MACRO ECONOMIC REFORMS AND SUSTAINABLE DEVELOPMENT IN SOUTHERN AFRICA

Report no. 5:

Electricity production

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EXECUTIVE SUMMARY

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Chapter 5

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1.
INTRODUCTION

1.1 Overview of total project

This report forms part of a suite of papers written for the World Wildlife Fund programme 'Macroeconomic reforms and sustainable development in Southern Africa'. The overall objective is to encourage the development of sustainable economic policies.

Countries participating in the programme are South Africa, Tanzania, Zambia, and Zimbabwe. In each country two sectors of the economy are being focused on. In South Africa the energy and water supply sectors have been chosen as they are key to improving welfare and enhancing economic growth. This report is one of ten papers covering different aspects of these two sectors.

The programme is being undertaken in several stages, starting with analyses of externalities and implications for internalising them into the relevant economic sectors, and moving progressively toward developing policies for sustainable development. This report is located in the first stage of the programme, and its outputs thus form inputs into subsequent phases.

The Development Bank of South Africa (DBSA) is the project secretariat for the South African component of the programme. The National Advisory Committee, comprising a wide range of stakeholders, is responsible for guiding the project.

1.2 Objectives of this report

This report forms a part of the focus on the energy sector in South Africa. Its objectives are to examine the macroeconomic implications of internalising environmental externalities into the electricity generation and supply industries. It does so by, first, reviewing the environmental impacts of electricity production and exploring different mitigation options. Secondly, the likely impacts of water pricing reform and electricity distribution industry restructuring on electricity prices are investigated. Finally, the restructuring of the electricity generation industry is analysed with a view to identifying factors likely to impact on mitigation options.

1.3 Structure of the document

The report is unusual in the sense that it comprises several stand-alone chapters, each with specific objectives and outputs designed to fit into subsequent phases of the programme. The report therefore has no concluding chapter – rather, the conclusions within each chapter are the main outputs. The report contains the following chapters:

Chapter 2: Environmental impacts of electricity production

Chapter 3: Mitigation of environmental impacts of electricity: supply options

Chapter 4: Impact of water pricing reform on electricity pricing

Chapter 5: Restructuring the electricity distribution industry and the impact on electricity prices

Chapter 6: Restructuring the electricity generation industry: factors likely to impact on efforts to mitigate environmental externalities

1.4 Limitations

In several areas the report was unable to obtain the necessary data to undertake more accurate quantification of various parameters. Data gaps are discussed in the relevant chapters.

2.

EXTERNALITIES AND THE SOUTH AFRICAN POWER SECTOR

2.1 Introduction

2.1.1 Objective of this chapter

This chapter analyses the environmental impacts of the bulk electricity supply sector and provides a valuation for several key impacts where information or previous studies are available. The research draws heavily on Clive van Horen's (1996b) assessment of externalities in South Africa's electricity sector. In that study Van Horen classified impacts as Class One (serious and measurable), Class Two (serious but not readily measurable), or Class Three (not likely to be serious). We revisit the following class one impacts with new information where available:

- the health impacts of air pollution;
- under-pricing for water supply;
- greenhouse gases.

The health impacts of coal mining for power generation are not considered, as that is covered in another study. We have looked at the possible impacts of air pollution and acidification on the environment. Most importantly, we have included in this analysis a first cut at the environmental benefits of electrification – one of the significant positive externalities of electricity in South Africa.

2.1.2 Overview of the electricity supply sector[1]

Figure 2.1 illustrates the current structure of the electricity supply industry. Generation and transmission are dominated by Eskom. There are a few self-producers, some of which sell to neighbouring communities. Eskom owns 93 per cent of all generation capacity in South Africa, municipalities own five per cent and private generators only two per cent.

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[1] Overview drawn from Davis and Wamukonya 1999.

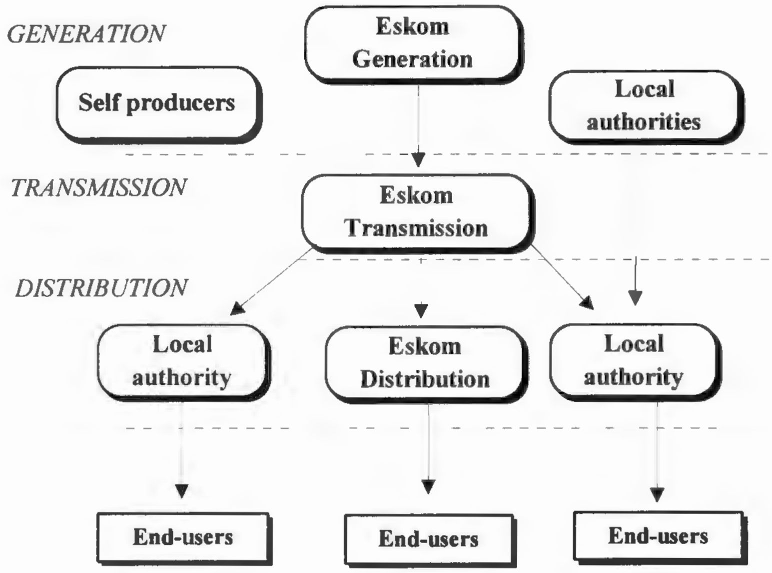

Figure 2.1: Structure of the South African electricity supply industry

The total quantity of electricity generated in South Africa in 1998 was 189 TWh (Eskom 1999). Eskom accounted for 95% of this total. Figure 2.2 presents the electricity flows in the South African industry for 1996, the latest year for which such detailed breakdowns are available.

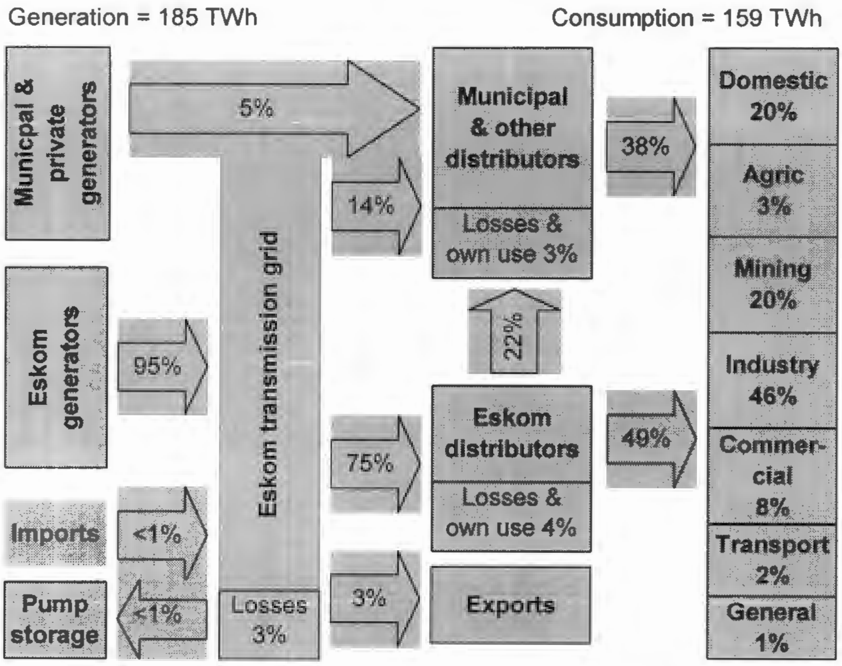

Figure 2.2: Energy flows in the electricity supply industry in 1996

South Africa's electricity generating technology is based largely on coal-fired power stations, mostly owned and operated by Eskom and largely concentrated near and to the East of Johannesburg – close to the main coal resources as well as the country's major demand centre.

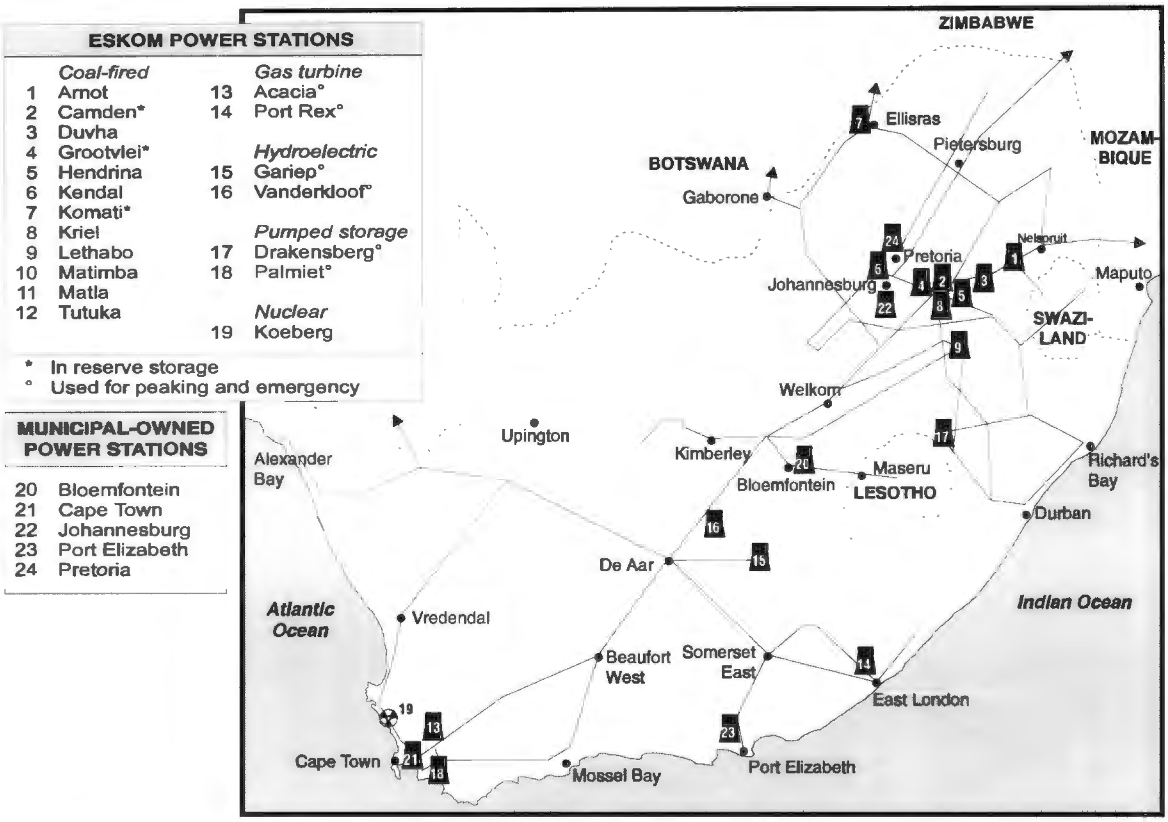

Figure 2.3: Geographical distribution of electricity generating stations in South Africa

As at the beginning of 1999, there are 38 power stations in the country, of which 23 are coal-fired accounting for 90 per cent of the total capacity of 42994 MW (including capacity in reserve and under construction). Three of Eskom's older coal stations are currently in reserve ('mothballed') due to the existence of excess capacity and these account for eight per cent of total capacity. The only non-coal stations of significance are the Koeberg station (five per cent of operational[2] capacity) and three pump storage facilities (four per cent of operational capacity) (NER 1999; Eskom 1999). This externality study, therefore, focuses largely on coal fired power generation, with some discussion of nuclear power. Table 2.1 presents the breakdown of capacity and electricity production by fuel source. Coal generation accounts for ninety per cent of all electricity produced and nuclear generation a further seven per cent.

2 'Operational' capacity excludes all moth-balled stations and units under construction.

Table 2.1: Capacity and gross electricity production by fuel type

Source: NER (1997b); NER (1999); Eskom (1999)

	Capacity (1998)[a] [MW]		Electricity production (1998)[b] [GWh]		Electricity production (1997)[c] [GWh]	
Coal	32 724	87,4%	170 750	90,4%	179 792	91,0%
Nuclear	1 840	4,9%	13 601	7,2%	12 647	6,4%
Pumped storage[d]	1 580	4,2%	2 626	1,4%	2 815	1,4%
Hydro	668	1,8%	1 852	1,0%	2 349	1,2%
Gas	606	1,6%	23	0,0%	20	0,0%
Bagasse	29	0,1%	86	0,0%	86	0,0%
Total	37 447	100%	188 938	100%	197 708	100%

Notes:

a) Excluding capacity in reserve and under construction.
b) Non-Eskom production estimated as the same as 1997 production.
c) 1997 is the most recent year for which non-Eskom electricity production is available. From 1997 to 1998 Eskom's production of electricity decreased by 0,4 per cent.
d) While pumped storage contributes to gross energy production, it is, in fact, a net user of electricity.

Eskom's coal-fired power stations generally exhibit high thermal efficiencies for this technology. Average efficiencies have consistently been over 34 per cent for the past six years, despite the use of low quality (high ash) coal and the use of dry-cooled technology which is generally slightly less efficient than wet-cooled stations.

The average age of Eskom's operational power stations is 14 years (weighted by capacity) – this figure is heavily influenced by several large stations constructed in the 1980s. Eskom's moth-balled stations are 30 years old on average and would typically have lower than average thermal efficiencies.

South Africa is known for being one of the world's low-cost producers of electricity world-wide. At the beginning of 1997, Eskom, the electric utility had the lowest industrial electricity tariffs in the world. At 2c/kWh, South Africa was followed closely by only New Zealand at 2,5 c/kWh (SANEA 1998). This could be attributed to a number of factors. First, South Africa's endowment with vast quantities of coal, coupled with plants situated near the mines, presents a significant cost advantage. Secondly, Eskom's key customers contribute more than 80 per cent of its sales revenue; these customers are both less expensive to serve and are generally in a position to negotiate favorable prices. Thirdly, as a parastatal enterprise, Eskom has not traditionally paid tax or dividends to government. This is likely to change with the new energy policy and revised Eskom Act (DME 1998b). Finally, the price of electricity has never included any part of the environmental and social impacts of electricity generation, which are the subject of this report.

2.1.3 General methodological issues

The generation of electricity produces various pollutants that could impose costs on society, individuals and the environment. These pollutants include air and water pollution as well as solid and/or toxic wastes. The identification and quantification of these pollutants, and the assessments of their impacts, both monetary and non-monetary, are important elements in a broader economic analysis of their benefits and costs of various production alternatives. In addition, information on the costs of pollution is also important for making policy decisions about what level of pollution may be economically justifiable and environmentally benign.

An externality is any impact on a third party's welfare that is brought about the action of an individual and is neither compensated nor appropriated (Pearce & Warford 1993). In the electricity sector this can occur where a power plant emits pollutants or waste products which, in turn, impact upon human health or the environment, where the costs of those impacts are not captured in electricity prices, and those who bear the costs are not compensated in any way (Van Horen 1996:11). . These external costs, however, are often costs actually incurred, such as medical costs, and not simply intangible changes in human welfare.

The basic approach taken in this analysis is to assess the damage costs of various externalities along what is called an impact pathway. An impact pathway begins with direct emissions or resource impacts, and relates them to changes in environmental quality. Individual health or environmental impacts are related to changes in environmental quality through a dose-response function. This function specifies the impact (eg deaths or lost work days) for a given change in environmental quality. These impacts must then be valued to convert them into monetary units. Valution issues are discussed in more detail in Section 2.3. Finally, these monetary impacts must be aggregated across individuals and time. Additional methodological discussion is presented under each impact described in the next sections.

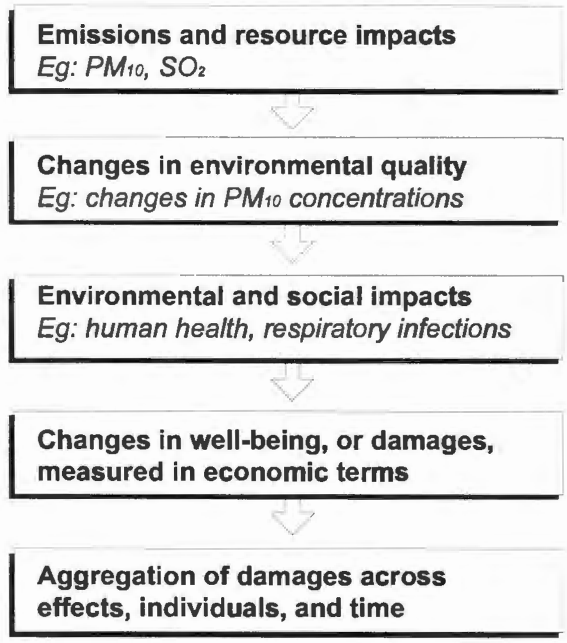

Figure 3.4: Damage function approach for estimating external costs

Source: Van Horen (1996b)

2.2 Externalities of coal fired electricity generation –

The production of electricity entails a wide variety of potential environmental and social impacts. Several major studies in North America and Europe have attempted to identify and quantify those impacts (reviewed in Van Horen 1996b), which inform this research in South Africa. This section will focus on identifying the emissions or resource impacts of electricity generation, while Section 2.3 will address valuation issues to provide external cost estimates.

2.2.1 Air pollution and human health

Air emissions from coal fired power stations are significant, as coal used in South Africa's power stations is generally of relatively poor quality with an average of 28 per cent ash content. Particulate emissions and ash production, if very high, could thus pose a danger to human health without environmental management initiatives undertaken by Eskom. The most important health impacts of airborne emissions (particulates, sulphur dioxide and nitrogen oxides) are illness and deaths associated with various respiratory disorders. To evaluate, we first look at overall emissions from Eskom's plants, as well as apparent changes in environmental quality.

To link air emissions to human illness requires an understanding of the air dispersion patterns, human exposure to environmental quality risks, and the dose-response functions that relate human health to environmental quality. Because most of this research has only been done in

North America and Europe, Van Horen (1996b) used a model developed in the United States for this purpose, called EXMOD (see Rowe et al 1994). Van Horen used South African wind and population data, and plant-specific data on emissions and stack characteristics from Eskom, combined with the dose-response functions in EXMOD, to arrive at estimates of human health impacts. We review some recent trends in emissions below, and update the damage cost figures under the valuation section.

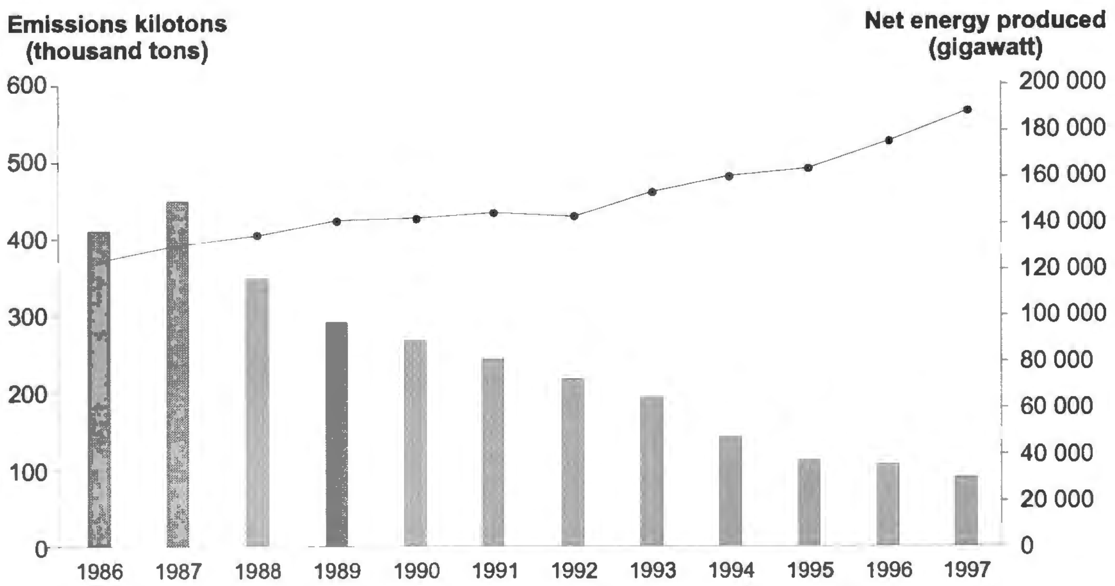

Figure 2.5 : Total particulate emissions and electricity production

Source: Eskom (1997)

Figure 2.5 shows that total particulate emissions have been reduced by 91 per cent over the last 15 years and relative emissions have been reduced to 14 per cent of 1986 levels by commissioning new plants and modifying existing plants for better efficiency. Even from 1996 to 1997, total particulate emissions decreased by 25,6 per cent and relative emissions by 30 per cent. Matimba power station (the winner of the 1997 environmental award) reduced its relative emissions to 22 per cent of the 1993 levels. All power stations have electrostatic precipitators, for example, and newer stations are being equipped with bag filters as well. Total sulphur dioxide and nitrogen emissions have been increasing (see Figure 2.6, but relative emissions (emissions/kWh) have still declined. The impact of all of these pollutants has been reduced, however, by Eskom's policy of high stacks, which help to disperse emissions more widely (Annegarn 1997).

Relative and total emissions from each power plant in 1994 are shown in Table 2.2. This data will be updated to 1997 for the final report, including comparisons between the two years.

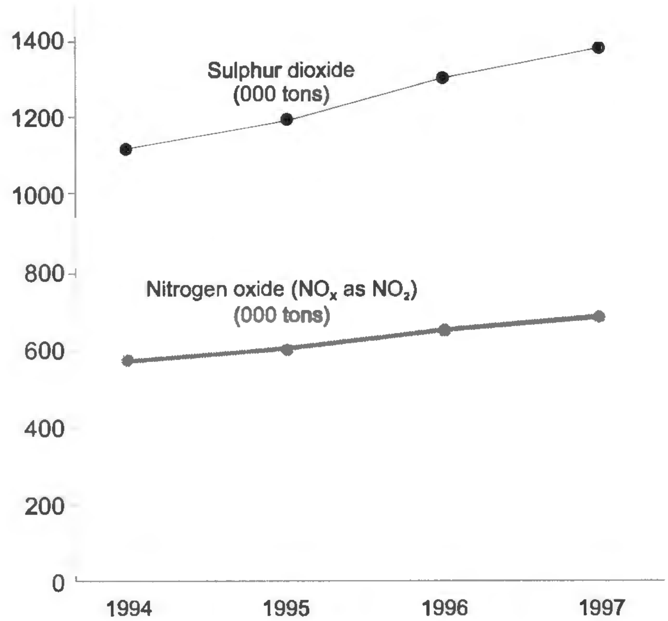

Figure 2.6: Total sulphur and nitrogen emissions

Source: Eskom (1997)

Table 2.2: Emissions from Eskom power plants (1994) – to be updated

Power plant	*Bag filters*	*TSP emissions*		*SO_2 emissions*		*NO_x emissions*	
		kt	*kg/MWh*	*kt*	*kg/MWh*	*kt*	*kg/MWh*
Arnot	3 (6) units	11,00	2,41	35,8	7,86	26,3	5,77
Duvha	3 (6) units	8,17	0,37	180,3	8,21	136,7	6,22
Hendrina	none	49,70	4,19	90,5	7,62	72,9	6,14
Kendal	none	4,63	0,24	167,8	8,65	123,2	6,14
Kriel	none	10,56	0,79	103,9	7,76	126,5	9,44
Lethabo	none	5,45	0,31	123,0	6,89	143,1	8,01
Matimba	none	22,58	1,00	193,8	8,54	92,4	4,07
Matla	none	4,54	0,24	149,4	7,97	130,9	6,99
Tutuka	none	5,79	0,33	122,2	6,97	108,9	6,21
Majuba		?	?	?	?	?	?
Total/av.		122,42	0,84	1166,7	7,88	960,9	6,49

While newer dispersion models have recently been developed that more accurately characterise the conditions of the Highveld (see Enslin et al 1998), it has not been possible to integrate these into an externality model during the course of this study. In the valuation section below we can therefore only adjust for overall emissions changes since 1994.

2.2.2 Air pollution and acidification

A major concern with sulphur emissions from coal-fired power stations has been the potential for acidic deposition on the scale of the 'acid rain' problems in Europe and North America. Acidic deposition can impact directly on human health, corrode materials, reduce crop yields, and also causes eutrophication in fresh water bodies (Cinderby et al 1988). Early studies focused on the Mpumalanga (then Eastern Transvaal) Highveld, where the concentration of power stations and industrial facilities is high and the atmospheric conditions unfavorable (Tyson et al 1988). More recent research has revealed, however, that this is not a large problem currently because of the much greater area over which these pollutants are dispersed than was previously supposed. Annegarn (1997) notes, for example that the large area over which these pollutants travel – several thousand kilometres from their source – disperses them to a level that is not a major health hazard. Enslin et al (1997) have taken up modelling this dispersion in the region, but the results have not yet been incorporated into an externality model such as EXMOD.

The degree to which acidic deposition is likely to become a problem in the future depends on emissions levels and concentrations, dispersion patterns, and sensitivity acidic deposition. A joint study by Eskom and CSIR Forestek (TRI 1994) also showed that atmospheric concentration of pollutants is not as high as initially suspected. As part of a global study on acid rain sensitivity and risk, the Stockholm Environment Institute rated the likelihood of significant acid damage in Southern Africa as relatively low until 2050 (Cinderby et al 1998). Although local damage could occur before then, that was the period in which many pollutants were expected to reach critical levels. Part of this result is also based on the fact that many South African ecosystems are not as sensitive to damage from acidification as are the tropical and hardwood forests that cover Central Africa, Europe, Eastern China and other hard-hit areas.

In the longer term, air pollution and acidification are likely to present both national and regional environmental problems – although probably more from low-stack-height sites than from power stations. Because this risk is lower in the short term, no attempt has been made to value these external impacts.

2.2.3 Water consumption and pricing

There are three different concerns about water use in power stations. First, power station water use could degrade the quality of water in the receiving body or other nearby water sources. This could include the pollution of ground water in coal fields through coal mining and waste disposal. Sulphate and sodium are common pollutants within the mining environment. Eskom has installed monitoring systems at all coal-fired power stations since 1984 (Eskom 1997). In addition to ground water pollution, there have been several incidents of surface water pollution. These included ash spills from leaking pipes, overflowing pipes, spillage resulting from pump failures and cooling tower spills. Eskom has adopted strict policies, however, regarding the quality of water the water it returns to the environment and strives towards a 'zero effluent' water policy, which means that the quality of water it returns to rivers and dams must be at least as good as the water it draws from the sources.

The second potential externality is related to the quantity of water required by power stations; this is quite large in comparison to many river supply systems, raising concerns about total water consumption in water-scarce catchment areas. Chapter Three of this report deals with Eskom's total water consumption in each catchment area compared to the DWAF allocation, and how that might be affected by new water management regimes. Trends in water consumption by plant are also addressed in that chapter, including the importance of new dry cooling technology, so will not be detailed here.

The third area of concern is the price that Eskom pays for water, and whether these prices reflect the true opportunity cost of water. The cost of supplying water is primarily dependent on the capital costs of constructing the necessary infrastructure, and then on the operating and maintenance costs. If historic costs are used as a basis for water pricing, and the capital infrastructure was constructed some time ago, then the price of water will be much lower than the cost of supplying an additional unit of water today (ie the marginal cost). Although research on the total opportunity cost of water is limited, it is unlikely that current prices to Eskom reflect marginal costs (although this is changing, as described in Chapter 3). The value of this external cost is estimated in Section 2.3.4.

2.2.4 Greenhouse gases and climate change

The last decade has seen significant advances in both understanding human-induced climate change and negotiating internationally on the issue. While South Africa's total emissions of greenhouse gases are tiny relative to the global total – carbon dioxide emissions from fossil fuel combustion are 1.4 per cent of the world total – emissions per capita are on par with some industrialised countries. More striking is fact that carbon emissions per unit of economic output (the 'carbon intensity' of the economy) is almost triple that of the OECD (IEA 1998). This reflects the predominance of coal-based power production and energy-intensive heavy industry in South Africa, as well as the relative inefficiency of some sectors. South Africa's reliance on abundant coal for electricity generation, for example, results in emissions per kWh considerably higher than many industrialised economies (NRDC/PSEG 1998). Because electricity is a vital input for many major industries in South Africa, Eskom's share of total

South African greenhouse gas emissions is relatively high. For 1988, Sholes and Van der Merwe (1995) report that electricity emissions are 43 per cent of total carbon dioxide emissions, which in turn make up two thirds of South Africa's contribution to greenhouse gas emisisons. The draft emissions inventory from South African Climate Change Country Study has yet to be finalised, but suggests that electricity supply sector's emissions in 1990 were almost 40 per cent of the total national emissions of all greenhouse gases (van der Merwe & Scholes 1998). In 1997, Eskom's total emissions of carbon dioxide from fuel combustion were 169 Mt (Eskom 1997). The potential damage costs associated with those emissions are discussed in section 2.3.5.

2.2.5 Environmental benefits of electrification

The mass electrification programme has been one of the most successful elements of the South African Reconstruction and Development Programme. Initiated by Eskom in 1991, and included as a key government programme after the 1994 elections, the programme has brought electricity to over 2,5 million homes, increasing the share of South Africa's population with access to electricity from 35 per cent in 1990 to 63 per cent at the end of 1997 (Eberhard & Van Horen 1995; DME 1998). Annual connections by Eskom and local government are shown in Figure 2.7. One of the drivers for the electrification programme has been the need to provide 'cleaner' and 'safer' forms of energy for low-income households: burning coal and wood indoors causes high levels of indoor air pollution, and paraffin use is linked to poisoning of children and accidental fires common in many urban townships. As households increase their consumption of electricity, so they will reduce – but generally not eliminate – the consumption of other household fuels. This process is complex, involving many social and cultural as well as economic factors (Mehlwana & Qase 1999; other SD reports), but nonetheless is likely to have significant environmental and health benefits for low-income households.

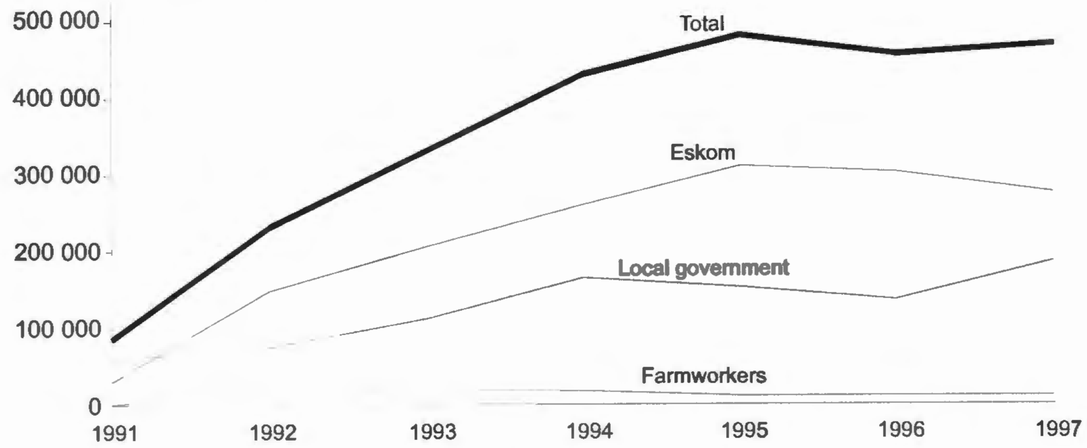

Figure 2.7: Yearly connections completed by local government and Eskom

One approach to valuing the environmental benefits of electrification would be to track the incidence of various health impacts (such as on respiratory illness and paraffin poisoning) in areas that were electrified over the past five years. The total impact of electrification would be the aggregate changes in illness levels times the valuation for individual morbidity and mortality. While this approach is appealing because it tracks actual illness data, it would require significant epidemiological research to cover the wide range of areas and communities that have been electrified. Furthermore, there is no way (without complex statistical analysis) of distinguishing between health effects from reduced indoor coal burning, for example, and effects of changing nutrition, demographics, primary health care levels or other factors.

A second approach to valuing the environmental benefits of electrification is to relate external costs to household fuels use, and estimate how those fuel-use patterns will change over time as a result of electrification. This approach is based on an assessment of the current environmental and health impacts of household fuels, taken from the damage cost analysis of van Horen (1996a). The assumption is that, as fuel use patterns change over time after electrification, external costs will change as a function of fuel consumption.[3] The change in fuel-use patterns will obviously vary from rural to urban areas and between the major geographic regions of the country, so several models of 'typical households' are required to estimate the national impact of electrification. Each step of the analysis is described in more detail below, beginning with fuel use patterns by region, and then electrification statistics and household external costs.

3 To be more accurate, some of the external costs should be regarded as fixed rather than variable costs. This is because there is a certain risk associated with using certain fuels (such as paraffin) independent of changes in monthly consumption. This fixed cost share is likely to be small, however, and, given the other uncertainties in the analysis, does not merit explicit modelling.

2.2.5.1 Baseline fuel use patterns

For the purposes of this analysis, two different divisions of newly electrified households are relevant. The first distinction is urban versus rural, particularly because of the proportionally higher use of fuelwood in rural homes. The second distinction is regional, again based on the different fuel use patterns: most importantly the higher use of household coal in Gauteng and Mpumalanga. For simplicity, this analysis divides urban South Africa into three regions: high coal-use areas (Gauteng/Mplumalanga), high paraffin- and gas-use areas (Western Cape/Northern Cape/Eastern Cape), and all other provinces (see Simmonds & Mammon 1996). Typical fuel-use patterns for rural areas are drawn from Davis and Ward's (1995) analysis of the Project for Statistics on Living Standards and Development Survey (SALDRU 1995).

Fuel-use patterns are related to access to fuels, affordability of different energy sources, and a wide range of social and cultural factors – all of which are dynamic in the changing political and economic environment in South Africa (Mehlwana & Qase 1999; Bank et al 1996; White et al 1996; Jones et al 1996). In urban unelectrified areas, coal tends to dominate in areas where it is accessible and inexpensive, while paraffin and to a lesser extent gas may replace it in areas further from the coal fields. This is particularly true for the energy-intensive uses such as cooking and space-heating. Figure 2.8 below shows the weighted estimated monthly household energy consumption for *unelectrified* households in four major urban areas broken down by fuel. Figure 2.9 shows the same estimates for *electrified* households. For this study, the 'urban coal' and 'urban paraffin and gas' regions correspond to Johannesburg and Cape Town, respectively, while the 'urban other' region is an average of Durban and Port Elizabeth. Note that most surveys only report fuel consumption *for houses that use that fuel*, so to get average fuel use across a population group, we have weighted the survey consumption data by the percentage of households using a given fuel (based on Simmonds and Mammon (1995)).

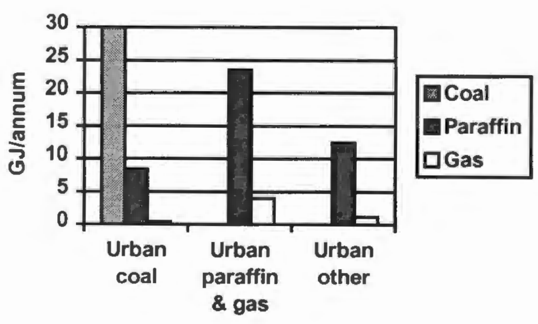

Figure 2.8: Estimated average monthly energy consumption by fuel in unelectrified urban households

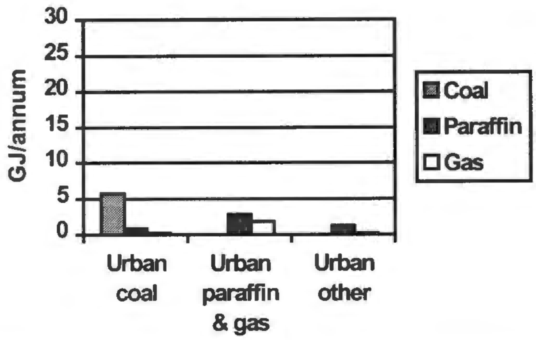

Figure 2.9: Estimated average monthly energy consumption by fuel in electrified urban households

Energy-use and fuel-use patterns in rural areas are more difficult to characterise because of the wide range of geographical areas. Wood is one of the most widely used fuel sources – both collected and purchased – along with paraffin, and to a lesser extent coal and gas (Davis & Ward 1995). Because most households collect wood, rather than purchase it, however, consumption data is difficult to obtain, and data on consumer expenditures will tend to underestimate total wood use. Figure 10 shows the estimated energy expenditure for *unelectrified* and *electrified* rural households (Davis & Ward 1995). What is striking about the comparison is that expenditure on wood and coal does not appear to be significantly lower in electrified homes. There are several reasons for this. First, the sample of electrified homes could also have higher average incomes and so be able to afford greater energy expenditure. Secondly, once households have electric lighting, family activities during the evening may actually increase, so that fuel-use for cooking and space-heating in the evening may increase. Thirdly, households may not be able to afford new electric appliances, nor will these serve the same social and cultural purpose as wood and coal fires (Mehlwana 1999). Davis and Ward conclude that electricity may primarily replace paraffin, rather than wood and coal, in the early years after electrification.

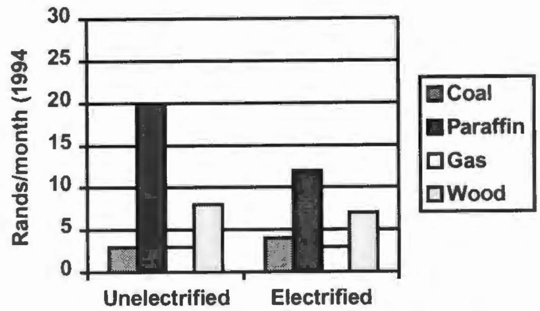

Figure 10: Average monthly energy expenditure by fuel in rural households – electrified vs unelectrified

2.2.5.2 Evolution of fuel-use patterns after electrification

One of the main lessons from the research on the electrification programme over the last five years is that households do not automatically switch to electricity for all uses after electrification. Five years after electrification, average household monthly consumption is only 138 kwh (NER 1996). While households will continue to need a similar amount of delivered energy for cooking, lighting, space-heating, and other purposes, they many substitute electricity for traditional fuels only gradually over time (and as income levels change). For this analysis, we create a 'typical household' for each region that includes assumptions about how fuel use changes after electrification. We assume that over the course of ten years, fuel-use patterns in *newly electrified* households should approximate those for *established electrified* households. This is because most of the basic data behind this research was collected in the early 1990s, before the mass electrification programme, so those homes classified as electrified had had access to electricity for many years. Although total delivered energy consumption could also rise over the period due to increased incomes, there is insufficient data to incorporate this into the model (and income growth is likely to be modest in the short term, in any case). Furthermore, because we want to show the decrease in local externalities related to non-electric fuels, we have not estimated electricity consumption for each housing group.

Figure 11 shows an example for a household in the urban coal group, indicating annual consumption of non-electric fuels in year 1 and year 10. Similar estimates were made for the other regional household groups. Note that, as with the previous figures, these consumption figures are average for all households. In other words, if only 10 per cent of homes use gas, and those that do use it use 14 000 MJ, then the average for all homes is 1 400 MJ per year.

The annual fuel savings are calculated as the consumption before electrification less consumption in a given year. These fuel savings are then used to calculate the reduced environmental impacts in Section 2.3.6.

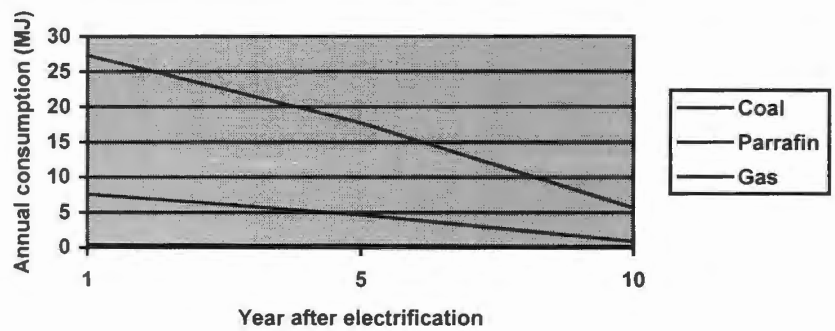

Figure11: Estimated change in fuel use patterns in 'urban coal' region

2.2.5.3 Electrification statistics

The electrification programme has made fastest progress in urban areas, where access is nearing saturation, while rural areas – particularly remote rural areas – are still largely unelectrified. As of the end of 1996, for example, 73 per cent of urban households had electricity, but only 21 per cent of rural households (NER 1996 – get 1997/8 numbers). Table 2.3 shows the annual electricity connections established in the three regions used for this analysis – the sum of the provincial electrification statistics aggregated as described above. Only connections through 1996 are shown, because we will evaluate the impact in 1997, when the 1996 homes will be one year out from electrification.

Table 2.3: Estimated annual electricity connections by group

Region[a]	1991	1992	1993	1994	1995	1996
URBAN						
High coal	12 300	34 800	49 700	65 200	71 600	67 941
Paraffin & gas	9 300	26 300	37 600	49 300	54 200	51 414
Other	11 700	32 900	47 000	61 700	67 800	64 268
RURAL	49 100	138 500	197 700	259 500	285 100	270 372
Total	82 470	232 555	331 909	435 756	478 767	453 995

Notes:
Provinces included are described in the text

a. Share of urban connections estimated based on 1996 data (NER 1996), as is rural-urban split; totals for 1991-1996 from NER (1997A).

For each year, the fuel-use pattern model is applied to the number of households in that region that are electrified. In 1995, therefore, homes electrified in 1993 are in 'year 1' after electrification, while homes electrified in 1994 are in 'year 1'. The aggregate changes in fuel use patterns are then linked to changes in environmental and health impacts in Section 2.3.6.

2.2.6 Subsidies to the nuclear industry

While van Horen (1996b) discussed the health and environmental risks of nuclear power generation in South Africa, insufficient data was available to place any value on this risk. On the other hand, the nuclear industry has traditionally been heavily subsidised by government, resulting in a 'fiscal externality'. Although Eskom's Koeberg power station never received a government subsidy, the overall nuclear industry received significant subsidies. The Atomic Energy Corporation (AEC), Council for Nuclear Safety and the former Nuclear Development Corporation (Nucor) for example, received 70 to 80 per cent of the Department of Minerals and Energy Affairs budget during the 1980s. More recently, with the closing down of nuclear fuel production and other aspects of the nuclear industry, these subsidies have declined considerably. In the 1998/99 budget for the Ministry of Minerals and Energy, for example, 44 per cent goes to the AEC and one per cent to the CNS (DME 1998a). It is difficult to judge whether this should be considered a subsidy that also benefits electricity. On one hand, Eskom no longer buys fuel domestically with government support (although this was more expensive than buying on the international market), and does not directly receive any funding from the AEC. On the other hand, the main reasons for funding the AEC, now that the nuclear bomb programme has been discontinued, are to promote the nuclear power and nuclear materials industries. Further discussions with government and analysts will be required to decide how and whether to allocate any of this funding to external costs in the power sector.

2.3 Valuation of environmental and health impacts

Both environmentalists and economists find it extremely difficult to assign monetary value that fully captures the worth of environmental resources or social costs for several reasons. First, there is uncertainty or lack of availability of physical estimates of environmental effects. Secondly, many environmental and human health 'goods' do not have market prices, so values must be estimated indirectly. Converting those impacts into monetary values involves not only complex methodological choices, but often touches on value judgements as well. A number of different approaches to valuation are used here, depending on the nature of the externality in question. In general, market costs are used wherever possible because of the lack of non-market valuation studies in South Africa. The non-market valuations draw on the international literature, adjusted for South Africa's economic situation, as described in the next section.

2.3.1 Mortality valuation – methodology and data

Valuing the risk of loss of life is one of the most challenging and controversial tools in environmental economics. An important distinction is that environmental economics does not attempt to *value life*, but rather to understand what resources society would spend to *reduce the risk of loss of life*. Individuals, firms, and governments make decisions every day about what kind of risks are acceptable, or what level of compensation is or would be sufficient to offset increased mortality risks. A review of the methodologies for valuing risk of loss of life is beyond the scope of this report. Given that no large-scale primary valuation studies linked to the environmental impacts of energy have been conducted in South Africa (that is, where individuals are asked their willingness to pay to avoid loss of life, or willingness to accept compensation), this analysis draws on two major European and North American studies (Rowe et al 1994, ETSU 1995).

Using international studies in a South African analysis entails transferring the valuation placed on loss of life to a country where the incomes are significantly lower. The concept of 'benefits transfer' involves adjusting willingness to pay or willingness to accept values between groups (nations, regions or even social groups) based on some measure of income. This concept and practice is not without controversy, as outlined for the climate change debate by Fankhauser, Tol and Pearce (1997). For the purposes of this analysis, we have not made new estimates of morality valuation, but rather adjusted the results of the earlier industry analysis (van Horen 1996) to reflect changes in inflation, population, and emissions levels. Implicitly, however, these estimates still rely on mortality valuations from international studies applied to South African per capita GDP.

2.3.2 Morbidity valuation – methodology and data

The valuation approach of morbidity adopted in this study is based on the opportunity cost approach. Thus the valuation of health effects generally includes actual expenditure on health care (both private and public), transport costs, medication and foregone time such as lost time at work. This approach is sometimes called the 'cost of illness' approach. As with mortality, rather than recalculating the valuations for each illness, we have adjusted the earlier results from Van Horen (1996) to reflect the changes in the South African economy and environment since that study was completed. For a detailed breakdown of the cost of illness, see Van Horen, Appendix 2.

2.3.3 Air pollution and human health

The results of the EXMOD environmental impacts model and valuation of damages related to human health were updated for three factors. First, total sulphur dioxide emissions – the most important contribution to health impacts according to earlier studies – have increased 18 per cent from 1994 to 1997 (Eskom 1997). At the same time, the population exposed to pollutants has also increased. Ideally, we would adjust the damages by population growth in the most affected areas only (largely northern and eastern South Africa). For this analysis, however, the national population growth of 6.7 per cent from 1994 to 1997 is used (Statistics South Africa 1998). More detailed population growth data will be included in the final report. Finally, the estimates in 1994 Rands were inflated to 1997 Rands. The results are presented in Table 2.4 below. In addition, electricity production by plant was not available by plant, so only total damages are shown, not damages per kWh.[4]

[4] Follow-up work includes: kWh generation by plant, 1997; more detailed population estimates for affected areas.

Table 2.4: Estimated health costs for air pollution from electricity generation by plant, 1997

	Low (R/m)	Central (R/m)	High (R/m)
Arnot	27.0	34.0	40.0
Duvha	134.0	190.3	237.5
Hendrina	108.6	139.1	164.3
Kendal	145.9	200.0	245.6
Kriel	112.9	164.3	208.2
Lethabo	138.1	188.7	230.9
Matimba	65.1	83.6	99.2
Matla	125.2	178.9	224.4
Tutuka	90.9	130.3	162.6
Majuba	12.1	16.6	20.4
Total	959.8	1325.7	1633.1

2.3.4 Water consumption and pricing

To assess the external cost associated with the under-pricing of water resources, we must establish and opportunity cost for water in each catchment area. Van Horen (1996) used early estimates of a national opportunity cost, but water policy has changed considerably since that time (see Chapter 4 of this report). At the time of writing, no new estimates of opportunity cost were available, nor was information provided by Eskom about prices paid for water at each power plant. Without this information, it will not be possible to include this externality in the overall assessment.[5]

2.3.5 Greenhouse gases and climate change

Estimating the damage costs associated with greenhouse gas emissions is an exceedingly difficult task for a number of reasons. First, greenhouse gases remain in the atmosphere for a long time, so changes in environmental quality and resulting damages are not only related to current emissions but also to past emissions. Second, the general circulation models used to estimate the relationship between emissions, changes in the GHG concentrations, and resulting climatic changes, are a relatively young science and contain a high degree of uncertainty. Third, translating climatic change into specific impacts (such as sea level rise, or changes in agricultural productivity) is also highly complex, and many studies do not consistently address global changes but look only at one region. Fourth, placing an economic value on these impacts, particularly illness and the potential loss of human life involves assumptions about

[5] Follow-up work includes: better estimates of opportunity cost of water; Eskom 1997 water usage and prices by plant.

how society and individuals value risk and raises significant theoretical hurdles. Finally, aggregating damages across time and across countries implicitly involves judgements about intergenerational equity, the importance of damage to poor versus wealthy communities, and the relative purchasing power of different currencies (Fankhauser & Tol 1997; Fankhauser & Tol 1996; Fankhauser, Tol & Pearce 1998; Fankhauser, Tol & Pearce 1997).

The Intergovernmental Panel on Climate Change 1995 report on the economic and social dimensions of climate change reviewed a range of studies on the damage costs of climate change. The authors did not provide a best guess, but simply noted a range of US$5-125 per ton of carbon reported in the literature, stressing the uncertainty of these estimates (Pearce et al 1996). For the purposes of this analysis, we will draw on one of the studies covered by the IPCC survey (Fankhauser 1995). The estimated marginal damage costs from that report were US$22,8 per ton carbon in 2001-2010 and US$25,3 in 2011-2020, for an average of US$24. To convert this to damage per ton of CO_2, we multiply by the relative weight of carbon to CO_2 (12/44), for $6,5 per ton of CO_2. We use this value as the central estimate for the damage cost. Fankhauser (1995) also calculates a 90% confidence interval for climate change damages from US$7,9 to US55,7 (average of two periods), which will be used for the low and high estimates of damage costs (US$2.1 and US$15.2 per ton of CO_2, respectively). These results were reported in 1990 US dollars, so they must be inflated to 1997 currency and converted to Rands. This yields low, central and high estimates of R13, R39 and R92 per ton of CO_2, respectively. Estimates of damage costs from greenhouse gas emissions are presented in Table 2.5.

Table2.5: Estimated damage costs from greenhouse gas emissions (1997 R m)

	Low	*Central*	*High*
Greenhouse gas damages	2199	6649	15549

Note that the damage estimate per ton of carbon is not specific to emissions in South Africa. The damage costs above are not costs that South Africa will necessarily incur, but a share of the global damages caused by carbon emissions. Greenhouse gas emissions are uniformly mixed in the atmosphere, so that the impact on any given country is related to the total emissions of all countries. Even if South Africa eliminated all greenhouse gas emissions, it would still suffer the impacts of climate change unless all other countries acted similarly. Therefore, although this external cost does reflect real damages in the future, control measures that only affect South Africa will not be effective in reducing this damage. South African climate change policy must be coordinated with the international negotiations and actions in other regions to effective reduce these risks.

2.3.6 Environmental benefits of electrification

2.3.6.1 External costs of household fuels

Van Horen (1996b) investigated the external costs of household fuels using a damage cost approach, and focusing mainly on health impacts. The impacts quantified included the following categories:

- mortality and morbidity from air pollution from coal and wood combustion;
- mortality and morbidity from accidental paraffin poisoning of infants;
- mortality and morbidity from fires and burns caused by paraffin and candles;
- social costs of fuelwood scarcity;
- greenhouse gas emissions from household energy sources.

These external costs are therefore the costs that can be *avoided* through electrification and the substitution of electricity for other household fuels. Of course, the use of electricity also releases air pollution and greenhouse gases, but this is captured in the other externality categories in this report; in this section we are only concerned with the avoided external costs from fuel substitution. Also note that the social costs of fuelwood scarcity (calculated based on the opportunity cost of the increased time that women must spend gathering wood) is not a health impact but is an important effect of household wood consumption that is not captured in the prices of fuelwood and is therefore an external cost. A summary of the values from Van Horen's study, adjusted for inflation, is presented in Table 2.6. There was not sufficient in Van Horen's study to estimate the external costs of household gas use – which are likely to be much lower than for other fuels because of low emissions. For the purposes of this analysis therefore, we have not included an external cost for LPG.

Table 2.6: Summary of external costs of household fuels (1997 Rands/GJ)

Source: adapted from Van Horen (1996b)

	Low	Central	High
Coal	2.07	4.65	8.30
Paraffin[a]	8.99	53.09	132.18
Wood[b]	9.12	33.33	80.80

Notes:

a. includes paraffin poisoning and 30% of costs of fired and burns

b. includes indoor air pollution and the social cost of fuelwood scarcity

2.3.6.2 Environmental benefits per household

Using the data presented in the preceding sections, we first calculate the annual environmental benefits of electrification for each of the typical household groups. An example is presented below in Table 2.7.

Table 2.7: Avoided external cost per 'urban coal' household, Year 1

Fuel	Annual energy savings (MJ)	Avoided external cost – central estimate (1997 R/MJ)	Avoided external cost – central estimate (1997 R)
Coal	2394	0,00465	11
Paraffin	746	0,053	40
LPG	24	-	-
Total	3164		51

2.3.6.3 Aggregating environmental benefits

In 1997, there were households that were electrified in 1991, 1992, and other years, so that each household group is at a different point in their evolution of fuel use patterns. These 'layers' of households must be added to arrive at the total benefit accruing in a given year for the entire country, as shown in Table 2.8 for the central estimate of external costs. Note that even though households electrified in 1991 are further along their energy transition, and thus have higher avoided external costs per households, there were fewer homes connected in the early 1990s that more recently, so the impact of that year class is generally less than 1994 or 1995.

Table 2.8: Central estimate of national environmental benefit from electrification programme, 1997 (R m)

Year electrified	Urban coal	Urban paraffin and gas	Urban other	Rural	Total
1991	4	6	4	4	18
1992	9	14	10	9	42
1993	10	17	11	11	48
1994	10	16	11	10	48
1995	7	12	8	8	35
1996	3	6	4	4	17
Total	43	71	48	46	208

Table 2.9 shows the low and high estimates of environmental benefits for 1997, as well as the benefit per kWh generated. This should only be taken as a rough first pass at these benefits,

given the limitations in the data underlying the analysis. The fuel consumption profiles should still be considered preliminary, and will be refined in the next phase of this study.[6] We have not, for example, been able to include any changes in rural fuelwood use associated after electrification (see Section 2.2.5.1). All of the limitations that apply to the underlying external cost analysis (see Van Horen 1996b) would also apply to this analysis as well.

Table 2.9: Estimated environmental benefits from electrification (1997 R)

	Low	*Central*	*High*
Total (R m)	38	208	510
c/kWh	0.02	0.11	0.27

2.3.7 Summary of external cost calculations

A summary of the external cost calculations, in total and per kWh, is presented in Tables 2.10 and 2.11. Note that water consumption is not yet included due to the lack of data from Eskom and on opportunity costs of water. Because electrification has environmental benefits rather than costs, these results enter into the total as negative costs (that is, benefits), partially cancelling out other costs. These results should only be seen as a first draft of this revised analysis of externalities. The data questions and follow-up actions discussed in previous sections need to be addressed to finalised the estimates.

Total external costs (not including water pricing issues) come to 7,7 billions Rands, with a range of 3,1 to 16,7 billion Rands. On a per unit basis, the central estimate for total costs is 4,1 mills/kWh (0,4 c/kWh), with a range of 1,6 to 8,9 mills/kWh. Average Eskom tariffs to industrial and mining customers are approximately 11 c/kWh, while residential tariffs from Eskom average 23 c/kWh (Eskom 1998). The external costs are then four per cent and two per cent of industrial and residential tariffs, respectively.

Climate change damage costs are the largest category of damages, although it is important to remember that these are global damage costs, not specific to South Africa. The environmental benefits of electrification are significant, at almost 25 per cent of the environmental costs of air pollution from power stations. The benefits of electrification in this analysis are likely to rise with further refinement of the data.

[6] Follow up research includes: better fuel expenditure and consumption data to generate profiles of homes, particularly in rural areas (SAFocus data request); querying the NER database for annual connections by urban and rural region as defined in this paper – 1991-1995.

Table 2.10: Summary of external costs of electricity generation (1997 R)

	Low	Central	High
Air pollution and health	960	1,326	1,633
Water consumption	-	-	-
Electrification	-38	-208	-510
Climate change	2 199	6 649	15 549
Total	3 121	7 767	16 671

Table 2.11: Summary of external costs of electricity generation (1997 mills/kWh)

	Low	Central	High
Air pollution and health	5,11	7,06	8,70
Water consumption	-	-	-
Electrification	-0,20	-1,11	-2,72
Climate change	11,71	35,40	82,79
Total	16,62	41,36	88,77

2.4 Policy implications

Given the external costs and benefits identified in this chapter, there are a range of technological and policy options that could reduce the damage costs associated with the electricity supply industry and preserve the benefits. Technical solutions, such as end-of-pipe pollution reduction equipment or alternative power generation technologies, are the subject of the next chapter on environmental mitigation options and costs. Policy options on how to influence technology choices in the electricity and other sectors are presented below, as well as those supporting the electrification programme.

2.4.1 Incorporating environmental costs – why and how

Although from a purely economic perspective, electricity prices should include all of the social and environmental costs associated with electricity production, in practice this is both difficult and potentially in conflict with other social objectives. First, to provide affordable energy for the masses of poor and unemployed people in South Africa will become more difficult if electricity prices increase. So even if internalising externalities were warranted in the overall economy, some provision must be made for the poor through, for example, a poverty or lifeline tariff. On the other hand, keeping prices of good such as electricity low tends to disproportionately benefits those who use the most – higher-income households and industry.

The second argument about electricity prices relates to whether in industry low prices are a strategic advantage that South Africa should exploit to bolster international competitiveness. Electricity-intensive industries such as the large aluminium smelters in South Africa are highly sensitive to any changes in electricity prices, and form the core of government spatial development initiatives designed to promote economic growth. The sustainability of such a strategy in the long run, however, is less clear. While South Africa does have abundant coal resources, domestic and international pressure and standards are moving towards more environmental controls, not less. If the large, long-term investments in the patial development initiatives are not able to adapt to the increased costs associated with environmental regulations, then their contribution to macroeconomic growth could be in jeopordy. (These issues are discussed in more detail in the paper for this project on *Manufacturing and economic growth* by Martine Visser.

Finally, we should stress that implementing pricing policies in the electricity industry that reflect economic and social costs would have to be accompanied by a similar policy in other sectors. It would not make sense to only increase electricity prices, when the prices of oil, gas and coal also do not reflect the significant external costs associated with these fuels.

2.4.1.1 Integrated resource planning

Including external costs in prices is not, however, the only policy tool available to incorporate environmental impacts into decision making. In industrialised countries, particularly the United States, the use of integrated resource planning (IRP) has been an important step in environmental regulation of public utilities.

IRP is an electricity planning methodology that integrates supply and demand side options for providing energy services at a cost that appropriately balances the interest of all stakeholders (Swisher et al 1997). It was developed in the United States in the 1980s and built on earlier electricity planning, the main objective of which was to provide a cheap and secure supply to meet the electricity demand, taking that demand as a given. IRP involves evaluating a much wider range of supply- and demand-side options to meeting services, and incorporating environmental impacts into that decision-making process. External costs can, for example, be added to financial costs when making a decision about resource selection in IRP, even without adding the external cost to the price of electricity. This can encourage socially optimal resource selection without such significant price increases. Note that while there is massive scope for increasing the efficiency of electricity use, and thereby reducing environmental impacts, this is beyond the scope of this paper focused on electricity supply. Other papers for this project on manufacturing and mining will address some options for energy efficiency and demand side management.

The Energy White Paper states that decision making in the electricity sector will be guided by IRP under the supervision of the National Electricity Regulator (NER) (DME 1998b). Eskom has already had an Integrated Electricity Planning process underway for several years, of which IEP7 is the latest planning document. This process has increased the range of demand-side management projects included in Eskom's planning, but environmental impacts have not been fully incorporated into the system. Moreover, in contrast to earlier plans, as of IEP7 the planning documents are not available to the public, so Eskom is not directly accountable to their customers or the public about investment decisions and their environmental impacts. The NER will be reviewing the plans, but it is unclear whether anyone outside the NER will be given access.

2.4.2 Importance of electrification funding

The environmental benefits of electrification point to the need to safeguard the funding and timely implementation of this important national programme. In the past, Eskom funded its portion of the electrification programme from internal resources, but did not pay tax and dividends to government. The Energy White Paper lays out a new vision where Eskom will have more of an arms-length distance from government – eventually paying taxes – in preparation for greater competition in the market. Electrification will instead be funded by an electrification levy administered by the NER under the Ministry of Minerals and Energy (DME 1998b; DME 1998a).

Eskom has been highly successful in meeting the electrification targets of the RDP, and this success should not be jeopordised by the changing industry structure and government responsibilities. Great care should be taken to ensure that the new electrification fund can be implemented effectively and that a balance of grid and off-grid electrification connections is appropriate.

2.4.3 Government capacity to monitor emissions

A prerequisite for implementing any type of pollution management legislation is for government to have the capacity to monitor compliance with regulations. In the electricity and other sectors, while co-operative and self-monitoring systems will remain important, government must build the capacity to monitor emissions and other pollutants. This is likely to be one of the key factors influence implementation of the various White Papers on

Environmental Managements, Integrated Pollution and Waste Management and related legislation (see DEAT 1998).

2.4.4 Rationalisation of water pricing

Clearly the imminent rationalisation of water pricing regimes will affect our estimates of the external costs associated with underpricing of water to Eskom. Tariffs to Eskom and supply agreements will be revised in light of new legislation and policy on water management. As indicated in Chapter 4, however, this is unlikely to have an impact on electricity prices in the medium term.

3.

MITIGATION OF ENVIRONMENTAL IMPACTS OF ELECTRICITY: SUPPLY OPTIONS

To be delivered separately

4.

THE IMPACT OF WATER PRICING ON ELECTRICITY PRICES

4.1 Introduction

This component of the WWF project Electricity Production paper had the following two objectives:

- to review water supply agreements for the electricity industry, focusing on Eskom's exposure to changes in the 'market price' for water; and
- to assess the potential impact of the new water pricing regime on electricity prices.

To meet these objectives, the scope of the work included reviewing Eskom's water supply contracts, including sources, prices, and institutional arrangements for supplying water to Eskom's power plants; and considering the influence of water price as an input to the cost of producing electricity. The analysis focuses on the period 1997 to 2004, with 1997 used as the base year.

The following basic assumptions have been made here:

- The analysis has included Eskom's major base load coal-fired power stations, and the Koeberg nuclear power station only; these accounted for 95% of all electricity generated in South Africa in 1996 (Eskom 1997a).
- Only water supply costs have been examined. Cost changes arising from changes in pollution charges related to the generation of electricity (for example, the impact of ash disposal on the water environment) have not been included in this report.

The primary data sources used were as follows:

- Eskom Annual Reports (Eskom 1997; 1998)
- Eskom's Integrated Electricity Plans (5 and 6) (Eskom 1996; 1997b)
- DWAF –Eskom water tariffs (van der Merwe 1999)
- DWAF Water Pricing Strategy (DWAF 1998)

4.2 Electricity generation and water use

4.2.1 Past trends

It is useful to provide a brief review of historical water use in relation to electricity generation. This data is presented in Table 4.1 and its graphical representation in Figure 4.1 shows the trends clearly.

Table 4.1: Electricity generation and water consumption, Eskom

Source: Eskom (1996; 1997; 1998)

	1986	*1987*	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*
Electricity (GWh x 1000)	127	133	139	143	146	149	148	154	160	165	179	188
Water (million kl pa)	229	243	226	227	225	211	209	219	210	211	229	229
SWC (l/kWh)	1,81	1,83	1,63	1,58	1,54	1,42	1,41	1,42	1,31	1,28	1,28	1,22

Note: SWC = specific water consumption.

Although electricity generation increased by 48% from 1986 to 1997, water consumption was the same in 1997 as it was in 1986. This has been achieved primarily through the investment in dry cooling technology for new generation plant.

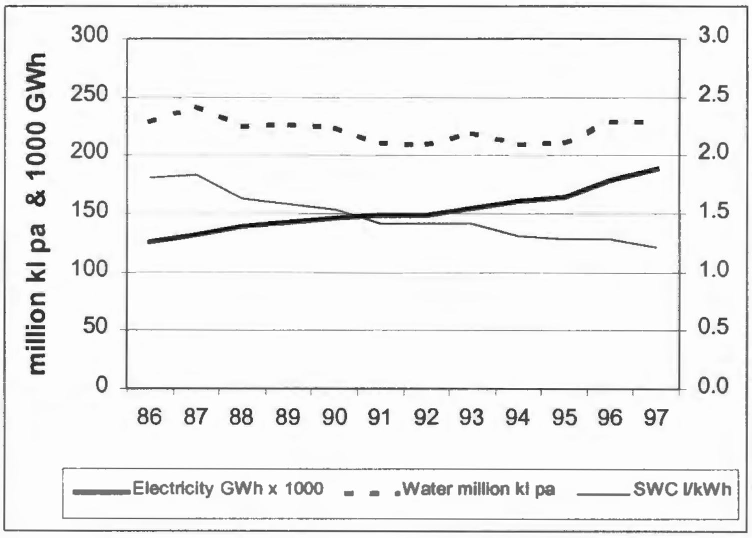

Figure 4.1 : Electricity generation and water consumption, Eskom

4.2.2 Water use and generation technology

The choice of cooling technology has a significant impact on water consumption. This is illustrated in Figure 4.2, which shows the relationship between electricity generation and water consumption of Eskom's operational and mothballed coal-fired power stations. The two lines represent a specific water consumption of two litres per kiloWatt hour (l/kWh) and 0,1 l/kWh.

Water-cooled coal-fired power stations typically consume of the order of 2 l/kWh (efficient ones slightly less, about 1,7 l/kWh), whereas dry-cooled power stations consume about 0,1 l/kWh.

There is a corresponding relationship between specific water consumption and plant age, which is shown in Figure 4.3. Newer water-cooled plants show an improvement in water use efficiency. The most recent plants are dry-cooled with a very significant reduction in specific water consumption.

The key operational statistics of Eskom's major power stations are summarised in Table 4.2.

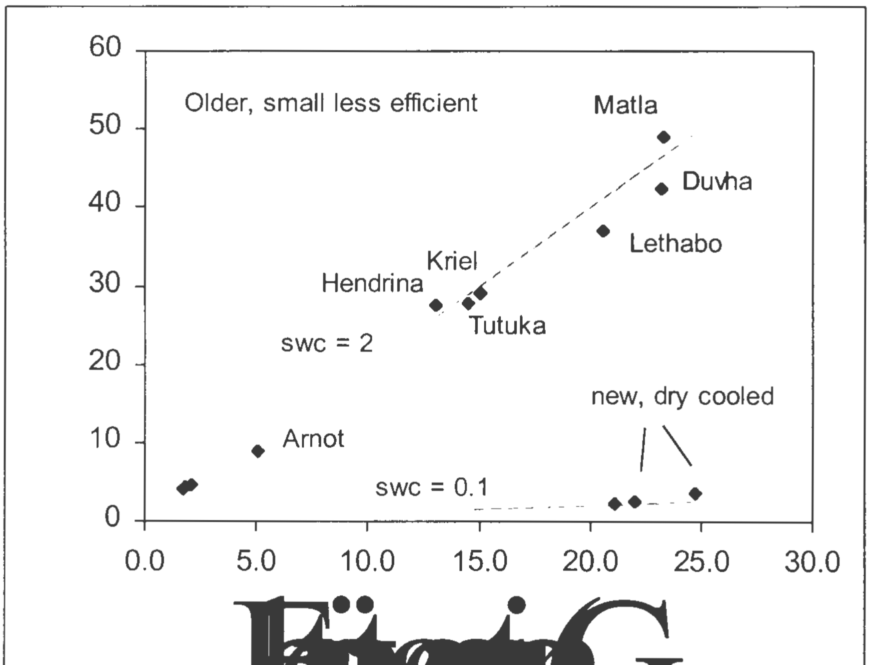

Figure 4.2: Influence of technology on water consumption

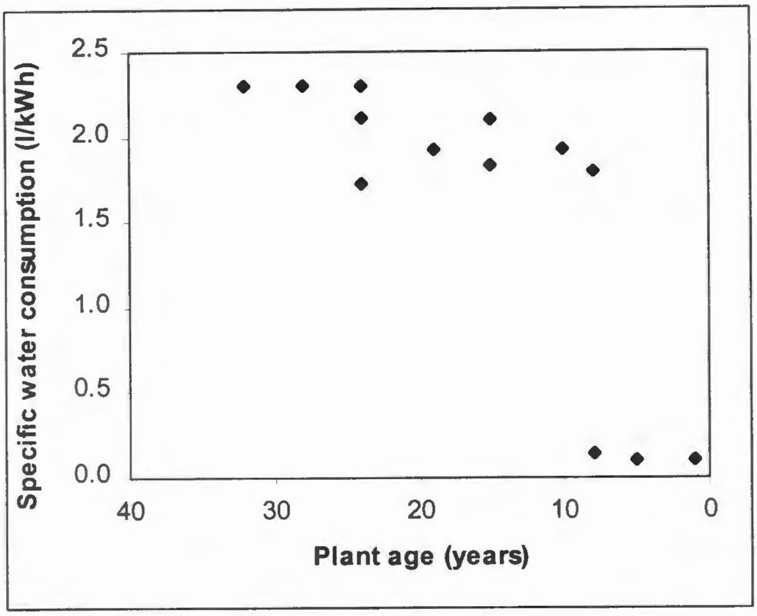

Figure 4.3: Water use efficiency and plant age

Table 4.2: Eskom power stations – key statistics for 1996

Plant	*Capacity*	*Status*	*Cooling technology*	*Age (years)*	*Electricity generated*		*Water consumption*
	(MW) net				*(GWh)*	*(million kl)*	*(l/kWh)*
Majuba*	3 672	expansion	dry	1	21,1	2,32	0,11
Kendal	3 840	fully operational	dry	5	22,1	2,43	0,11
Matimba	3 690	fully operational	dry	8	24,7	3,46	0,14
Lethabo	3 558	fully operational		8	20,6	37,09	1,80
Tutuka	3 510	fully operational		10	14,5	27,82	1,92
Duvha	3 450	fully operational		15	23,2	42,41	1,83
Matla	3 450	fully operational		15	23,3	49,01	2,10
Kriel	2 850	fully operational		19	15,1	29,07	1,93
Hendrina	1 900	fully operational		24	13,1	27,57	2,11
Arnot	1 320	4 of 6		24	5,1	8,82	1,73
Camden	1 520	mothballed		28	1,8	4,25	2,30
Grootvlei	1 130	mothballed		24	2,0	4,70	2,30
Komati	906	mothballed		32	1,7	4,02	2,30

* Data for Majuba is for maximum capacity (plant is being constructed and three out of six planned generating sets are operational).

4.3 Electricity generation and water resources

4.3.1 Overview of water supply to Eskom power stations

The water supply to Eskom's coal fired power stations is summarised in Table 4.3. There are five main river systems which supply water to the Eskom Power stations: the Komati-Olifants River system (which supplies Duvha, Hendrina, Arnot and Komati), the Usutu River system (which supplies Kendal, Matla, Kriel and Camden), the Usutu-Vaal system (which supplies Tutuka), and Vaal River system (which supplies Lethabo and Grootvlei), the Slang / Tugela River system (which supplies Matimba) and the Mokolo-Crocodile River system (which supplies Matimba).

Table 4.3: Water supply to Eskom power stations (1998)

Station	*Cooling technology*	*Primary water supply system*	*Status of power station*	*Net operational capacity (MW)*	*Net reserve capacity (MW)*
Duvha		Komati	fully op.	3 450	
Hendrina		Komati	fully op.	1 900	
Arnot		Komati	4 of 6	1 320	660
Komati		Komati	mothballed		906
Matimba	dry	Mokolo	fully op.	3 690	
Majuba	dry	Tugela	expansion	1 836	1 836
Kendal	dry	Usutu	fully op.	3 840	
Matla		Usutu	fully op.	3 450	
Kriel		Usutu	fully op.	2 850	
Camden		Usutu	mothballed		1 520
Tutuka		Usutu-Vaal	fully op.	3 510	
Lethabo		Vaal	fully op.	3 558	
Grootvlei	dry	Vaal	mothballed		1 130
Total				29 404	6 052

The operational capacity of the power stations supplied by each major river system is summarised in Table 4.4. Much of South Africa's coal-fired generation capacity (75 per cent) is reliant on water from three River systems, the Komati, Usutu and Vaal. These three river systems are interconnected in a complex way, which is described in the following two sections. The descriptions follow Pegram (1999).

Table 4.4: Water consumption by supply system

River system	*Operational capacity*		*Water consumption 1996*		*DWAF allocation*
	(MW)	*(%)*	*(million kl pa)*	*(%)*	*(million kl pa)*
Komati	6 670	21	69	31	85
Usutu[b]	10 140	32	80	36	55
Usutu – Vaal[b]	3 510	11	28	13	70
Vaal	3 558	11	37	17	na
Slang / Tugela	3 672[a]	12	2,3	1	35
Mokolo	3 690	12	3,5	1	na
Total	31 240	100	220	100	

Notes:

a. At full operational capacity (three out of six generator sets in operation at present)

b. Matla Power Station gets its water from both the Usutu and Usutu-Vaal systems. No information on the split was provided. In the above figures, 100% of Matla's water consumption is included as part of the Usutu system.

4.3.2 The Komati-Olifants supply system

The water supply from the Komati-Olifants River system to Eskom Power Stations is depicted in Figure 4.4.

The Komati-Olifants supply system provides water to Eskom's Arnot, Komati, Hendrina and Duvha power stations (as well as Hendrina municipality) from the Komati River. Water can be pumped 220 metres up from Vygeboom Dam to the Bosloop pump station, from where it can be pumped a further 280 metres up to Wintershoek pump station, and then up another 100 metres and on to Arnot, Hendrina and Duvha. Duvha and Hendrina power stations can also be supplied from Witbank Dam on the Olifants River. The Vygeboom Dam may be augmented from weirs on the Gladdespruit and Poponyane streams via a gravity flow canal. Water can also be abstracted from the Gemsbokhoek weir and pumped to the power stations via the Bosloop pump station. Water from Nooitgedacht Dam may be pumped 250 metres up via the Klipfontein balancing reservoir to Komati power station or may be used to supply the other power stations via the Wintershoek pump station. The Nooitgedacht-Wintershoek pipeline may be reversed to augment Nooitgedacht dam from Vygeboom Dam and Gemsbokhoek weir. Lastly, water from the Usutu system can be transferred into Nooitgedacht Dam via the Camden pump station.

The water supply from the Komati River to the Eskom Power stations dominates water use within the Upper Komati River system. Total water use for power from the Komati River system was 69 million kilolitres in 1996, compared to an allocation of 18 million kilolitres per annum to irrigation and 6 million kilolitres per annum used by the urban and domestic sectors.

The total mean annual run-off for the upper Komati River System is approximately 278 million kilolitres.

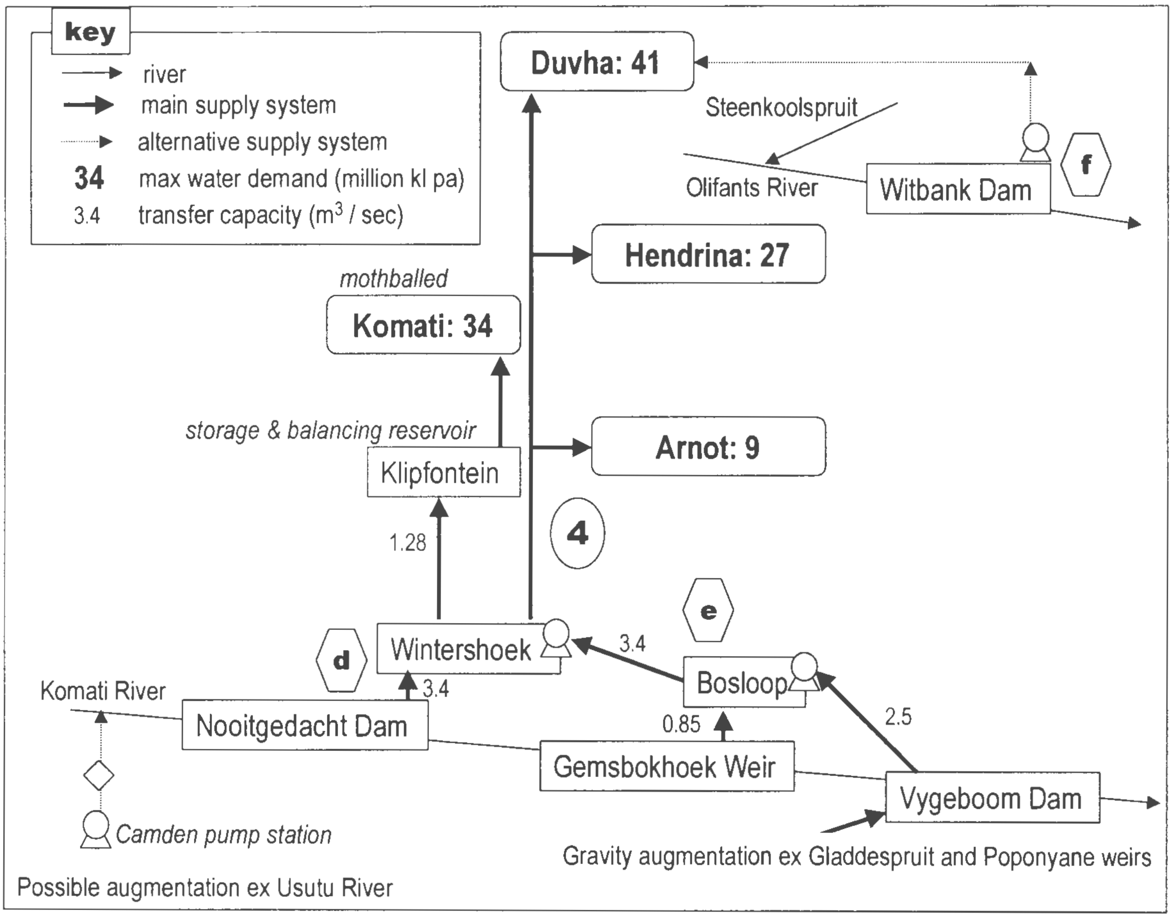

Figure 4.4: The Komati-Olifants water supply system

4.3.3 The Usutu-Olifants and Assegaai-Vaal water supply systems

The water supply network from the Usutu-Olifants and Assegaai-Vaal River systems to the Eskom power stations is shown in Figure 4.5.

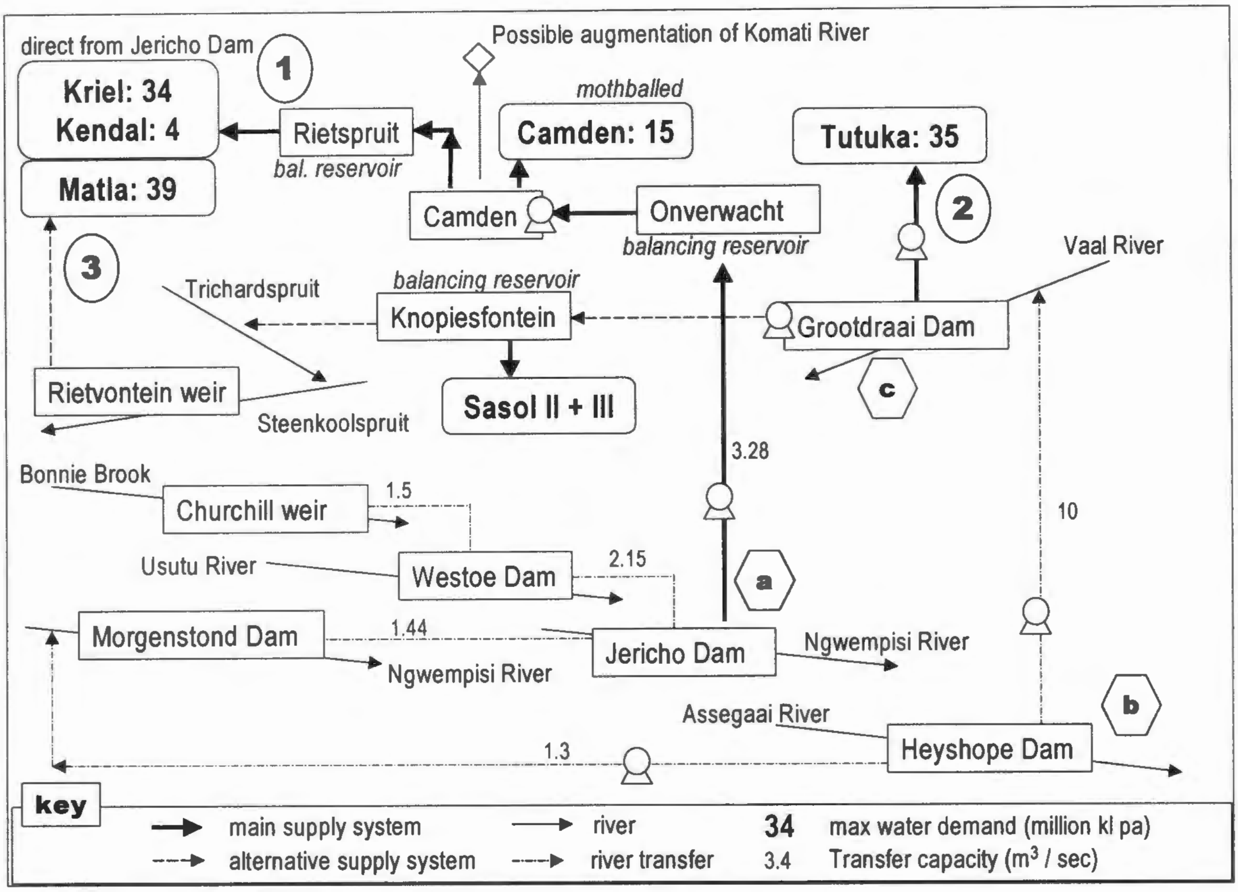

Figure 4.5: The Usutu and Usutu-Vaal water supply systems

The **Usutu-Olifants supply system** provides water from the upper Usutu catchment to Eskom's Camden, Kriel, Matla and Kendal power stations (as well as Ermelo and Davel municipalities). Water is pumped 250 metres up from Jericho Dam to Onverwacht, from where it is gravity fed to Camden pump station. From there it may be pumped directly to Camden power station or up a further 120 metres to the Rietspruit balancing reservoir and then on to Kriel, Kendal and Matla power stations. Although all three of these power stations may also be supplied from the Olifants River, Kriel and Kendal are usually supplied directly from Jericho Dam. Water can also be transferred into the Komati system upstream of Nooitgedacht from the Camden pump station. Jericho Dam is augmented via a gravity tunnel from Westoe Dam, which in turn is gravity fed by a canal from Churchill weir on the Bonnie Brook. Water can also be pumped 120 metres up from Morgenstond Dam, either into Jericho Dam or directly into the transfer pipeline up to Onverwacht (a balancing reservoir). The supply from Morgenstond may be augmented from Heyshope Dam, but this option has not been used.

Assegaai-Vaal-Olifants supply system. Water from Heyshope Dam may be pumped 375 metres up to the Balmoral canal and into the upper Vaal River, where it is used to augment the supply to Tutuka power station as well as the transfer to the upper Olifants River system from the 364 million m^3 Grootdraai Dam. Alternatively it may be released from the Balmoral canal via the Ngwempisi River into Morgenstond Dam. Water for Tutuka is pumped 140 metres directly up from Grootdraai Dam, whereas water to the Olifants River system is pumped 170 metres up to the Knoppiesfontein balancing reservoir. Water may be released from here into the 15 million m^3 Trichardsfontein balancing dam and then on to the Rietfontein weir from where it is pumped 90 metres up to Matla power station (and Kriel or Kendal if necessary). Water can also be released down to Witbank Dam, where the Naauwpoort pump station can pump it 150 metres back up to Duvha and Hendrina power stations. The Knoppiesfontein balancing reservoir may also release water via the 2.3 million m^3 Bossiespruit balancing dam to supply Sasol II & III.

Water supply to the Eskom power stations accounts for about 70% of total water use within the Usutu and Assegaai River catchments. There is very little irrigation in the Usutu and Assegaai catchments. Forestry represents about ten per cent of the land area of the Churchill, Westoe and Jericho catchments and about 20 per cent of the Morgenstond catchment, but is insignificant in the Heyshope Dam catchment. Agriculture accounts for about 25 per cent of total use in the Usutu-Assegaai Catchments. Domestic and urban demand for water within the Usutu River system catchment is a small proportion of the total (about four percent).

4.3.4 Water resource allocations

The Eskom Integrated Energy Plan Number 6 (IEP6) states that existing water allocations are sufficient to cater for the projected growth in electricity generation capacity and the corresponding growth in water demand (Eskom 1997b: 6). The plan notes, however, that existing allocations are likely to come under pressure for reallocation if they are not utilised for a long period (Eskom 1997b: 7)

4.4 The existing Department of Water Affairs and Forestry – Eskom water tariffs

Information was obtained from the Department of Water Affairs and Forestry (DWAF) on the three principle water supply agreements between it and Eskom. No information was provided by Eskom. The following descriptions are based on personal communications with Paul van der Merwe (1999), who is responsible for the Eskom tariffs at DWAF.

4.4.1 The Komati Government Water Scheme

The Komati water scheme provides water to Eskom's Hendrina, Arnot and Duvha power stations. Eskom pays R3 816 million annually in fixed capital costs to DWAF. In addition, Eskom also pays for refurbishment costs (if any), which vary from year to year. No information on these costs was provided. Eskom performs operation and maintenance of the system and hence does not pay operating costs to DWAF. No information on operating costs was available from Eskom. The allocated quantity of water involved here is 85 million kilolitres per annum, compared to the actual consumption of 69 million kilolitres in 1996.

4.4.2 The Usutu Government Water Scheme

The Usutu Government Water Scheme supplies Eskom's Kriel, Matla and Kendal power stations. Eskom makes an annual payment of R22 866 million to DWAF for the capital costs of the scheme and also pays refurbishment, betterment and operating and maintenance costs to DWAF. These are paid monthly and vary from year to year. No information on these costs was provided. The quantity of water involved here is 55 million kilolitres per year.

4.4.3 The Usutu-Vaal Government Water Scheme

The agreement in respect of the Usutu-Vaal Government Water Scheme, which supplies Eskom's Tutuka and Matla (again) power stations, is more complicated than the above two agreements. Eskom pays an annual capital amount of R30 955 million per annum for both the Grootdraai (Phase 1) and Heyshope Dam (Phase 2) components of the system. For the Grootdraai Dam component, it pays 57 per cent of the annual (varying) refurbishment and operating and maintenance costs. In addition, it pays (currently) R1,02 per kilolitre for water received from this component. This tariff is equal to the Vaal River tariff because the water used by Eskom directly affects water availability within the Vaal River system. At the Heyshope Dam component Eskom pays 56 per cent of the refurbishment and betterment costs and the fixed operating and maintenance costs, but no part of the variable operating and maintenance costs. This is because all the water goes to the Vaal River system and these costs are allocated to that system. Eskom receives around 70 million kilolitres of water per annum out of the Grootdraai Dam component of this system.

4.4.4 Slang River Government Water Scheme

The agreement in respect of the Slang River Government Water Scheme (Zaaihoek Dam), which supplies Eskom's Majuba power station (still under construction), entails an annual capital payment to DWAF of R9 440 million and 55 per cent of the refurbishment and betterment cost on a monthly basis by Eskom. Eskom pays a negligible part of the variable operating and maintenance costs here, because most of the water goes to the Vaal River system (and these costs are covered in the Vaal River tariff). The quantity of water involved here is around 35 million kilolitres per annum, but Eskom currently uses only around two million kilolitres per annum of this. (Three of the six generation sets are in operation).

No information was made available on the Mokolo River supply to Matimba, the Vaal River supply to Lethabo, and the water supply to Koeberg.

4.4.5 Current water cost estimates

Water costs by power station were obtained for 1994 and are presented in Table 4.5. Except for the incomplete DWAF data presented above, more recent information could not be obtained. For the purposes of the modelling exercise, described below, both of these sources of information were used.

Table 4.5: Water prices and costs for Eskom power stations

Supply system – power station	*Average price (c/kl)*		*1997 consumption (million kl pa)*	*1997 total costs (R million)*
	1994[a]	*1997[b]*		
Komati – Arnot	55	70	9	6.3
Komati – Duvha	59	75	36	27
Komati – Hendrina	40	51	23	11,7
Usutu – Kendal	178	226	2.4	26
Usutu – Kriel	79	100	32	32
Usutu/Vaal – Matla	1,23	156	42	65
Usutu/Vaal – Tutuka	66	84	39	33
Vaal – Lethabo[c]	12	30	37	11
Mokolo – Matimba	50	63	3	1.9
Average / total	66	96	223	213,9

Notes:

a. Data quoted in van Horen (1996)

b. 1997 figures were updated from 1994 based on the CPI using a factor of 1,27 (CPI = 9,0, 8,7 and 7,4 in 1994 1995 and 1996 respectively).

c. The Vaal River tariff was adjusted in 1997.

4.5 The impact of the new DWAF water policy on water costs

4.5.1 The DWAF pricing strategy

DWAF published a new water pricing strategy for comment at the end of 1998 (DWAF 1998). This pricing strategy was developed in accordance with the White Paper on a National Water Policy for South Africa (1997) and the National Water Act 1998. The primary implications of this pricing strategy on water costs for power generation are summarised below.

Exposure. The DWAF-Eskom water contracts are subject to the new pricing strategy and all of the contracts will be renegotiated in the near future.

Key policy and strategy objectives. There is a significant shift towards greater emphasis on demand-side measures to manage water resources in South Africa, with the explicit recognition of the potential role for prices to affect water demand. Although the four objectives of social equity, ecological sustainability, financial sustainability and economic efficiency are given equal weight in the pricing strategy, it is the sustainability and efficiency objectives that will have most impact on the price of water for power generation (see below).

Ecological sustainability: the reserve. The creation of an ecological resource (to secure sustainability) may directly affect the price of water to Eskom where existing allocations do not make sufficient allowance for this. This impact could potentially be quite large. At present no information is available on how the reserve might affect water prices to Eskom.

Ecological sustainability: a water resource management charge. There will be an introduction of water resources management charges (to support the goal of ecological sustainability). These charges are not expected to be large in comparison to infrastructure-related costs.

Efficiency: an economic resource charge. The strategy document states that a move to economically efficient water pricing means that the price of water should reflect the opportunity cost of its use in the next best alternative. The price of water will include an 'economic' resource charge which reflects the economic scarcity of water. Initial, very approximate, estimates of this change range from about 1 c/kl to 30 c/kl. (These 'sample case study' estimates were done as part of the preparatory work for the pricing strategy. No estimates of the likely economic resource charges that will be applicable to Eskom are available.

Infrastructure costs and pricing. The financial costs of water schemes will be re-evaluated to include a depreciation charge (based on periodically re-valued assets) and a return on asset charge. Historically, financial costs have been calculated on the basis of fund accounting using historical costs. These changes are likely to have a significant impact on the capital costs of the water schemes serving Eskom's power stations.

Assurance of supply. Water resource development costs will be allocated in proportion to the estimated average annual use of *maximum* water allocations to the different sectors or users supplied by the scheme. Eskom would thus pay a premium for requiring a high level of assurance of supply. (The strategy document assumes that Eskom requires an assurance of supply of 100 per cent.)

Peak demand. In the case of conveyance infrastructure (pipelines, pumps etc), the costs will be divided in proportion to the required peak rates of supply to the different users.

Unit volumetric prices. Prices will be expressed in cents per kilolitre and will be a function of actual usage.

Transparency. The new pricing strategy embraces the principle of transparency whereby all water cost and price information will be made available to stakeholders and interested parties.

Phasing in of charges. The maximum increase will be restricted to 20 per cent per annum during the first number of years, with the objective of achieving full cost recovery (including the economic resource charge and the water resource management charge) within ten years. The pricing document is not explicit as to whether this increase is in nominal or real terms. For the purposes of this analysis, this restriction is assumed to be in real terms.

4.5.2 Anticipated impact on water costs

Eskom anticipates that the cost of water supplied to its power stations will double over a period of a few years (Eskom 1997b). More detailed information on the likely levels of the new water tariffs that will be applied to Eskom was not available at the time of writing this report, but Eskom's expectation can be safely assumed to be correct. Given the constraint of a maximum annual increase in water tariffs, the actual target tariff that will be applied in the future is, at least to some extent, academic. The modelling undertaken for the purposes of this report has assumed an annual real increase of 20 per cent over the next five years.

4.6 The impact of water price changes on electricity prices

A spreadsheet model was developed to analyse the impact of water prices on electricity prices. The base data used to inform the development of the model is shown in Appendix 1.

The modelling assumptions are explained in the spreadsheet model. The most important of these are summarised below:

- Future water consumption by power station is assumed to be in proportion to the operational capacity of the power station.
- Water supply to Matla is assumed to be fully derived from the Usutu-Vaal system (whereas in practice Matla also gets water from the Usutu-Olifants system). This assumption will not affect the overall results in a significant way.

- The price elasticity of demand for electricity is not included in the model.
- The base year of the analysis is 1997.
- The future electricity generation projection is based on IEP6. This assumes that there will be no re-commissioning of mothballed plant in the next five years, with the exception of Arnot. It is assumed that one generation set is commissioned per year for Majuba.
- The real annual increase in electricity costs is assumed to be three per cent.
- The total cost of water supply to Eskom in 1997 was assumed to be R227 million (this figure was calculated on the basis of available data and estimates of missing data, and needs to be confirmed with Eskom). This represented about 1,3 per cent of the total costs of bulk electricity production and distribution.
- The average price of water supplied to Eskom was estimated to be 101 c/kl in 1997.
- It was assumed that this average price would increase to 226 c/kl (in 1997 Rands) by 2004, an absolute increase of 126 per cent. An annual maximum increase of 20 per cent was applied to each individual supply tariff, as per the new DWAF water pricing strategy.

The preliminary results of the modelling exercise are presented below.

The results of the analysis must be qualified by the lack of reliable data on both current and future water costs and prices. If or when better data becomes available, the model can be used to more accurately assess the likely effect of changing water costs on water prices.

- The additional expenditure on water arising from water tariff increases would amount to R295 million over seven years (1998 to 2004) – that is, an average of an additional R42 million per year.
- This represents a 1,1 per cent increase in total costs and is equivalent to a 0,15 c/kWh increase in the unit cost of electricity production over the seven years.
- On a tariff of 10 c/kWh, the increase in the price of electricity would be 1,5 per cent (spread over seven years). On a tariff of 25 c/kWh, the increase would be 0,6 per cent spread over seven years.

4.7 Conclusion

The results of the analysis show that even substantial increases in the price of water over the next five years will not significantly affect the cost and price of electricity.

Although there is considerable uncertainty in some of the input data, more reliable data is unlikely to change this overall conclusion. The model developed for the purposes of this analysis can be used to verify this assertion if or when more reliable data becomes available.

5.

RESTRUCTURING OF THE ELECTRICITY DISTRIBUTION INDUSTRY AND THE IMPACT ON ELECTRICITY PRICES

5.1 Introduction

This chapter aims to provide an overview of end-user electricity prices in South Africa, and to analyse the potential effects on electricity prices of industry reforms. The significance of this work largely lies in an effort to provide a context for the quantification of environmental externalities in electricity supply. If the anticipated change in electricity prices is of an order of magnitude greater than the level of externalities, then pricing for externalities will have little or no effect on consumer demand. In other words, the pricing signals provided by externality pricing will be swamped by other factors. If this is the case, incorporating environmental externalities into electricity prices will only affect the usage patterns of those large energy-users which are especially sensitive to electricity prices (and who are usually supplied directly by Eskom at specially negotiated tariffs). Such pricing strategies would largely be tax-generating policies and, as such, contribute little to dealing with environment concerns, unless the tax revenues generated are directly recycled into environmental projects.

The analysis has centred on the prices and cost information collected by the National Electricity Regulator (NER).[7] This database includes information on all municipal distributors in South Africa, Eskom's distribution entities, and all other distributors. While the database represents the most extensive and detailed coverage of the distribution industry, it has a number of limitations, the most important of which is the age of the data. Information collected since the 1995/6 financial year (June to June for municipalities) has not been properly verified and cannot be relied on with any confidence.

This chapter is structured in the following way:

- First, the current structure of the distribution industry is described, along with an overview of government's proposals for restructuring.
- Secondly, the structure and level of electricity prices and costs in the country's distribution industry are analysed.

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7 The co-operation of the NER in making this data available is gratefully acknowledged.

- Thirdly, the report analyses the main factors which will influence future prices, including trends at the wholesale level, and the effects of distribution industry restructuring.
- Finally, there are some concluding remarks.

5.2 Industry structure and proposals for change

South Africa's electricity distribution industry (EDI) comprises Eskom's distribution division, a large number of municipal distributors, and a handful of other distribution agencies. Each distributor is required to obtain a licence from the NER, which also has jurisdiction over prices. Licence conditions include a requirement that the distributor fulfil an electrification programme.

5.2.1 Eskom distribution

Eskom's distribution group supplies electricity to a large number of households and other consumers. Eskom is the single largest distributor in the country, accounting for 60 per cent of sales volume and 40 per cent of all end-users. Table 5.1 shows the number of customers, sales and staff numbers for Eskom distribution and the rest of the industry.

Table 5.1: Eskom distribution 1998

Source: NER (1999a), Eskom (1999)

	Eskom distribution	*Non-Eskom distributors*	*Total*	*Eskom as % of total*
Number of customers	2.6 million	3.4 million[8]	6.0 million	43%
Energy sales to end-users [GWh]	102 788	74 207[9]	176 995	58%
Staff	16 651[3]	17 823[10]	34 474	48%

While a large number of Eskom's customers are low-income urban dwellers, Eskom is also the principal authority responsible for supply to rural areas. In the past, Eskom had a relatively small distribution division, focussing on the supply of power to large industrial users and municipalities. The exception to this was supply to commercial farmers, for which Eskom has always taken primary responsibility. Since then Eskom's distribution activities have grown tremendously. This has been mainly due to the initiation of the electrification programme,

8 Calculated as 1996 total plus two years of electrification connections (300 000 per annum).

9 The quantity of electricity sold by Eskom to municipalities, plus their own generation, and adjusted for 5 per cent distribution losses.

10 For 1995/6 financial year – latest reported statistics.

together with Eskom's take over of a number of utilities in the former homelands. Table 5.2 presents a breakdown of Eskom's sales to different customer categories.

Table 5.2: Eskom's sales to categories of customers, 1998

Source: Eskom (1999)

Category	*Number of customers*	*Sales [GWh]*
Redistributors	736	68 666
Residential	2 376 069	5 989
Commercial	27 273	801
Industrial	10 354	53 683
Mining	750	31 645
Rural	148 369	3 725
Traction	40	3 439
International	4	3 197
Own usage	61	309
Total	2 563 656	171 454

5.2.2 Non-Eskom distributors

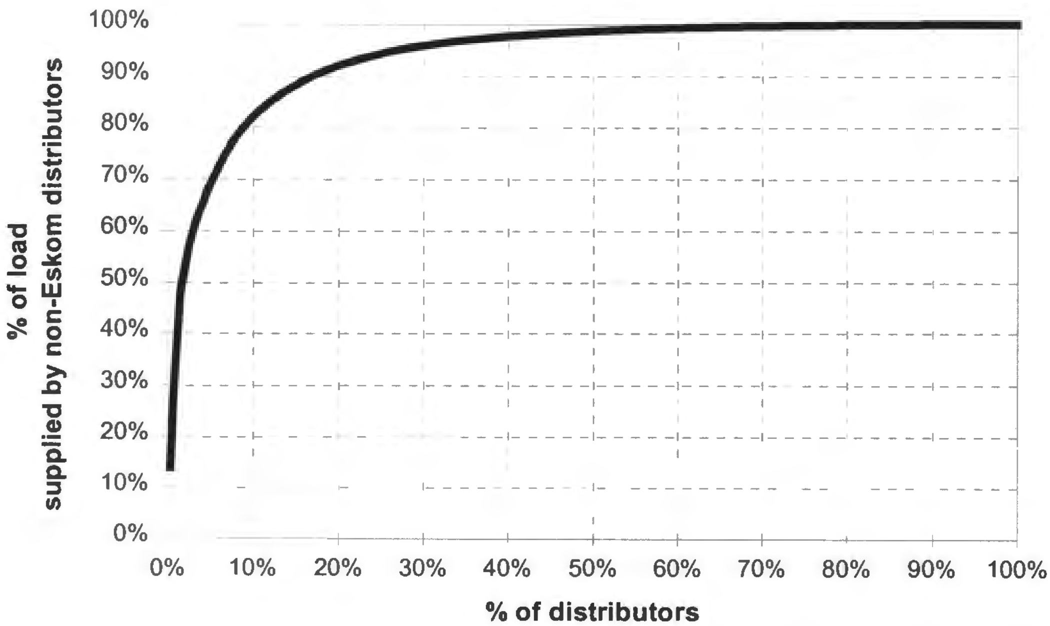
There are 337 non-Eskom distributors (principally municipalities and district councils) currently with a licence to supply electricity. Table 5.3 presents statistics on these distributors, broken down by province.

Table 5.3: Municipal distributors, by province,1995/6[11]

Source: NER 1999b

Province	*Number of distributors*	*Average number customers*	*Total number of customers*	*Average sales (MWh)*	*Total sales (GWh)*
Gauteng	31	26 984	836 510	840 112	26 043 481
Kwazulu/Natal	29	20 280	588 127	438 151	12 706 366
Mpumalanga	27	6 612	178 515	427 735	11 548 858
Western Cape	79	7 644	603 841	109 871	8 679 778
Eastern Cape	39	6 256	243 984	93 055	3 629 128
North West	26	3 840	99 838	119 640	3 110 635
Free State	59	3 378	199 318	37 176	2 193 377
Northern Province	13	3 849	50 040	74 261	965 394
Northern Cape	34	2 239	76 110	19 336	657 420
Total	337		2 876 283		69 534 437

For most provinces, the average number of customers per distributor is less than 7 000 and the average size of annual sales is correspondingly low. In fact, 73 per cent of municipal distributors serve fewer than 5 000 customers, and 42 per cent serve fewer than 1 000. Similar statistics can be stated for sales volumes, where the ten largest distributors account for 56 per cent of all sales and 48 per cent of all (non-Eskom) customers (NER 1999b). This domination of the largest distributors is shown in Figure 5.1, where it can be seen that only ten per cent of distributors account for as much as 80 per cent of the load supplied by non-Eskom distributors.



11 Statistics are derived from the NER database on the electricity distribution industry. The latest reliable

Figure 5.1: Proportion of load supplied

Source: Own analysis of NER database

In addition to Eskom and municipal electricity suppliers, there are a small number of other distributors. These include the following:

- ***Eskom joint ventures***

  Phambile Nombane: This is a joint venture between Eskom, Electricité de France and East Midlands Electricity, which has electrified 60 000 houses in the Khayelitsha area of Cape Town and now operates the undertaking on behalf of Eskom.

  Transitional Electricity Distributor (TED): This distributor was created from Keskor, the erstwhile supply authority for the former Kangwane 'homeland'. Keskor was a 50/50 joint venture between Eskom and the former Kangwane Government, whose share was transferred to the new local authorities established in the area to create TED.

  Uitenhage Electricity Supply: A joint venture between Eskom, private industry and the local authority to supply electricity in this Eastern Cape town.

- ***Private companies***

  A small number of private companies distribute electricity. These are usually large mining or industrial businesses that supply power to nearby settlements.

- ***Other***

  There are a small number of other small distributors, including district councils, the National Parks Board (at the Kruger National Park), KwaZulu Finance and Investment Corporation, and provincial authorities in several provinces. Together, these distributors account for less than one per cent of all electricity consumed in the country.

5.2.3 Proposals for distribution industry restructuring

Over the past 15 years there have been many investigations into the electricity supply industry in South Africa. An investigation of the municipal electricity sector was included in the initial brief of the influential De Villiers Commission in 1983, but was removed following pressure from local governments. In 1992, the Department of Mineral and Energy Affairs and the Permanent Finance Liaison Committee of the Department of Finance conducted investigations into the problems of the industry. These investigations recommended rationalisation of the distribution industry, but were not acted on. By 1993, the challenges of the electrification

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figures are for the 1995/6 financial year.

programme led to calls for the establishment of a national form to address electrification issues, leading to the creation of the National Electrification Forum (NELF) with support from Eskom and the participation of a wide range of stakeholders. NELF presented a set of recommendations to Cabinet in the second half of 1994, leading to the establishment of the NER in early 1995. The NER was required to subject the industry to independent regulation, oversee electrification and facilitate the rationalisation of the distribution industry.

The NER attempted to rationalise the electricity distribution industry through its first licensing of electricity distributors. This initiative failed to result in any effective rationalisation and, in the absence of a clear policy framework to guide it under these circumstances, the NER turned to the government for direction. An Electricity Working Group was subsequently appointed, to investigate the possible restructuring of the financial relationship between local government and the electricity sector, and to develop proposals for the rationalisation of the industry. After wide ranging consultations with stakeholders, the Electricity Working Group presented its proposals to Cabinet for approval. Cabinet referred the proposals to an inter-Ministerial committee which, in turn, created an internal government committee known as the Electricity Restructuring Interdepartmental Committee (ERIC). ERIC's investigations were completed in October 1996 and submitted to Cabinet. On the basis of its report, Cabinet resolved on 6 February 1997 that:

1. the electricity distribution industry should be consolidated into the maximum number financially viable and independent regional distributors;
2. transparent, cost reflective tariffs, an electrification levy and a capped tax for part funding of municipal services should be introduced; an electrification fund should be established;
3. political consultations should be conducted with the major stakeholders by the Ministers of Minerals and Energy, Trade and Industry, Finance, Public Enterprises, Provincial Affairs and Constitutional Development, and Labour;
4. a full-time transformation team should be established to investigate detailed issues and to plan and implement the transformation process.

The government's White Paper (DME 1998) on energy policy restates these recommendations as follows:

> Government will consolidate the electricity distribution industry into the maximum number of financially viable regional electricity distributors (REDs).... The REDs will be owned by Government. Control of all distribution network assets must pass to the companies and Government will determine appropriate mechanisms for achieving this.

The White Paper goes on to state that a 'transitional structure' will be implemented, consisting of Eskom distribution as well as municipal distributors, and will be a separate company from Eskom generation and transmission.

5.2.4 Price regulation

The economic rationale for regulation of electricity prices lies in the monopoly power which utilities have. While Eskom does not have a statutory monopoly, it is a *de facto* one, and all distributors have a licensed monopoly to distribute electricity within their supply jurisdictions. Governments in industrialised and developing nations alike are increasingly turning towards competition as an alternative to regulated monopolies. However, evidence indicates that competition can be difficult to encourage, and price regulation continues to be an important element of the industry.

It is somewhat unusual to have government establish a regulatory authority to control the prices of public-sector utilities. In the past, the South African system of governance relied on the oversight of government (in the case of Eskom) and local councils (in the case of municipal distributors) to ensure that electricity utilities did not abuse their position of market power. However, the case for regulating public utilities essentially relies on two arguments:

- Firstly, oversight by local councils was not found to be sufficient to protect consumers – councils have tended to use electricity as a revenue-generating source to cross-subsidise other services. While it can be argued that profits are recycled into community services, the distortion of prices is economically inefficient.
- Secondly, utilities have tended to be increasingly commercialised and so less inclined to pursue the 'public interest' and rather concentrate on earning healthy financial returns. Coupled with a growing reluctance on the part of governments to interfere in management decisions, there is a case for 'arm's length' regulation of public utilities.

In South Africa the NER was established with authority to issue licences and control electricity prices of all electricity undertakings in the country. This marked the implementation of a new policy of regulation in the industry, subjecting Eskom and municipal distributors to regulatory oversight for the first time.

Since its establishment, the NER has yet to issue clear guidelines or approach to the issue of price regulation. Instead it has tended to deal with applications for price increases on an annual basis. Eskom adjusts its prices annually, as do municipalities. These increases are presented to the NER for approval, which has the authority to impose a lower price increase on any utility.

Eskom's applications for price increases have tended to be uncontroversial as they have always been below the rate of inflation. The NER has approved these increases to date.

The presence of a large number of municipal distributors has allowed an opportunity for 'bench-marking' among distributors. The NER has implemented a system of comparisons between distributors in order to inform decision making. The intention has been to progressively encourage convergence of prices among different distributors, although different cost structures have limited the extent to which convergence can be achieved without financial transfers between distributors.

The future of electricity prices in South Africa will be influenced, to a significant degree, by the development of the regulatory regime as well as the emergence of competition in parts of the market. While it may be expected that tighter regulation will tend to exert downward pressure on prices, the NER may recognise that in certain cases necessary investment in refurbishment and grid extension will increase distributors' costs, and so justify price increases.

5.3 Electricity prices and costs in South Africa

This section will examine price structures and levels, and analyse the current cost structure in the electricity distribution industry.

5.3.1 Price structures

The set of price structures utilised in the distribution industry include:

- straight-line tariffs: where only an energy fee is charged;
- two-part tariffs: where a fixed monthly fee and an energy fee are charged;
- three-part tariffs: where a fixed monthly fee, a maximum demand charge and an energy fee are charged;
- declining block: where the energy fee is split into (at least) two parts, with consumption above a certain amount being charged at a lower rate;
- time-of-use tariffs: where the energy charge varies with the time of use and season;
- special tariffs: these are suited to large users and include commodity-indexed prices, interruptible supplies, and prices that change from year to year in a stipulated manner.

This section will review the tariffs structures currently employed in the distribution industry.

5.3.1.1 Domestic tariffs

Domestic tariffs are mostly structured either as two-part tariffs or straight-line tariffs.

Eskom offers customers the choice of HomePower or Homelight. The former is a two-part tariff suited to high energy users, and the latter a straight-line tariff suited to low energy users. If consumption is greater than 250 kWh/month for a 60A supply, it is cheaper for a customer on Homelight to switch to HomePower.

Domestic tariffs are designed to cover the fixed and variable costs of supply, as well as including a component to recover the investment costs in electrification. While the two-part tariff more closely reflects the cost structure, the straight-line tariff encourages low-income households to consume some electricity since there is no fixed part to the tariff which would act as a barrier to consumption.

A straight-line tariff also offers a degree of cross-subsidisation to low-income households. Very low consumption of electricity is usually an indication of poverty and, with straight-line tariffs, these households contribute very little to covering the costs of supplying them, especially if the utility has had to invest in new distribution infrastructure.

Eskom offers different domestic tariff levels depending on the size of the installation (20A supplies are cheaper than 60A supplies). In addition, higher tariffs are charged where the cost of providing a supply is higher. Eskom's domestic tariffs are presented in Table 5.4.

Eskom had piloted the use of flat rate tariffs (ie a fixed monthly fee) for 2.5A supplies, but found this option unacceptable to users and difficult to collect. As a result, this load-limited supply option (which is still a pilot) is now charged at the same tariff as Homelight 1 (20Amp supply).

Table 5.4: Eskom's domestic tariffs, 1999

Tariff	*Supply*	*Fixed monthly fee (R)*	*Energy charge (c/kWh)*
HomePower	60A	42,66	23,19
Homelight 1 *(capital cost less than R2.451 per connection)*	2.5A	0	33,37
	20A	0	33,37
	60A	0	39,96
Homelight 2 *(capital cost less than R1,140 per connection)*	20A	0	28,89
	60A	0	32,48

Most municipalities do not offer a choice of domestic tariff, but have tended to move towards the use of a straight-line tariff only, partly because it is suited to prepayment metering.

5.3.1.2 Rural tariffs

Eskom offers two tariffs for rural customers (mostly commercial farms and other non-domestic users operating off rural networks). These are:

- *Landrate:*

  Four Landrate tariffs are offered. Landrate 1 to 3 are for rural customers with a maximum demand up to 150 kVA. The tariff has a fixed part and a declining block energy charge (consumption greater than 700 kWh/month is charged at a lower rate). Landrate 4 is for customers who use less than 1 000 kWh/month.

  Landrate Dx is primarily for remote telecommunications sites where the demand is not worth metering, and is charged at a fixed monthly rate.

  In addition, Eskom may charge rural consumers a monthly 'rental' or an upfront fee to cover the cost of providing infrastructure to connect the consumer.

- *Ruraflex:*

  This is for three-phase rural customers who can take advantage of time-of-use tariffs. Energy charges are differentiated into peak, off-peak and standard rates. The times of peak and off-peak as well as the prices charged vary with summer and winter.

5.3.1.3 Commercial tariffs

Commercial tariffs are usually structured as two-part tariffs. For larger users, particularly those on three-phase, three-part tariffs are also offered. These consist of a fixed monthly fee, an energy charge and a maximum demand charge. These tariffs are only usefully employed where the maximum demand is significantly large and worth the expense of metering. Three-part tariffs can be more cost-reflective than single or two-part tariffs since they more closely match the costs of providing service (the monthly fee), the cost of providing capacity (the maximum demand charge) and the marginal costs of electricity supply (the energy charge).

Eskom has introduced a straight-line tariff for low-consumption business users.

5.3.1.4 Wholesale, industrial and mining tariffs

A wider variety of tariff structures is in use for large consumers such as municipal distributors as well as industrial and mining customers. These include the following:

- A selection of three part tariffs (monthly fee, energy charge and maximum demand charge).
- Time-of-use tariffs, with incentives to shift demand to off-peak times.
- Interruptible supply contracts (Eskom only), where there is a discount for the right to disconnect the customer when capacity constraints are reached.

- Commodity-indexed tariffs (Eskom only), where the price is indexed to the price of the commodity produced by the user. These arrangements are designed to be 'revenue-neutral', in that the average price over the economic cycle is designed to match a certain target, but with deviations from this average level as commodity prices change. These tariffs share the risk of production between the utility and the user.
- Special contracts (Eskom only) – again where Eskom enters into medium- or long-term contracts with consumers on tariffs which are designed to more closely match Eskom's changing costs of supply.

5.3.2 Price levels

Price levels vary significantly among distributors. Table 5.5 and Figure 5.2 present basic statistics for the main tariff categories. Tariffs vary by over 30c/kWh, and standard deviations are 6c/kWh or more. Figure 5.3 shows the distribution of tariffs for domestic customers.

Table 5.5: Electricity prices in South Africa, 1995/6 (c/kWh)

Source: Own analysis of database, NER (1999b)

	Domestic	*Agricultural*	*Mining*	*Manufacture*	*Commercial*	*Transport*
Sample size	330	95	12	174	291	38
Minimum	9,0	6,8	7,1	2,3	11,0	10,0
Maximum	44,8	40,0	35,0	88,4	44,6	88,0
Median	23,9	24,5	18,1	21,1	26,9	24,4
Mean	24,6	24,5	19,9	22,5	27,1	26,3
Std dev.	5,7	6,0	8,6	8,7	6,6	13,3
Weighted average	18,9	23,1	11,1	11,5	21,2	15,2

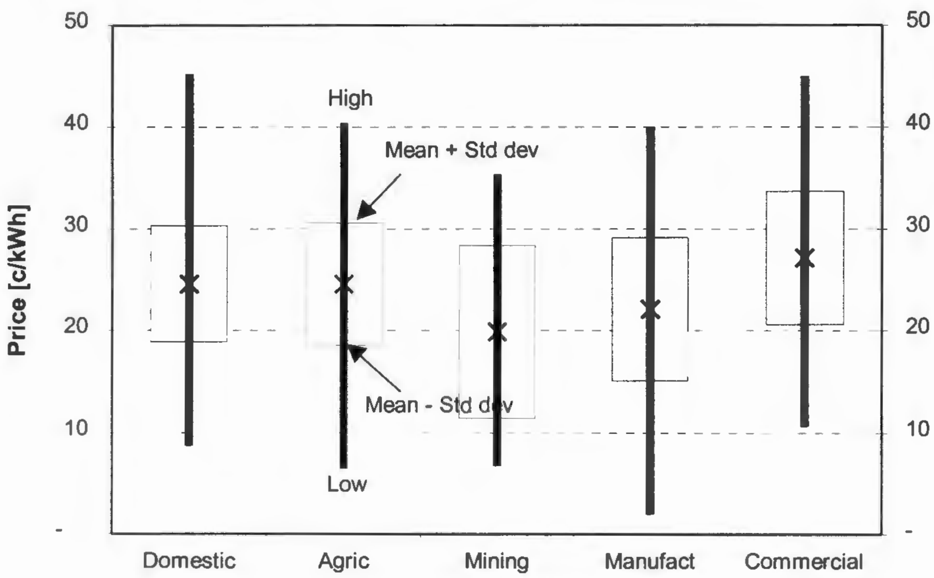


Figure 5.2: Graph of price levels showing low, high, mean and standard deviations for each tariff category 1995/6

Source: Own analysis of NER database (NER 1999b)

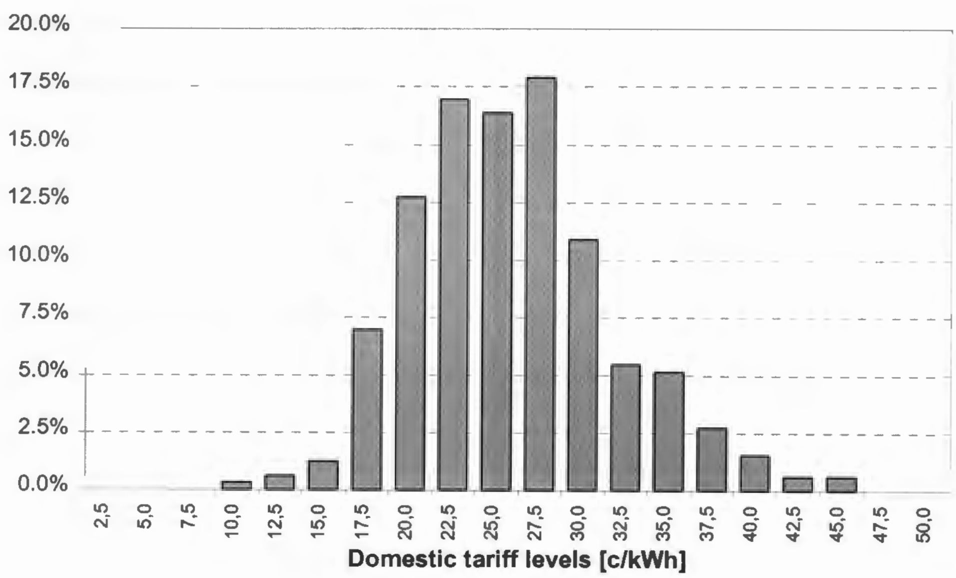
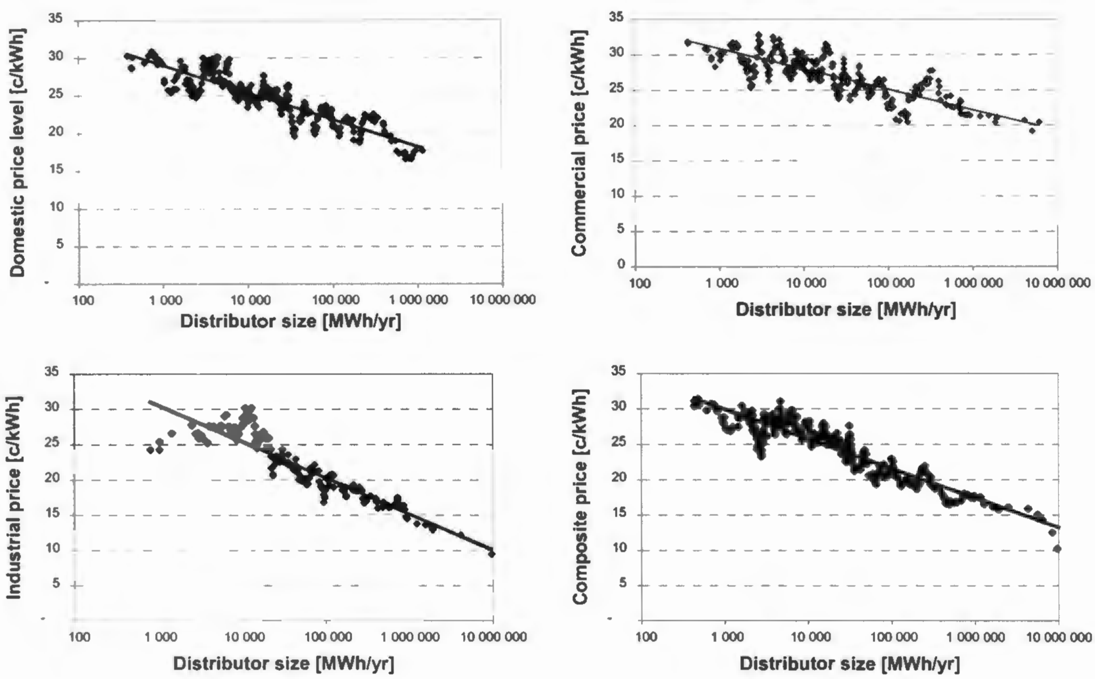


Figure 5.3: Distribution of price levels for domestic tariffs 1995/6

Source: Own analysis of NER database (NER 1999b)

There is a clear relationship between price and the size of a distributor. The graphs presented in Figure 5.4 show this relationship to be logarithmic (the scale of the X-axis is logarithmic). For domestic and commercial tariffs, the price decreases by three to four cents every time the size of the distributor increases ten-fold. For industrial tariffs, the slope is steeper, with prices decreasing by 5.5 cents with every ten-fold increase in scale. Composite prices represent total revenue divided by total sales, and indicate the revenue requirement of a distributor.

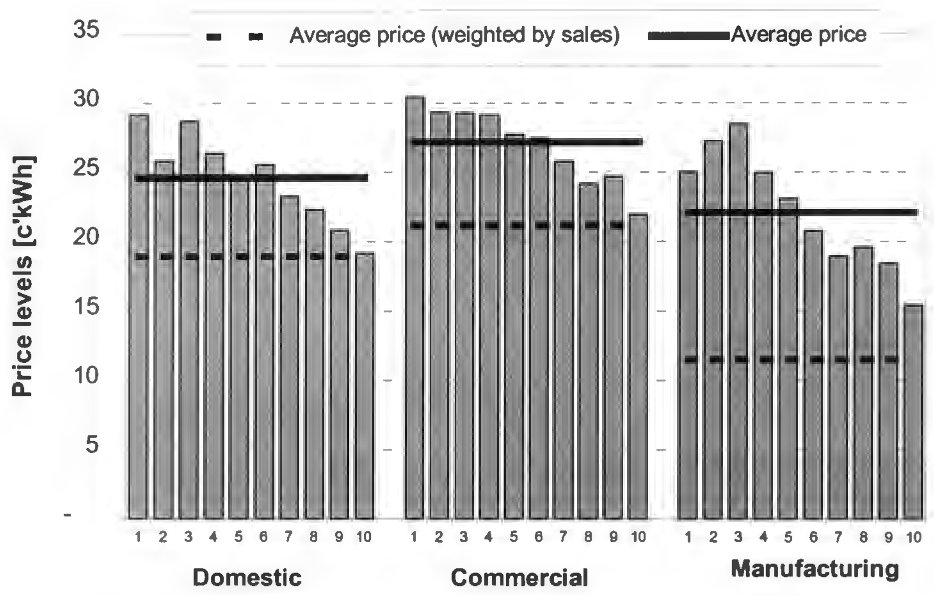


Note: Prices are 10 point moving averages.

Figure 5.4: Electricity prices vs total sales

Source: Own analysis of NER database (NER 1999b)

This relationship between size and price is also exhibited in Figure 5.5, which shows the average price charged by distributors ranked in order of their size, and grouped into ten groups. It is interesting to note that the average price, when weighted by sales, is lower than even the average of the largest ten per cent of distributors. This is because the weighted average is dominated by the largest few distributors.



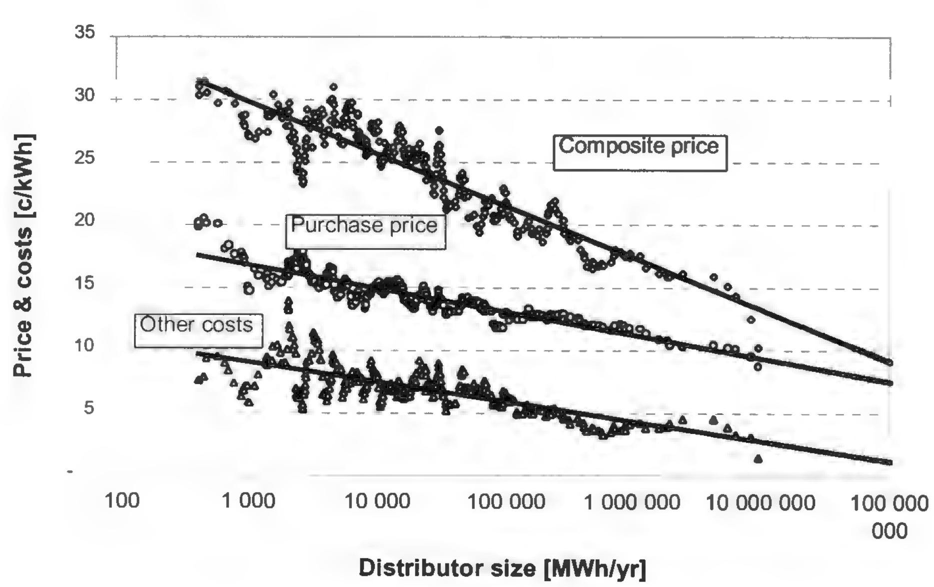
Note: Each bar represents the average price charged by 10% of the distributors, when ranked in order of size

Figure 5.5: Average prices charged by distributors against size

Source: Own analysis of NER database (NER 1999b)

5.3.3 Supply costs

Prices decrease with size since costs also decrease. Figure 5.6 shows that the costs of power purchases as well as other distribution costs exhibit the same logarithmic relationship with distributor size.



Note: prices and costs are 10 point moving averages.

Figure 5.6: Costs and prices against distributor size

Source: Own analysis of NER database (NER 1999b)

While the costs of power purchases and other distribution costs tend to decrease with size in a similar manner, this is much steeper than the average price charged, as exhibited by the 'composite price'. This suggests that distributor's margins also decrease with size. Figure 5.7 shows that, while there is a decrease in surplus (per unit sold) as the distributor increases with size, there is a wide scatter in the data, particularly for smaller distributors where the surplus may be very large or even negative.

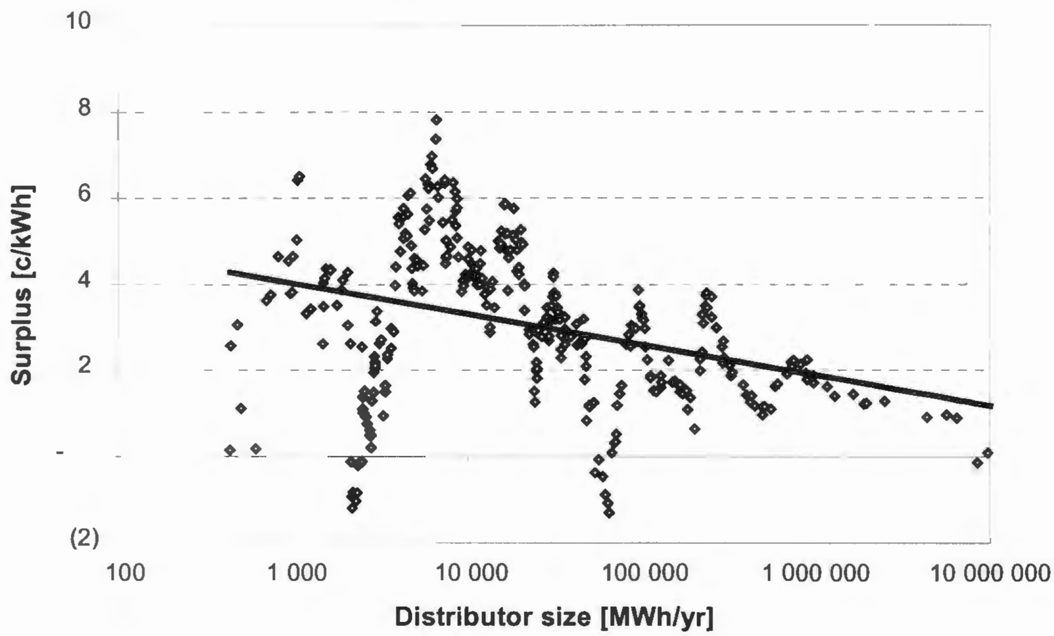


Figure 5.7: Surplus vs distributor size

Source: Own analysis of NER database (NER 1999b)

The fact that a number of distributors make a loss on electricity distribution indicates that financial viability may be a problem. Since losses are predominantly a problem for smaller distributors (over 75 per cent of those making a loss sell less than 100 000 MWh/yr), this indicates that financial viability improves with size.

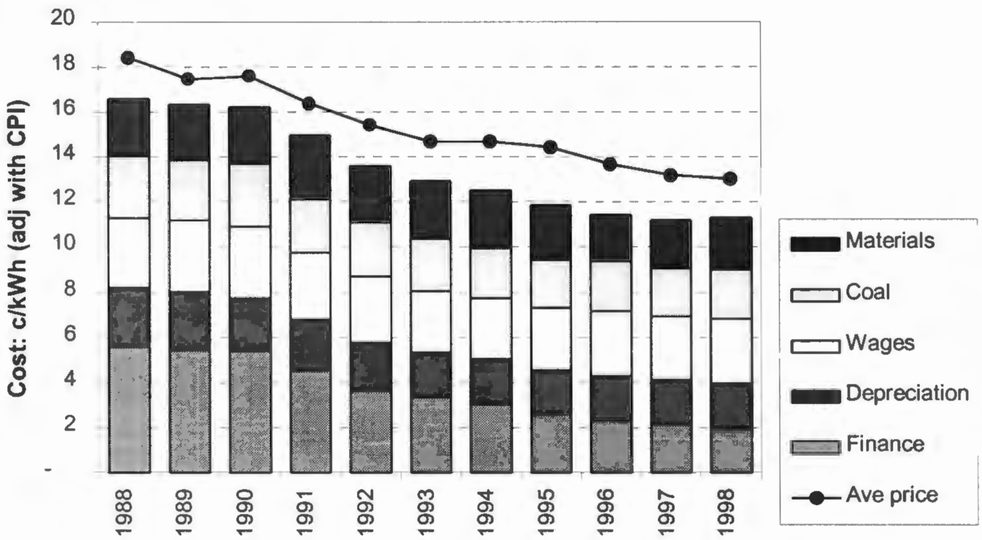
5.4 The future for electricity prices in South Africa

The future trend in electricity prices to end-users will be dominated by two factors: trends in costs of electricity generation, and rationalisation of the distribution industry. Each of these will be discussed below.

5.4.1 Wholesale prices

While an analysis of the future costs of electricity generation is beyond the scope of this chapter, it is useful to point out some of the underlying influences that may affect this. Firstly, and most importantly, one of the reasons that electricity prices are currently low in South

Africa is because no new capacity has had to be ordered for over a decade. Over-investment in the 1980s has led to surplus capacity, and no need to build or finance new capacity. Eskom has been steadily decreasing its debt load, so the cost of servicing debt has been reduced significantly. Since Eskom pays neither tax nor dividends (at present), this has meant that an increasing share of the rent associated with electricity generation has been used to reduce electricity prices to consumers.



Note: 'Nominal' figures converted to 'real' using CPI.

Figure 5.8 Trends in Eskom's cost structure

Source: Own analysis of Eskom annual reports

Figure 5.8 exhibits trends in Eskom's cost structure over the past decade. It can be seen that there have been substantial decreases in costs, and prices, over this period. This reduction in costs can largely be attributed to the decreasing burden of finance charges, as well as depreciation costs. It can be seen from Table 5.6 that these two items have contributed 80 per cent of Eskom's cost reductions.

Table 5.6: Contribution to Eskom's cost reduction (c/kWh)

Source: Own analysis of Eskom annual reports

	Finance	*Depreciation*	*Wages*	*Coal*	*Material*	*Total*
1988	5,62	2,60	3,08	2,72	2,58	16,60
1998	1,95	2,02	2,86	2,19	2,29	11,31
Change	-3,67	-0.58	-0,22	-0,53	-0,29	-5,30
Percentage change	-65%	-22%	-7,2%	-20%	-11%	-32%
% contribution to total reduction	69%	11%	4%	10%	5%	100%

Inevitably, as Eskom is required to make new investments in generation capacity, this downward trend in prices and costs is not sustainable. While Eskom's future costs are confidential information, their projections for prices indicate that no more price reductions in the medium term are envisaged.

There is no doubt that new capacity will be more expensive than the average cost of existing capacity. How this feeds through into prices will depend on the size of the cost differential, as well as the rate of growth in demand.

The emergence of a competitive market for wholesale power will also have an impact on prices. While the introduction of competition may be expected to exert downward pressure on prices, this may not necessarily be the case for two reasons. Firstly, competition would probably involve the introduction to the market of private players, who would be expected to require a higher rate of return on investments than does Eskom. This would tend to increase prices. Secondly, new entrants into the market would probably be required to build new capacity (unless Eskom was broken up and sold off). As discussed above, this would almost certainly be at a higher cost than Eskom's current average cost. However, the potential for efficiency gains from competition should not be discounted, and the introduction of a new market structure may contribute to lower prices than otherwise may have been expected.

5.4.2 Distribution costs

It is certain that rationalisation of the distribution industry will lead to lower tariffs for many end-users. Given the fragmentation of the industry, many of the smaller distributors are failing to capture the economies of scale possible in distribution. By reducing the number of distributors, and by increasing their scale of operation, government hopes that the industry will capture these economies of scale, and so contribute to lower costs and prices.

The government's White Paper on energy policy calls for the establishment of the 'maximum number of financially viable regional electricity distributors'. The question of viability will depend critically on the electrification responsibilities placed on distributors, and if separate electrification funding arrangements are put in place this will increase the number of viable distributors. At present, government has indicated that it intends centralising electrification funding through the establishment of an electrification fund (sourced through levies) and the centralised allocation of resources to new electrification projects. This system will effectively act as a cross-subsidisation mechanism between different consumer groups and will benefit those distributors responsible for the large rural populations of KwaZulu/Natal, Eastern Cape and Northern Province.

Work conducted to date on new distribution companies (Van Horen & Thompson 1998) has tested the viability of five regional distributors. This choice of five distributors was based on the proposals contained in the report to government on this topic (ERIC 1996). These regions are:

- Northern (RED A): comprising most of Northern, Mpumalanga and North West Provinces, and the northern portion of Gauteng;
- Western (RED B): comprising all of the Western Cape and a portion of the Northern Cape;
- Central (RED C): comprising all of the Eastern Cape, most of the Northern Cape and Free State, and a portion of North West Province;
- Eastern (RED D): comprising all of KwaZulu-Natal and the eastern portion of the Free State;
- Wits (RED E): comprising the remainder of Gauteng province.

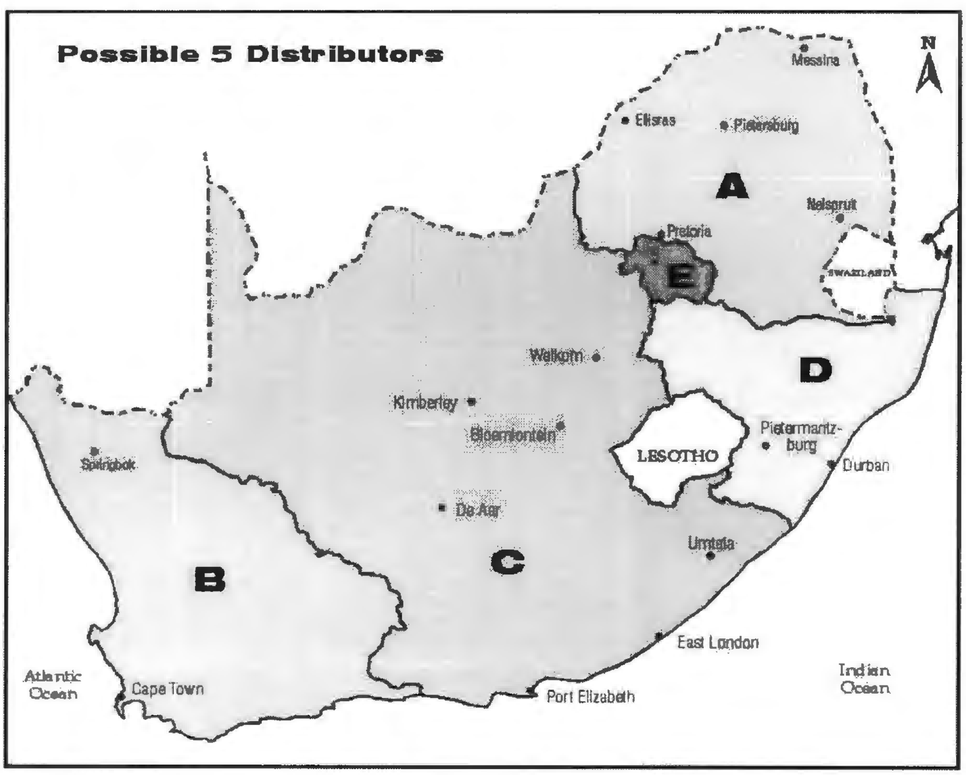


Figure 5.9: Possible regional distributors

Such a configuration would yield distribution companies with sales of between 12 and 60 GWh/year, and with a customer base of approximately one million customers each.

Table 5.7: Electricity consumers and consumption in each RED 1995/6

Source: Own analysis of NER database, NER 1999b

RED	*Domestic consumers*	*Non-domestic consumers*	*Total consumers*	*Domestic consumption* (GWh/yr)	*Non-domestic consumption* (GWh/yr)	*Total consumption* (GWh/yr)
A – Northern	1 012 035	75 685	1 087 720	4 173	55 254	59 428
B – Western	701 159	61 779	762 938	4 355	8 639	12 994
C – Central	871 817	70 087	941 904	3 669	13 021	16 691
D – Eastern	878 490	33 086	911 576	10 119	20 810	30 929
E – Wits	980 794	52 769	1 033 563	9 503	30 103	39 606
Total	4 444 295	293 406	4 737 701	31 820	127 828	159 648

Turning to the estimation of economies of scale possible in distribution, it is evident from the analysis above that one of the major sources of cost reductions is a reduced purchase price. However, it is necessary to urge caution here. The principal reason for differences in purchase price between different municipalities lies in their different load factors and load sizes. These do not disappear with institutional reform unless the number of bulk purchase points can be reduced. This is possible in metropolitan areas where there are a number of suppliers currently being supplied from different Eskom supply points. Combining these would yield some benefit from an after-diversity factor, but it should be noted that most metropolitan authorities are already benefitting from the lower end of purchase prices and so the cost reduction would be small. Further, it should be stressed that this is not an economy of scale, but merely a 'zero-sum' game. That is, whatever distributors gain from a reduced purchase price, Eskom loses. As a result, it would seem inevitable that bulk prices would have to rise to make up for any loses in revenue. Consequently, a more realistic assumption is that bulk purchase prices tend to converge to the weighted average of existing prices. These are shown in Table5.8 to be between 7,9 and 9,2 c/kWh.

Efficiency gains are possible from the economies of scale in distribution. While it may be optimistic to assume that distribution costs in small towns and rural areas will converge to those in higher density urban areas, it is certain that there will be some gains. In addition, there will be an averaging of distribution costs within a distributor, effectively acting as a mechanism to cross-subsidise more costly consumers supplied by the distributor. As a first-pass approximation, it is assumed that distribution costs will approach those of a large distributor, and this is represented in Table 5.8.

A third element of the price build-up for end-user tariffs is the transfer from electricity revenues to local authorities' general accounts in order to contribute to local authority service provision. It is inevitable that any rationalisation of the distribution industry would have to preserve some transfer of funds to local authorities, otherwise their stability would be undermined. In order to keep overall transfers to local authorities at existing levels, this would amount to a 'tax' on electricity of approximately 1c/kWh sold. Imposing a cap on this tax set at the average transfer would inevitably mean that some municipalities could increase their revenues from electricity, whereas others would have to decrease them.

Finally, it is assumed that regional distributors would be run on a commercial basis, and would be expected to earn a positive return on assets. It is impossible to get a true value of the distribution industries' asset base, or to know how much of this is debt-financed. As a result, it is difficult to ascertain the level of return suitable. Eskom could provide an indication – it has a debt-equity ration of approximately 1, and earns a profit of 15 per cent of turn-over. Applying this ratio to the distribution industry would mean that a reasonable return would add a further 1,7 to 2,1 c/kWh to the overall average price.

Combining these cost elements gives an average price, or revenue requirement, of between 12,4 and 15,1 c/kWh, as shown in Table 5.8. This is some 25-40 per cent lower than existing average prices found in the industry, and most municipal consumers would see substantial price reductions.

Table 5.8: Estimate of price build up for REDs, 1995/6, in c/kWh

RED	*A – Northern*	*B – Western*	*C – Central*	*D – Eastern*	*E – Wits*
Purchase price	7,9	9,2	9,0	8,5	8,2
Other distribution costs	1,8	2,8	2,7	2,2	2,1
Local authority tax	1,0	1,0	1,0	1,0	1,0
Profit	1,7	2,1	2,0	1,9	1,8
Total average price	12,4	15,1	14,7	13,6	13,1
Existing average price	20,6	25,4	25,9	21,3	17,4
Reduction	39%	40%	42%	36%	25%
Existing weighted av. price	12,5	18,7	16,1	16,4	15,1
Reduction	1%	19%	9%	17%	13%

This reflects an estimate of the average, or composite price, level for regional distributors. Naturally, prices for domestic or industrial consumers will be different from this. Without knowing the relationship between costs and consumer categories, it is only possible to estimate these relationships based on existing price patterns. Applying this to the price levels indicated above, gives estimated end-user price levels as shown in Table 5.9. Note that in Table 5.9 adjustments have been made for inflation so price levels are reported in 1999 terms.[12]

Table 5.9: Estimated end-user prices after rationalisation, 1999, in c/kWh

RED	*A – Northern*	*B – Western*	*C – Central*	*D – Eastern*	*E – Wits*
Domestic[13]	16,5	19,3	17,6	17,5	17,0
Commercial	18,0	18,9	19,9	18,9	19,9
Industrial	13,7	15,0	16,2	14,0	15,9
Mining	9,9	15,3	18,8	18,1	12,8
Total average price	15,0	18,4	17,8	16,5	15,8

Note: Prices are adjusted by inflation to reflect 1999 terms

While these prices may seem much lower than averages currently found in the industry, it should be stressed that they are not that much different from the weighted average of current tariffs. Thus, while some consumers, particularly in smaller towns, are likely to benefit from substantially reduced prices, this is primarily because costs are being shared over a much larger consumer base. This cross-subsidisation from consumers in larger load centres to consumers in smaller centres is a much stronger effect than the economies of scale reaped through rationalisation.

5.5 Conclusions

There are a number of pressures on electricity prices, independent of environmental concerns. On the generation side, as existing surplus capacity is reduced, new generation options will come on-stream at a higher cost than Eskom's current average costs. This will tend to put upward pressure on prices. The extent to which prices will actually increase is difficult to predict, but is anticipated to be relatively small, at least in the medium term.

Within the distribution industry, the proposed rationalisation of the industry will have far-reaching effects on prices. At present, prices vary widely among distributors, and rationalisation will tend to remove this differentiation. Three factors will come into play:

- Firstly, there will be economies of scale in distribution, which will affect the costs of distribution (excluding the costs of power purchases).

12 This adjustment is from June 1996 to December 1998 and is a factor of 1,21

13 In fact, domestic prices are likely to be significantly higher in order to recoup electrification costs. It seems unlikely that domestic tariffs in a restructured industry will be any less than Eskom's current Homelight tariffs of 33c/kWh.

- Secondly, there will be cost sharing within each regional distributor, effectively providing cross-subsidies from larger centres to smaller centres. This will be especially felt in the power purchase cost element of prices. Under a regional distributor, prices will be set on the basis of the average costs of power purchases, rather than the costs within each locality.
- Thirdly, there will be uniformity in transfers to local authorities and the rate-of-return earned. Again, this will mean that prices in some areas will tend to decrease, whereas those in other areas will tend to increase.

Analysis indicates that the latter two factors are more important than the first, and so price changes will tend to converge towards the weighted average of existing prices, with some small overall economies of scale improving efficiencies. This will mean that consumers in small areas will likely see large price reductions, whereas those currently served by larger distributors will not see much change in prices.

6.
RESTRUCTURING THE ELECTRICITY GENERATION INDUSTRY: FACTORS LIKELY TO IMPACT ON ENVIRONMENTAL PERFORMANCE

6.1 Introduction

The past two decades have seen significant restructuring of a number of countries' electricity supply industries. These changes have involved the privatisation of public utilities, a movement away from regulated, vertically integrated monopolies and the introduction of greater competition in the generation and distribution of electricity. The interaction of the electricity supply industry with the environment has evolved in response to these changes, as well as in response to changes in public perceptions of the importance of environmental issues and the gradual evolution of approaches to dealing with externalities. All these changes pose new policy and regulatory challenges.

In South Africa the focus is currently on the restructuring of the electricity distribution industry. However, the need to restructure the electricity generation industry (EGI) in the medium term is raised by the White Paper on energy policy, which notes that if the electricity industry is to continue to be in a position to supply adequate, reliable, low cost electricity in an environmentally sustainable manner the government will have to consider various developments over time, namely:

- giving customers the right to choose their electricity supplier;
- introducing competition into the industry, especially in the generation sector;
- permitting open, non-discriminatory access to the transmission system; and
- encouraging private sector participation in the industry. (DME 1998: 29)

To introduce competition and private sector participation into the South African electricity generation industry will entail a significant restructuring of Eskom. No formal proposals have been put forward as to how this might be done. Nor have the possible environmental implications of restructuring the generation sector (or any other aspect of the electricity industry for that matter) been considered. And this even though, the Department of Environmental Affairs and Tourism has embarked on a 'comprehensive and integrated programme' of environmental law reform that will have far-reaching implications for the electricity industry.

This chapter explores the interaction between options for restructuring the electricity generation industry in South Africa and different approaches to regulating environmental externalities. The aim is to shed some light on the factors that are likely to affect the EGI's environmental performance under different restructuring scenarios. More especially the focus is on the following questions:

- To what extent should environmental considerations influence the restructuring and the choice of outcomes of the process?
- How will different restructuring options possibly impact on environmental performance?
- How should the regulation of the EGI and the regulation of environmental externalities be managed in the future?

To introduce the discussion and to place the things in context we start by defining what is meant by restructuring.

6.1.1 What is meant by restructuring?

The term 'restructuring' is widely used as a catchall-phrase for any significant state-initiated changes or reforms. However, even private companies 'restructure' their operations. In the present context restructuring refers to a range of broad reforms affecting the electricity supply industry, which include the following:

- Restructuring of the structure of the electricity industry with a view to making it more efficient. This may involve eliminating certain monopolies and allowing market forces greater scope.
- Deregulation of markets dealing in tradable commodities with a view to making them more competitive and hence more efficient.
- Re-regulation of natural or legal monopolies in the industry with a view to trying to replicate positive market incentives and to maximise their effectiveness and efficiency.
- Encouraging private sector participation through the partial or total privatisation of state assets and, more importantly, the removal of barriers to entry preventing or discouraging private investment in the industry.

- Corporatisation of public enterprises to ensure they operate autonomously of government, are subject to management accountability, and operate under the same legal and other conditions as private sector companies (Trollip 1996: 5-3).

Ideally, the impact on environmental performance of each of these aspects of 'restructuring' should be considered separately. Some effort is made in this direction, but given that all restructuring processes have involved more than one of the above changes and many have involved all five, it is not possible to be too precise. Current developments suggest that all five aspects will feature in the restructuring of the South African electricity industry as well.

6.2 International trends: lessons relevant to South Africa

6.2.1 Environmental issues and the electricity industry

Over the years there have been significant changes in the way governments have sought to regulate environmental externalities produced by the electricity industry. Curlee (1993:928) argues that in the USA these changes have evolved in response to:

- improvements in our ability to measure emission levels and reduce the uncertainty about the environmental damage associated with those emissions;
- greater capacity to assess the geographical incidence of environmental damage;
- technological developments to contain or reduce emissions;
- the development of methods to value environmental damages; and
- an increasing preference among the general public and policy makers for market-based approaches to internalising externalities.

Notable trends in the way environmental externalities generally, but more particularly those associated with the electricity industry, are dealt with include the following:

- There is a strong move towards imposing stricter environmental standards. The more affluent countries such as Canada, Denmark, Holland, Germany and the USA have taken the lead in this.
- There is a trend for the responsibility for environmental regulation and controls to move from local governments to national governments, and national environmental agencies. This is particularly noticeable in the USA, where the Environmental Protection Agency dominates environmental regulatory activities.
- More information about the likely environmental impacts of new facilities and new technologies is being made public as a result of requirements to prepare and circulate

environmental impact statements for all large-scale developments that have the potential for significant environmental degradation.

- Finally, and most significantly, the methods used by governments to deal with externalities have evolved. From doing nothing or very little governments sought to address environmental concerns by way of consultation in the 1960s. In the 1970s and 80s there was an overwhelming shift towards command and control regulations, while more recently governments have begun to make greater use of economic or market based instruments. (Curlee 1993: 929-30)

What do these changes mean for the electricity industry? Very briefly, they affect investment decisions, technology choices, planning timeframes, the need to manage regulatory risk, and so on. They also affect the day-to-day operations of utilities, as managing environmental impacts has become an important dimension of generating electricity. The internalisation of externalities has altered the cost structure of utilities' operations as well, with implications for the price of electricity. In effect, utilities have had to become far more responsible in their use of environmental resources.

The shift towards greater use of economic or market-based approaches to dealing with environmental externalities is very significant as it introduces concepts of private ownership to resources that were previously regarded as common property, such as air. In doing so, markets are created where previously none existed.

It is, however, generally acknowledged that markets or economic incentives are not always effective when it comes to dealing with environmental crises such as abnormal pollution build-ups due to unusual weather patterns. In these circumstances, direct controls and prohibitions offer regulators greater immediacy, predictability and flexibility than market-based instruments. The trend is therefore towards using a variety of instruments or a 'mixed approach' whereby market-based instruments are used to regulate and reduce emission during normal periods and direct controls are reserved for dealing with situations that pose immediate and serious risks. Table 6.1 compares the underlying logic, the instruments, and gives a brief critique of both the command and control approach and the economic or market-based approach.

Table 6.1: Comparing approaches to addressing externalities

Command and control approach	**Economic or market-based approach**
Approach based on:	*Approach based on:*

• defining environmental targets and permissible amounts or concentrations of emissions; • defining technological specifications for the performance or design of equipment and facilities; • each standard is used as a reference for evaluation or a target for legislative action or control; • one or more standard can be set to achieve specific environmental quality goals.	• the economic understanding that externalities arise because market prices do not capture the full social costs of certain activities; • the economic analysis that shows that competitive markets optimise resource allocation when price is equal to marginal cost; • the belief that competitive markets elicit optimal cost minimising behaviour from market participants.
Instruments *i) Non-marketable permits to discharge* These permits are based on the premise that certain activities are prohibited, unless a 'right to pollute' is granted. Permits cannot be transferred to other sites, industries or processes and they are usually granted subject to certain technology or emissions standards *ii) Technology-based standards* The aim is to prescribe the technologies firms must use so as to reduce emissions. In most instances 'the best practical means' or the more stringent 'best available control technology' must be used to control pollution. *iii) Uniform performance standards* The aim is to specify an emission rate maximum that all pollution sources must comply with. Firms can decide how to comply with the specified rate. *iv) Penalties* The aim is to make permits and standards	*Instruments* *i) Emission fees & pollution taxes* The aim is to force firms to internalise the cost of their externalities and thus induce them to reduce emissions to an optimal level. Theoretically, an emission fee should be equal to the net marginal social damage caused by the firm's emissions, but practically emission fees are based on what is acceptable and sufficient to elicit the desired abatement response from firms. *ii) Marketable emission permits* The aim is to use the market mechanism to allocate costs of pollution abatement. The regulator issues permits to individual firms stipulating how much of a given pollutant they may emit. This gives the regulator control over the quantity of emissions. Once issued, firms may trade their permits. Firms that can reduce emissions cheaply will reduce emissions below their initial allocation and thus have excess permits to sell to firms either expanding production or entering the industry.

enforceable by specifying penalties that can be imposed if firms are in breach of a standard or the terms of their contracts.	
Critique • These measures are unnecessarily expensive and inflexible, as they do not allow firms to choose how to realise the required levels of abatement. • The information required to manage technology standards is enormous and often contested. • These measures tend to be very rigid – unable to accommodate economic and environmental changes. • Non-marketable permits encourage the continued use of old industrial plant, as to install a new technology would require repeating the costly licensing process. • With uniform standards there is no incentive for firms to reduce pollution below the level required even if the cost of doing so is minimal. • Technology standards do not guarantee the efficient operation of the prescribed devices or process. • Permit systems are open to corruption as they require a few officials to make subjective judgements on matters that involve large sums of money. • Where regulatory agencies have to work closely with industries, there is a danger of 'regulatory capture'.	*Critique* • These measures have not eliminated the need for standards, environmental monitoring, enforcement and other forms of government regulation. At best they can only alleviate the government's capacity problems. • The effects of economic instruments are not as predictable as command-and control measures. • These instruments are not suited to dealing with environmental crisis situations. • They require, in some instances, more sophisticated institutions than under command-and-control systems to implement and enforce them.

• The specification of technology standards requires a high level of expertise on the side of the regulator, and can involve protracted negotiations.	

6.2.2 Restructuring and the environment

The relevance of lessons from other countries' restructuring experiences needs to be considered in the light of the present structure of the electricity industry in South Africa, and the capacity of both the electricity and environmental regulators to implement and manage changes. This synthesis of lessons is drawn primarily, but not exclusively from the review of experiences in Appendix 3:

- Utilities operating in a competitive environment do not readily value medium-to-long-term environmental risks, especially if price competition becomes the main incentive driving decision-making.
- Restructuring can lead to lower electricity prices. Where this makes electricity more competitive relative to other energy sources, or enables low-income households to increase their consumption, the environmental impacts will be positive. However, if the lower price does not reflect the social cost of electricity, it will encourage inefficient consumption.
- Effective environmental regulation requires the national government to take the lead in setting standards, regulatory frameworks, markets for environmental resources and dealing with environmental externalities that cross geographical boundaries. Regional and local governments need to be actively involved in evaluating the potential environmental effects of developing new facilities.
- Making public information about the potential environmental impacts of new facilities and new technologies in the planning phases has increased the level of public participation in decision making around new facilities and the care with which such new facilities have been planned.
- Different environmental impacts require different responses. There are local impacts, regional pollutants and international problems. For instance, measures to deal with acid rain explicitly may require the use of market-based mechanisms.
- Environmental regulations evolve over time because new information becomes available, environmental problems become severe and society's preferences change. As a result compliance targets are not and should not be static.

6.3 The EGI and the environment in South Africa

6.3.1 The structure of the EGI in South Africa

Table 6.2 below looks at the current structure of the generation sector.

Table 6.2: Structure of the EGI in South Africa, 1996

Source: NER (1996: 6)

Type	*Licensee*	*No of stations*	*Licensed capacity (MW)*	*% of total licensed capacity*	*Net energy sent out (MWh)*	*% of total net energy sent out*
Coal	Eskom	13	35 627		163 540 690	
	Municipalities	8	1932		4 909 583	
	IPPs	2	728		3 704 536	
Gas turbine	Eskom	2	342		-950	
	Municipalities	5	264		20 280	
Hydro	Eskom	6	661		1 320 357	
	Municipalities	3	4		10 010	
	IPPs	1	3		12778	
Nuclear	Eskom	1	1 840		11 775 050	
Pumped storage	Eskom		1 400		- 753 620	
	Municipalities	1	180		- 98 360	
Bagasse	IPPs	1	29		59 999	
Eskom total generation			39 870	92,7	175 881 527	95,3
Munics total generation			2380	5,5	3 636 466	2,0
IPPs total generation			759	1,8	4 982 360	2,7
Total for South Africa			43 009	100	184 500 535	100

Eskom Generation controls nearly 93% of the licensed generation capacity in South Africa. With this capacity it produced nearly 95% of the energy sent out in 1996. The dominance of Eskom's coal fired stations is notable. Most these stations are located on the Mpumalanga Highveld around Witbank, close to the country's major coal reserves. Also notable is that Eskom's coal-fired power stations are among the largest in the world.

To add to Eskom Generation's dominance is the fact that most municipal generators' capacity dates from the mid-1960s and is therefore old compared to Eskom's capacity. It is also notable that Eskom sends out more energy than its share of generation capacity. This is primarily because Eskom has concluded various capacity displacement agreements with municipal generators to sell electricity to them at a discount if they withdraw their capacity, and because municipalities anyway tend only to use their capacity for peak lopping. In 1997 Eskom's share of net energy sent out increased to 98.3% of the national total.

In addition to controlling generation, Eskom Transmission has an absolute monopoly in the transmission sector. This means that should an IPP wish to sell electricity to a customer not directly connected to its power station (or related local network) it would have to use Eskom Transmission's network to wheel its electricity. At present, Eskom Transmission could either refuse or charge an exorbitant wheeling tariff, thereby forcing the customer to purchase electricity from Eskom Generation. Eskom's monopoly also extends to the trading of electricity in the southern African sub-region. No other participant in the ESI in South Africa is allowed to trade electricity across South Africa's borders.

The strength of Eskom is further emphasised by its complete dominance of the southern African electricity market. In 1993 Eskom owned nearly 84% of the generating plant in Southern Africa and 41% of all generating plant in Africa. With this plant Eskom produced almost 88% of the electricity in Southern Africa and 45% of the electricity in Africa. At an international level Eskom is amongst the largest electricity utilities in the world.

Any proposal for restructuring generation in South Africa will have to contend with dominance of Eskom in this sector.

6.3.2 The environmental impacts of the EGI

Table 6.3 highlights some of the more important environmental impacts currently associated with the generation sector in South Africa. A more detailed discussion of these impacts can be found elsewhere in this study.

Table 6.3: Environmental impacts of the EGI

Source: adapted from Fox-Penner (1997: 335)

Type	*Kind of impact*	*Importance of impacts*
Coal-fired	*Air impacts:* Sulphur dioxide Nitrogen oxides and ozone Air toxins Particulates Carbon dioxide	Coal fired generation is the principal source of air pollution in South Africa. It is aggravated by the fact that many power stations are designed specifically to burn very low grades of coal. Of particular concern is the fact that it is concentrated in a very small area in Mpumalanga.
	Water impacts: Water consumption Thermal discharges Waterborne wastes Disruption of ecosystems	Electricity generation normally requires large amounts of water, and can be an important source of pollution. Most Eskom power stations operate a zero discharge policy and some of the newer ones have pioneered the use of dry cooling technology.
	Land impacts: Degradation	The use of open-cast coal mining, the impact of acid rain and waste disposal impact negatively on land quality
Hydroelectric and pumped storage	*Water impacts:* Disruption of ecosystems Displacement of people	Most hydroelectric plants are part of schemes whose principal purpose is water supply. Their significant environmental disruption can only be partly attributed to electricity generation.
Gas turbine	*Air impacts:* Air pollutants	The use of gas is limited. Within a coal-dominated system its impacts are benign, even though plant is old and less efficient than combined cycle gas turbine technology.
Nuclear	*Air impacts:* Air pollutants *Water impacts:* Water pollutants Thermal discharges *Nuclear waste:* Fuel processing Waste transport, processing & storage *Nuclear accidents*	The environmental impacts associated with the *normal operation* of nuclear plants are significant and particularly persistent. There is little clarity as to how spent fuel will be reprocessed or disposed of. The decommissioning of a plant poses additional environmental problems that have not been addressed. The risk of a devastating accident exists, although it is small.

6.3.3 The regulatory frameworks governing the EGI

Table 6.4 sets out the governance structures within which the EGI in South Africa operates.

Table 6.4: Governance of the EGI

Sources: Mitford-Barberton (1991), Fuggle & Rabie (1983), NER (1996), IEA (1996)

Type of regulation	*Authority*	*Scope*
Energy policy	Dept of Minerals & Energy (DME)	Develop energy policy for South Africa Oversee the implementation of policy
Licensing	National Electricity Regulator (NER)	License of generation capacity. Set operational and safety standards.
Investment in new plant	NER (after consulting Eskom)	Evaluate all plans for new capacity Submit all plans from municipalities and IPPs to Eskom for evaluation.
Pricing	NER	Approve all wholesale and retail tariffs. Monitor special contracts with large consumers.
Eskom	Dept of Public Enterprises	Appoints Eskom's governing body. Oversees performance.
Environment Air quality	Dept of Health, Environment & local governments.	Control of scheduled processes by 'best practical means' using certificates; Rudimentary emission standards; Zoning of land use.
Water quality	Depts of Water Affairs, Environment, Health & many other authorities, including local governments.	Ensure the quality of drinking water; Set, monitor and enforce effluent standards; Control specific pollutants; Approve developments requiring water; Conserve specific ecosystems and habitats.
Nuclear materials	DME Council for Nuclear Safety	Oversight of the production, use, storage, disposal and transport of nuclear materials.

The National Electricity Regulator (NER) was established in 1995 to regulate and manage the entire electricity supply industry. Thus far it has established a licensing framework for all distribution, transmission and generation activities, but it is doubtful whether it currently has sufficient capacity to monitor these licenses effectively. The NER is also in the process of rationalising the 2000-odd retail tariffs found in the distribution industry, but this is proving to be difficult. Among its more important contributions to date is the research it conducted into options for restructuring of the electricity distribution industry which had an important influence on current restructuring plans put forward in the White Paper on energy policy (DME 1998).

Monitoring and regulating the environmental impacts of the generation industry is very fragmented. At present Eskom has the most extensive programme for monitoring the environmental performance of its own power stations and other agencies are generally reliant on this information. This is not a desirable situation given that it is subject to significant moral hazard. In addition the dominant approach to mitigating environmental externalities in South Africa is that of 'command and control'. The weaknesses of this approach are noted in Table 6.1.

6.4 Options for restructuring the EGI in South Africa

The focus here is on outlining realistic options for restructuring the EGI in South Africa. At present, neither the government nor the NER has put forward any proposals in this regard. Eskom's position is similar to model one below. Others have proposed restructuring along the lines suggested by model two (see Mountain 1994 and Mphiri et al 1998). The debate is thus focussed on whether Eskom Generation should be allowed to remain intact or whether it should be broken up. A further issue is the privatisation of Eskom Generation (or parts thereof) and possibly of the municipal generation capacity as well. This debate is politically charged, but is an option that the government cannot ignore, given that Eskom is the 'crown jewel' of state enterprises and would command a very attractive price.

6.4.1 Models for restructuring the EGI

Soon after NER was established, a number of 'task teams' were set up to investigate various aspects of the ESI. Among these was the Electricity Market Task Team whose brief was to 'make recommendations to the NER regarding the need for an electricity market in South Africa, as well as the required future structure, operation and commercial interfaces between the participants in such an electricity market' (NER 1996: 2-6). This task team examined four possible ways of organising the electricity industry, namely: monopoly, single purchaser, wholesale competition and retail competition (these models are described fully by Hunt et al (1996: 21-87)). Although it did not make a specific recommendation as to which model should be adopted, it is evident that the task team favoured establishing a structure compatible with wholesale competition. Figure 6.1 illustrates the structuring of a wholesale market.

In the wholesale competition model the distributors, retailers and large customers are allowed to choose their supplier. The generators therefore have to compete for buyers. For this model to work there must be free access to the transmission grid, which would be operated by a neutral provider. A market operator would also need to be established to manage the electricity market and ensure a smooth flow of electricity between sellers and buyers. The distributors would maintain regional monopolies and would be obligated to serve all customers in their areas. The advantages claimed for this model include:

- greater competitive pressure on generators which would tend to increase efficiency and, thus, drive prices down;
- more accurate pricing of electricity and therefore incentives to use it more efficiently; and
- the distributors carrying less of the risk incurred by the generators.

The main disadvantage of this model is that it requires a sophisticated market to bring buyers and sellers together and to provide real-time monitoring of all contracts.

The wholesale competition model assumes that there would be an unspecified number of separate generating companies participating in the electricity market. The task team did not explore this aspect further. As a means of taking the debate forward two proposals for structuring the generation sector are presented and discussed below. Both models are illustrated in the context of the wholesale competition market structure.

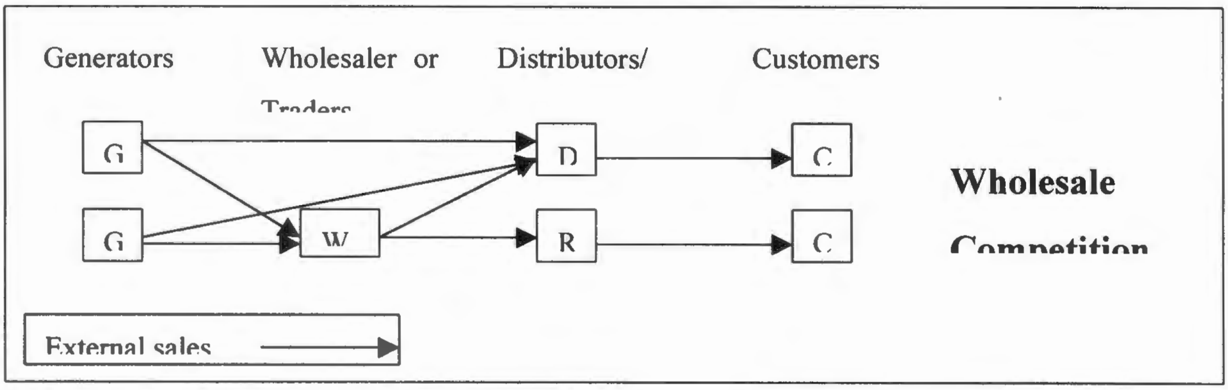


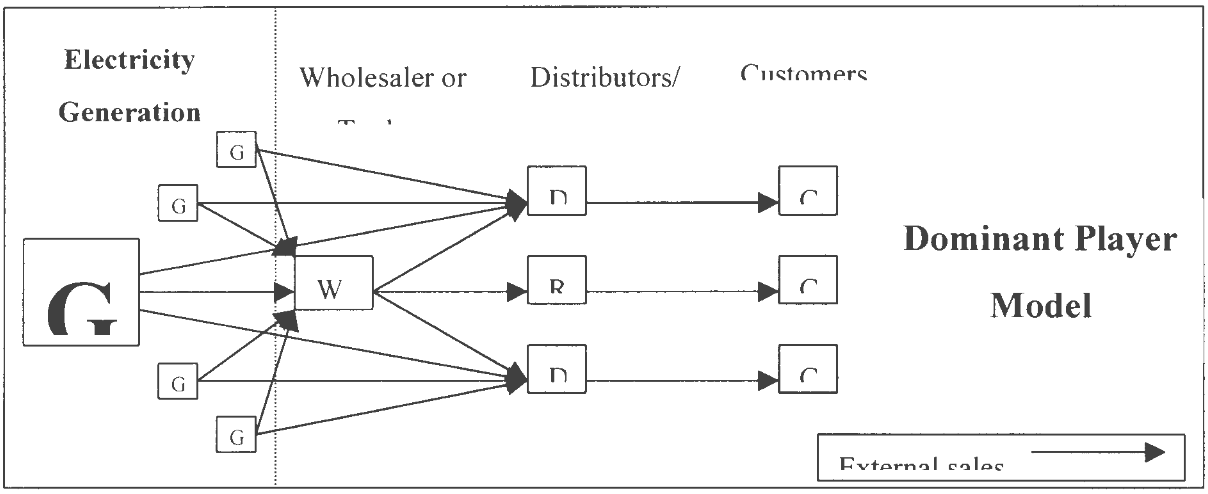
Figure 6.1: The electricity industry organised to allow for wholesale competition

6.4.1.1 Model one: the dominant player model

As the name suggests, a single utility company dominates the EGI in this model. There may be any number of smaller IPPs, co-generators or municipal generators, but their combined output would be comparatively small, say less than 25% of total output.

In effect, this model closely describes the current structure of the EGI in South Africa, except that the smaller electricity producers are not as yet allowed to sell their electricity either to Eskom Transmission or to third parties outside their distribution networks. Eskom Generation is thus not only a dominant player, but also a monopolist – it alone can sell electricity to Eskom Transmission. If, however, Eskom Transmission were to begin to function as a single purchaser or if wholesale competition were introduced, but the structure of the EGI were not changed then the dominant player model of the EGI as illustrated in Figure 6.2 would apply exactly.

In this model the rules governing the market would (in theory) apply equally to all the market players, irrespective of their size or market share. This model is likely to emerge when the rules governing a monopolistic market structure are changed to allow for greater competition, but nothing or very little is done to address the dominant position of the utility that benefited from the previous monopoly situation.



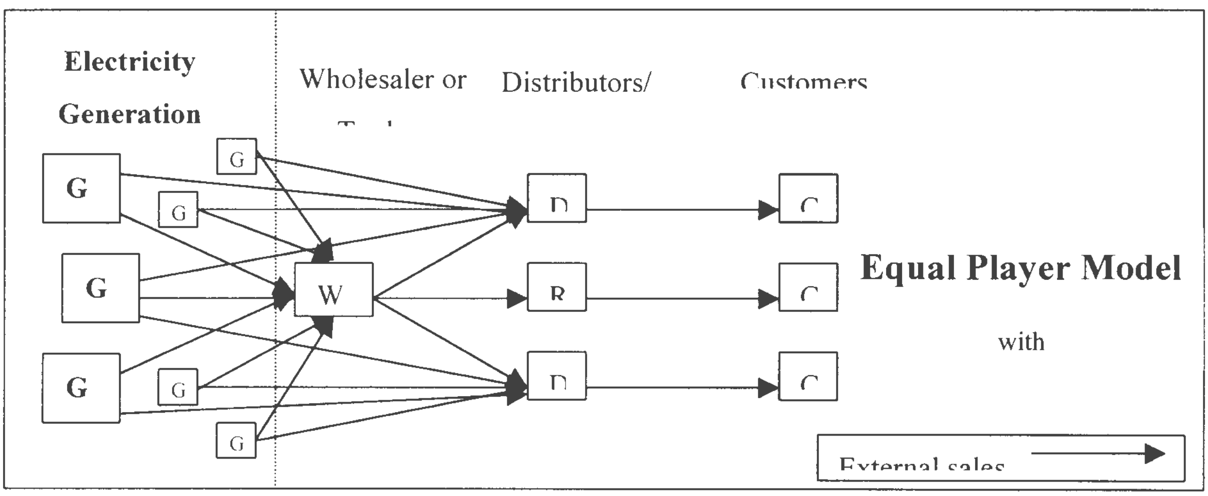


Figure 6.2: Dominant player model for the EGI

Figure 6.3: Equal player model for the EGI

6.4.1.2 Model two: the equal player model

In the equal player model the utilities may vary in size, but no single one would occupy a dominant position. For present purposes it is assumed that there would be a number of 'larger' companies with similar capacities (say between ten and 15 per cent of market share) and any number of smaller companies.

The equal player model does not exist in South Africa given the existing monopolistic market structure, and it would not naturally emerge if the market rules were changed to allow for greater competition. To establish this market structure Eskom Generation would have to be restructured into a number of smaller companies and these companies would have to operate independently of each other. They would not necessarily have to be privatised, but any form of collusion between companies would undermine the market.

From the point of view of ensuring the emergence of an effective and efficient competitive market there can be no doubt that the equal player model is preferable.

6.4.2 Restructuring the ownership of the EGI

Nearly 98,2 per cent of generation capacity is currently publicly owned, either by Eskom Generation (92,7 per cent) or by nine different local governments (2,5 per cent). Eskom Generation is a separate operating unit of Eskom. Eskom was recently converted from a statutory body into a public company with the national government as its sole shareholder. This conversion into a public company, the formation of various independent operating units and the separation of core and non-core activities into different companies is widely seen as preparing the way for the privatisation of at least part of the government's interests in Eskom. It is expected that when the government does decide to sell it will only sell its generation, distribution and auxiliary interests, but will retain control over the transmission network. As with other privatisation initiatives to date the government will probably only sell a stake in the different companies, as opposed to selling them off completely.

Many factors impact on the price investors are willing to pay for state owned enterprises. An obvious one is the availability of suitable investors. Eskom Generation is the fourth or fifth largest utility in the world (depending on the measure used). This effectively reduces the number of potential investors to a mere handful, which could result in the privatisation not being properly contested and the price being sub-optimal. The alternative would be for the government to break up Eskom Generation into a number of smaller companies and sell shares in each of these separately. This would enable a far wider range of investors to participate, increasing the competition and, as a result, possibly increasing the revenue government raises from the process.

Another important factor is the structure of the market. If the enterprise is a natural monopoly or is given monopoly rights it is likely to command a higher price than if it were simply one of a number of enterprises in a competitive market – other things being equal. The reason for this is obvious: a monopoly offers investors higher rates of return than a competitive company. The implication is that the government could raise more revenue by privatising Eskom Generation as a dominant player as opposed to breaking it up into a number of equal players and privatising them separately. However, the immediate revenue gains of retaining the dominant player market structure need to be balanced against the longer-term costs to the economy of higher electricity prices, a less flexible generation sector and the implicit risk that such a market structure creates for the government. Conversely, the lower privatisation revenues associated with the equal player model need to be assessed against the likely benefits of a more competitive market structure.

Should the government decide to restructure its generation interests, how it does so will depend largely on how it decides to make the trade-off between maximising revenue and establishing a robust market for electricity. Other factors such as the desire to promote black economic empowerment may be considered as well. At present it seems unlikely that the possible environmental impacts of different ownership structures will count for much in the choice, unless these can be shown to be significant (as would be the case with Koeberg).

6.5 Restructuring and regulatory frameworks

One of the important dimensions of restructuring is that it changes the 'rules of the game' by which the electricity supply industry operates, and therefore impacts upon the regulatory framework. Indeed, in many countries a central aim of restructuring has been to change the regulatory framework in order to introduce greater competition and to draw clear lines between the state's administrative interests, its supervisory responsibilities and its business interests.

In this context, the special interventions aimed at bringing about restructuring must be distinguished from the normal regulatory interventions that characterise the state's day to day role in the industry. These normal interventions may include actions in the following areas (Trollip 1996):

- Control of national resources.
- Regulation of monopoly power, with an emphasis on promoting competition.
- Oversight over markets to ensure they are delivering efficient outcomes.
- Oversight of consumer prices and the levying of taxes, possibly using taxes as an instrument of energy and environmental policy.
- Promotion of energy efficiency.
- The development and use of new technologies.
- Strict control over nuclear energy.
- The environmental regulation of the electricity and related industries.

- Emergency response measures.

The choice of regulatory regime for the EGI is greatly influenced by the state's preferred approach to regulation generally, the choice of instruments to be used and the institutional structure of the industry itself.

6.5.1 Approaches to regulation

At a conceptual level a useful distinction can be drawn between an interventionist approach and a frameworks approach to regulation. Figure 6.4 illustrates the two approaches.

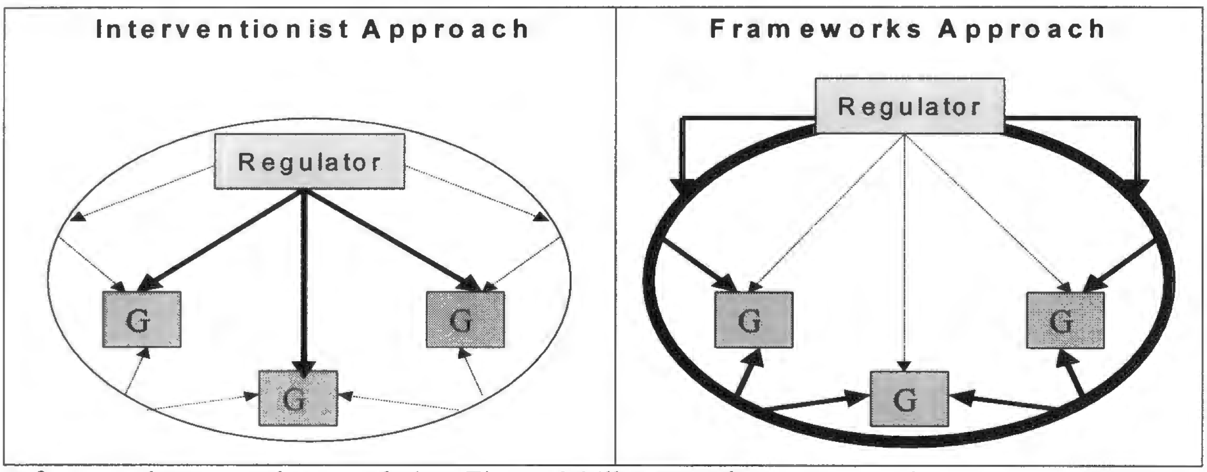


Figure 6.4: Two approaches to regulation

In the interventionist approach the regulator – either a government department or an agency – is an active participant in the operations of the industry. Hence figure 6.4 shows the regulator lying inside the rather weak governing framework. The key feature is that the regulator seeks to implement government policy by way of direct interaction with the utilities and other stakeholders in the industry (illustrated by the bold arrows between the regulator and the utilities). The form this interaction takes may vary widely, but includes consultation, negotiation, direct control over key decisions such as planning and pricing (especially if they are owned by the state) or prescribing detailed rules to which utilities must adhere. Such rules can include rate of return regulation, incentive regulations, and the use of integrated resource planning. Utilities look to the regulator for direction as opposed to responding to market forces, hence the thin arrows from the governing framework. In this approach the regulator takes an active interest in the individual decisions and actions of utilities, and if they are not to its liking will seek to change them through direct intervention. The decision to intervene and the nature of the intervention is often at the discretion of the regulator. As a consequence this approach to regulation is very open to corruption.

The key feature of the frameworks approach is the existence of a strong, usually market-based structure or framework within which the industry operates. The regulator's principle role is to maintain the integrity of the framework by ensuring that the rules of the game are equitable and lead to efficient and sustainable outcomes. In some systems the regulator may be directly responsible for operating certain markets such as the electricity exchange or the market in emissions permits. In others there may not be a specific 'electricity regulator'. Instead the framework may be established by competition and industrial safety legislation in general. If, over time, it appears that the outcomes are not in line with expectations the regulator may seek to adapt the framework so as to alter the incentives faced by utilities. This indirect approach is illustrated by the bold arrows in the right-hand diagram. Ideally the regulator would seek to maintain an arms-length relationship with all industry stakeholders, consulting them on certain issues relating to the framework, but otherwise leaving them to get on with servicing the market and making a return for their investors. It would be up to the utilities to respond to the market opportunities and competitive pressures exerted by other utilities within the confines of the regulatory framework. It is generally acknowledged that this hands-off approach is less susceptible to corruption.

These different approaches probably require equal levels of expertise to operate effectively. However, the nature and location of this expertise may differ widely between the approaches. In the interventionist approach most of the expertise will probably need to be located with the regulator if it is to exercise effective direct control over the utilities. By contrast, the frameworks approach would require fewer experts with the regulator and far more with the utilities. The regulator would need sufficient capacity to operate certain markets and monitor the overall system, whereas the utilities would need to invest in the management, forecasting, planning, and trading skills they require to compete effectively.

The interventionist approach to regulation is most likely to be found where the industry has strong monopolistic characteristics and is state-owned. This is often because governments fail to make a distinction between the role of the state as owner and the broader public interest. The interventionist approach has also long been seen as the best means of realising certain social goals (such as energy security) and dealing with the risks of monopolies and environmental externalities. By contrast, the frameworks approach functions best where there are a number of equal players competing with each other; in other words it is more likely to be found where there are a number of players in the EGI.

In many instances, a central purpose of restructuring is to move away from the interventionist to the frameworks approach to regulation by changing the structure of the electricity industry so as to create appropriate markets and ensure there are a sufficient number of competing utilities. Indeed, in South Africa the government has sought to drive aspects of the overall restructuring process by reforming the regulatory institutions and adopting a different approach.

6.5.2 Restructuring the regulation of the electricity industry

Much of the restructuring that has taken place thus far has focused on clarifying the roles and responsibilities of the various government departments and agencies involved in the energy sector, and in the electricity industry specifically. The convening of the National Electricity Forum in 1993 and its recommendation that an independent regulator should be established to oversee the restructuring process was an important development in this regard. The NER was subsequently established. Its role is to promote an effective and efficient supply industry and ensure that the electrification process proceeds as rapidly as is feasible. Its main tool for achieving this is the power to issue licenses and to determine supply conditions including price. It was hoped that the NER would undertake the process of rationalising the distribution industry by refusing licences to those local authorities that do not have the capacity to meet their responsibilities. This was not possible, however, largely because of the lack of information on local authorities' distribution activities. So the NER issued temporary licenses to all 400-odd distributors and permanent licences for transmission and generation. Since then, the issue of restructuring the EDI has been the subject of various investigations, but there is little to show in terms of forward movement. Even the recent White Paper on energy policy merely points to the need for further study of the issues (DME 1998:29-32). The White Paper also indicates that the role of the NER and 'the complete details of the regulatory regime have yet to be finalised' (DME 1998: 45). As things stand, the government envisages the development of a regulatory regime that will:

- ensure the effective accountability of public utilities to implement national policy decisions, without affecting their ability to manage their commercial affairs independently;
- broaden the involvement of stakeholders in utility governance processes;
- expedite the introduction of integrated resource planning; and possibly
- introduce and maintain effective competition within the electricity supply industry. (DME 1998: 45)

It would thus appear as if the overall trend is away from the highly interventionist (and secretive) approach of the past to a more transparent and institutionalised interventionist approach. There is some indication the frameworks approach may be adopted in certain areas, for instance with regards to competition among generators and giving customers choice of supply. But there certainly does not appear to be any intention, at present, to adopt the frameworks approach more widely.

6.5.3 Restructuring and environmental regulation

Thus far initiatives to restructure the electricity industry in South Africa make only passing reference to the need to consider environmental factors and to ensure sustainable development. Nothing concrete has been done to explicitly integrate environmental issues into planning the restructuring process. Indeed the White Paper simply notes that 'the overall regulatory responsibility for energy related impacts lies with the Department of Environmental Affairs and Tourism' and that the Department of Minerals and Energy 'has no regulatory responsibility regarding the impacts of energy on the environment'. There is nevertheless an acknowledgement that due to the 'inevitable interaction between environmental and development goals' an integrated approach encompassing these two issues is needed. To this end the DME undertakes to pay attention to environmental issues in studies it undertakes, and to co-operate with the Department of Environmental Affairs and Tourism in monitoring various environmental impacts of bulk energy supply and on governance issues. (DME 1998:79-86) At present, co-operation between the two departments on energy or environmental policy is minimal, and on restructuring the electricity industry it is non-existent.

And yet the Department of Environmental Affairs and Tourism has embarked on a 'comprehensive and integrated programme' of environmental law reform that will have far reaching implications for the electricity industry. The National Environmental Management Bill aims to provide the legal framework for environmental management and governance in South Africa. The bill proposes the establishment of a Committee for Environmental Co-ordination whose role would be to manage the performance of environmental functions by various government departments by means of 'environmental implementation plans' and 'environmental management plans'. The purpose of these plans will be to spell out how various departments will ensure that their policies and programmes comply with specified environmental principles and national norms and standards.

The department has also released a White Paper on Integrated Pollution and Waste Management (DEAT 1998). This summarises the role of government in controlling pollution as:

- establishing and maintaining an effective system of integrated pollution control and waste management;
- ensuring that all sections of the system use the same approach to pollution management incorporating source based minimisation and control, environmental media impact management and remediation;
- establishing and maintaining a system of clearly defined points of entry for permit and/or authorisation applicants;
- establishing and maintaining a system of permit and/ or authorisation application evaluation;
- establishing and maintaining a nation wide system of standards and procedures for setting standards;
- establishing and maintaining a system of nation-wide monitoring;
- establishing and maintaining a nation-wide system of permit and/ or authorisation enforcement;
- establishing and maintaining a system of interdepartmental interaction at permit and/ or authorisation evaluation, monitoring and enforcement stages;
- establishing and maintaining a system of information collection, management and dissemination to all relevant sectors of South African population; and
- establishing capacity building and awareness raising programmes and ensuring proper public participation and integration into decision making processes.

Clearly, permits or authorisations are a central feature of the proposed pollution control policy. These instruments are defined as follows:

> In the context of this discussion, the terms permit and/or authorisation are used to indicate a set of conditions which result from negotiations between the issuing authority, the applicant and any relevant specialists. While it is, therefore, possible and even desirable that certain quantified limits to such aspects as emissions and discharges may be included in the permit or authorisation, it will also include specifications of what monitoring will be conducted, by whom, with what frequency and where the results must be sent and with what frequency. (DEAT 1998)

The Department of Environmental Affairs and Tourism has also considered the use of economic instruments to control pollutants. It concluded that, although these instruments may be highly effective and efficient in many instances, they do not remove the need for the bulk of government capacity in pollution control and should not be seen, especially in the short term, as a replacement for the use of direct controls. The department noted further that the introduction of these instruments would assist in improving the effectiveness of environmental management in South Africa and that there are few legal barriers to their implementation (DEAT 1998). Apart from noting the possibility of using these instruments, however, no work appears to have been done as yet around actually designing systems for their implementation.

The overall approach to environmental regulation is thus very interventionist, being dominated by the use of environmental management plans and of direct command and control instruments, as well as the strong move to implement and manage environmental policy centrally. These developments will have far-reaching implications for the electricity industry, and could significantly affect the restructuring process. Clearly there is an urgent need to integrate thinking and work in these two policy areas.

6.6 Conclusion: restructuring factors likely to affect environmental performance

What emerges from the above discussion is that two important processes are underway that will impact extensively on the electricity industry, but particularly the generation sector. While restructuring is intended to enhance the efficiency and sustainability of the industry, the proposed changes to the environmental regulatory framework seek to foster efficient resources use and overall sustainable development. The irony is that these two processes are being pursued more or less independently of each other. Consequently, there is a real possibility that the restructuring process could undermine certain environmental objectives, or vice versa. Therefore to conclude this discussion we look at areas which could impact on the environmental performance of the EGI. These include:

(a) Unbundling Eskom

The unbundling of Eskom into separate generation, transmission and distribution entities exposes the costs of each sector, including the environmental costs. In the past it was argued that the cost of pollution was part and parcel of the privilege of having electricity. Now the real cost of say coal-fired generation relative to cogeneration or wind energy can be exposed. Also, the environmental benefits of electrification can be separated from the environmental costs associated with a particular mode of generation. In the past Eskom argued that a trade-off existed between electrification projects and installing desulphurisation equipment in coal-fired power stations. Given that generation and distribution are no longer vertically integrated, this trade-off no longer exists at the industry level. Eskom Generation has its budget, which is completely separate from that for electrification. Therefore if Eskom Generation has to spend a billion Rands on pollution control equipment, the cost of electricity may increase, but the electrification programme will not be placed in jeopardy.

(b) Changing the structure of the generation industry

It was noted above that the dominant player model describes the current structure of the generation industry. If the government decides to preserve Eskom Generation as is it will make the introduction of a competitive wholesale market very nearly impossible. As at present Eskom Generation would seek to use its market power to price other generators out of the market and would undermine the scope of market incentives to elicit optimal resource use.

The equal player model offers far greater opportunities for using market incentives to get utilities to clean up their act. If the environmental cost of operating each generation plant were converted directly into a 'green tax' on the electricity from that plant it would create an enormous incentive for firms to seek ways to clean-up and thus improve their competitive position. Such an individualised environmental tax would have little effect on firm behaviour in the dominant player model, as the dominant company would be the price-setter, and subject to little competitive pressure.

In the equal player model this 'green tax' could take the form of emissions charges or marketable pollution permits. To be effective, both these instruments depend on there being a sufficient number of market participants. In the dominant player model the costs associated with these instruments would simply be passed directly on to the consumer.

Moving to the equal player model and getting firms to internalise the cost of environmental externalities could result in generating capacity being used very differently to the current situation. At present Eskom Generation operates a power pool based on least-cost dispatching, but these costs exclude environmental externalities. In the new set-up dispatching would still be based on least cost, but the costs would now include environmental externalities. This could result in a different set of generators being used and would place pressure on firms to clean up.

(c) The nature of competition in the electricity market

Poorly regulated competition could undermine many of the positive aspects of the equal player model noted above. Such competition would tend to drive down the price of electricity below the social cost of generation as firms seek to minimise 'non-essential costs' by cutting on labour and reducing expenditure on pollution abatement. Mechanisms would need to be found to ensure this does not happen. For instance it would be important to move away from technology standards where compliance is based on installation, but there is no guarantee that the technology will be maintained and used effectively.

(c) Emergence of IPPS

An equal player model would encourage investment in IPPs, which in general are far more likely to invest in cogeneration, bagasse, gas, coal discards or micro-hydro generation capacity. This would impact on the energy mix used to generate electricity as a competitive wholesale market would create the necessary incentives for firms to take advantage of the neglected opportunities in these areas.

(e) The ownership of generation

In the past there was a definite conflict between the state's role as owner of Eskom and its role as custodian of the environment, although this has been resolved to some extent by the corporatisation of Eskom. However, there is still a conflict of interests given that the state is now the sole shareholder of Eskom and thus the beneficiary of any dividends. Returns to the state could be significantly reduced if the Department of Environmental Affairs and Tourism were to require Eskom Generation to retrofit abatement equipment to its generators. Indeed the cost to the fiscus could well exceed the current budget of this department. Privatising Eskom Generation, even partially, would tend to reduce this conflict.

It is often argued, however, that the state is less able to influence the behaviour of privately owned utilities as these are, in the first instance, accountable to their shareholders. This argument ignores the fact that the state can probably exercise greater control over utilities by way of regulation than they can by way of ownership given that the range of regulatory incentives or sanctions is far greater than the sanctions or incentives associated with ownership. Regulatory incentives could include subsidies, tax breaks, fines, the withdrawal of operating licenses and imprisonment, whereas if the state owns a utility the only thing it can do to influence behaviour is provide the funding to make the change, issue directives or replace the management.

The argument that the bottom-line is what drives private utilities and therefore they tend not to act in the public interest is, firstly, largely untrue and, secondly, does not necessarily differentiate privately owned utilities from public utilities. Experience has shown that public utilities are not above using their monopoly positions to further their own interests at the expense of the public interest. It is also well known that many public utilities are in financial difficulties precisely because they have been exposed to the discipline of the bottom-line. There is also ample evidence from other sectors in this country of privately owned companies that are leaders when it comes to environmental performance.

(f) The relationship between industry and environmental regulation

A key risk of the current electricity restructuring and environmental regulation reform processes is that they will work against each other, undermining the efficiency gains offered by the former and the environmental benefits envisaged by the latter. If the electricity regulator simply approves projects on economic criteria and the environmental regulator only uses environmental criteria, few projects are likely to get through both processes and those that do are almost certainly going to be sub-optimal in both areas. This can be partly overcome by the regulators working closely together, or by the electricity regulator specifying environmental planning criteria. Even in this instance, however, utilities are relying on the electricity regulator's ability to predict the thinking of the environmental regulator and future state of the environment, rather than making their own risk analysis of what investments to make in abatement technology.

This lack of freedom to choose can be aggravated where specific abatement technologies are prescribes by the environmental regulator and the electricity regulator sets electricity prices according to the normal 'cost-plus pricing' that allows for the automatic passing on of prudently incurred environmental compliance costs. In this instance the historical cost of compliance becomes the basis for setting tariffs. This does not encourage utilities to be proactive about reducing emissions. If they were to invest in different or additional abatement the electricity regulator may deem their expenditures to have been unnecessary given existing environmental regulations. This problem can be resolved by the electricity regulator moving towards market-based price setting mechanisms. (Andrews & Govil 1995: 890)

Finally, with reference to the questions posed in the introduction, it is evident from the preceding discussion that:

- any restructuring of the electricity industry, but particularly the generation industry, must give explicit consideration to environmental issues, and where appropriate these issues should inform the outcomes of the restructuring process;
- restructuring of the generation industry that fosters competition, creates effective markets for electricity and encourages private investment is on balance more likely to enhance environmental performance, as it will ensure the optimal distribution of investments in abatement and provide greater opportunities to use market-based approaches to controlling externalities.
- the process of reforming the environmental regulatory system must take cognisance of the changes occurring in the electricity industry, and seek to maximise the opportunities they offer;

- the electricity and environmental regulators must co-ordinate their activities to maximise their impact and to avoid conflicts that skew incentives and result in perverse outcomes;
- the regulators should seek to move towards a framework approach to regulation as opposed to relying on the interventionist approach.

Appendix 1
POWER GENERATION AND WATER RESOURCES

BASE DATA

	1997	*1996*	*Change 1996-97 (%)*	*Av. yearly change 1993-97 (%)*
FINANCIAL PERFORMANCE INDICATORS				
Revenue, Rm	20 448	18 687	9,4	10,1
Net income, Rm	3 083	3 072	0,4	15,7
Property, plant and equipment in commission, Rm	64 112	58 007	10,5	8,5
Net expenditure on property, plant & equipment, Rm	5 444	5 364	1,5	10,9
Net interest-bearing debt, Rm	26 991	27 298	(1,1)	(0,5)
Average price per kWh sold, cents[1]	11,85	11,30	4,9	5,3
Average total cost per kWh sold, cents[2]	10,08	9,46	6,6[3]	5,3
BUSINESS PERFORMANCE				
Return on total assets, %	11,30	11,65	(3,0)	1,4
Real (inflation-adjusted) return on total assets, %	3,62	3,89	(6,9)	(2,7)
Debt-equity ratio	1,08	1,25	(13,6)	(13,8)
Value created per employee, R'000	360	330	9,1	11,9

1. Revenue per kWh sold (total sales).
2. Operating expenditure and net interest and finance charges per kWh sold (external sales).
3. This change is 6,2% if the non-recurring profit of 1996 is excluded.

TECHNICAL/BUSINESS PERFORMANCE INDICATORS: OPERATIONS				
Total electricity sold, GWh[1]	172 550	165 370	4,3	4,6
Coal burnt in power stations, Mt	90,2	85,4	5,6	4,9
Water consumed by power stations, Ml	224 754	215 199	4,4	(0,1)
Peak demand on integrated system, MW	28 329 (30 June)	27 967 (24 July)	1,3	4,6
ASSETS IN COMMISION AT 31 DECEMBER				
Nominal capacity, MW [2]	39 154	38 497	1,7	0,1
Net maximum capacity, MW [2]	37 175	36 563	1,7	0,2
Power lines (all voltages), km	267 600	255 745	4,6	2,8
OTHER KEY STATISTICS				
Staff employed at 31 December, number [3]	39 241	39 857	(1,5)	(2,3)
Customers at 31 December, number (thousands)	2 244	1 877	19,6	32,9

1. Includes internal sales of 334 GWh.
2. The difference between nominal and net maximum capacity reflects auxiliary power consumption and reduced capacity caused by age of plant and/or low coal quality.
3. Excludes employees of subsidiary companies.

Appendix 2
THE IMPACT OF WATER PRICE CHANGES ON ELECTRICITY COSTS

A SPREADSHEET MODEL

	1997	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*
Base line cost data								
Total unit cost of electricity sold (c/kl)	10.08	10.38	10.69	11.01	11.35	11.69	12.04	12.40
Total costs (R million)	17,416	18,476	19,602	20,795	22,062	23,405	24,831	26,343
Additional costs arising from the change in the price or unit cost of water								
Annual (R million)	-	23	41	48	56	67	27	33
Cumulative (R million)	-	23	64	112	169	236	263	295
Percentage increase in total costs								
Annual (%)	-	0.1%	0.2%	0.2%	0.3%	0.3%	0.1%	0.1%
Cumulative (%)	-	0.1%	0.3%	0.5%	0.8%	1.0%	1.1%	1.1%
Additional cost of electricity								
Annual (c/kl)	-	.001	0.02	0.03	0.03	0.03	0.01	0.02
Cumulative (c/kl)	-	.001	0.04	0.06	0.09	0.12	0.14	0.152
Cumulative percentage impact on the price of electricity to consumers								
Assumed average retail prices								
group 1 (10 c/kWh)	-	0.1%	0.4%	0.6%	0.9%	1.2%	1.4%	1.5%
group 2 (15 c/kWh)	-	0.1%	0.2%	0.4%	0.6%	0.8%	0.9%	1.0%
group 3 (20 c/kWh)	-	0.1%	0.2%	0.3%	0.4%	0.6%	0.7%	0.8%
group 4 (25 c/kWh)	-	0.1%	0.1%	0.2%	0.4%	0.5%	0.5%	0.6%

Notes

An analysis of the price elasticity of demand of electricity arising from the additional cost of electricity has not been incorporated.

The choice of cooling technology will have a much greater impact on water demand as new capacity is built (or old capacity is recommissioned) than the price elasticity of demand for electricity

Appendix 3

RESTRUCTURING AND ENVIRONMENTAL PERFORMANCE: INTERNATIONAL EXPERIENCES

A survey of electricity industry restructuring experiences shows that ideological and economic – more typically fiscal – considerations were by and large the driving forces behind most such processes. There is not a single instance where environmental considerations provided the driving rationale for the restructuring of any country's electricity industry, though they may have influenced the shape of the restructuring outcomes.

Because the environmental impacts of electricity generation are dependent on the type of power plant being used, it follows that the impact that restructuring has on environmental performance will be largely a function of any changes that occur in the types of power plants used, their efficiencies and pollution control capabilities, and the intensity of their use (Fox-Penner 1997: 334). Until very recently, little attention appears to have been paid to the effect that the different restructuring experiences have had on the environmental performance of the electricity industries concerned.

This is not to say that environmental issues are not important and have not significantly affected the electricity generation sector. Indeed, many of the regulatory responses to such issues have had a profound effect and have precipitated far-reaching changes to the electricity industry. Some of these developments are noted below.

Environmental issues taken into account in restructuring

As noted, a mix of ideological, economic and fiscal considerations have been the driving forces behind all electricity industry restructuring processes, whether in the United Kingdom, the Scandinavian countries, New Zealand or Uganda. Nevertheless there are a number of instances where environmental considerations have impacted on the restructuring processes themselves, or been taken into account in a way that is likely to impact on the medium-to-long-term direction of the electricity industry.

The way nuclear generating plant was dealt with in the restructuring of generation industry in England and Wales is a notable example of a case where environmental risks and costs influenced the restructuring process. Initially, the intention had been to privatise all the nuclear plant (which supplied about 20 per cent of the electricity in 1989) within National Power. To compensate it for the decommissioning costs, operational and regulatory risks of nuclear power National Power was allocated 70 per cent of the total generating capacity, compared to the

30 per cent for PowerGen. However, the financial institutions persuaded the government that the nuclear risks were too great for the private sector, and the nuclear plant was withdrawn from the sale at the last moment. Hence, three companies, two private and one public, emerged from the restructuring process with a market share split as follows: 50 per cent to National Power, 30 per cent to PowerGen and 20 per cent to Nuclear Electric. In addition the government imposed an 11 per cent levy on all non-fossil generation, in the guise of a 'green tax', to supposedly help support the decommissioning costs of nuclear plants, but which in reality continues to subsidise the nuclear industry (Bunn 1996: 1-4).

In Norway the desire to manage the environmental uncertainty (variations from normal precipitation) associated with an industry where 99,6 per cent of electricity is generated by hydroelectric plant was an important consideration in the formation of the Power Pool in 1971 (Wiedswang 1994). By allowing for the trading of power at a common 'marginal value', this market facilitated the optimal utilisation of the system to the extent that independent utilities joined in. In 1991 the Norwegian government deregulated the market further by passing an act allowing for general third party access to transmission – that is, all Norwegian utilities could now transmit power through all Norwegian transmission networks. This allows for the optimal use of the country's hydroelectric capacity. Similar considerations have impacted on the deregulation of electricity markets in Sweden and Finland, and have also informed the creation of a Nordic electricity market and grid.

Denmark provides an interesting case where environmental considerations have tended to work against the introduction of competition. While there are no legal monopolies in the Danish generation industry, the entire electricity industry is subject to a non-profit system whereby only costs relevant to electricity supply can be included in the price. In addition, the industry is dominated by a range of political and regulatory agreements that seek to satisfy public concerns about the environment and sustainable growth. For instance, in 1990 utilities 'agreed' to build 100MW of windmills, as well as implement a range of other measures to reduce CO_2 output. According to Hoffmann (1994) this 'cobweb of centrally initiated regulations' inhibits efforts to introduce competition.

Impact of restructuring on environmental performance

The success of restructuring initiatives is invariably measured in terms of factors that provided the rationale for embarking on the processes in the first place. These commonly include improving efficiency, introducing competition, reducing the cost of electricity, creating opportunities for private investment, selling-off state assets, and so on. Since most restructuring initiatives do not take environmental issues into consideration, only limited attention has been given to evaluating their impact on environmental performance. Because 'environment' was not an issue or objective it is not considered when measuring the success or otherwise of different restructuring processes. The brief discussion that follows does not purport to fill this gap. The aim is to highlight the fact that restructuring of the electricity industry, particularly the generation sector, can impact significantly on environmental performance and that this is an area that requires further study.

(a) Efficiency of resource utilisation

When assessing the efficiency gains resulting from restructuring or deregulation the focus is typically on staffing, capital utilisation and other financial measures. So, for instance, 48 000 people were employed in the electricity industry in England and Wales in 1990. Five years later, the restructured successor companies generated about the same amount of power with only 46 per cent of the staff! Unfortunately, there is rarely any reference to whether environmental resources are being used more efficiently or whether the changes are socially and environmentally sustainable. A number of examples illustrate that this issue is certainly important (see Bunn (1996), Henny (1996), Pirvola (1994) and Wiedswang (1994)):

- The deregulation of the electricity market in Norway has facilitated the more efficient use of the country's existing hydroelectric generating plant. As a result less new plant has had to be built, which is a positive environmental externality.
- In discussions around deregulating the electricity market in Finland, Pirvola (1994) noted that freeing the market would change attitudes to power-plant construction and that economic considerations would tend to dominate at the expense of the long-term interests of the industry, society and the environment.
- Proponents of the Nordic Electricity Exchange note that bringing together the Norwegian hydro-dominant, the Finnish thermal-dominant and the Swedish balanced systems could realise great efficiencies in the overall use of resources.
- In the British experience, the higher cost of capital in the privatised markets has tended to discourage investment in both nuclear and coal plant, but favoured combined cycle gas turbines.
- It has been suggested that the privatised British generation companies are retiring older coal plant five to ten years earlier than would otherwise have been the case, due to high potential environmental costs.

- In Britain, Nuclear Electric increased output from its existing plant by 40 per cent in the five years after the 1990 restructuring of the industry; as a result the government is considering splitting the company in two and privatising the newer plant.
- There is evidence that the current 'market' price in Britain is distorting the profile of investment in new plant away from the efficient mixture of base-load and peaking plant which is usually considered appropriate in large power systems. Almost all of the new plant is contracted for base-load.

(b) Getting prices right

To date, all restructuring or deregulation initiatives have promised to lower the cost of electricity to consumers, and there is evidence that this has happened in most instances. However, to ensure the efficient use of resources it is important to 'get prices right', that is, they should reflect the social cost of different resource-use options accurately. Given that most electricity in Britain is generated using non-renewable fossil fuels it is conceivable that the lower prices are sending the wrong signals to consumers. Instead of encouraging greater end-use efficiency, lower prices encourage inefficient consumption. By contrast, in Finland the competitive nature of heating provided by combined heat-and-power plants has encouraged their widespread use and made a significant contribution to the improvement of air quality. Similarly in Norway, lower electricity prices have encouraged households to switch from oil to electric heating systems.

(c) Changes in energy mix

The British restructuring has had a tremendous impact on the mix of primary energy sources used to generate electricity, which in turn has impacted significantly on the environmental performance of the industry. Three related trends are evident:

- Investment in the gas sector has been significant (15,7GW in eight years). This 'dash for gas' has been strategically motivated. Distribution companies have been anxious to co-invest with IPPs in order to counterbalance the price setting power of the generators. Furthermore, the cash-rich generators have been equally keen not to be left out this sector.
- Increased efficiency has enabled Nuclear Electric to expand its market share significantly. The role of nuclear energy is set to increase further with imports from France.
- There has been a movement away from coal generation partly in response to what is happening in the gas and nuclear sectors, and partly as a result of cost factors and environmental concerns about meeting sulphur limits (British coal is more expensive and

higher in sulphur). Breaking the link with the electricity industry led to 80 per cent of the coal mines closing in the five years following restructuring.

In the Nordic countries there are indications that the introduction of the Nordic Electricity Exchange could contribute to the better utilisation of different primary energy sources by facilitating a more efficient mix of hydro and thermal generating capacity.

Experience in the Scandinavian countries, Britain and the USA suggests that cogeneration can meet a significant share of the demand for electricity, but that the institutional barriers preventing fair competition need to be removed to give these generators access to markets. Where restructuring has led to competitive markets, investments in cogeneration have tended to increase.

(d) Investment in improving the environment

In the USA there is concern that the introduction of price competition will create a situation where 'all power producers will have a single dominant incentive: to minimize all environmental compliance costs that add no marketing benefits' (Fox-Penner 1997: 343). There is evidence that increased competition has substantially reduced the number of renewable energy programmes in both the USA and other countries.

(e) Development of new technologies

One of the more uncertain aspects of restructuring is what its impact on technological development is likely to be. It can be argued that the more competitive environment will encourage firms to invest in R&D in order to gain a competitive edge. By the same token investment in 'blue sky'-type research with uncertain yet potentially significant benefits may suffer. This change in the mix of R&D may negatively affect realising improvements in environmental performance in the longer term, given that research efforts will be concentrated on improving the bottom-line rather than on solving environmental problems.

In assessing the environmental impacts of different restructuring and deregulation processes, there are two key questions:

- Could the improvements in environmental performance arising from restructuring have been realised in some other way, more particularly through regulation?
- Could the negative impacts on environmental performance have been avoided by changing certain aspects of the restructuring process?

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