed likely. The activities that incumbents and new entrants must perform are identical, but must be duplicated, eg management functions, customer service functions and so on. As such there will be a redistribution of effort, which with improvements in labour productivity will see employment levels remaining constant.

9.2.2. Is unemployment a bad thing necessarily?

Much of the preceding discussion of employment has focused on the aggregate. It is highly likely that there will be instances of a net loss in specific countries or regions. Is any net loss of employment opportunity in the sector a bad thing?

Firstly we need to consider the nature of skill sets within the sector, and their transferability. It is likely that most operatives within the sector fall into skilled labour groups either manual or "white collar". This, of all the groups, are usually mobile, re-trainable, and valuable. As such it is unlikely that these individuals will remain unemployed for sustained period, and highly likely that they will find alternate employment. As such the net loss is likely to be small, and indeed as overall labour productivity rises, could be beneficial at an aggregate level to the economy.

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[26] European Commission (Various from 1998-2005)Employment in Europe

[27] European Commission (2001) The Effects of the Liberalisation of the Electricity and Gas Sectors on Employment

9.2.3. Conclusions

- There has been a reduction in employment in the Utilities industry through liberalisation
- This reduction in employment has been a consequence of increases in labour productivity which is directly attributable to the introduction of competitive forces
- This reduction in employment is however not a bad thing as many of the individuals affected are likely to have been redeployed elsewhere in the economy, driving further, wider economic growth.

9.3. Regional Champions

There has been considerable attention focused on the creation of national and regional champions in the electricity sector. The creation of these champions is often at the expense of small local countries. Figure 9.1 shows the ownership structure of the largest utilities in Europe, clearly demonstrating the development of these champions.

Figure 9.1: Presence of largest companies in selected individual Member States

	Electricity		Gas	
Company	LARGEST	OTHER SIGNIFICANT	largest	OTHER SIGNIFICANT
Austria	VERBUND	RWE, EON, EDF	OMV	GDF, RWE
Belgium	E-BEL	EDF, ESSENT, NUON, CENTRICA	DISTRIGAS	ESSENT, NUON, CENTRICA
Denmark	ELSAM	E2, VF, EON	DONG	
Finland	FORTUM	VF, EON	GASUM	
France	EDF	E-BEL, ENDESA	GDF	TOTAL
Germany	RWE	EON, VF, EDF	EON	WINGAS, RWE, EXXON, SHELL
Greece	PPC		DEPA	
Ireland	ESB	NIE (Viridian)	BGE	RWE
Italy	ENEL	E-BEL, ENDESA, EDISON, VERBUND	ENI	EDISON
Netherlands	E-BEL	ESSENT, NUON, EON	SHELL	EXXON
Portugal	EDP	ENDESA	GDP	
Spain	ENDESA	IBERDROLA, EDP, ENEL, UNION FENOSA	GAS NAT	BP, IBERDROLA, CEPSA
Sweden	VF	EON, FORTUM	EON	DONG,
UK		EDF, EON, RWE, CENTRICA	CENTRICA	SHELL, EXXON, BP, EON, EDF, RWE
Poland	BOT	PKE, PAK, E-BEL, EDF	PGNIG	
Czech R	CEZ	RWE, EON	RWE	EON
Slovakia	ENEL	TEKO, RWE, EDF, EON	SPP (GDF, EON)	
Hungary	MVM	EDF, EON, RWE	MOL	GDF, RWE, EON, ENI
Slovenia	HSE		GEOPLIN	

source: DG TREN estimates

Source: European Commission

The critical point here is however that this could be seen as a result of liberalisation, but it is in fact a consequence of privatization and hence ownership.

At the outset to this report, definitions were offered of liberalisation, competition and privatization. These suggested that the terms are often confused, but are not comparable. While liberalisation and competition are linked, privatization is a potential consequence but not a foregone conclusion and not necessary as a state-owned company could simply be regulated and subjected to competition from new entrants.

As it happens, liberalisation has generally resulted in the privatization of state-owned entities. These entities operating in competitive markets have generally sought to improve their efficiency, market share and boost financial performance. This has lead to acquisitions and mergers of companies in the sector, and the creation of regional champions.

Is this a bad thing? The answer to this question depends on one's view of the objectives of liberalisation. If the aim is to improve productivity and drive lower prices to the benefit of consumers, then the creation of champions is a good thing, if the objectives are to maintain local employment, then the creation of champions is bad.

However, few will disagree with the primary objective being to reduce prices to consumers, as such, productivity gains and investment is easiest driven through large scale national and regional champions.

All of these things are cyclical however. This is driven by usual competitive forces. National champions are created through financial power and driven through the prospect of productivity gains. Once a national or regional champion is formed, productivity gains fall, over time, lower cost new entrants arrive and enter the market, reducing market share, and so the cycle goes on (of course all of this is within the context of sector regulation). This has certainly been witnessed in the UK and Spanish markets where national champions were present in the late 1990's but new entrant generators entered the market, reducing market share. These new entrants are now being bought and integrated into the champions again. There will undoubtedly be a further cycle.

9.3.1. Conclusions

- There has been the creation of a small number of national and regional champions.
- The creation of these champions however is at best an indirect consequence of liberalisation.
- The real basis for the formation of champions is the change in ownership to private companies which has permitted these moves. This is therefore not deemed a direct result of liberalisation.

9.4. Short Term Rises in Price

A subsidy is defined by the OECD as "*any measure that keeps prices for consumers below market levels, or for producers above market levels, or that reduce costs for consumers and producers by giving direct or indirect price support*".

Subsidies can take many forms. A review of energy subsidies in the EU was published in 2004 by the European Environment Agency[28]. The review identified a range of mechanisms by which subsidies were channelled to the energy industries, including:

- Direct transfers and low interest loans to producers or consumers

[28] Energy Subsidies in the European Union: a brief overview, European Environment Agency, January 2004

- Tax exemptions and rebates, including accelerated depreciation allowances and tax credits
- Price controls and limits on market access
- Services provided by government below cost e.g. R&D
- Trade restrictions, such as quotas and technical standards
- Preferential planning consents and access to resources

From an economic perspective subsidies are distortions that will normally reduce welfare. Prices should reflect the opportunity costs of resources and then we can be confident that the use of the resources is optimised. But one person's subsidy may be another person's policy instrument. A list of policy instruments to promote, say, hydrogen or clean coal technologies could well include many of the mechanisms in the above list.

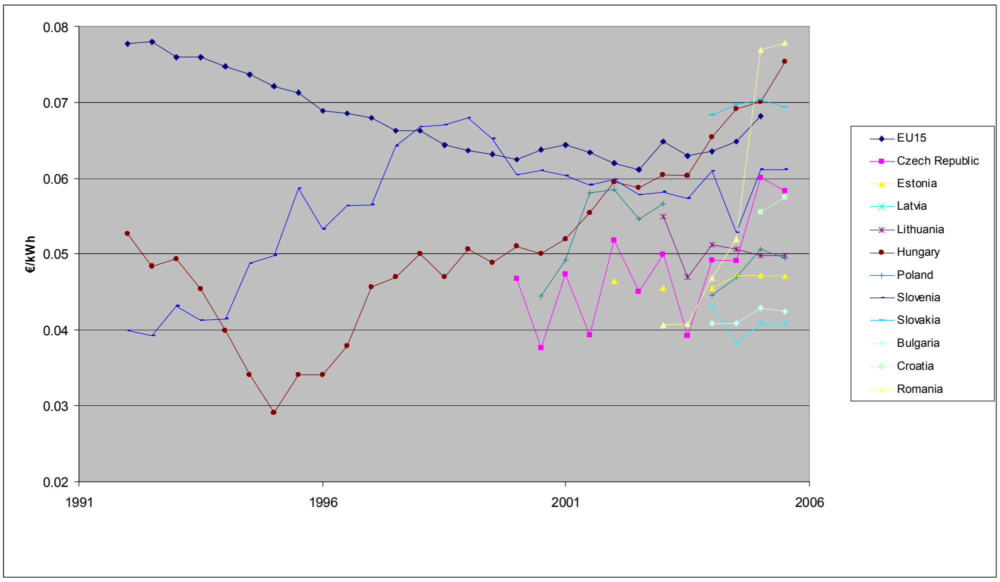
Using this rather wide definition of subsidy the EEA calculated that subsidies to the energy industry within the EU15 were €29 billion in 2001. Aid to the coal sector is now authorised by a Council Regulation that replaces the expired ECSC Treaty. In 2001, when the ESCS Treaty was still in force, aid through capital grants was €6.3 billion; aid through the taxation system is estimated at a further €6.6 billion. Capital grants to the development of gas infrastructure in the EU are permitted under certain conditions; tax incentives for the exploration and production of oil and gas are widely used. EEA estimated total support to the oil and gas industry at €8.7 billion. Support to renewable energy through feed-in tariffs, purchase obligations and grants is estimated at €5.3 billion and aid to the nuclear industry at €2.2 billion. Of the total, the majority, some €21.0 billion is off-budget through taxes and regulations.

Subsidies are very common throughout the economy. Many companies, and even government institutions, subsidise for example meals for employers or parking spaces in cities. This sort of subsidy does not distort competition; it is simply part of the remuneration of the employee and the only contentious aspect may be the debate with fiscal authorities about taxation of the benefit; there is no economic significance. The problems arise when financial support and regulations are put in place by the state to enhance the competitiveness of certain products, processes or regions. This is why within the EU the debate is normally formulated in terms of state aids.

The position of the EU on state aids is simple in principle but extremely complex in practice. The general principle laid down in Article 87(1) of the EC Treaty is that state aid is prohibited, but that Article itself provides for derogations from the principle and there are specific provisions in other legislation. Particularly important for the energy sector are the Community guidelines on state aid for environmental protection, (2001/C 37/03); these give strong priority to Kyoto objectives for climate change. This has provided the basis for support regimes to renewables and could in the future justify support for other technologies with environmental advantage such as carbon sequestration.

Many of the countries recently acceding to the Community practised large subsidies in the energy sector. In most cases these took the form of capital grants to the domestic coal industry and power generation. Some countries enjoyed gas at concessionary prices. There was widespread use of cross-subsidy where preferred groups, generally domestic consumers, enjoyed lower prices than other groups with the same or lower costs of supply. On joining the Union the countries undertook to observe the EU state aids regime and much has been done to conform to this requirement. Figure 9.1 shows the price of electricity to industry in the CEEC countries since 1992.

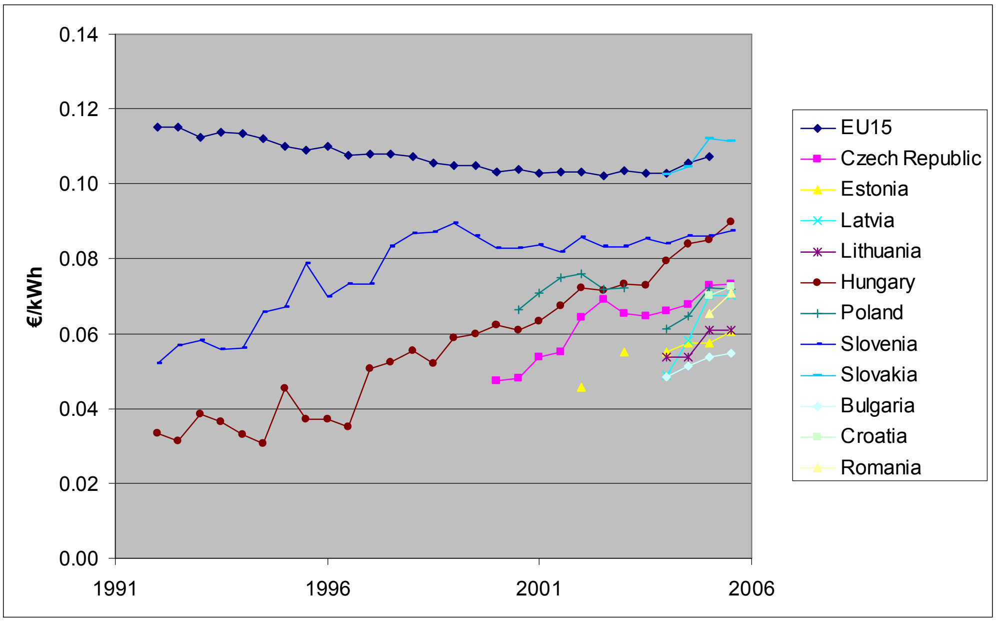
Figure 9.1 Price of electricity to medium sized (Ie) industry in the CEEC countries since 1992.



Source Eurostat

It is evident, especially in the longer time series for Hungary and Slovenia that prices have increased substantially and in some cases they are now close to the EU15 mean. In almost all cases there is some degree of convergence towards the EU15 level. Figure 9.2 shows a similar plot for household consumers.

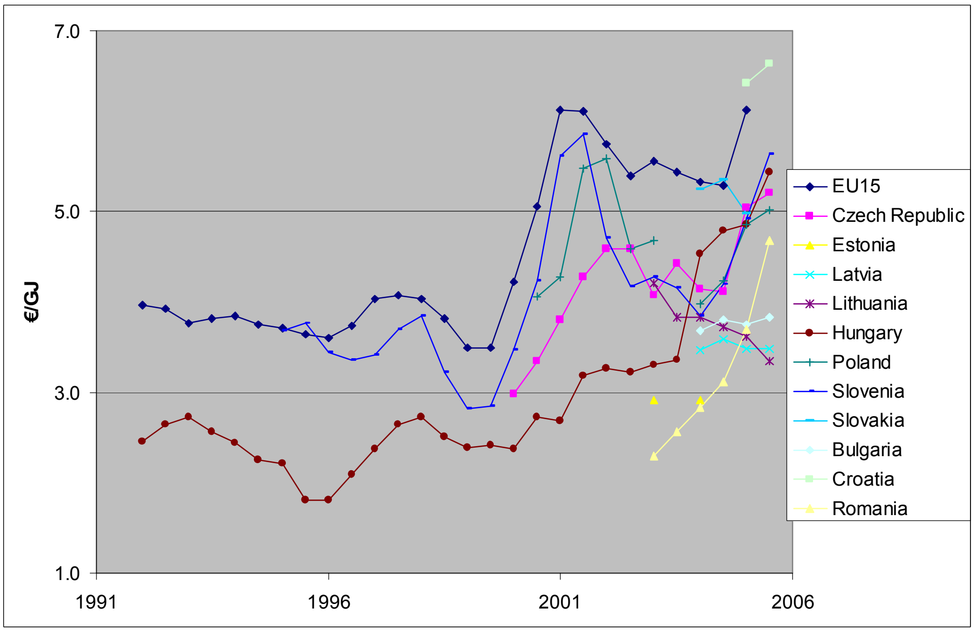
Figure 9.2 Price of electricity to households in the CEEC countries since 1992.



Source Eurostat

The deviation here from EU15 prices was originally higher than for industry, as a consequence of cross-subsidy in favour of households. A trend to convergence is clear; again, it is especially visible in the long time-series for Hungary and Slovenia, but is also evident in the other countries. Similar behaviour is evident in the gas industry. Figure 9.3 shows the development of prices to medium sized industrial consumers (Class I3).

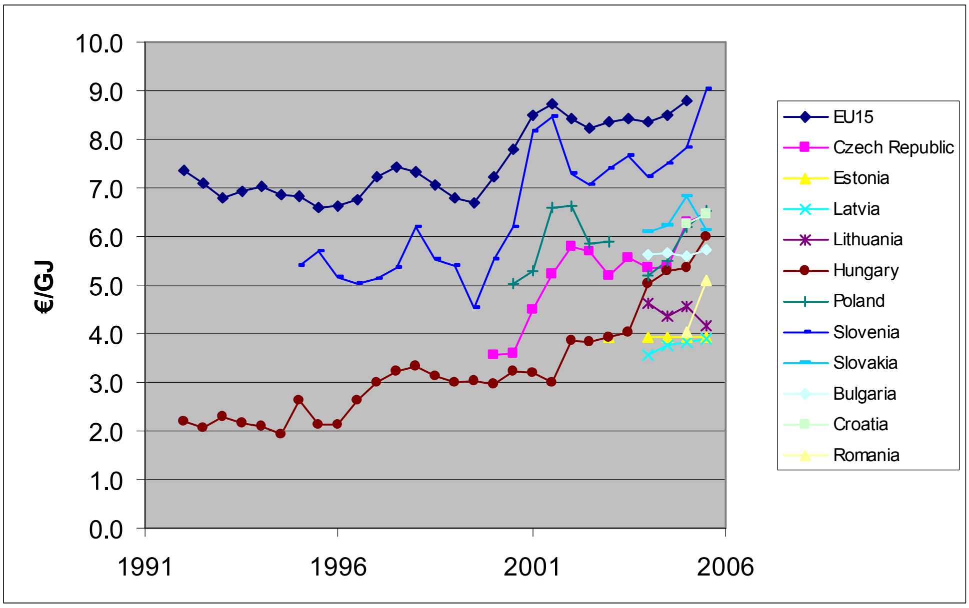
Figure 9.3 Price of gas to medium sized industry in the CEEC since 1992.



Source Eurostat

The rapid increases in price are even more evident here than for electricity and the convergence on the EU15 level is more fully accomplished, probably because of the stronger link to international markets in this industry. Figure 9.4 shows the price evolution for gas to households. The same trends are evident.

Figure 9.4 Price of gas to households in the CEEC since 1992



Source Eurostat

9.4.1. Conclusions

- State aids in favour of specific companies, sectors or regions distort competition and are undesirable unless they are clearly directed at an accepted policy goal
- There are accepted principles within the EU for the sanction of state aid, even if they are complex in application
- Subsidies are a common market based instrument for the implementation of policy and even in the EU15 the level of subsidy for this purpose is extremely high; the rational is that the importance of guiding the economy through this intervention exceeds the loss of welfare from the inefficiencies that accompany the intervention
- The recently acceding countries practised high levels of direct and cross-subsidy and faced a huge challenge against great political opposition to raise prices to market levels
- The countries have generally been successful in moving the price regime towards market levels, although in some cases there appears to be more to be done
- There are great benefits to the national economy to be gained from these changes in terms of energy efficiency and environmental impacts and in clearing the ground for an effective liberalised market

9.5. The cost efficiency of liberalisation

The discussions around the costs of liberalisation are difficult. Primarily the costs of the liberalisation process relate to:

- the business costs of separation, eg separation of management functions, human resources, IT, billing systems and so on
- the increased regulatory costs, eg returns and monitoring; and
- changes to financing base and financial strength, impacting potential debt arrangements.

These are clearly a transitional issue, and are one off costs to be born by business, and ultimately consumers (where in regulated businesses the costs can be pass on through regulatory formula) and shareholders (who will take a one off charge to profit and loss and hence equity). What is the quantum of these costs however, and how do they relate to the overall benefits?

The costs of liberalisation are known in some countries, particularly the UK. There have been three government examinations of the costs of implementing liberalisation. In electricity:

- an evaluation of the opening up of electricity markets to competition has been shown to have cost the UK electricity suppliers £850 million[29].
- A subsequent analysis of the way that electricity has been traded in the UK has found that this change has cost £580 million[30].

Similar data are available for gas. In the UK, the introduction of domestic competition to gas markets cost an estimated £350-500million[31].

While these costs are substantial, most have been recovered through combinations of regulatory mechanisms and through one off charges to shareholders.

Taking these figures broadly, and adding them up, a total cost of £87/customer in the UK. Against this, there are published figures stating that in the early years of liberalisation savings to customers amounted to £30/customer per year for electricity and £40/customer/year for gas. These changes therefore have a very short payback period in a cost benefit sense also.

9.5.1. Conclusions

- Liberalisation has occurred at a cost, approximately £1 billion in the UK alone.

The cost per customer is small, approximately 10% of average bills, and a fraction of the total benefit of lower prices. Therefore the benefits of liberalization far outweigh the costs.

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[29] UK National Audit Office Report: Office of Gas and Electricity Markets - Giving domestic customers a choice of electricity supplier (HC 85 2000-2001) - Executive Summary (84 KB)

[30] NAO report (HC 624 2002-2003): The New Electricity Trading Arrangements in England and Wales

[31] UK National Audit Office Report - Office of Gas Supply: Giving customers a choice - The introduction of competition into the domestic gas market (HC 403 1998/99) - Full report [1,036 Kb]

10. Conclusions

This report has investigated whether there is a case for liberalisation and whether the process of liberalisation works. At the outset, five key challenges to the process of liberalisation were posed, and were subsequently tested. Our findings against each of these challenges can be summarized as follows:

Question & Analysis undertake	Conclusion
Does Liberalisation lower Prices? • Regression analysis for electricity, gas and spark spreads against consumer prices for a range of consumers • Regression analysis of prices against indicators of competition (blend of the degree of market opening, the market share of the 3 largest companies and the unbundling of the TSO)	**YES**
Does liberalisation increase price volatility? • Segmented the data to examine short medium and long term price movements • Considered the scope of pass through to consumers	**YES** Actually liberalisation leads to competitive markets with attendant volatility. But, we have determined that: • price volatility is necessary to reflect the dynamics of supply and demand at the margin and to stimulate investment. • There is no evidence to show volatility feeds through to consumer prices. • That volatility, while high in early periods, has reduced over time.
Does liberalisation inhibit investment? • Plotted the evolution of prices against capacity additions in the UK, Spain, France and Germany electricity and gas markets	**NO** There is clear evidence suggesting capacity continues to be added, but that more experience is required to determine whether investment is sufficient.
Do liberalised markets provide a reliable and secure supply? • Looked at measures of reliability, utilisation and availability and reserve margin. • Developed measures of fuel diversity	**YES** There is good evidence that electricity and gas systems have become more reliable and diverse, but there are a range of PSOs and regulations that are important in support of some of the extreme events.

Do liberalised markets effectively interact with public policies? • Looked at the evolution of prices as a proportion of incomes • Looked at changes in carbon intensity against GDP. • Looked at the evolution of emissions performance	**YES** There is strong evidence that public policies have been maintained in social, industrial and environmental regards. There is also evidence that the implementation of these public policies has become more efficient and that costs of compliance have reduced.

This set of statements should be considered against a few caveats, which have been presented in more detail in Section 1. The particular caveats are:

- The availability and completeness of publicly available data.
- The consistency of data.
- The definitions of data.
- The analysis showing correlation does not always show causation.

However, even with these in mind, in pretty much all cases, the available evidence has suggested that liberalisation is at least as good, and in the majority of cases better than monopoly markets.

Annex A – Statistical Results

Regression analysis is a technique for estimating the relationship between measured quantities. The measured quantity that is to be described is known as the dependent variable and the quantities that are used to describe the observed behaviour of the dependent variable are known as the independent variables. Frequently the relationship is constrained to be linear because the mathematics of linear relationships is very easy. Many physical relationships are linear and then the constraint is not critical. Relationships in the social sciences are rarely linear and the constraint is important. Positive results in the social sciences are sometimes better viewed as demonstrating the existence of a relationship rather than as a reliable formula for prediction.

Regression analysis generates a range of performance criteria. Some measure the success of the formulation as a whole in explaining the observed variation in the data and some measure the significance of the individual coefficients contained within the formulation. The Annex presents for each regression several performance criteria; they are included for readers who are interested in the statistical detail. For the general reader we draw attention here just to three parameters that are commonly used. We illustrate their use with respect to the first regression, that is a pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ia consumers against the degree of market opening (MO) and the contestable market (3G).

The parameters to which we which to draw attention are the value of R2 for the regression as a whole and the value of the t-statistics and the 95% confidence limits for the coefficients.

The value of R2 for the regression in question is 0.457. The statistic is more usually quoted as a percentage, i.e. 45.7%. It describes the percentage of the variation in the original data (in this case price) that can be explained by variation in the driving factors (in this case market opening and the contestable market). Variation is measured by the variance of the data, i.e. the sum of squares around the mean. For a problem of this complexity a value of 45.7% is rather good.

The values and t-values of the coefficients of MO and 3G are -0.00074 and -0.000335. Each of these is associated with a t-statistic (-4.86 and -2.39 respectively). The t-statistic is defined as the value of the coefficient divided by the estimated standard error; it is a measure of how accurately the coefficient has been determined. It is often useful to express the significance of the influence of an independent variable through the probability that the coefficient of that variable is different from zero, i.e. is describing a real physical or behavioural relationship. The t-statistics can be used to estimate this probability by comparing the derived value to a tabulated distribution. The critical value in the table will be a function of the confidence level required and the number of degrees of freedom in the estimation that is in turn determined by the number of observations and the number of parameters estimated. To avoid constant reference to a tabulated distribution the summary results include estimates of the upper and lower limits of the coefficients at the 95% confidence limit. So from the summary results we can see that the 95% confidence limits for the coefficient of MO are -0.00104373 and -0.0004372. There is a 95% probability that the coefficient lies within this range. We can therefore be reasonably confident that the independent variable MO is genuinely associated with lower prices. In fact the value of the t-statistic in this case is rather high and higher confidence is warranted. Reference to the tabulated t-distribution shows that the critical value of t for the 99.9% confidence limit is about 3.2, so the association is very significant. The limits on the coefficient for 3G are between -0.00061399 and -5.6328E-05, so 3G is significant at the 95% level, but only just.

We note also some weaknesses in the statistical analysis. There is significant correlation between the dependent variables in some of the formulations. This is inevitable because the dependent variables are various measures of competition and in the nature of things they are likely to develop in parallel. This does not weaken the case for a general relationship between price and competition, but it does introduce uncertainty into the estimates of the individual coefficients.

We should also note that there are theoretical objections to pooling time series and cross-sectional data. Cross-sectional analysis seeks to relate the observed behaviour in different countries to varying states of competition and tends to detect long-run relationships. Time series analysis seeks to detect adjustments to increasing competition as it develops within the country and tends to identify short-run adjustments. The relationships are not necessarily the same and therefore when pooling the data it is unclear what exactly is being measured. Pooling cross-sectional and time-series data is often done when neither data set is large enough to obtain significant results as is the case here. This observation strengthens the earlier remark that the results of the regression analysis should be seen more as establishing a significant link between price and competition rather than as a reliable quantitative guide to that relationship.

Summary Results

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ia consumers against market opening (MO) and contestable market (3G)

Regression Statistics	
Multiple R	0.676639
R Square	0.457840
Adjusted R Square	0.443938
Standard Error	0.023877
Observations	81

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.037551	0.018776	32.934450	0.000000
Residual	78	0.044467	0.000570		
Total	80	0.082018			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*

Intercept	0.169092	0.011137	15.182575	0.000000	0.146920	0.191265
MO	-0.000740	0.000152	-4.860925	0.000006	-0.001044	-0.000437
3G	-0.000335	0.000140	-2.393028	0.019114	-0.000614	-0.000056

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ia consumers against composite competition indicator CI

Regression Statistics	
Multiple R	0.664102
R Square	0.441032
Adjusted R Square	0.433957
Standard Error	0.024090
Observations	81

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.036173	0.036173	62.331895	0.000000
Residual	79	0.045845	0.000580		

Total	80	0.082018			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.158333	0.008805	17.982033	0.000000	0.140807	0.175859
CI	-0.052710	0.006676	-7.895055	0.000000	-0.065999	-0.039421

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ia consumers against market opening (MO) and contestable market (3G) (logarithmic formulation)

Regression Statistics	
Multiple R	0.601011
R Square	0.361214
Adjusted R Square	0.344835
Standard Error	0.296712
Observations	81

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*

Regression	2	3.883056	1.941528	22.053281	0.000000
Residual	78	6.866969	0.088038		
Total	80	10.750025			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.260854	0.475971	0.548047	0.585225	-0.686731	1.208440
ln MO	-0.569352	0.124460	-4.574566	0.000018	-0.817133	-0.321570
ln 3G	-0.058135	0.046354	-1.254160	0.213529	-0.150418	0.034148

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ia consumers against composite competition indicator CI (logarithmic formulation)

Regression Statistics	
Multiple R	0.611914
R Square	0.374439
Adjusted R Square	0.366520
Standard Error	0.291760
Observations	81

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4.025227	4.025227	47.286605	0.000000
Residual	79	6.724799	0.085124		
Total	80	10.750025			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-2.012205	0.071209	-28.257889	0.000000	-2.153942	-1.870468
ln CI	-0.626421	0.091096	-6.876526	0.000000	-0.807742	-0.445099

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ie consumers against market opening (MO) and contestable market (3G)

Regression Statistics	
Multiple R	0.381158
R Square	0.145281
Adjusted R Square	0.130286

Standard Error	0.011950
Observations	117

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.002767	0.001384	9.688609	0.000130
Residual	114	0.016280	0.000143		
Total	116	0.019047			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.073218	0.003198	22.895016	0.000000	0.066882	0.079553
MO	-0.000106	0.000053	-1.991266	0.048843	-0.000212	-0.000001
3G	-0.000103	0.000068	-1.510396	0.133709	-0.000237	0.000032

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ie consumers against market opening (MO)

Regression Statistics

Multiple R	0.358018
R Square	0.128177
Adjusted R Square	0.120596
Standard Error	0.012017
Observations	117

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.002441	0.002441	16.907543	0.000074
Residual	115	0.016606	0.000144		
Total	116	0.019047			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.074323	0.003130	23.743040	0.000000	0.068123	0.080524
MO	-0.000161	0.000039	-4.111878	0.000074	-0.000239	-0.000084

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ie consumers against contestable market (3G)

Regression Statistics	
Multiple R	0.339930
R Square	0.115553
Adjusted R Square	0.107862
Standard Error	0.012103
Observations	117

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.002201	0.002201	15.024682	0.000177
Residual	115	0.016846	0.000146		
Total	116	0.019047			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.067987	0.001847	36.805164	0.000000	0.064328	0.071646
3G	-0.000195	0.000050	-3.876169	0.000177	-0.000294	-0.000095

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ie consumers against composite competition indicator CI

Regression Statistics	
Multiple R	0.381147
R Square	0.145273
Adjusted R Square	0.137841
Standard Error	0.011898
Observations	117

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.002767	0.002767	19.545908	0.000022
Residual	115	0.016280	0.000142		
Total	116	0.019047			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.073161	0.002694	27.158707	0.000000	0.067825	0.078497
CI	-0.000105	0.000024	-4.421075	0.000022	-0.000152	-0.000058

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ie consumers against composite competition indicator CI (logarithmic formulation)

Regression Statistics	
Multiple R	0.327987
R Square	0.107576
Adjusted R Square	0.099816
Standard Error	0.209884
Observations	117

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.610661	0.610661	13.862478	0.000306
Residual	115	5.065904	0.044051		
Total	116	5.676565			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*

Intercept	-2.182427	0.166698	-13.092060	0.000000	-2.512624	-1.852229
ln CI	-0.136345	0.036620	-3.723235	0.000306	-0.208883	-0.063808

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ia and Ie consumers against market opening (MO), contestable market (3G) and Class

Regression Statistics	
Multiple R	0.678751
R Square	0.460703
Adjusted R Square	0.452363
Standard Error	0.019981
Observations	198

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0.066165	0.022055	55.242552	0.000000
Residual	194	0.077452	0.000399		
Total	197	0.143617			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.123231	0.005288	23.302697	0.000000	0.112801	0.133661
MO	-0.000246	0.000072	-3.429118	0.000740	-0.000388	-0.000105
1-3g	-0.000251	0.000081	-3.083728	0.002342	-0.000411	-0.000090
Class	-0.035232	0.002973	-11.850872	0.000000	-0.041095	-0.029369

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ia and Ie consumers against a composite competition indicator CI and Class

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.678749
R Square	0.460700
Adjusted R Square	0.455169
Standard Error	0.019930
Observations	198

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.066164	0.033082	83.289920	0.000000
Residual	195	0.077453	0.000397		
Total	197	0.143617			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.123317	0.004614	26.726629	0.000000	0.114217	0.132416
CI	-0.024841	0.003222	-7.710295	0.000000	-0.031195	-0.018487
Class	-0.035231	0.002965	-11.881984	0.000000	-0.041078	-0.029383

Pooled cross-sectional and four year six-monthly time-series analysis of industrial electricity prices to Class Ia and Ie consumers against a composite competition indicator CI and Class (logarithmic formulation)

Regression Statistics	
Multiple R	0.472462
R Square	0.223220

Adjusted R Square	0.215253
Standard Error	0.100563
Observations	198

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.566694	0.283347	28.018148	0.000000
Residual	195	1.972032	0.010113		
Total	197	2.538726			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-1.056970	0.010175	-103.878552	0.000000	-1.077038	-1.036903
ln CI	-0.251458	0.034113	-7.371311	0.000000	-0.318736	-0.184180
Class.log(CI)	0.037850	0.011884	3.185126	0.001685	0.014414	0.061287

Pooled cross-sectional and four year six-monthly time-series analysis of double-differenced industrial electricity prices to Class Ie consumers against market opening (1991 base year)

Regression Statistics	
Multiple R	0.316473
R Square	0.100155
Adjusted R Square	0.091974
Standard Error	0.015089
Observations	112

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.002787	0.002787	12.243260	0.000675
Residual	110	0.025044	0.000228		
Total	111	0.027831			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.035879	0.008385	4.279033	0.000040	0.019262	0.052496
MO	-0.000322	0.000092	-3.499037	0.000675	-0.000504	-0.000140

Pooled cross-sectional and four year six-monthly time-series analysis of double-differenced industrial electricity prices to Class Ie consumers against market opening (1995 base year)

Regression Statistics	
Multiple R	0.346797
R Square	0.120268
Adjusted R Square	0.112271
Standard Error	0.014139
Observations	112

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.003006	0.003006	15.038118	0.000180
Residual	110	0.021990	0.000200		
Total	111	0.024997			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.036600	0.007857	4.658196	0.000009	0.021029	0.052171
MO	-0.000334	0.000086	-3.877901	0.000180	-0.000505	-0.000164

Regression Statistics	
Multiple R	0.419041
R Square	0.175596
Adjusted R Square	0.160469
Standard Error	0.014509
Observations	112

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.004887	0.002444	11.608340	0.000027
Residual	109	0.022944	0.000210		
Total	111	0.027831			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.048658	0.009021	5.393995	0.000000	0.030779	0.066537
MO	-0.000547	0.000114	-4.814896	0.000005	-0.000772	-0.000322

3G	0.000258	0.000082	3.158248	0.002054	0.000096	0.000420

Regression Statistics	
Multiple R	0.581745
R Square	0.338428
Adjusted R Square	0.326289
Standard Error	0.012317
Observations	112

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.008460	0.004230	27.879513	0.000000
Residual	109	0.016537	0.000152		
Total	111	0.024997			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.057194	0.007658	7.468211	0.000000	0.042016	0.072373

MO	-0.000696	0.000096	-7.225171	0.000000	-0.000887	-0.000505
3G	0.000416	0.000069	5.995310	0.000000	0.000279	0.000554

T-Test (Two-Sample Assuming Unequal Variances) on electricity prices to Class Ie consumers in countries with MO =100% and other levels of market opening

Regression of prices for gas to industrial consumers in Class I3 against German border prices 1997 to 2005 on a six-monthly basis

Regression Statistics	
Multiple R	0.958805
R Square	0.919307
Adjusted R Square	0.913927
Standard Error	0.276935
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	13.105915	13.105915	#########	0.000000
Residual	15	1.150391	0.076693		
Total	16	14.256306			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.595832	0.261704	6.097841	0.000020	1.038022	2.153642
BP	1.079987	0.082616	13.072436	0.000000	0.903896	1.256079

Pooled cross-sectional and four year six-monthly time-series analysis of industrial gas prices to Class I3 consumers against unbundling of the (TSO) and the extent of the contestable market (CM)

Regression Statistics	
Multiple R	0.510409
R Square	0.260517
Adjusted R Square	0.239976
Standard Error	0.759682
Observations	75

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	14.638759	7.319380	12.682658	0.000019

Residual	72	41.552436	0.577117
Total	74	56.191195	

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6.231661	0.179440	34.728428	0.000000	5.873955	6.589368
TSO	-0.870404	0.180780	-4.814708	0.000008	-1.230783	-0.510026
CM	-0.007448	0.003961	-1.880652	0.064064	-0.015344	0.000447

Pooled cross-sectional and four year six-monthly time-series analysis of industrial gas prices to Class I3 consumers against composite competition indicator CI (logarithmic formulation)

Regression Statistics	
Multiple R	0.469288
R Square	0.220231
Adjusted R Square	0.209550
Standard Error	0.135338
Observations	75

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.377640	0.377640	20.617526	0.000022
Residual	73	1.337102	0.018316		
Total	74	1.714743			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.661891	0.017182	96.721421	0.000000	1.627647	1.696135
log CI	-0.053432	0.011767	-4.540653	0.000022	-0.076884	-0.029979

Pooled cross-sectional and four year six-monthly time-series analysis of industrial gas prices to Class I3 consumers against unbundling of the (TSO), the extent of the contestable market (CM) and border prices (BP)

Regression Statistics	
Multiple R	0.604183
R Square	0.365037
Adjusted R Square	0.338207
Standard Error	0.708891

Observations	75

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	20.511859	6.837286	13.605840	0.000000
Residual	71	35.679336	0.502526		
Total	74	56.191195			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3.060851	0.942497	3.247597	0.001778	1.181564	4.940137
TSO	-0.923389	0.169404	-5.450811	0.000001	-1.261171	-0.585607
CM	-0.008218	0.003703	-2.219498	0.029649	-0.015601	-0.000835
BPs	0.897140	0.262425	3.418649	0.001046	0.373879	1.420402

Pooled cross-sectional and four year six-monthly time-series analysis of industrial gas prices to Class I3 consumers against unbundling of the (TSO) and the extent of the contestable market (CM); coefficient of border prices (BP) constrained to unity

Regression Statistics

Multiple R	0.566066
R Square	0.320431
Adjusted R Square	0.301554
Standard Error	0.704712
Observations	75

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	16.859935	8.429967	16.974731	0.000001
Residual	72	35.756539	0.496619		
Total	74	52.616474			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.697308	0.166456	16.204377	0.000000	2.365485	3.029131
TSO	-0.929463	0.167699	-5.542451	0.000000	-1.263765	-0.595162
CM	-0.008306	0.003674	-2.260810	0.026794	-0.015630	-0.000982

Pooled cross-sectional and four year six-monthly time-series analysis of industrial gas prices to Class I1 and I2 consumers against

unbundling of the (TSO), contestable market (CM) and Class

Regression Statistics	
Multiple R	0.626204
R Square	0.392132
Adjusted R Square	0.370422
Standard Error	1.152503
Observations	88

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	71.975827	23.991942	18.062632	0.000000
Residual	84	111.574169	1.328264		
Total	87	183.549995			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	9.430945	0.317465	29.707034	0.000000	8.799631	10.062259
Class	-0.996818	0.245715	-4.056814	0.000111	-1.485449	-0.508188

TSO	-1.150497	0.269887	-4.262884	0.000053	-1.687196	-0.613797
CM	-0.026992	0.005166	-5.224528	0.000001	-0.037265	-0.016718

Pooled cross-sectional and four year six-monthly time-series analysis of industrial gas prices to Class I1 and I2 consumers against unbundling of the (TSO), contestable market (CM, border prices (BP) and Class

Regression Statistics	
Multiple R	0.721856
R Square	0.521076
Adjusted R Square	0.497995
Standard Error	1.029133
Observations	88

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	95.643411	23.910853	22.576247	0.000000
Residual	83	87.906585	1.059115		
Total	87	183.549995			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	4.042584	1.174582	3.441723	0.000908	1.706388	6.378780
dummy	-0.996818	0.219412	-4.543135	0.000019	-1.433220	-0.560416
TSO	-1.126851	0.241049	-4.674786	0.000011	-1.606288	-0.647415
CM	-0.029781	0.004651	-6.403390	0.000000	-0.039032	-0.020531
BPs	1.497246	0.316729	4.727214	0.000009	0.867285	2.127208

Pooled cross-sectional and four year six-monthly time-series analysis of industrial gas prices to Class I4 and I5 consumers against unbundling of the (TSO), contestable market (CM), border prices (BP) and Class

Regression Statistics	
Multiple R	0.769871
R Square	0.592701
Adjusted R Square	0.560756
Standard Error	0.565552
Observations	56

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	23.737625	5.934406	18.553803	0.000000
Residual	51	16.312274	0.319849		
Total	55	40.049898			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3.540496	0.815080	4.343738	0.000067	1.904155	5.176837
Class	-1.040249	0.173611	-5.991819	0.000000	-1.388788	-0.691709
TSO	-0.950246	0.163861	-5.799103	0.000000	-1.279210	-0.621282
CM	-0.007377	0.003499	-2.108681	0.039904	-0.014401	-0.000354
BP	0.554889	0.229963	2.412944	0.019457	0.093218	1.016559

Pooled cross-sectional and four year six-monthly time-series analysis of industrial gas prices to Class I4 and I5 consumers against unbundling of the (TSO), contestable market (CM) and Class; coefficient of border prices (BP) constrained to unity

Regression Statistics	
Multiple R	0.774667

R Square	0.600109
Adjusted R Square	0.577038
Standard Error	0.580295
Observations	56

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	26.277762	8.759254	26.011786	0.000000
Residual	52	17.510571	0.336742		
Total	55	43.788333			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	2.004023	0.189828	10.557032	0.000000	1.623105	2.384941
Class	-1.049577	0.178069	-5.894230	0.000000	-1.406898	-0.692257
TSO	-0.981913	0.167292	-5.869444	0.000000	-1.317610	-0.646217
CM	-0.008826	0.003507	-2.516747	0.014967	-0.015863	-0.001789

Regression Statistics	
Multiple R	0.867925
R Square	0.753293
Adjusted R Square	0.742079
Standard Error	0.029534
Observations	24

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0.058593	0.058593	67.174675	0.000000
Residual	22	0.019189	0.000872		
Total	23	0.077782			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.011906	0.026056	-0.456946	0.652189	-0.065943	0.042131
GBP	0.885966	0.108097	8.196016	0.000000	0.661786	1.110146