

Incentive Regulation of Electricity Distribution  
Networks: Lessons of Experience from Britain

*Tooraj Jamasb and Michael Pollitt*

June 2007

CWPE 0709 and EPRG 0701

---

**Incentive Regulation of Electricity Distribution Networks:  
Lessons of Experience from Britain**

---

*Tooraj Jamasb*\*  
**Faculty of Economics  
University of Cambridge**

*Michael Pollitt*  
**Judge Business School  
University of Cambridge**

**19 June 2007**

---

\* Corresponding author. Faculty of Economics, Electricity Policy Research Group, University of Cambridge, Sidgwick Avenue, Austin Robinson Building, Cambridge CB3 9DE, United Kingdom. Telephone: +44-(0)1223-335271, Fax: +44-(0)1223-335299, Email: [tooraj.jamasb@econ.cam.ac.uk](mailto:tooraj.jamasb@econ.cam.ac.uk)

The authors would like to thank anonymous referees for their detailed comments and acknowledge the support from the Swiss State Secretariat for Economic Development (SECO) and the UK Economic and Social Research Council (ESRC) for this study.

## **Abstract**

This paper reviews the recent experience of the UK electricity distribution sector under incentive regulation. The UK has a significant and transparent history in implementing incentive regulation in the period since 1990. We demonstrate the successes of this period in reducing costs, prices and energy losses while maintaining quality of service. We also draw out the lessons for other countries in implementing distribution sector reform. We conclude by discussing the place of incentive regulation of networks within the wider reform context, the required legislative framework, the need for appropriate unbundling, the importance of quality of service incentives, the regulatory information requirements and the role of sector rationalisation.

JEL Classification: L52, L94, Q48

Key words: Electricity, liberalisation, regulation, benchmarking

---

## 1. Introduction

In the mid-1980s, Britain pioneered an extensive privatisation and market-based reform of the state-owned industries. A particular aspect of the British reform that has attracted much attention has been the use of restructuring, competition, and independent regulation in infrastructure and network industries such as telecoms, transport, and energy including the electricity industry. For instance Joskow (2006), in a substantial review of incentive regulation in electricity transmission and distribution networks, takes the UK as his primary example. Joskow's focus is the link between theory and practice with detailed discussions of some of the actual incentive regimes in place. This paper, however, is empirical in focus and is aimed at reviewing the broader historical experience and the evidence on the performance of incentive regulation of electricity distribution network operators (DNOs) in the UK and its lessons – good and bad - for other countries, particularly those at an early stage in their overall electricity reform.

These reformed industries consist of potentially competitive and natural monopoly network activities. The reforms have separated these activities followed by introduction of competition in the former and by regulating the latter. The aim of network regulation is to facilitate competition over the networks based on non-discriminatory access to these and to improve their efficiency. An innovative and important part of the regulation of natural monopoly networks has been the use of an incentive-based regulatory regime which, in the absence of competition, attempts to mimic competitive market pressures.

The effects of incentive-based regulation can best be assessed in the long-run as the firms need time to adjust to their new operating environment and the sector regulators must gain experience. The length and features of the British reform make it relevant for drawing useful lessons for other countries. The aim of this paper is to assess the context, process, and performance of the British model of incentive-based regulation of electricity distribution networks.

We then draw lessons of experience for other countries and in particular in non-reforming countries. Since the British reform, many countries around the world and Europe have embarked on reforming their sectors with the latter partly driven and coordinated by the European Commission's Electricity Directives. Many other countries however lag behind in their progress with reform as a result of unsuccessful reform proposals and or because they lack the sort of pressure that being directly bound by the Electricity Directives give. For example, the Swiss sector is the least reformed sector in the OECD-Europe and is one for which this paper may be directly relevant.

---

The next section discusses the main aspects of incentive-based regulation and benchmarking of electricity distribution networks. Section 3 consists of a review of the background and the experience with distribution network regulation in Britain. Section 4 describes the five-year distribution price control reviews since the privatisation of the industry. Section 5 addresses some specific issues of importance in distribution network regulation. Section 6 draws some general lessons from experience for other countries.

## **2. Incentive-Based Regulation and Benchmarking of Electricity Distribution Networks**

### **2.1 The electricity industry**

Electricity is an indispensable part of modern social and economic life. A reliable and efficient electricity industry is crucial for economic development and competitiveness. The electricity sector is a network industry comprising distinct but inter-related activities with many actors whose production and consumption decisions affect the operation of the whole system.

The electricity system consists of generation, transmission, distribution and supply (or retailing) activities. Generation comprises production and conversion of electric power. Transmission involves long distance transportation of electricity at high voltage. Distribution is transportation of low voltage electricity through local networks and consists of overhead lines, cables, switchgear, transformers, control systems and meters to transfer electricity from the transmission system to customers' premises. The supply function consists of metering, billing, and sale of electricity to end-users. The generation and supply activities are generally regarded as potentially competitive while the transmission and distribution networks are characterised as natural monopolies.

The network characteristics of the industry and economies of coordination among the different activities led to creation of vertically integrated structures in many electricity sectors. At the same time, end-users are diverse - including residential, commercial, and industrial consumers - with different usage patterns with different economic values attached to their consumption. Moreover, the strategic importance of the sector and public service view of provision of electricity often justified public ownership of the industry.

Electricity is a technically homogeneous and non-storable product and system reliability requires that supply and demand are matched simultaneously. At the same time, the

---

electricity industry is highly capital intensive with much of the assets becoming sunk costs upon investment. As the existing assets in place need to be renewed and demand continuously increases, the sector can experience investment cycles. At the same time, the assets have long economic lives with long-term implications for the composition of the sector.

The electricity reforms have generally regarded the generation and supply activities as potentially competitive while the transmission and distribution networks are natural monopoly activities that need to be regulated.

## **2.2 Electricity sector reforms and incentive regulation**

Since the mid-1980s, a world-wide reform trend has transformed the institutional framework, organisation, and operating environment of the infrastructure and network industries including electricity. This has given rise to considerable interest in incentive-based regulation of the natural monopoly segments of the reformed industries.

In the electricity sector, reforms have involved measures such as privatisation, establishment of sector regulators, introduction of competition into generation, design of organised wholesale and retail markets, and unbundling of generation, transmission, distribution, and retail activities (Joskow, 1998; Newbery, 2002). Incentive regulation must therefore be viewed within the wider context of regulatory reform of the sector.<sup>1</sup>

Moreover, some shortcomings in the incentive properties of the traditional rate-of-return (ROR) regulation, most notably over-capitalisation of the regulatory asset base shown by Averch and Johnson (1962) were also apparent prior to the reforms. The trend towards sectoral reforms and the renewed interest in regulation have led to advances in the theoretical and conceptual aspects of incentive regulation as an alternative to the traditional rate-of-return or cost-of-service regulation.<sup>2</sup>

From an economic point of view, the aim of electricity reform in general and incentive regulation of networks in particular is to provide utilities with incentives to improve their operating and investment efficiency and to ensure that consumers benefit from the gains. Within this context, the aim of incentive regulation is to achieve these objectives

---

<sup>1</sup> As such, the theory and empirical evidence on the merits of private ownership and privatization in the context of market-oriented infrastructure reforms can be characterized as inconclusive (Jamasp et al., 2004a; Mota, 2004; Zhang et al., 2002). However, when accompanied by effective regulation, privatization has achieved efficiency improvements.

<sup>2</sup> In the US, incentive regulation is often referred to as Performance Based Regulation (PBR).

---

through financial reward or penalty incentive schemes. Shleifer (1985) suggests that incentive regulation can mimic the outcome of the markets by setting an external performance standard that represents some average industry performance excluding the firm in question.

The most widely discussed and adopted schemes are based on price cap, revenue cap, yardstick regulation, and targeted-incentive regulation models. Other incentive models include sliding scale, menu of contracts, and partial cost adjustment (see Joskow, 2006 for a review of the theoretical properties of different models). In practice, regulators have adopted a variety of approaches to incentive regulation and many incentive schemes use a combination of different models.

### **3. The British Electricity Sector Reform and the Regulation of Distribution Networks**

#### **3.1 The historical context**

The history of public utilities and network industries and their regulation in Britain constitutes a remarkable tale. In 1812, public supply of town gas began and rapidly developed into a competitive industry with many firms involved. The “wasteful” competition” was ended by the 1860 Metropolis Gas Act making provisions for establishing local natural monopolies. The industry also saw alternative incentive regulation schemes offered to the firms such as a basic price system, maximum prices, and sliding scales (see Hammond, et al. 2002; Joskow and Schmalensee, 1986).<sup>3</sup> The post-1945 period then witnessed the nationalisation of municipal and private utilities and infrastructure industries. Finally, the period between the late-1980s until mid-1990 was characterised by the privatisation of these industries and the return of incentive regulation.

The first known case of incentive regulation of network utilities dates back to 1855 and the sliding scale plan in Britain approved in the Sheffield Gas Act for the Sheffield Company a supplier of town gas. This was followed by a similar plan in 1893 for the electricity industry. The first case in the US is the sliding scale scheme in Boston Plan

---

<sup>3</sup> The basic price system was based on fixed prices and dividends. When actual revenue would be lower than the allowed revenue by the basic price, a specified portion of the difference between the basic and actual revenue would be shared between the shareholders (as extra dividends) and employees (as bonuses). Under the sliding scale system, lower prices would be rewarded by higher dividends (for detailed descriptions see Hammond et al., 2002).

---

of 1906 for the price of gas. The above scheme was later abundant due to high inflation rates which followed its implementation (Schmidt, 2000).

The history of electricity supply industry (ESI) in Britain dates back to the late nineteenth century. Electric light first emerged as the fourth generation lighting technology to replace other sources of lighting, such as town gas, as the modest modern source of energy to this date.<sup>4</sup> Initially, the expansion of electric lighting was slow due to existence of relatively cheaper and well developed town gas system (Byatt, 1979). The origins of the regulation of the industry with respect to matters such as licensing, obligation to serve, pricing, reliability, safety, and theft, etc. date back to the early formation days of the industry (House of Commons, 1882). Despite considerable technological progress in the industry, the role of distribution networks within the ESI has, since the inception years of the industry, largely remained unchanged.<sup>5</sup>

The first public electricity supply companies in Britain were a small hydro-electric plant established in Godalming, Surrey in 1881 and a supply company in Brighton in 1882 (Cheshire, 1996). From its formation until nationalization in 1947, the industry was fragmented and based on a large number of small private or municipal companies. In 1926, the Central Electricity Board (CEB) was established and mandated to build a national high-voltage grid, standardize the frequencies across the distribution system, and oversee the planning and construction of new generation capacity. The completion of National Grid in 1933 and integration of some local distribution networks contributed to cost and reliability improvement of electricity supply (Fouquet and Pearson, 2006). However, in 1933-34, there were still a total of 635 distribution undertakings one-third of which operated with nineteen different voltages. Also, about 400 of the undertakings accounted for less than 10 percent of the total sales of distribution undertakings (Chick, 1995).

The proliferation of a large number of small scale utilities was to a great extent the result of failure on the part of the central government to define a proper framework for the organization of public utilities and therefore leaving the matter largely in the hands of municipalities (Byatt, 1979). At the time of nationalization there were still 569 distribution entities of which only two-fifths were directly supplied by the grid. Nationalisation brought the private and municipal utilities under the state ownership. Moreover, nationalisation consolidated the fragmented structure of the industry into the

---

<sup>4</sup> Lighting by candles, gas, and kerosene represented the first, second, and third generation of lighting technologies correspondingly (Fouquet and Pearson, 2006).

<sup>5</sup> Although, due to progress on various generation and network technologies and active networks, the future role of electricity distribution networks is expected to undergo major changes (see Jamasb, Nuttall, Pollitt, 2006 for a review of the future technologies).

---

British Electricity Authority (BEA) responsible for generation and bulk transport of electricity and sixteen independent Area Electricity Boards (AEBs) in England (12), Wales (2), and Scotland (2) in charge of distribution, metering, billing, and customer service functions (Cheshire, 1996).

The nationalization of the electricity industry took place within the backdrop of a wider nationalisation of a number of key industries in the years following the Second World War (Bliss, 1954; Chick, 1995; Millward and Singleton, 1995). In the run up to privatization and reform of the sector in 1990, the ESI achieved significant improvement in labour productivity partly due to the capital intensive nature of the industry. However, total factor productivity only showed modest gains and the industry was less efficient in relation to those of countries such as the US and France (Pryke, 1981). Nationalisation, however, greatly facilitated the standardization of the system as in France while the standardization of the fragmented system in Germany took longer (Helm, 2003). The standardization and rationalization of the sector after nationalization provided a sector structure that was more suitable for the privatization of the industry later on.

### **3.2 The UK 1990-reform and its effect on distribution regulation**

The UK government's intention to introduce legislation to allow private companies to provide electricity was clear as early as 1982 (Electricity Consumers' Council, 1982). In February 1988, the government laid out its plans for the industry in the White Paper *Privatising Electricity* (Secretary of State for Energy, 1988). The White Paper stated that competition would 'create downward pressures on costs and prices, and ensure that the customer comes first'.<sup>6</sup>

As with the nationalization, the privatization and reform of the electricity sector in Britain took also place against the backdrop of a general political paradigm shift in the 1980s toward withdrawal of state involvement in economic activity and ownership of key industries (Vickers and Yarrow, 1993). At the same time, an economic paradigm shift was emerging in favour of implementing market mechanisms in infrastructure and network industries traditionally viewed as vertically integrated natural monopolies. Both of the paradigm shifts applied to the electricity supply industry.

The British electricity reform involved all the elements of a full sector reform including restructuring, privatization, regulation, and competition. An independent regulator

---

<sup>6</sup> Cited in MacKerron and Watson (1996, p.186).

---

Office of Energy Regulation (Offer) was established in 1990. Later in 1999, Offer merged with the Office of Gas Regulation (Ofgas) to form Office of Gas and Electricity Markets (Ofgem)

Shortly prior to privatisation, 12 regional electricity companies (RECs) replaced the 12 area boards and transmission became the responsibility of the National Grid Company (NGC), a company fully owned by the RECs. Each REC owned and operated the distribution network in its authorized area. At privatization each REC had a supply (retailing) business engaged in the bulk purchase of electricity and sale to customers and mostly consists of metering, billing and contract management. The distribution business of the RECs was and is significantly more capital-intensive than the supply business. Distribution and supply businesses were uncoupled to some extent (accounting separation was required) and the RECs were defined as Public Electricity Suppliers (PESs) that could supply electricity outside their franchise area over other distributions networks for a regulated access charge. In 1999, the distribution and supply activities were legally separated and the Utilities Act of 2000 replaced the PESs with licensed distribution network operators (DNOs).

Following the privatization, initially, the main focus of the reform was on implementing competition in the wholesale electricity market which had proved more complex than anticipated. In England and Wales this involved separation of nuclear generation from fossil generation and the creation of two large fossil fuel generators. This created insufficient competition. A more competitive market was eventually achieved through further asset divestiture and new entry.<sup>7</sup> The natural monopoly transmission and distribution networks had to be regulated. Although the network charges account for about 30% of end-use electricity prices, the potential for efficiency gains in the networks was targeted later. Initially, the large profits made by the new private owners brought the importance of network regulation into public focus. However, regulation was gradually tightened and performance and distribution of efficiency gains improved.

Ofgem has tight restrictions to ensure that each regional monopoly distribution business is held in a separate corporate entity, ring-fenced from all other activities carried on within the licensee's group. This ring-fencing arrangement is to protect capital providers as well as consumers. Additionally, companies are required to pass some of the benefits from mergers or acquisitions over to consumers immediately following the merger (Ofgem, 1999c).

---

<sup>7</sup> See Newbery (1999) and Helm (2003) for detailed discussion of introducing competition in the wholesale electricity generation and retail markets in the UK.

---

There have also been significant changes in the way that DNOs structure their business and the range of activities in which they are involved. For example, several have active second-tier supply businesses and most are active in the supply of gas as well as electricity. This provides opportunities for joint marketing of the two fuels. At the beginning of 2007 two DNOs were in different ownership from their former supply businesses. Following a series of significant mergers the distribution businesses of the 14 original RECs are currently owned by 7 independent companies.

### **3.3 The performance under distribution price control reviews**

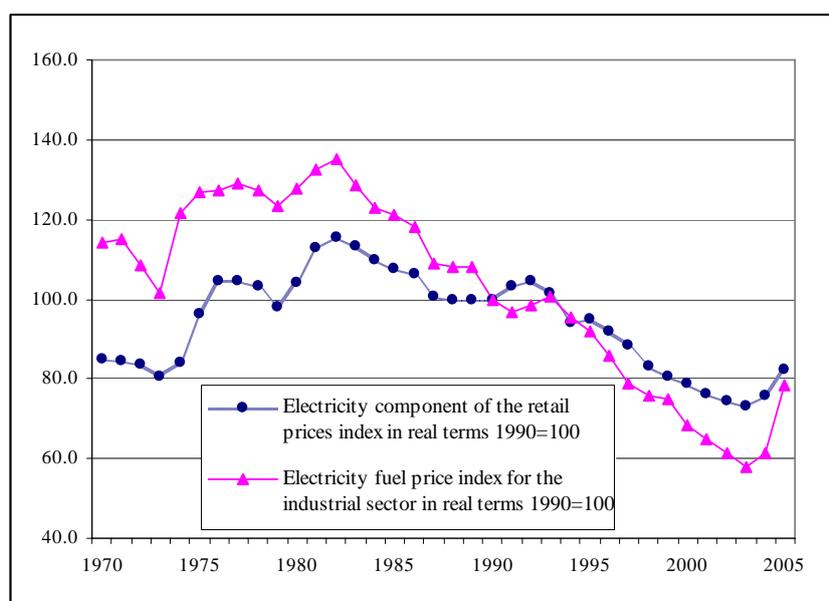
According to Henney (1994), by 1994, the majority of customers had seen no price benefit from the privatisation of the electricity supply industry. Small domestic and commercial customers effectively financed the privatisation, while the largest customers lost the benefit of their special agreements. Only the medium-sized (1–5MW) maximum demand customers benefited as these were able to purchase cheaper electricity from the generators. Additionally, domestic prices initially increased, relative to industrial prices, by about 5 per cent more than expected, with the increase being concentrated in the early years of the reform (Yarrow, 1992). By that time, it was also becoming evident that a tougher regulation of access charges of the natural monopoly distribution utilities was necessary as a means of reducing final prices.

Henney (1994) explains the rise in prices and profits after privatisation as a regulatory failure, in terms of the lax setting of the initial price control. Also, the government did not factor in the potential productivity gains at the time of restructuring. Moreover, the scope for higher gearing was not anticipated. According to Domah and Pollitt (2001), RECs' total costs declined over the period 1985–86 to 1988–89 by an average of 0.8 per cent p.a., while net controllable costs declined at a rate of 0.3 per cent p.a.

There is general agreement that the first price control period for 1990/91-1994/95 underestimated the potential for efficiency improvement. The price controls during this period were set prior to privatisation and hence were designed to make the sale of the assets a success, not to pass on predicted efficiency improvements to consumers. However, the evidence suggests that this was corrected by successive, increasingly challenging, incentive-based regulation and price control reviews.

The second and third price control reviews for 1995/96-1999/00 and for 2000/01-2004/05 periods respectively significantly reduced real distribution charges and there is ample evidence that they succeeded in achieving significant efficiency improvements

and delivering the gains to customers. Domah and Pollitt (2001) find that labour productivity of the RECs nearly doubled between 1990-91 and 1997-98. Similarly, de Oliveira and Tolmasquim (2004) show that the customer per employee number ratio of the RECs increased from 309 in 1990/91 to 681 in 1999/00. Figure 1 shows the path of overall retail and industrial electricity prices (including generation costs).



**Figure 1: Electricity price developments**  
**Source: Department of Trade and Industry**

Table 1 shows between 1991/92 and 1998/99 savings to residential customers from reduction in distribution and transmission charges have been 9 percent. During the same period, price reductions originating from competitive generation market have been 10 percent although this can largely be attributed to reduction in the cost of fuel.

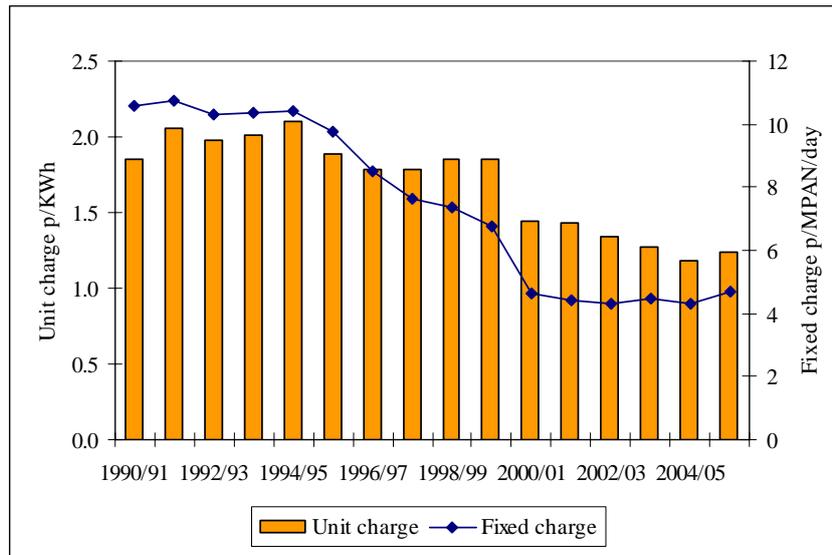
Source	%
Lower generation costs (mainly fuel)	10
Lower distribution and transmission charges	9
Lower supply business margin	1
Lower fossil fuel levy*	9
Total	29

\* The fossil fuel levy was introduced to limit the effect of reform of the sector on coal industry. The levy was gradually phased out. Price reduction due to lower levy can therefore not be attributed to the effect of reform on prices.

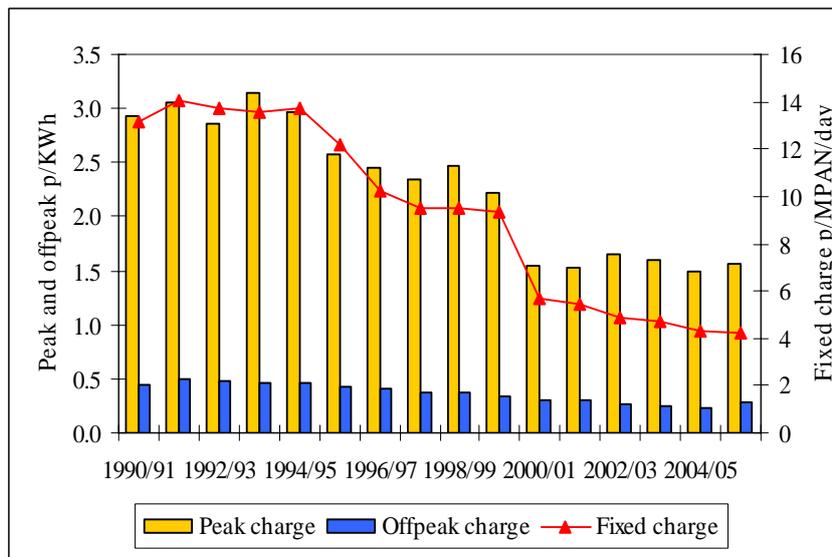
**Table 1: Sources of price reduction to domestic users 1991/92-1998/99**  
**Source: Littlechild (2000)**

Figures 2-5 show the development of average distribution charges in real terms for residential and non-residential customers over time. As shown in Figure 2, residential

customers with unrestricted charges have benefited from reductions both in their unit and fixed charges. The relative reductions are in particular stronger in the fixed charges. Similarly, residential customers on Economy 7 schemes with separate peak and off-peak unit charges have seen significant reductions in these as well as their fixed charges (Figure 3). The patterns in distribution access charging reductions are consistent with the increasing degree of toughness of the three five-year distribution price control reviews to be discussed in later sections.

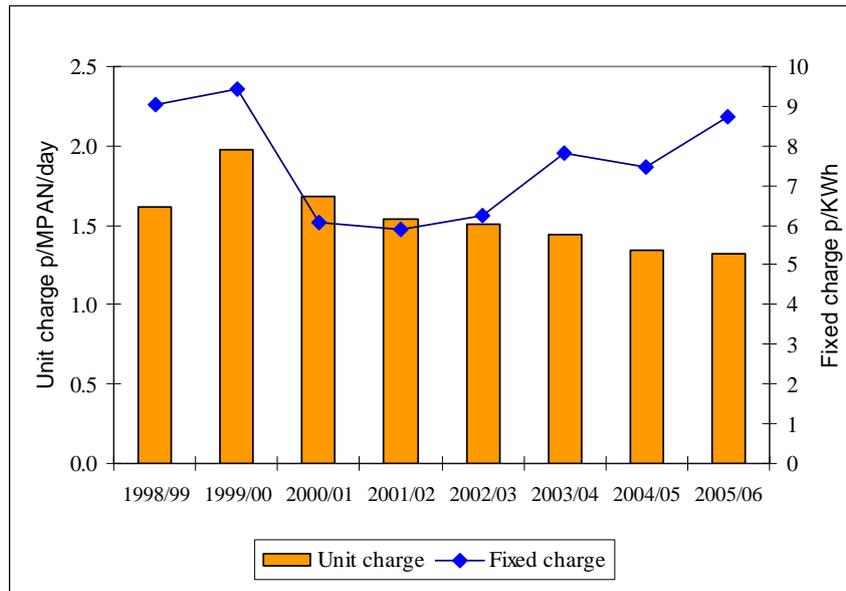


**Figure 2: Domestic unrestricted access charges (2005/06 prices)**  
**Source: Ofgem**



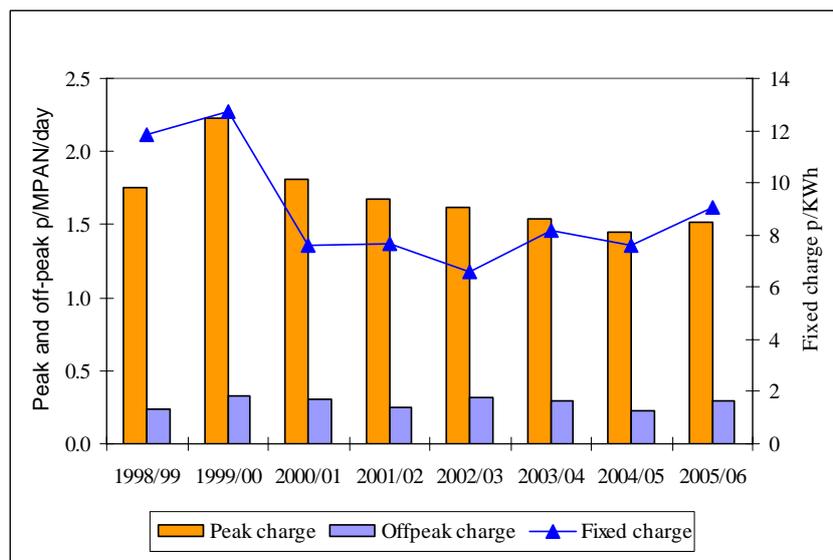
**Figure 3: Domestic Economy 7 charges (2005/06 prices)**  
**Source: Ofgem**

For non-residential customers, consisting of commercial and industrial users, the time-series are somewhat shorter and refer to the more recent 1998/99-2005/06 period. As shown in Figures 4 and 5, during this period, these customers have seen some reductions in their unit charges. The fixed charges, however, show a decline in initial years and then tend to rise towards the end of the period to stay slightly below the 1998/99 levels.



**Figure 4: Non-domestic unrestricted charges (2005/06 prices)**

Source: Ofgem



**Figure 5: Non-domestic Economy 7 charges (2005/06 prices)**

Source: Ofgem

The distribution price control reviews have also improved the relative position of the UK distribution charges and end-user prices among the member countries in the EU. As shown in Table 2, following the efficiency gains and stricter price control reviews since 1995, the UK network (distribution and transmission) access charges are now among the lowest in the EU. Moreover, the reduction in distribution charges has also contributed to an increase in affordability of end-user prices. As a result, the share of income spent on electricity by low-income consumers in the UK is also among the lowest in the EU (see European Commission, 2005).

	Number of regulated transmission companies	Number of regulated distribution companies	Approximate network tariff – large users (€/KWh)	Approximate network tariff – low voltage commercial (€/KWh)	Approximate network tariff – low voltage household (€/KWh)
<b>Austria</b>	3	133	0	51	53
<b>Belgium</b>	1	26	11	-	51
<b>Denmark</b>	10	120	19	25	48
<b>Finland</b>	1	91	10	26	37
<b>France</b>	1	161	12	40	48
<b>Germany</b>	4	950	9	53	62
<b>Greece</b>	1	1	8	-	-
<b>Ireland</b>	1	1	-	48	50
<b>Italy</b>	1	173	9	41	67
<b>Luxembourg</b>	2	10	7	62	72
<b>Netherlands</b>	1	12	-	-	40
<b>Portugal</b>	3	13	4	39	37
<b>Spain</b>	1	308	69	34	33
<b>Sweden</b>	1	184	10	17	40
<b>UK</b>	3	17	5-12	11-23	17-34
<b>Norway</b>	1	170	11	25	-
<b>Estonia</b>	1	42	11	31	40
<b>Latvia</b>	1	8	-	-	-
<b>Lithuania</b>	1	2	6	23	42
<b>Poland</b>	1	14	13-26	48-88	37-50
<b>Czech Rep</b>	1	327	3	-	36
<b>Slovakia</b>	1	3	6	17	37
<b>Hungary</b>	1	6	2	48	30
<b>Slovenia</b>	1	5	8	38	31
<b>Cyprus</b>	0	1	-	-	-
<b>Malta</b>	0	1	-	-	-

1. General: data excludes levies related to, for example PSOs and renewables or CHP promotion.  
2. Germany: the category Ib is not typical of commercial customers of this size (annual load 1000 hours)  
3. In Italy there are 10 companies owning a share of the national transmission network.

**Table 2: Distribution and transmission access charges (excluding charges and levies)  
Source: European Commission (2005)**

---

## 3.4 Assessments of the impact of reform

### 3.4.1 *Efficiency and productivity studies*

There are a number of efficiency and productivity studies which illustrate the performance of the UK RECs immediately before and after privatisation. Pollitt (1995) reports a comparative study of 136 US and 9 UK distribution utilities using 1990 data and finds the relative performance of UK utilities comparable to those of the US. Burns and Weyman-Jones (1994) apply mathematical programming techniques to measure the change in the performance of the RECs between 1973 and 1993. The study finds that the initial post-privatisation productivity growth is a continuation of the pre-privatisation trend indicating the effect of a lax initial price control review. Moreover, the results indicate an increase in performance diversity among the RECs after privatisation. Also, Burns and Weyman-Jones (1996) use an econometric cost function to examine the efficiency of the RECs between 1980 and 1992. The results show evidence of improved cost efficiency in the years following the 1990 privatisation of the RECs.

Hattori et al. (2005) examined the efficiency of the UK and Japanese distribution companies between 1985 and 1998 using data envelopment analysis (DEA) and stochastic frontier analysis (SFA) techniques. The DEA results indicate that following the reform, the efficiency differences among the UK firms increased. The results of Malmquist productivity index show a decline in productivity prior to the reform between 1985/86 and 1989/90.

Moreover, during the first price control review for the 1990/91-1994/95 period the annual productivity index for all RECs grew by an annual average of 1.2 percent. This was then followed by an annual average increase in productivity index of 10.7 between 1995/96 and 1997/98. The sharp increase in efficiency for this period has been attributed to the tougher second distribution price controls enforced for the 1995/96-1999/00 period.

Giannakis et al. (2005) re-examine the productivity of the UK RECs between 1991/92 and 1998/99. The study finds variations between the operating expenditures (Opex) and total expenditure (Totex) performance of the network companies indicating scope for trade-off between their operating and capital expenditures (Capex). In addition, the Malmquist productivity index results show significant improvement during the period of study.

---

### ***3.4.2 Cost-benefit analysis of the reform***

While efficiency and productivity analysis can be used to measure the efficiency effects of reforms on the sector, the overall economic efficiency resulting from reforms can best be examined by social cost-benefit analysis (SCBA). Domah and Pollitt (2001) provide a detailed social cost-benefit analysis of the effect of reform on the UK distribution companies. The study finds that per unit revenue of the distribution and supply businesses rose with an average of 22 percent above the preprivatisation-period level during the first price control period. During the second price control, the unit costs of the RECs fell 20 percent between 1994 and 1998. Also, labour productivity nearly doubled in 1997–98 over the 1990–91 level.

In addition, the study estimates the cost of restructuring and privatisation (at 1995 prices) at about to £1.1 billion at a 6 per cent discount rate. This cost reduces the benefits of restructuring and privatising the distribution and supply businesses of the RECs. Based on the experience of electricity supply industries in Northern Ireland and Scotland and of Nuclear Electric, and the performance of the area boards during the period 1979 to 1989, the study predicts that unit costs might have fallen by 2 per cent p.a. if privatization had not occurred. Comparing this counterfactual scenario with what actually happened the study predicts net efficiency gains from privatisation, which started accruing to consumers after 1999, will amount to about £6.1 billion. The net efficiency gains of the RECs are, however, very sensitive to the discount rate used, mainly due to the skewness in the distribution of these gains.

The Domah and Pollitt (2001) study identified how the net benefits were shared among consumers, government and producers in society. Of the total net benefit of £6.1bn in the base case consumers are expected to gain £1.1 billion (at 2 per cent counterfactual cost fall and 6 per cent discount rate) relative to continued public ownership of the RECs. With the special NGC rebates of 1995–96, the total benefits to consumers amounted to £2 billion; however, consumers lose at a 10 per cent discount rate. However, these benefits to customers were derived from predictions of future price falls, which began in 2000. By 1998, consumers had lost considerably from privatisation of the RECs. The government have gained £9 billion from privatization proceeds (£8.2 billion) and windfall taxes (£1.3 billion) which after loss of flow dividend/tax revenue would give a net benefit of about £5.0 billion from the restructuring and privatisation of the RECs.

---

## **4. Distribution Price Controls**

### **4.1 The first distribution price control review**

The initial *distribution price control review* of the RECs were put in place by the government and executed by the Department of Energy at the time of restructuring, and permitted price increases that ranged up to 2.5 percentage points above the inflation rate (OFFER, 1994). Responsibility for future price controls was placed under an independent regulatory body, initially called OFFER and later Ofgem. Price controls on the RECs' supply businesses only allowed price rises limited to no more than inflation during the period 1990/91 to 1994/95.

The leniency on the companies may be linked to the desire by the government to facilitate the sale of the assets by guaranteeing high prices for a fixed period. Indeed, the government did not consult the regulator on the terms of the first price control. Also, the government seems to have been unaware of the scale of potential for efficiency improvement in these companies. The companies showed high share prices well beyond their floatation values and paid increasing dividends to their shareholders.

It should be noted that the initial problems associated with implementing the reform were not limited to the regulation of distribution networks in the first price control period. During the same period, the ineffective structure and competition in wholesale market also led to large profits for the generators. Brower, Thomas, and Mitchell (1997) show that the profit to revenue ratio of the UK generators were in decline between 1985/86 and 1989/90 and consistently lower than those of the US utilities (though this could be due to high costs as well as under-pricing). However, in 1990/91 the UK generators catch up with the US firms and increasingly widen their lead until 1994/95.

### **4.2 Subsequent distribution price control reviews**

At the time of the second price control review (1995-00 period), the companies had shown significant potential for efficiency gain. The period 1990 to 1995 saw large increases in the profitability of the RECs, leading to large rises in their share prices. Moreover, the successful flotation of NGC jointly owned by the RECs in mid-1995 indicated the undervaluation of the assets at privatisation. The windfall gains to shareholders of privatised utilities put the government under pressure. As a result, the RECs were obliged to make a one-off 50 pound payment to each of their customers.

Moreover, in 1997, a one-off wind-fall tax of £1.5 billion was imposed on the RECs payable in two instalments.

As discussed, the first distribution price control review period (DPCR1) for the 1990/91-1994/95 period set by the Department of Energy was generous to the companies. In August 1994, for the second distribution price control review (DPCR2) for the 1995/96-1999/00, OFFER introduced reductions averaging 14 percent in final electricity prices to take effect in April 1995, requiring price cuts in real terms of 11–17 percent in distribution charges in 1995/96. Distribution charges were, thereafter, required to fall by an X-factor of 2 percent per year in real terms for the duration of the price control review. However, a high takeover bid for Northern company shortly after the announcement of the price controls indicated that the utilities still had significant potential for cost savings. The event triggered a revision of the 1995/96-1999/00 price control which resulted in further reductions in real terms of between 10 and 13 percent in 1996/97 and increasing the X-factor to 3 percent. In addition, the price controls were modified in 1998 to allow RECs to make additional charges to facilitate competition in supply.

The third price control review (DPCR3) for 2000/01-2004/05 introduced further cuts on distribution businesses averaging 3 per cent for the next five years, with an initial cut in RECs' distribution revenue by about 23.4 per cent (though some of the initial cut represented a transfer of costs to the legally separate supply businesses). This amounted to an overall initial revenue cut of £503 million at 1995 prices (Ofgem, 1999a). Table 4 summarizes the rate reductions under distribution and supply price control reviews.

<b>Period</b>	<b>Rate of price (cost) decrease</b>
1990–91 to 1994–95	Variable up to 2.5% above the inflation rate
1995 to 1995–96	11–17% (average of 14%)
1996 to 1996–97	10–13%
1997 to April 2000	Average of 3% p.a.
2000 to 2004–05	One-off cut in distribution revenue by 23.4% in 2000–01; then a 3% p.a. fall in unit revenue until 2005

**Table 4: Summary of distribution price controls for RECs in England and Wales**  
**Source: Domah and Pollitt (2001)**

---

### 4.3 Ofgem's distribution price control review 2005/06-2009/10

The basic characteristics of Ofgem's approach to distribution price control can be stated as follows.<sup>8</sup> An initial consultation document is issued around 18 months before the end of the current price control period. This document discusses the timetable and issues for consideration in the upcoming control period. This is followed by several subsequent documents. At each stage responses are invited from interested parties and these are publicly available in the Ofgem library unless marked confidential. A 'Final Proposals' document is issued within six months of the end of the price control with details of the X factors which Ofgem proposes to apply to each company from the beginning of the next control period. Companies have one month to decide to appeal to the competition authority, the Competition Commission (formerly the Monopolies and Mergers Commission) if they are unwilling to accept the proposed price control. An appeal on distribution prices has happened once so far when Scottish Hydro-Electric did not accept its final distribution and supply price controls proposed by the regulator for 1995-2000.<sup>9</sup>

The incentive regulation model of distribution networks in Britain consists of a hybrid of incentive schemes. Under the current arrangements, the operating expenditure, capital spending, and quality of service (including network energy losses) are incentivised separately and under different types of schemes within a building block framework.

The utilities' controllable operating expenditures (Opex) are incentivised by benchmarking these against an efficient frontier made up of the best practice DNOs in the sector. The allowed Opex of individual DNOs is set such that it requires them to close a specific proportion of their performance gap relative to the frontier during the price control period. In addition, all DNOs are given a general technical efficiency improvement target that is common to all DNOs.

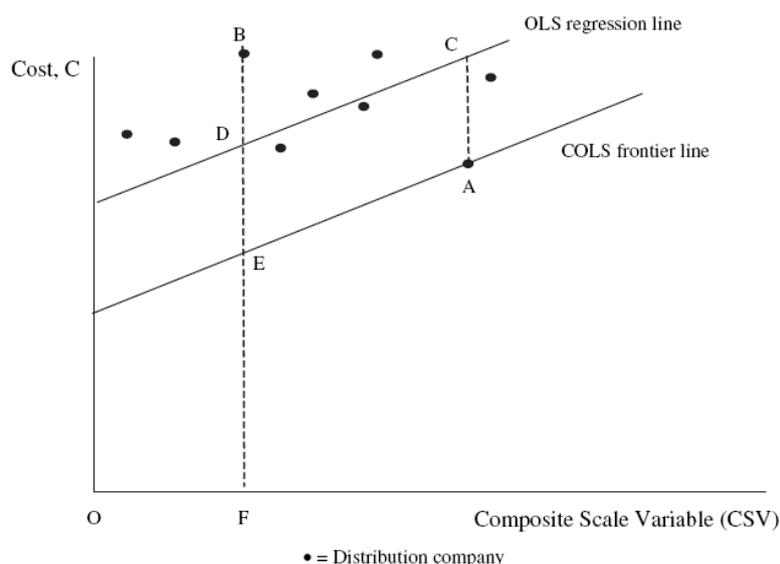
In the latest two distribution price control reviews, Ofgem have used a relatively simple regression methodology where they obtain an adjusted measure of operating costs for each company and plot this against a measure of their composite output. They have then carried out an Ordinary Least Squares (OLS) regression of operating costs against output. Finally, they have shifted this line downwards, based on the technique of

---

<sup>8</sup> This section draws significantly on Pollitt (2005).

<sup>9</sup> See MMC (1995). Ofgem's jurisdiction covers Great Britain only not Northern Ireland. Electricity and gas in Northern Ireland is regulated by Ofreg. Northern Ireland Electricity appealed against Ofreg's distribution price control for the period 1997-2002 (see MMC, 1997).

corrected ordinary least squares (COLS), to obtain a frontier line against which inefficient firms are compared (Figure 6). In 2004 (and 1999) the data used for the regression analysis were for a single year (2004: 2002-2003 and 1999:1997-1998) for the 14 companies. In Figure 6, the efficiency score of firm B is given by the ratio  $EF/BF$ . This represents the extent to which actual costs could be reduced while still keeping firm B on the efficient frontier.



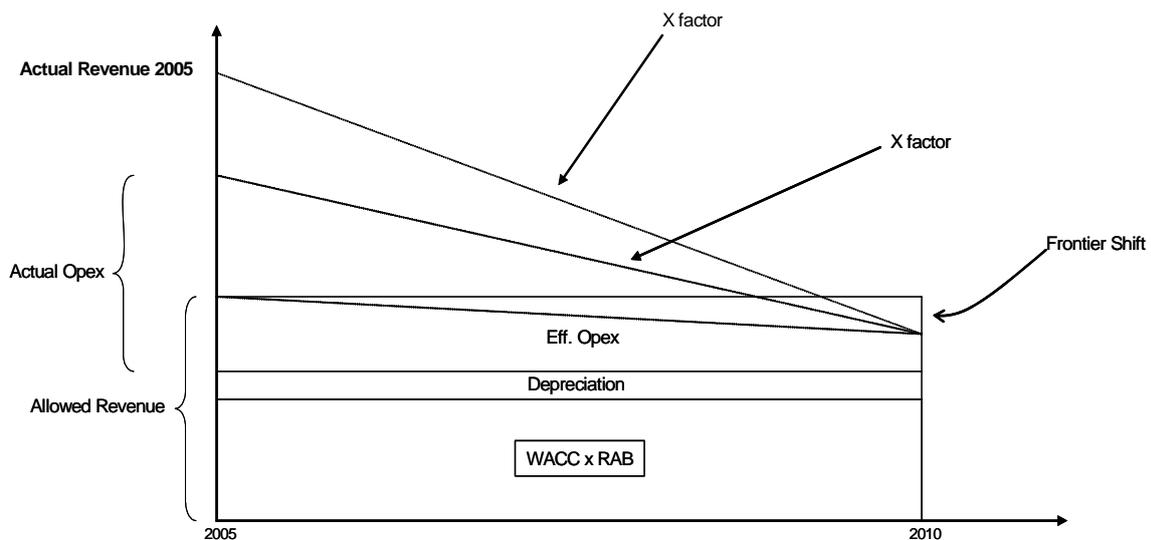
**Figure 6: Illustration of the COLS method**

In the next stage, the regulatory asset base (RAB) for each DNO is determined, on which they are entitled to earn an allowed rate of return. While the existing assets in the RAB are gradually depreciated, in the long run, their stock of capital will increasingly consist of new capital investments. The initial RAB (used from the second price control period) in the case of the RECs was based on their market capitalisation at privatisation. The rate of return is set based on a weighted average cost of capital (WACC) measure which uses a specific reference debt and equity split, reference market rate of return and debt interest rate and a relevant equity beta. Firms are free to choose their own actual level of gearing. The pre-tax rate of return in the latest price control has been set at 6.9 percent.

New capital investments are increasingly driving the regulated revenue of DNOs, as operating expenditures fall and new investments are added to a growing regulatory asset base. The process for assessing the required level of capital expenditure over a price control period is as follows. Utilities must draft business plans which include projected capital expenditure. These are then audited by a firm of engineering consultants,

working for Ofgem. Usually these consultants recommend lower levels of capital expenditure than that proposed by each utility. This gives a base level of required capital expenditure to which an incentive scheme is applied. The incentive scheme resembles a menu of contracts regulation model. The menu of contracts approach is appealing at the presence of strong information asymmetry. However, this approach is not widely used in practice with the main difficulty being development of a set of suitable menu of options.

The allowed Opex and Capex of the utilities together with their regulatory asset base form the basis of the calculation of the utilities' total allowed revenues. The allowed revenues are in turn the basis for determination of the utilities' X-factors and initial prices applicable to their tariffs for the duration of the price control period. Figure 7 shows a simple illustration of setting the X-factors and allowed revenue. DNOs are allowed to recover their capital costs (weighted average cost of capital \* regulatory asset base), depreciation costs, and operating expenditures. The utilities' actual revenue should reach the efficient level of allowed revenue by the end of the price control period. This can be achieved by an infinite number of combinations of a price reduction in the first year and subsequent reduction through X-factors. Traditionally, Ofgem have opted for an immediate and differentiated reduction in initial prices combined with equal X-factors for all DNOs. This means that customers can benefit from the expected efficiency gains immediately and then expect more moderate reductions in subsequent years.



**Figure 7: Opex benchmarking and determination of allowed revenues and X-factors**

---

Quality of service and network energy losses are incentivised separately through performance targets. The targets for each DNO are individual and deviation from these results in company specific penalties and rewards calculated based on an elaborate system. The reward and penalty affect the total allowed revenue. In order to avoid jeopardizing financial viability of the companies, the maximum amount subject to quality of service reward and penalty scheme is capped as a percentage of allowed revenue. Collectively, these incentive schemes amount to a revenue cap incentive regulation.

Due to the presence of trade-offs between Opex, Capex, quality of service, and network losses, from an economic efficiency point of view, it is preferable to use an integrated benchmarking model. Such a model would be based on a single total expenditure (Totex) measure where all cost measures as well as some measure of monetary values of service quality and network losses are added together. The hybrid system in Britain is contrary to the notion of integrated overall incentive regulation. However, the adopted approach – segmented regulation - gives more control to the regulator to address specific areas of focus. It also involves less complicated modelling than would a fully integrated benchmarking model and is more transparent in its operation. At the same time, the current incentive system does not reflect the potential trade-off between the specific regulated aspects of the utilities.

## **5. Some Issues in Regulation Benchmarking**

Joskow (2006) suggests that there are a number of questions that regulators have to answer in applying incentive regulation. These include: what is the source of information about the costs and cost reduction potential; whether to offer one specific regulatory contract or a menu of contracts; what benchmarks to use in assessing performance; what should be the power of the incentive scheme; and how comprehensive should the incentive scheme in covering all variables of interest? We take a slightly different approach focussing on the variables which should be interest to regulators and how the UK has incentivised them. We examine issues to do with identifying the right X-factor (which includes opex savings), incentivisation of quality of supply, network losses and new investments. Each of which poses particular challenges within the price review process. Each of these issues has been faced by Offer/Ofgem in the UK.

---

## 5.1 Setting the right benchmark

The appeal of benchmarking as a practical approach to operationalize the concept of incentive regulation is evident. In particular, benchmarking has the potential to reduce information asymmetry between the regulator and the firm.

However, the information requirement for conducting a robust benchmarking exercise has proved to be more complicated than expected. Establishing the appropriate reporting formats, standardisation of data, and ensuring the quality of data have been non-trivial. Moreover, the legal aspects surrounding the collection of the required data and the use of benchmarking have caused delays and complicated some regulatory proceedings.

A major reservation against assigning firm specific X-factors has been that the cost saving incentives can be blunted if companies are not allowed to retain efficiency savings beyond the next price review. Benchmarking may result in firms having to run to stand still and hence there may be strong incentives to subvert the regulatory process.

Frontier approaches are also susceptible to shocks and errors in data. This is especially the case when cross-sectional data is used and there is no allowance for errors. In order to minimise problems due to data errors there should be very careful handling of data accuracy. Recognising the importance of data quality in benchmarking, the Norwegian and UK regulators have made considerable efforts to improve data standardisation and accuracy.

Determining the future rate of movement of the frontier is problematic. Measures of past productivity growth usually include both frontier shift effects and movements towards the frontier. However, the problem can be reduced if firms are compared to world best practice as the variation in world best practice frontier shifts (given international benchmarking) is small (1-2% p.a.). Once efficiency scores are calculated, the crucial assumption in deciding the X-factors is the rate at which the efficiency gaps can be closed. The regulators will need to make allowance both for this and for in-country heterogeneity.

The issue of the scope for the use of benchmarking in incentive regulation has been important. For example, separate analysis of capital costs and operating expenses can encourage intermediation between these cost categories. Firms may attempt to seek higher capital expenditure to reduce operating costs. While, in principle, benchmarking should ideally apply to total costs, this is difficult given the heterogeneous nature of capital (which could simply be a function of differing accounting standards). As a

---

result, regulators in leading countries such as the UK and Norway have made considerable effort to handle the possibility of intermediation. International comparisons are often restricted to comparison of operating costs because of the heterogeneity of capital but this may limit their applicability.

Moreover, strategic behaviour or gaming by firms within the regulatory process is a longstanding regulatory issue as the regulator is dependent, to a degree, on information supplied by the firms. However, although benchmarking may not prevent gaming entirely it could relate to it (see Jamasb et al., 2003, 2004). Di Tella and Dyck (2002) examine the strategic behaviour associated with price-cap regulation of electricity distribution utilities in Chile. The findings indicate a downward cost trend, but one year in four the cost was about 1.4 percent above trend. These cost reversals occurred in the year preceding a price review. The cost increase appears to lead to higher returns for stock prices of the firms. The study suggests that this represents a perverse incentive in the regulation model, as cost reversal in the year of price determination leads to higher prices in the following control period.

Furthermore, in many cases, though mostly in developing countries, lack of regulatory experience and inadequate implementation of incentive regulation models have led to major contract renegotiations (Benavides and Fainboim, 1999; Abdala, 2001; Basañes et al., 1999). Guasch (2003, 2004) finds that contract renegotiations after the award of infrastructure concessions have been significantly more likely for concessions under price cap than for rate of return regulation models. Renegotiations often reduced the incentive property of the regulation models by making them more similar to rate of return regulation. In addition, the achieved efficiency gains were often not passed to consumers and instead benefited the companies or the government (Estache et al., 2003). Maintaining the incentive property of the UK price cap regulation can gradually become difficult as the share of benchmarked costs declines (Thomas, 2004).

## **5.2 Quality of service**

The social and economic costs of supply interruptions are substantial.<sup>10</sup> At the same time, introduction of incentive regulation has brought to attention the issue of the trade-offs between costs and non-tradable outputs or attributes of the utilities. In particular, regulators are concerned with the trade-offs between capital and operating costs on the one hand and service quality on the other. Incentive regulation tends to narrow down the

---

<sup>10</sup> This section draws significantly from Giannakis et al. (2005).

---

focus of the utilities on those aspects of their operation that are incentivised by the scheme. Under the prevalent incentive regulation schemes, utilities face strong incentives to undertake cost savings. Therefore, in the absence of specific regulation quality of service is likely to deteriorate.<sup>11</sup>

Improving quality of service involves operating and capital costs for the utilities. However, the companies have better information about their ability to improve quality and the associated costs than the regulator. At the same time, the socio-economic cost or customer valuation of quality is difficult to measure. From a pure economic point of view, the optimum is where the marginal cost of improving quality is equal to the socio-economic value of quality improvement. In the absence of proper incentives to achieve optimal quality, it is very unlikely that a regulated utility will be offering optimal quality. Either the incentives to improve quality will be too low and there will be under-performance or the regulatory process will have allowed expensive quality investments which push the level of quality above the optimal level.

A survey of the literature in Sappington (2005) concludes that there are no simple policy solutions for effective regulation of quality of service but they depend on the information available to the regulator, institutional settings, and consumer preferences. The paper argues in favour of providing the regulated firm with proper reward and penalty incentives for service quality when the regulator has sufficient information on consumer preferences and production technologies.

The concern surrounding the impacts of incentive regulation on service quality has been recognised ever since price cap regulation was first implemented as part of the British telecommunication industry restructuring (Waddams Price et al., 2002). However, the strong focus of regulators on incentivising quality is of more recent date as reforms progressively evolve beyond pure cost efficiency considerations to encompass non-marketable aspects of the distribution networks.

Tangerås (2003) argues that, when quantity is regulated, yardstick competition results in lower quality than under individual regulation although under individual regulation, the quality would be too high. In principle, the above argument also holds for revenue and price cap regulation models. Evidence shows that utilities respond to explicit service quality incentives and strong regulation can prevent deterioration of quality. For example, evidence from the UK and Norway shows that, although their approaches to regulation differ, utilities have responded to quality of service incentives. Also, Ter-

---

<sup>11</sup> It should be noted that quality of electricity services can be affected at generation, transmission, and distribution stages of the system.

---

Martirosyan (2003), in a study of performance based regulation of the US electric utilities finds that, in the absence of explicit regulation, quality of service tends to decline. At the same time, the individual non-incentivised reliability indicators do not necessarily improve (CPB, 2004). This indicates both the power of incentives and the importance of defining the appropriate indicators.

There are different approaches for providing quality incentives to distribution utilities: (i) marginal rewards and penalties, (ii) absolute fines, and (iii) quality-incorporated benchmarking (Frontier Economics, 2003). The marginal reward and penalty scheme is based on reward or penalty per unit of quality improvements (degradation) that reflect marginal value of quality to customers. In equilibrium, a profit-maximising firm will operate at an efficient level according to its individual marginal cost curve. These mechanisms are referred to as “decentralised”, as they allow firms to choose their level of quality provision.

Absolute fines are centralised and require the company to pay a specified amount if quality drops below a threshold. Although absolute schemes are economically inferior to marginal ones, they entail broader social and political benefits by ensuring that customers are protected by performance standards. Regulators can also use a combination of marginal and absolute incentives. Quality-incorporated benchmarking is also based on marginal rewards and penalties. For example, under price cap regulation, a company that improves quality may be allowed to raise its price by an amount that reflects the social value of the increased quality. Similar to marginal reward and penalty schemes, these methods are decentralised, thus minimising the need for regulatory intervention. The challenge associated with incorporating service quality in benchmarking is to balance the cost and quality-oriented incentives.

Moreover, cost-quality benchmarking introduces the dynamic benefits of competition into the provision of service quality. In effect, by using benchmarking, regulated firms compete to deliver an optimal bundle of cost and service quality. Thus, in addition to static gain maximisation (achieved by adjusting the quality level subject to a fixed cost curve), firms also face an incentive to pursue long-term investments that shift quality provision costs downwards.

In designing quality-incorporated regulatory mechanisms, regulators are faced with the task of determining a market demand curve for service quality. Lack of detailed and accurate data is also a common problem. For instance, the Norwegian regulator estimates interruption costs at an aggregate level, where customers are classified as being either residential/agricultural or industrial/commercial (Langset et al., 2001).

---

Service quality regulation also involves a political aspect that can come into conflict with economic considerations. Customers's valuation of quality may differ between distribution companies. This would imply that individually tailored service qualities are the efficient outcome. However this may be politically unacceptable if poorer regions ended up with worse levels of quality.

At the same time, regulators have not yet explicitly integrated quality of service in their benchmarking exercise. A notable exception is, however, Norway which introduced quality-dependent revenue caps in 2001 (Heggset et al., 2001; Langset et al., 2001).

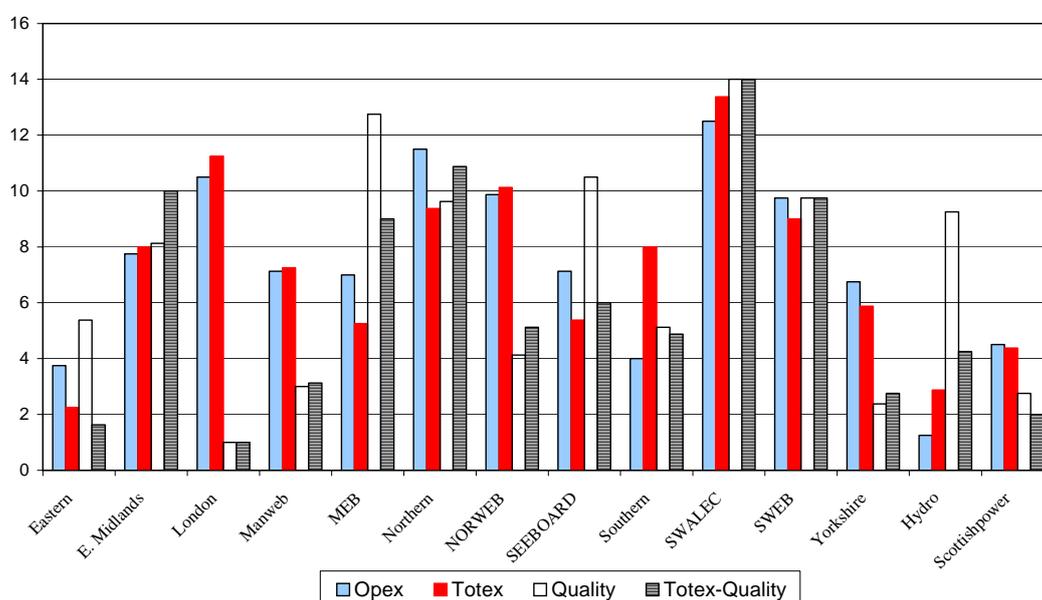
### ***5.2.1 Quality of service in the UK under incentive regulation***

Conceptually, inclusion of service quality in an overall efficiency benchmarking of utilities has clear incentive advantages and this has been advocated in other studies (see e.g. Giannakis, et al., 2005; Ajodhia and Hakvoort, 2005). In Norway, such an approach has been used in the 2002-2007 distribution price control and is also expected to be used for the next price control. Giannakis, et al. (2005) report a benchmarking study of the UK distribution companies between 1990/91 and 1998/99. The study finds significant changes in the rankings of the companies when benchmarked in terms of operating cost, total cost, quality-only, and combined cost-quality models (Figure 7). The results indicate that there are potential trade-offs between cost (operating and capital) and quality and that partial cost benchmarking does not sufficiently capture the service quality dimension.

As mentioned in Section 4.3, from an economic efficiency point of view, due to presence of trade-offs between Opex, Capex, service quality, and losses, it is preferable to use an integrated approach to benchmarking. Such an approach could, for example, be based on obtaining a monetary value such as willingness to pay (WTP) for well-defined measures of quality and adding the cost of (expected) service interruptions to the utilities' total costs. To the extent the utilities can improve their actual quality of service performance they can retain the difference between the actual and expected cost of interruptions. Hence, the utilities will have incentive to improve service quality up to the point where the cost of doing so equals the WTP value of quality.

The current regulatory arrangements in the UK treat Opex, Capex and service quality separately. This may provide firms with distorted incentives that lead them to adopt an inefficient output mix. Under the current regulatory regime, a firm receives greater benefits from saving Opex than by an equal amount of Capex reduction (Ofgem, 2003a). Thus, firms may seek to capitalise Opex to obtain higher efficiency score and

allowed revenue. Unless utilities face incentives that reflect the social value of service quality, they are unlikely to provide socially optimal levels of quality.



**Figure 7: Average annual company rankings from Models Opex, Totex, Quality and Totex-Quality (1 is best, 14 is worst) 1991/92-1998/99**

A further issue is related to the periodicity of the price reviews. Under the present scheme, companies retain 27% of the present value of a cost reduction made in the first year of a review period but only 6% of the present value of an equal cost saving made in the final year (Ofgem, 2003a). Thus, companies may delay efficiency improvements and/or adopt distorted capital investment programmes. Such distortions of incentives exist for quality enhancing investments, where the quality benchmarks are reset every five years. This means that any benefits of investments may not be retained beyond the current distribution price review period.

Between 1990 and 2000, quality of service in Great Britain was regulated through guaranteed standards of performance, which entitle consumers to compensation if the firms breach them, and overall standards, which refer to system-level performance. Originally, 10 guaranteed standards were applied and a further one was introduced in 1998. Overall standards were also set for each firm. The regulator has progressively tightened the standards and consultations with DNOs and other stakeholders have been carried out. However, there is no direct evidence with regards to the effectiveness of the reward and penalty schemes (Waddams Price et al., 2002). However for the current price control period (2005-2010) considerable improvements in quality are expected.

---

The third price control review set company-specific quality standards for 2004/05 on the basis of their historic performance (Ofgem, 1999a). The regulator and the companies generally supported the introduction of an incentive-based regime for service quality regulation (Ofgem, 1999b). However, since the necessary foundation work had not been carried out, it was proposed that the incentive mechanisms should be developed as part of a work programme, the Information and Incentives Project (IIP), and applied from 2002/03, rather than the start of the price control period (2000/01).

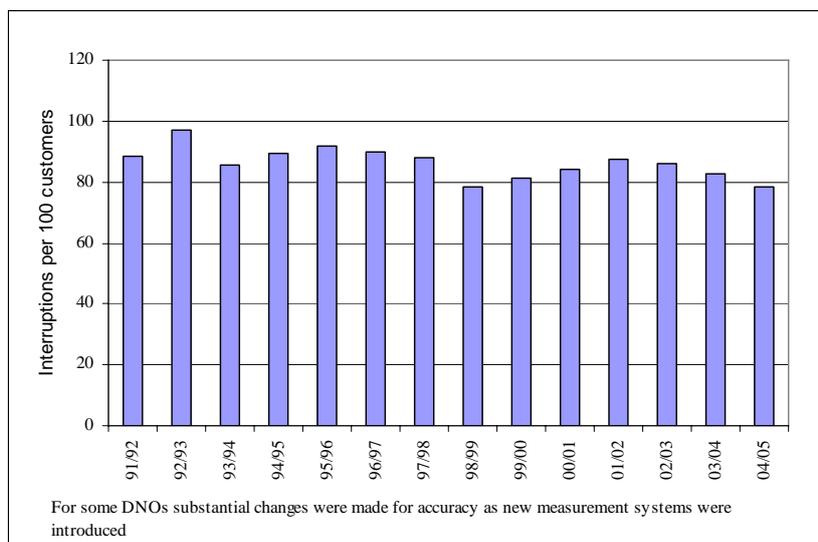
The progress of the IIP illustrates some of the challenges involved in setting up incentives for quality of service. The IIP was divided into two main parts. The first part, culminated in September 2000, defined output measures for service quality, set guidelines for improving measurement accuracy, and constructed a framework for reporting and monitoring. Regarding measurement accuracy, it was estimated that the quality measurements conducted by DNOs involved errors of up to 30% in some quality measure (Ofgem, 2000).

Although inaccuracies in data may have some effect on the level of efficiency measured for the firms, the rates of change are less likely to be affected. Data from recent years are more accurate as Ofgem requested the DNOs to install measurement systems with 95% accuracy by April 2002 and an independent auditor was appointed to examine measurement issues. It is noteworthy that Ofgem has expanded considerable effort to harmonise the data on service quality which have subsequently been utilised to devise reward and penalty schemes for the companies in relation to performance standards.

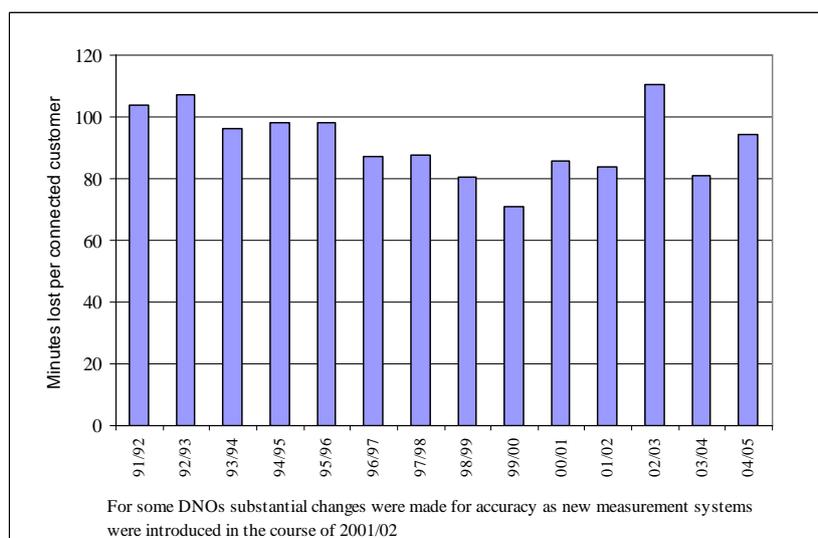
The second part of the IIP, focused on incentive regulation schemes for quality of service. The current scheme, which came into operation in April 2002, links the quality of service performance of DNOs to their allowed revenue. The arrangements consists of mechanisms that (i) penalise utilities for not meeting their targets, (ii) reward utilities that exceed targets, and (iii) reward frontier performance by guaranteeing less strict standards for the next control period (Ofgem, 2001). In order to mitigate regulatory risk, the exposure of the firms has been limited to up to 4% of their revenue (see next sub-section for more details). In practice, the IIP's scheme is similar to the marginal penalties (rewards) scheme, with the addition of a payment cap. However, it is unlikely that these marginal incentives are calibrated such that they reflect the full social value of quality (Frontier Economics, 2003).

In the UK, for the purposes of regulation, the main measures of quality of service in distribution networks, in terms of revenue exposure, are supply interruptions per 100 customers (availability of service) and number of minutes lost per connected customer

(reliability of service). Figure 8 shows that, in the post-reform period, the number of interruptions in the UK has gradually decreased. The figure indicates a marked decline in interruptions during the second price control review. During the third price control review, the interruptions initially show some increase and then decline at the end of the period. Figure 9 shows the number of minutes lost per connected customer for the same period. As shown in the figure, during the three price control reviews, the reliability of service has also generally improved. Overall the trends in quality measures indicate improvements under incentive regulation. It should be noted that some variations from one year to another can be caused by measurement errors and weather conditions.



**Figure 8: Average number of interruptions per 100 customers per year**  
**Source: Ofgem**

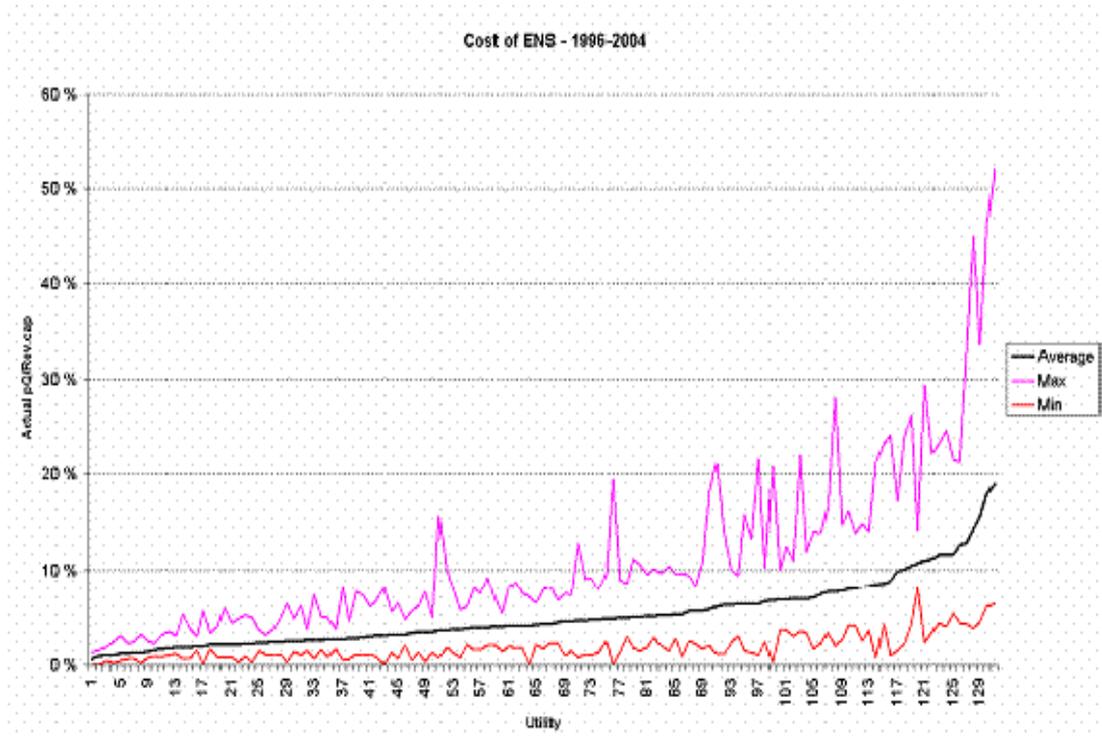


**Figure 9: Average number of minutes lost per connected customer per year**

---

Source: Ofgem

Inclusion of the cost of non-delivered energy based on WTP measurements can affect different utilities to rather different degrees. Figure 10 shows the calculated cost of energy non-supplied as percentage of revenue caps for 130 Norwegian distribution utilities in increasing order. As shown in the figure, it is possible that, at the extreme ends of the spectrum, some firms may be rewarded or penalised significantly by inclusion of the cost of non-delivered energy. At the initial price control periods, the regulator must be confident about the quality of data and particular circumstances of 'outlier' firms and special cases that may give rise to large deviations from the main body of observations.



**Figure 10: The cost of energy not-supplied (ENS) as percentage of revenue cap for 130 Norwegian electricity distribution utilities**

Source: Dalen (2006)

It is important to decide whether the WTP values used are uniform across the country and for all companies. There is reason to believe that this value can differ across the country and hence in different distribution service areas. To the extent that regional differences in WTP values are not reflected in the incentive scheme, the adaptation of utilities to socially efficient service quality levels can be distorted. A survey of WTP commissioned by the UK regulator Ofgem indicates that such valuation differences among different regions and consumer groups indeed exist (Ofgem, 2004a). At the same

---

time, the overall WTP of networks for a given unit of quality also depends on the composition of their customers. For example, industrial customers generally assign a higher value and opportunity cost to service quality than residential and commercial customers.

Nevertheless, the potential political sensitivities of explicit use of differentiated service quality valuations are clear. However these sensitivities may be a particular feature of central government, local governments may be much freer to assign different quality valuations compared with their peers. It is important to note that the marginal cost curve of improving service quality varies across the companies. An implication of subjecting the firms to their marginal cost of quality improvements is that, in the long-run, this could result in differentiated service quality levels across the country.

If there are substantial performance differences in term of quality of service, the share of quality incentives as their total allowed revenues can be substantial. The effect of the value of quality on total allowed revenues for some utilities may become stronger than those of the Norwegian utilities depicted in Figure 10. It is preferable to first aim at bringing the quality of service to comparable levels across the sector before integrating them with the companies' own costs and incorporating them fully into the benchmarking model.

For some firms with low quality performance, the transition to a high quality network may require large capital investments and time. In the UK, there is a 46 percent allowed increase in real capital investments in the 2005-2010 distribution price control period over the previous period that is partly intended to improve the quality of service during this period. Exempting investments from benchmarking offers some flexibility in addressing investment related priority targets. In contrast, it must be noted that, total cost benchmarking methods do not have built-in mechanisms that would signal increased investment in specific areas such as quality. In Norway, the regulator has incorporated the value of non-delivered energy to customers as a cost in the benchmarking model. The values are obtained from surveys and studies of different consumer groups. Both the UK and Norwegian benchmarking models, despite the differences in their approach, have succeeded in improving the quality of service.

### ***5.2.2 Quality of service incentives within UK price controls***

As noted, regulation pertaining to quality of service of DNOs has evolved gradually since the first distribution price control review. Quality of service in distribution networks is multi-faceted and extends beyond the number and length of service

interruptions. Recognising this, the quality of service incentives in Ofgem's price controls through revenue exposure consist of: (i) interruption (continuity of service) incentives, (ii) guaranteed standards of performance, (iii) quality of telephone service, and (iv) a discretionary reward scheme.

The fourth price control review has significantly increased the targets and provided stronger incentive to achieve these. Table 5 shows the revenue exposure of the DNOs to quality of service performance measures for the third (1995/99-2004/05) and fourth (2005/06-2009/10) price control reviews. The interruption incentives are supply interruptions per 100 customers (CI) and number of minutes lost per connected customer (CML). Individual CI and CML targets are set for the companies and performance is measured in relation to the targets.

<b>Incentive Arrangement</b>	<b>Third Distribution Price Control Review 2000/01-2004/05</b>	<b>Fourth Distribution Price Control Review 2000/01-2004/05</b>
Interruption incentive scheme: - Duration of interruptions - Number of interruptions	+/-1.25% +/-0.5%	+/-1.8% +/-1.2%
Storm compensation arrangements	-1%	-2%
Other standards of performance	Uncapped	Uncapped
Quality of telephone response	+/- 0.125%	+0.05% to -0.25%
Quality of telephone response in storm conditions	+/- 0.125%	0 initially +/-0.25% for 3 years
Discretionary reward scheme	Not applicable	Up to + 1m pounds
Overall cap/total	+2% to -2.875%	4% on downside No overall cap on upside

**Table 5: Revenue exposure to quality of service**  
**Source: Ofgem (2004b)**

The guaranteed standards of performance cover 12 specific aspects of the service. While these incentives affect the companies' regulated revenue, the standards of performance involve payment of compensation to individual customers under defined circumstances (Table 6). In principle, companies are indifferent as to whether they settle quality-related payments by transacting with the government (through fines) or with consumers (through compensation or reduced prices). However, the latter option is politically more attractive as it compensates those who have experienced poor service quality (Waddams Price et al., 2002).

Reporting code	Service	Performance Level	Penalty Payment
GS1	All DNOs to respond within 3 hours on a working day (at least) 7 am to 7 pm, and within 4 hours on other days between (at least) 9 am to 5 pm , otherwise a payment must be made	Respond to failure of distributors fuse (Regulation 10)	£20 for domestic and nondomestic customers
GS2	Supply restoration: normal conditions (Regulation 5)	Supply must be restored within 18 hours, otherwise a payment must be made	£50 for domestic customers and £100 for non-domestic customers, plus £25 for each further 12 hours
GS2A*	Supply restoration: multiple interruptions (Regulation 9)	If four or more interruptions each lasting 3 or more hours occur in any single year (1 April – 31 March) , a payment must be made	£50 for domestic and nondomestic customers
GS3	Estimate of charges for connection (Regulation 11)	5 working days for simple work and 15 working days for significant work, otherwise a payment must be made	£40 for domestic and nondomestic customers
GS4*	Notice of planned interruption to supply (Regulation 12)	Customers must be given at least 2 days notice, otherwise a payment must be made	£20 for domestic and nondomestic customers
GS5	Investigation of voltage Complaints (Regulation 13)	Visit customer’s premises within 7 working days or dispatch an explanation of the probable reason for the complaint within 5 working days, otherwise a payment must be made	£20 for domestic and nondomestic customers
GS8	Making and keeping Appointments (Regulation 17)	Companies must offer and keep a timed appointment, or offer and keep a timed appointment where requested by the customer, otherwise a payment must be made	£20 for domestic and nondomestic customers
GS9	Payments owed under the standards (Regulation 19)	Payment to be made within 10 working days, otherwise a payment must be made	£20 for domestic and nondomestic customers
GS11A*	Supply restoration: Category 1 severe weather conditions (Regulation 6)	Supplies must be restored within 24 hours (see table 2.2 below), otherwise a payment must be made	£25 for domestic and non domestic customers, plus £25 for each further 12 hours up to a cap of £200 per customer
GS11B*	Supply restoration: Category 2 severe weather conditions (Regulation 6)	Supplies must be restored within 48 hours, otherwise a payment must be made	£25 for domestic and non domestic customers, plus £25 for each further 12 hours up to a cap of £200 per customer
GS11C*	Supply restoration: Category 3 severe weather conditions (Regulation 6)	Supplies must be restored within the period calculated using the following formula: $48 \times \left( \frac{\text{total number of customers interrupted}}{\text{category 3 threshold number of customers}} \right)$	£25 for domestic and non domestic customers, plus £25 for each further 12 hours up to a cap of £200 per customer
GS12*	Supply restoration: Highlands and Islands (Regulation 7)	Supply must be restored within 18 hours, otherwise a payment must be made	£50 for domestic customers and £100 for non-domestic customers, plus £25 for each further 12 hours

\* Customers need to claim under these standards, for the remaining standards payments are automatic

**Table 6: Guaranteed standards of performance**

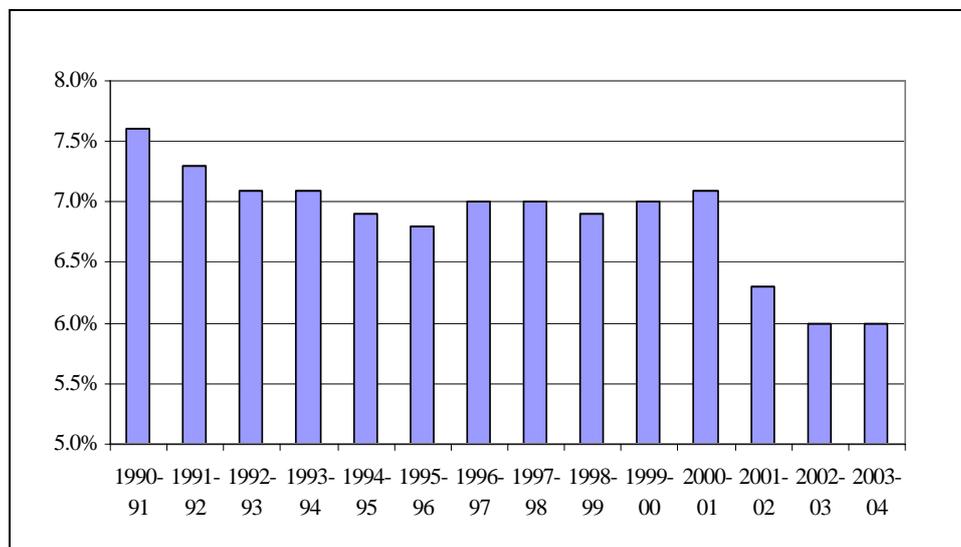
**Source: Ofgem (2005)**

---

### 5.3 Network energy losses

The term energy loss refers to physical losses (as heat, noise, or theft) during distribution through a network. Energy losses can be broken down into variable, fixed, and non-technical losses. The value of losses can, however, vary according to time of day and time of year. Losses also contribute to the emissions of pollutants and greenhouse gases.

The UK has higher transmission and distribution losses than countries such as Germany, France, Italy and United States, but lower than Spain, Canada and Ireland (Ofgem, 2003b). Approximately 7 percent of electricity transported in the U.K. is reported as electrical losses (Ofgem, 2003b).<sup>12</sup> According to one estimate, energy losses in the distribution networks are around £900 million i.e. equivalent to 5 percent of the average annual electricity bill (Ofgem, 2005). Figure 11 shows that, since liberalisation, energy losses, as percentage of energy delivered, in distribution networks has gradually declined. In particular, there is a marked reduction in losses during the 2001/02-2003/04 period.



**Figure 11: Distribution losses in the UK as percentage of energy delivered**  
Source: Ofgem

The distribution price control review also provides incentives for reducing losses in distribution networks. There has been a significant improvement in the loss percentage during the third price control period. The distribution losses targets were set from the first through to the second and third price control reviews (Ofgem, 1999b). Each DNO

---

<sup>12</sup> This section draws mainly on Yu et al. (2007).

---

is evaluated based on a yardstick loss figure derived by taking total GWh losses for all firms and constructing a composite explanatory variable weighted on GWh (70%), transformer capacity (20%), and network length (10%).

Financial penalties up to 0.25 percent of revenue are imposed on distribution firms if losses exceed the yardstick losses. Rewards are available for firms if the losses have decreased below yardstick levels (Ofgem, 1999b). Currently, an additional financial rewards and penalties of the incentive at 2.9 pence per kWh is applied to the difference between the actual and the target level of losses valued by the incentive rate in the first year. The reward and penalty falls in a straight line over ten years.

Starting from the fourth price control period, for every kWh of loss reduction (increase), DNOs will be rewarded (penalized) at 4.8 pence per kWh (in 2004/05 prices). Losses targets are set between the ranges of 4.96% to 8.73% among DNOs (Ofgem, 2004b). The target level of losses is based on a proportion of units distributed and is fixed for five years. The fixed target would be based on past performance of the DNO, as measured by the average proportion of energy lost between 1994/95 and 2003/04. The rolling retention mechanism will be in place to ensure that DNOs receive full benefit of incremental improvements in performance for a period of 5 years.

In many cases, DNOs will face conflicting incentives on losses, capital efficiency, operating efficiency, and quality of supply. For example, due to the location of system open points, the loss-related incentives can conflict with the quality of service incentives. Such conflict can also occur between Capex and losses where firms may prefer to invest in conventional transformers rather than low-loss transformers in order to reduce expenditures (Ofgem, 2003b).

#### **5.4 Incentivising efficient new investments**

As mentioned earlier, minimising the cost of network expansion and upgrade is a major issue for the regulators and benchmarking of new investment can be an increasingly important part of the price control process.

The investment efficiency incentive scheme adopted by Ofgem as part of the 2005-2010 distribution price control review exhibits some flexibility for firms to perform better than their allowed and expected investment needs. This approach also enables the firms, when possible, to take the trade-offs with operating expenditures into consideration. Joskow (2006, p.44), in his discussion of this, notes that this incentive scheme is ‘the

---

most direct and extensive application of Laffont and Tirole's [1993] menu of cost-contingent contracts result that I have ever seen.'

At the same time, for the 2005-10 price control review, the regulator has allowed a substantial increase in capital investments aimed at modernisation of the networks. The 45% increase in capital expenditure allowance from £3,882 million for the 2000-05 review period to £5,623 million (excluding quality of service) has resulted in a positive average X-factor for the sector as a whole for the first time.<sup>13</sup> The increase in allowed investments has been accompanied by an incentive scheme that is based on allowing higher returns on actual investments for making lower investments than the target level.

The distribution price control review introduced a sliding scale system for capital investment incentives. The incentives are outlined in Table 8. PB Power were the engineering consultants who reviewed the companies capital expenditure plans. The higher the ratio selected by the company to PB Power's assessment the weaker the incentive if the company actually delivered its investment below budget. Therefore, a company that selected as its base allowed revenue the lowest ratio of its cost to PB Power's estimate could keep 40% of any under-spend while the company that selected the highest ratio could only keep 20% of any under-spend. Thus a company who estimated that it needed to spend £140m when PB Power estimated only £100m was required to have a base target of £115m. If the company actually achieved £100m it would receive £100m plus an incentive payment of £0.6m. By contrast a company that said it needed £100m against PB Power's £100m and then actually achieved £100m would receive a £100m plus an incentive payment of £4.5m. This is a menu of contracts approach to regulation which encourages companies to more correctly reveal the true estimated cost of capital investments.<sup>14</sup>

An investment increase of such magnitude may appear as being rather generous to companies. However, this is a reminder that conventional benchmarking methods do not necessarily send proper signals to the regulator about the need for asset renewal and thus for increased capital investments across the sector as a whole. It may be argued that by limiting the benchmarking exercise to Opex Ofgem have maintained the flexibility to respond to the cyclical nature of investments in distribution networks and need for an overall increase in capital investments (Figure 12). In Norway, on the other hand, as shown in Bye and Hope (2005), the introduction of rate of return regulation in 1991 and subsequently the benchmarking based regime incentive regulation in 1997 resulted in a decline in network investments (Figure 13).

---

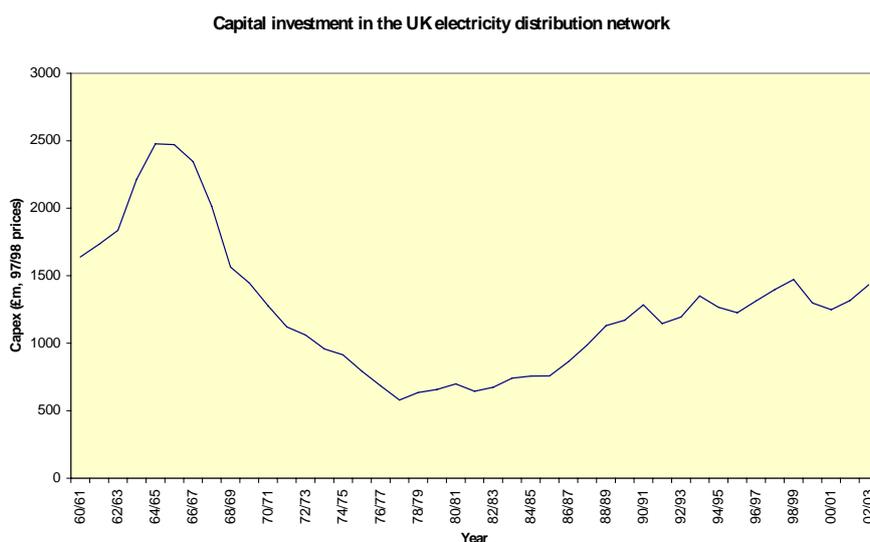
<sup>13</sup> 48% increase including investments earmarked for quality of service.

<sup>14</sup> See Baron (1989).

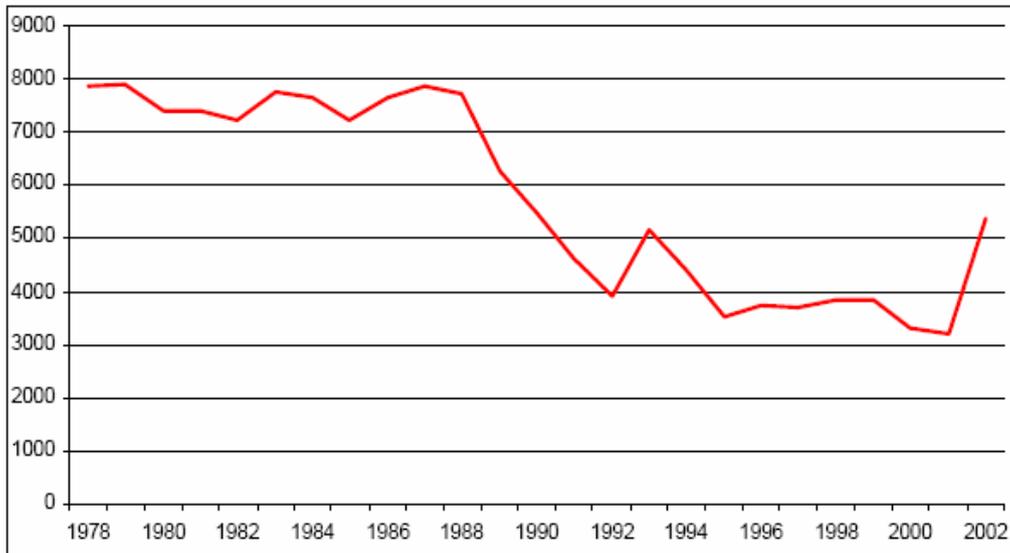
DNO:PB Power Ratio	100	105	110	115	120	125	130	135	140
Efficiency Incentive	40%	38%	35%	33%	30%	28%	25%	23%	20%
Additional income	2.5	2.1	1.6	1.1	0.6	-0.1	-0.8	-1.6	-2.4
as pre-tax rate of return	0.200%	0.168%	0.130%	0.090%	0.046%	-0.004%	-0.062%	-0.124%	-0.192%
Rewards & Penalties									
Allowed expenditure	105	106.25	107.5	108.75	110	111.25	112.5	113.75	115
Actual Exp									
70	16.5	15.7	14.8	13.7	12.6	11.3	9.9	8.3	6.6
80	12.5	11.9	11.3	10.5	9.6	8.5	7.4	6.0	4.6
90	8.5	8.2	7.8	7.2	6.6	5.8	4.9	3.8	2.6
100	4.5	4.4	4.3	4.0	3.6	3.0	2.4	1.5	0.6
105	2.5	2.6	2.5	2.3	2.1	1.7	1.1	0.4	-0.4
110	0.5	0.7	0.8	0.7	0.6	0.3	-0.1	-0.7	-1.4
115	-1.5	-1.2	-1.0	-0.9	-0.9	-1.1	-1.4	-1.8	-2.4
120	-3.5	-3.1	-2.7	-2.5	-2.4	-2.5	-2.6	-3.0	-3.4
125	-5.5	-4.9	-4.5	-4.2	-3.9	-3.8	-3.9	-4.1	-4.4
130	-7.5	-6.8	-6.2	-5.8	-5.4	-5.2	-5.1	-5.2	-5.4
135	-9.5	-8.7	-8.0	-7.4	-6.9	-6.6	-6.4	-6.3	-6.4
140	-11.5	-10.6	-9.7	-9.0	-8.4	-8.0	-7.6	-7.5	-7.4

**Table 8: Sliding scale matrix for incentivising Capex in the UK DNOs by Ofgem in 2005-2010 distribution price control review**  
Source: Ofgem (2004b, p. 87)

Dalen (1998) examines investment incentives of firms under yardstick competition while distinguishing between industry-specific and firm-specific investments. The paper suggests that under yardstick competition, industry-specific investments with spill-overs that benefit all firms are reduced. At the same time, firm-specific investments that only improve the relative efficiency of the individual firm will increase. An example of industry-specific type of investments is research and development (R&D) and innovation spending, which despite their relatively small share in total spending have significant long-term efficiency benefits for the sector as a whole.



**Figure 12: Capital investment in the UK electricity distribution network**  
Source: Ofgem (2006)



**Figure 13: Investment in network capacity. Mill NOK (2002 prices)**  
**Source: Bye and Hope (2005)**

It is conceivable that firms will have a reduced incentive to use their private information and invest in technologies that may not be explicitly rewarded in the price control model as the regulator may extract the rents from such investments *ex-post*. The magnitude of such industry-specific investments in electricity distribution utilities is, however, likely to be low but the benefits could be disproportionate to the expenditure. In 2004 Ofgem introduced the possibility for DNOs to recover up to 0.5% of their revenue p.a. to fund R&D investments under the Innovation Funding Incentive (IFI). Mott Macdonald BPI (2004) estimated the net present value of benefits from the IFI scheme at about £386m as opposed to an increase in consumer expenditure of £57m.

Thus, Ofgem’s benchmarking model can be described as a short-term efficiency benchmarking model as it includes only operating costs. The long lead times necessary for the firms to achieve any new asset structure in the long-run must be achieved through the allowed capital expenditure.

Achieving long-term efficiency improvements can involve short-term increases in Capex and/or Opex expenditures that may not generate immediate efficiency improvements. Indeed, short-term expenditure increases can deteriorate the firms’ short-term relative performance. This can in turn prevent firms from embarking on efficiency improving investments that have long-term gains. More specifically, long-term efficiency improvement targets should be facilitated with incentives allowing the firms to keep the benefits of efficiency gains.

---

The mismatch between the long-term horizon of investments and short price control periods can have a negative effect on the cost of financing investments (Ofwat/Ofgem, 2006). Longer regulatory periods (e.g. seven or ten years) can reduce uncertainty with regards to long-term investments and retaining their benefits. However, even substantially longer regulatory review periods will likely not fully incentivise investments in innovations with even longer payback periods.

## **6. Lessons of Experience from Britain**

Joskow (2006, p.78-79) notes that '[i]ncentive regulation in practice is considerably more complicated than incentive regulation in theory' and makes ten observations about the relationship between theory and practice in incentive regulation. The UK illustrates many of his points. Of particular interest are Joskow's observations that incentive regulation is not straightforwardly different from rate of return regulation, involves an evolutionary process with learning along the way and that, if anything, it is becoming more complicated as time goes on.

In this section we explicitly ask what other countries – at earlier stages of reform - can learn from the British experience of the past 16 or so years with incentive regulation. We can derive some general insights from the cumulative experience with incentive regulation of networks from Britain and around the world.

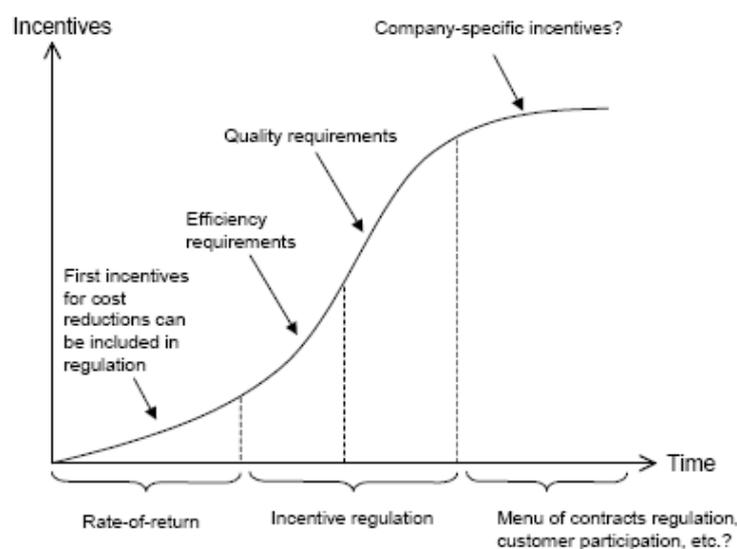
New incentive regulation and benchmarking models have grown out of the conventional regulation models and the need for new approaches to stimulate efficiency improvement in the monopoly segments of reformed industries. It is likely that different parallel national models will exist in different countries. However, the constant interaction between the regulators and firms and the cumulative experience from around the world will ensure that network regulation will continue to evolve and innovate. Finally, the “consultative” or ‘constructive engagement’ approach which has been suggested as an alternative to mainstream models of regulation in certain circumstances.<sup>15</sup> The approach is based on engaging the main stakeholders in the process of regulation. It is, however, too early to judge whether this represents a major step in the evolution of regulation. Figure 13 indicates the incentive properties of different regulation models.

It is rather important that the reform framework and regulatory approach take the countries' institutional endowment and capacity into consideration. At the same time, it

---

<sup>15</sup> See Civil Aviation Authority (2005) for a description of this model in the case of UK airports.

is crucial to recognize that compromising on main economic features of regulation can reduce its effectiveness. In this regard, a transparent set of rules, processes, and outcomes are particularly important. In countries without the tradition of independent regulation, the new regulator may be weak in terms of mandate and authority. In such cases, transparency is particularly important as insight into the procedures and process will reduce the possibility of regulatory capture. For example, incentive regulation and benchmarking were first practised and have been more successful in the countries such as the UK and Norway with a tradition of open and transparent bureaucratic systems. In the case of regulation this increases the checks and balances of the process and ensures a credible process which is crucial to any regulatory framework.



**Figure 13: The evolution pattern of regulation**  
**Source: Viljainen (2005)**

Network regulation can play a significant role in reducing the cost of electricity supply. In the UK the efficiency gains from incentive regulation of the distribution networks are at least comparable (in terms of relative share in final price) to those gained from competition in the wholesale markets. New Zealand, by contrast, where the reform failed to properly regulate the distribution companies saw the reform gains achieved in the generation sector captured by the distribution companies as higher profits (see Bertrand and Twaddle, 2006).

As discussed in the previous sections, the British model of distribution network incentive regulation has brought about significant price reductions to the customers. Admittedly, in the initial years the companies made large profits which with the benefits of hindsight could have been avoided. This can partly be attributed to underestimation

---

of the potential for efficiency improvement in the networks, the focus on implementing competition in generation and the price formulae set out by the government as part of the selling off the assets rather than to ineffectiveness of incentive regulation per se.

As noted above, through the subsequent price control reviews, the British network regulation model has successfully: substantially reduced distribution access charges, maintained and improved quality of service, and ensured sufficient investments. A tough regime of operating expenditure benchmarking has meant that the benchmarked share of total revenues has consistently been reduced. This has focussed regulation on dealing effectively with the persistent question of investment adequacy and the long-term reliability of the networks. The question of how to correctly incentivise new investments, especially as these become more significant due to replacement cycles and the demands of new distributed/renewable generation, emerges as an important challenge to both incentive regulation approach and benchmarking.

Although the fragmented regulation and benchmarking approach consisting of the benchmarking of operating expenditures, the review of capital investment plans, and penalty/reward schemes for quality of service and network energy losses do not strictly conform to an ideal integrated theoretical framework, this approach has performed well and has given the regulator flexibility to address and incentivise specific aspects of network regulation.

As noted in Jamasb and Pollitt (2005), the process of liberalisation towards the internal electricity market in the European Union is currently the only cross-country broad reform process in progress. Although the pace of the EU-wide reform has been slow, the centralised initiatives and the Electricity Directives have managed to maintain some momentum in the process. In the absence of EU-led initiatives, many member countries would have undertaken considerably less progressive reform measures. For example, Switzerland by the virtue of not being a member of the EU has not been obliged to take part in the liberalisation of the European electricity sector liberalisation. In the absence of external pressure from the EU, the domestic support has not been sufficiently strong to press forward a reform agenda.

But does this mean that countries like Switzerland have foregone improvement in terms of the efficiency of the sector or economic competitiveness? The answer may lie partly in the current efficiency level of the sector and partly in the potential for improvement in the sector. The latter must be carefully viewed within the backdrop of institutional factors that may constraint implementation of a workable reform. A partially implemented reform can indeed be less desirable than a non-reformed sector. The

---

history of the British electricity distribution networks shows that the past nationalisation harmonized the technical standards and reduced the number of networks over time making some potential economies of scale available. This facilitated the subsequent privatisation and introduction of incentive regulation in the UK. In the area of the introduction of incentive regulation, as in other areas of electricity reform, the question is whether the costs of implementation outweigh the benefits (Joskow, 2006; 2002)?

The following more specific insights from the electricity distribution sector reform in Britain and elsewhere offer several insights and lessons of experience for other countries at earlier stages of reform in general and incentive regulation of networks in particular.

- ***Incentive regulation and the wider reform*** - In the implementation of incentive regulation for the distribution networks, it is not necessary to introduce the reform steps in the same order as in the British case. Contrary to common practice worldwide, it is not imperative to implement incentive regulation of distribution networks at the same time as or after introducing competition in the wholesale and retail markets. A crucial role of the distribution system in reforms is to provide regulated third-party access for wholesale and retail market competition over the networks. However, access to networks is an entirely different matter from incentive regulation of them. Neither is privatisation a prerequisite for implementing incentive regulation as the publicly owned Norwegian and Dutch electricity distribution networks illustrate. It may, however, be useful to distinguish between local and municipal ownership on the one hand and state ownership on the other as the latter may be less efficient. It then follows that, if the introduction of competition is not feasible or desirable, there is no reason for not considering incentive regulation of the networks on its own merits. Likewise, lack of willingness or support for privatisation of networks should not be an obstacle for incentive regulation of this.<sup>16</sup>
- ***Reform policy*** - A recent OECD report on regulatory reform in Switzerland states that “*An evolutionary process is underway, partly in anticipation of market opening, toward consolidation, partnership and cooperation, and sale of public equity.*” (OECD, 2005, p.126). There is reason to believe that ad hoc and

---

<sup>16</sup> The case of incentive regulation of municipal and county owned utilities in Nordic countries is testimony to this. However the consequences of applying incentive regulation – designed for profit maximising private companies - to locally/publicly owned companies may need to be better understood. See Magnus (2000) for a discussion of the case of introduction of incentive regulation for locally owned utilities in Norway.

---

unsupervised structural and positioning in advance and anticipation of the actual reform are not only unhelpful but are also likely to constrain and complicate the implementation of a future reform and the tasks of the regulator. Any restructuring or reorganisation with a view to a reform should ideally take place under the oversight of an independent sector regulator (although this was not the case in Britain) and as part of a coherent reform agenda. The British reform benefited greatly from initially having 14 independent, roughly comparable, DNOs to regulate. Such early developments can create new vested interests and put in place ineffective structures that regulation cannot easily alter or correct their effect. This is due to the fact that capital has proven significantly more mobile and proactive than the process of rule-making for reforms. The sectoral and cross-sectoral consolidations in the EU where firms have acted to position themselves ahead of the actual reform or establishment of strong independent regulator (as in Germany) illustrate how progress towards an effective market can be frustrated in the absence of clear reform policies.

- ***Legislation and independent regulation*** - The reform law should be clear regarding the aims of the reform and the regulator's mandate and areas over which it should have authority. Independent regulation has become the prerequisite and cornerstone of reform of infrastructure and network industries. Establishment of an independent regulatory authority should take place by mandate from and soon after the necessary legal base is in place. In the Netherlands, lack of legislative clarity with regards to the benchmarking approach led to legal challenges by the utilities and new legislation (Nillesen and Pollitt, 2007). At the same time, legislation should avoid being too specific on some central matters that should normally be the domain of regulatory discretion. For example, whether the regulator should use specific approaches to incentive regulation or use benchmarking or perhaps international benchmarking needs to be the preserve of the independent regulator. In Sweden, by requiring ex-post regulation of distribution networks, the law has in part led to adoption of an incentive regulation model that has resulted in major disputes between the regulator and firms.
- ***Unbundling and ring-fencing distribution*** - Effective separation of the networks from the competitive segments is crucial. Legal separation of the networks and ring-fencing of the distribution assets and costs from the rest of vertically integrated structures is essential for effective incentive regulation schemes and benchmarking. This should ideally be done as early as possible and prior to the start of incentive regulation to avoid strategic behaviour. Jamasb,

---

Nillesen, and Pollitt (2003) show that regulators have identified definition and allocation of distribution costs and assets as important in incentive regulation and benchmarking. Ofgem has invested considerable effort in effective separation on distribution from supply (retailing) business. Structural shortcomings cannot easily be mitigated by other means.

- ***Quality of service*** – The use of performance targets combined with a penalty and reward incentive system has improved the quality of service in the UK distribution utilities. This approach, though perhaps not perfect, is in contrast to a purely cost-oriented benchmarking, which could lead to perverse economic incentives. It is important for countries to take quality of service and related investments into account when introducing incentive regulation. The British example shows that incentive regulation can also be effective for improving quality of service and security of supply of the networks. However it is not clear as to what the correct allocation of risks is (Joskow, 2006, p.51) or how to correctly integrate costs, loss reduction and quality of service into a performance benchmark (Giannakis et al, 2005, Joskow, 2006 and Yu et al., 2007).
- ***Information and data requirement*** - Availability of high quality data is crucial to a well functioning incentive regulation scheme and all reforms have had to spend considerable effort to improve the legal aspects of information disclosure and to improve the quality of data and standardisation of reporting formats. It should be noted that while benchmarking can reduce the information asymmetry between the regulator and the regulated firm, the information requirements can still be significant. This is particularly true for countries where the number of firms is large. As the information base for many of smaller firms is limited, the time between the present and a future reform is well-spent on establishing the legal basis for information disclosure requirements and standardising and simplifying the collection of data. Incentive regulation can, in some respects, be built on less, but high quality, information as opposed to traditional rate of return regulation that can be rather information intensive.<sup>17</sup>
- ***Number of networks and priorities*** – Some countries such as Germany, Nordic countries, and Switzerland have a large number of utilities. This provides a suitable basis for the use of advanced benchmarking techniques and without necessarily having to recourse to international benchmarking. There are about 900 distribution utilities in the above two countries ranging from large networks

---

<sup>17</sup> This is illustrated by the substantial reporting requirements put on companies by FERC in the US.

---

in vertically integrated structures to very small municipal utilities. It is generally desirable for regulators to have a large number of utilities for comparison and efficiency benchmarking. Also, evidence suggests that companies need not to be very large to reach rather efficient scales (e.g. Growitsch et al., 2005). However, having a large number of very small networks can be inefficient from the scale efficiency point of view. For example, auditing and quality control of data will demand more resources. This may also have implications for the benchmarking approach. For example, control and approval of a large number of small utilities' investment plans can be costly, lengthy, and complicated. It may be that a move towards a smaller number of roughly equally sized distribution companies is a desirable goal from the point of view of efficiency of system operation and regulation.

A practical and pragmatic approach for introduction of incentive regulation is, therefore, to initially focus on regulation and benchmarking of a modest number of the largest companies that constitute a significant majority of total customers. Initially, the large majority of smaller utilities many of which may even lack suitable accounts for incentive regulation and benchmarking can only be subjected to standardisation of their accounts. The smallest networks may then gradually be encouraged to merge to improve scale efficiency, after merger they may be subjected to benchmarking.

However, while acquiring uniform technical and financial data may be difficult, it is easier to focus on tariff and revenue data which are easier to determine. In many cases, the indirect pressure from the achievements of other regulated utilities should lead to some efficiency improvements in these utilities. In a transition period, simple measures such as comparison and publication of distribution tariffs are likely to produce some performance improvements in these utilities. Evidence from Germany with publication of distribution tariffs suggests some reduction in the highest tariffs - although the lowest tariffs showed signs of increase (Growitsch and Wein, 2005).

- ***Economies of scale and rationalisation*** – Studies of economies of scale in electricity distribution networks suggest that these *need not* be very large to benefit from economies of scale (e.g. Growitsch et al., 2005). It is likely that technological progress has reduced the scale effect on the cost distribution networks. However, this does not necessarily mean that there are no benefits from scale economies or rationalisation of the structure of the networks. Growitsch et al. (2005) find that although the most efficient small firms are as

---

efficient as the most efficient large firms, the dispersion of efficiencies is considerably greater for small firms. This would seem to be consistent with the view that sufficient managerial skills for a large number of small firms may not be available or affordable.

Thus in countries which continue to have a very large number of small network utilities it is rather likely that there is scope for significant gains from rationalisation. Norway and the Netherlands have encouraged and achieved mergers and partnerships aimed at efficiency improvement among their distribution utilities.

### ***Postscript: Electricity network regulation in the future***

In closing, we note the impact of future innovation on network regulation. Technological progress has in the past and will continue in the future to transform the nature and economics of networks. It is therefore very important that any regulatory framework will provide the right incentives for innovation and adoption of new technologies in the networks. It is also important that the regulatory system is flexible. The UK system of regulation has performed well from 1990 to 2006. However it will need to evolve in the face of new technology and the challenge of demands from electricity consumers and producers for cleaner and more decentralised production (see Jamasb et al., 2006).

Thus an important question is whether the UK regulation model provides the necessary incentives for innovation and accommodates the “active networks” of future with renewables, distributed generation, micro-generation, and active demand. Micro-generation units installed by households, industrial CHP, decentralised renewable generation sources will impose new challenges on networks.

This implies that European electricity regulators should take into account the power and long-term effects of incentive schemes in influencing the features and behaviour of regulated firms. In responding to the choice of benchmarking models and target variables firms are led to follow a certain path. This can mean a narrow focus on a limited number of strategic variables. Regulatory models will therefore need to be reviewed and evolve constantly to meet the needs of future networks.

---

## References

- Abdala, M.A. (2001). Institutions, Contracts and Regulation of Infrastructure in Argentina, *Journal of Applied Economics*, Vol. IV (2), 217–254.
- Ajodhia, V. and Hakvoort, R. (2005). Economic Regulation of Quality in Electricity Distribution Networks, *Utilities Policy*, Vol. 13, No. 3, 211-221.
- Averch, H. and Johnson, L. L. (1962). Behaviour of the Firm under Regulatory Constraint, *American Economic Review*, 52 (December), 1052-1069.
- Baron, D. P. (1989). Design of Regulatory Mechanisms and Institutions, in Schmalensee, R. and Willig R. D. (eds.), *Handbook of Industrial Organization*, Amsterdam: North-Holland.
- Basañes, C.F., Saavedra, E., Soto, R. (1999). Post- Privatization Renegotiation and Disputes in Chile. Infrastructure and Financial Markets Division, Sustainable Development Department, Inter-American Development Bank, Washington, D.C.
- Benavides, J., Fainboim, I. (1999). Private Participation in Infrastructure in Colombia: Renegotiations and Disputes. Infrastructure and Financial Markets Division, Sustainable Development Department, Inter-American Development Bank, Washington, D.C.
- Bertrand, G. and Twaddle, D. (2005). Price-Cost Margins and Profit Rates in New Zealand Electricity Distribution Networks Since 1994: The Cost of Light Handed Regulation, *Journal of Regulatory Economics*; Vol. 27:3 281–307.
- Bliss, B. (1954). Nationalisation in France and Great Britain of the Electricity Supply Industry, *International and Comparative Law Quarterly*, Vol. 8, April, 277-290.
- Brower, M., Thomas, S., and Mitchell, C. M. (1997). Lessons from the British Restructuring Experience, *The Electricity Journal*, April, 40-51.
- Burns, P. and Weyman-Jones, T. G. (1994). Regulatory Incentives, Privatisation and Productivity Growth in UK Electricity Distribution', CRI Technical Paper No. 1, London: CIPFA.

- 
- Burns, P. and Weyman-Jones, T. G. (1996). Cost Functions and Cost Efficiency in Electricity Distribution: A Stochastic Frontier Approach, *Bulletin of Economic Research*, Vol. 48:1, 41-64.
- Bye, T. and Hope, E. (2005). Deregulation of Electricity Markets – The Norwegian Experience, Discussion Paper No. 433, Research Department, Statistics Norway, September.
- Byatt, I. C. R. (1979). *The British Electrical Industry 1875-1914: The Economic Returns to a New Technology*, Clarendon Press: Oxford.
- Chessire, J. (1996). UK Electricity Supply under Public Ownership, in Surrey, J., *The British Electricity Experiment – Privatization: The Record, the Issues, the Lessons*, Earthscan: London.
- Chick, M. (1995). The Political Economy of Nationalisation: The Electricity Industry, in *The Political Economy of Nationalisation in Britain 1920-1950*, Milward, R. and Singleton, J. (eds.), Cambridge University Press, Cambridge.
- Civil Aviation Authority (2005). *Airport Regulation – the process for constructive engagement*, Civil Aviation Authority: London.
- CPB (2004). Better Safe Than Sorry? - Reliability Policy in Network Industries, Netherlands Bureau for Economic Policy Analysis, No. 73, December.
- Dalen, D. M. (2006). Presentation at the International Scientific Conference of the Bundesnetzagentur (BnetsA) on Incentive Regulation in the German Electricity and Gas Sector, Bonn/Bad Godesberg, 25-26 April.
- Dalen, D. M. (1998). Yardstick Competition and Investment Incentives, *Journal of Economics and Management Strategy*, Vol. 7, No. 1, Spring, 105-1026.
- De Oliveira, R. G. and Tolmasquim, M. T. (2004). Regulatory Performance Analysis Case Study: Britain's Electricity Industry, *Energy Policy*, Vol. 32, 1261-1276.
- Di Tella, R., Dyck, I.J.A. (2002). Cost Reductions, Cost Padding and Stock Market Prices: The Chilean Experience with Price Cap Regulation, Harvard NOM Working Paper 03-22; HBS Working Paper 03-050.

- 
- Domah, P. and Pollitt, M. (2001). The Restructuring and Privatisation of Electricity Distribution and Supply Businesses in England and Wales: A Social Cost-Benefit Analysis, *Fiscal Studies*, Vol. 22, No. 1, 107-146.
- Electricity Consumers' Council (1982), Annual Report and Accounts, London: Electricity Consumers' Council.
- Estache, A., Guasch, J.L., and Trujillo, L. (2003). Price Caps, Efficiency Payoffs and Infrastructure Contract Renegotiation in Latin America, Policy Research Working Paper 3129, World Bank, Washington, D.C.
- European Commission (2005). Report on Progress in Creating the Internal Gas and Electricity Market, Technical Annex to the Report from the Commission to the Council and the European Parliament, Commission Staff Working Document SEC(2005) XXXX, Commission of the European Communities, Brussels.
- Fouquest, R. and Pearson, P. J. G. (2006). Seven Centuries of Energy Services: The Price and Use of Light in the United Kingdom (1300-2000), *The Energy Journal*, Vol. 27(1), 139-177.
- Frontier Economics (2003). Developing Monopoly Price Controls, Workstream B, Balancing Incentives. A final report prepared for Ofgem, Standard project document, London, March.
- Giannakis, D., Jamasb, T., and Pollitt, M. (2005). Benchmarking and Incentive Regulation of Quality of Service: An Application to the UK Electricity Distribution Networks, *Energy Policy*, Vol. 33, Issue 17, November, 2256-2271.
- Growitsch, C., Jamasb, T. and Pollitt, M. (2005). *Quality of Service, Efficiency and Scale in Network Industries: An analysis of European electricity distribution*, Electricity Policy Research Group Working Paper No.05/04.
- Growitsch, C. and Wein, T. (2005). Negotiated Third Party Access – An Industrial Organisation Perspective, *European Journal of Law and Economics*, Vol. 20, 165-183.
- Guasch, J. L. (2003). Infrastructure Concessions in Latin America and the Caribbean: The Renegotiation Issue and Its Determinants, *Infrastructure and Financial Markets Review* 9(2), June, Sustainable Development Department, Infrastructure

---

and Financial Markets Division, Inter-American Development Bank, Washington, D.C.

Guasch, J.L. (2004). Granting and Renegotiating Infrastructure Concessions. World Bank Development Studies Series, World Bank, Washington, D.C.

Hammond, C. J., Jones, G., and Robinson, T. (2002). Technical Efficiency under Alternative Regulatory Regimes: Evidence from the Inter-war British Gas Industry, *Journal of Regulatory Economics*, Vol. 22:3, 251-270.

Hattori, T., Jamasb, T., and Pollitt, M. (2005). Electricity Distribution in the UK and Japan: A Comparative Efficiency Analysis 1985-1998, *The Energy Journal*, Vol. 26, Issue 2, 23-47.

Heggset, J., Kjølle, G. H., Trengereid, F., and Ween, F. (2001). Quality of Supply in the Deregulated Norwegian Power System. IEEE Porto Powertech 2001, Porto, September.

Helm, D. (2003). *Energy, the State, and the Market: British Energy Policy Since 1979*, Oxford University Press: Oxford.

Henney, A. (1994). *A Study of the Privatisation of the Electricity Supply Industry in England & Wales*, EEE: London.

House of Commons (1882). Bill to facilitate and regulate supply of Electricity for Lighting in Great Britain and Ireland: As amended by Select Committee, 1882 (200), House of Commons, London.

Jamasb, T., Nillesen, P., and Pollitt, M. (2004). Strategic Behaviour under Regulatory Benchmarking, *Energy Economics*, Volume 26, 825-843.

Jamasb, T., Nillesen, P., and Pollitt, M. (2003). Gaming the Regulator: A Survey, *The Electricity Journal*, Vol. 16, Issue 10, December, 68-80.

Jamasb, T., Nuttall, W. J., and Pollitt, M. (2006). *Future Electricity Technologies and Systems*, Cambridge University Press: Cambridge.

Jamasb, T., Mota, R., Newbery, D., Pollitt, M. (2004). Performance of Electricity Sector Reforms: A Survey of Practice and Evidence, Cambridge Working Papers in

---

Economics CWPE0439, CMI Electricity Project CMI EP 47, Department of Applied Economics, University of Cambridge.

Jamasb, T. and Pollitt, M. (2005). Electricity Market Reform in the European Union: Review of Progress toward Liberalisation & Integration, *The Energy Journal*, Vol. 26, Special Issue, 11-41.

Joskow, P. L. (1998). Electricity Sectors in Transition, *The Energy Journal*, Vol. 19, No. 2, 25-55.

Joskow, P. L. (2002). 'Electricity Sector Restructuring and Competition: A Transaction-Cost Perspective', in Brousseau, E. and Glachant, J. M., *The Economics of Contracts*, Cambridge University Press: Cambridge.

Joskow, P.L. (2006). Incentive Regulation in Theory and Practice: Electricity Distribution and Transmission Networks. Cambridge Working Papers in Economics No.0607 and Electricity Policy Research Group Working Paper Series No.0511.

Joskow, P.J., Schmalensee, R. (1986). Incentive Regulation for Electric Utilities, *Yale Journal on Regulation*, Vol. 4, No. 1, 1-49.

Laffont, J-J. and Tirole, J. (1993). *A Theory of Incentives in Regulation and Procurement*, Cambridge, M.A.: MIT Press.

Langset, T., Trengereid, F., Samdal, K., and Heggset, J. (2001). Quality Dependent Revenue Caps — A Model for Quality of Supply. CIRED 2001, June, Amsterdam.

Littlechild, S (2000) 'Privatization, Competition, and Regulation in the British Electricity Industry, With implications for Developing Countries' Energy Sector Management Assistance Program (ESMAP), February, World Bank

MacKerron, G. and Watson, J. (1996). The Winners and Losers So Far, in Surrey, J., *The British Electricity Experiment: Privatisation, the Record, the Issues*, Earthscan Publications Ltd.: London.

- 
- Magnus, E. (2000). Owner Attitudes and Public-company Behaviour in a Restructured Electricity Sector, in Magnus, E. and Midttun, A. (Eds.), *Electricity Market Reform in Norway*, MacMillan Press: London.
- Millward, R. and Singleton, J., Eds. (1995). *The Electricity Industry, in The Political Economy of Nationalisation in Britain 1920-1950*, Cambridge University Press, Cambridge.
- MMC (1995). Scottish Hydro-Electric plc: a Report on a Reference under Section 12 of the Electricity Act 1989. Monopolies and Mergers Commission, London.
- MMC (1997). Northern Ireland Electricity Plc: A Report on a Reference under Article 15 of the Electricity (Northern Ireland) Order 1992. Monopolies and Mergers Commission, London.
- Mota, R.L. (2004). Comparing Brazil and USA Electricity Distribution Performance: What Was the Impact of Privatisation? Cambridge Working Papers in Economics CWPE 0423, Department of Applied Economics, University of Cambridge.
- Mott Macdonald BPI (2004). Innovation in Electricity Distribution Networks, Final Report, Brighton: Mott Macdonald BPI.
- Newbery, D.M. (2002). Issues and Options for Restructuring Electricity Supply Industries CMI Working Paper CMI EP 01, DAE Working Paper WP 0210, Department of Applied Economics, University of Cambridge.
- Newbery, D. M. (1999). *Privatization, Restructuring, and Regulation of Network Industries*, The MIT Press: Cambridge, Mass.
- Nillesen, P.L. and Pollitt, M.G. (2007). The Consequences for Consumer Welfare of the 2001-2003 Electricity Distribution Price Review in The Netherlands, *Journal of Regulatory Economics* (forthcoming).
- OECD (2005). Regulatory Reform in Switzerland: Seizing the Opportunities for Growth, SG/SGR(2005)5, Special Group on Regulatory Policy, General Secretariat, November, Organisation for Economic Co-operation and Development, Paris.

- 
- Offer (1994). The Distribution Price Control: Proposals, Office of Electricity Regulation, Birmingham.
- Ofgem (2006). Our Energy Challenge: Ofgem's Response, Office of Gas and Electricity Markets, May, London.
- Ofgem (2005). 2004/05 Electricity Distribution Quality of Service Report, Office of Gas and Electricity Markets, November, London.
- Ofgem (2004a). Consumer Expectations of DNOs and WTP for Improvements in Service (June 2004), 145f/04, Report prepared by Accent Marketing & Research for the Office of Gas and Electricity Markets, London.
- Ofgem (2004b). Electricity Distribution Price Control Review, Final Proposals, 265/04, November, Office of Gas Electricity Markets, London.
- Ofgem (2003a). Developing Monopoly Price Controls. Update Document, Consultation Document, February, Office of Gas and Electricity Markets, London.
- Ofgem (2003b). Background Study on the Use of Benchmarking to Assess Efficiency for the 2005 Distribution Price Control. Prepared by Cambridge Economic Policy Associates (CEPA) for the Office of Gas and Electricity Markets, 109/03, September, London.
- Ofgem (2001). Information and Incentives Project, Incentive Schemes. Final Proposals, Decision Document, December, Office of Gas and Electricity Markets, London.
- Ofgem (2000). Information and Incentives Project, Output Measures and Monitoring Delivery between Reviews. Final Proposals, Consultation Document, September, Office of Gas and Electricity Markets, London.
- Ofgem (1999a). Review of Public Electricity Suppliers 1998–2000. Distribution Price Control Review, Initial proposals, Consultation Document, October, Office of Gas and Electricity Markets, London.
- Ofgem (1999b). Reviews of Public Electricity Suppliers 1998 to 2000. Distribution Price Control Review, Final Proposals, Consultation Document, December, Office of Gas and Electricity Markets, London.

- 
- Ofgem (1999c). Electricity Distribution Licences: Initial Proposals on Standard Conditions for the Financial ‘Ringfence’, A Consultation paper, Office of Gas and Electricity Markets, London
- Ofwat/Ofgem (2006). Financing Networks: A Discussion Paper, Office of Water Regulation/Office of Gas and Electricity Markets, February, London.
- Pollitt, M. (1995). *Ownership and Performance in Electric Utilities*. Oxford: Oxford University Press.
- Pollitt, M. (2005). The Role of Efficiency Estimates in Regulatory Price Reviews: Ofgem’s Approach to Benchmarking Electricity Networks, *Utilities Policy*, Vol.13, No.4, 279-288.
- Pryke, R. (1981). *The Nationalised Industries: Policies and Performance Since 1968*, Martin Robinson: Oxford.
- Sappington, D. E. M. (2005). Regulating Service Quality: A Survey, *Journal of Regulatory Economics*, Vol. 27, Issue 22, 123-154.
- Schmidt, M. R. (2000). *Performance-Based Ratemaking: Theory and Practice*, Public Utilities Reports, Inc., Vienna, Virginia.
- Secretary of State for Energy (1988). Privatising Electricity: The Government’s Proposal for the Privatisation of the Electricity Supply Industry in England and Wales, Cm 322, HMSO, London
- Shleifer, A. (1985). A Theory of Yardstick Competition, *Rand Journal of Economics*, Vol. 16, 319-327.
- Tangerås, T. P. (2003). Yardstick Competition and Quality, Swedish Network for European Studies in Economics and Business, Discussion paper, April. Weblink: <http://www.snee.org/filer/papers/205.pdf>
- Ter-Martirosyan, A. (2003). The Effects of Incentive Regulation on Quality of Service in Electricity Markets. Department of Economics, George Washington University, Working Paper, March.
- Thomas, S. (2004). Evaluating the British Model of Electricity Deregulation. *Annals of Public and Cooperative Economics*, Vol. 75, No. 3, 367–398.

- 
- Vickers, J. and Yarrow, G. (1993). *Privatization: An Economic Assessment*, The MIT Press: Cambridge, Mass.
- Viljainen, S. (2005). Regulation Design in the Electricity Distribution Sector- Theory and Practice, PhD Thesis, Lappeenranta University of Technology.
- Waddams Price, C., Brigham, B., and Fitzgerald, L. (2002). Service Quality in Regulated Monopolies, Working Paper CCR 02-4, August, Centre for Competition and Regulation, University of East Anglia.
- Yarrow, G. (1992). British Electricity Prices Since Privatisation, Regulatory Policy Institute, Studies in Regulation, Paper No. 1, Oxford.
- Yu, W., Jamasb, T. and Pollitt, M. (2007). Incorporating the Price of Quality into Benchmarking UK Electricity Distribution, Cambridge Working Papers in Economics and Electricity Policy Research Group Working Paper Series (forthcoming).
- Zhang, Y.F., Parker, D., Kirkpatrick, C. (2002). Electricity Sector Reform in Developing Countries: An Econometric Assessment of the Effects of Privatisation, Competition and Regulation, Working Paper 31, Centre on Regulation and Competition, Institute for Development Policy and Management, University of Manchester.