THE IMPACT OF ELECTRICITY PRICE INCREASES AND RATIONING ON THE SOUTH AFRICAN ECONOMY

Final Report to the National Electricity Response Team (NERT) Economic Impact Task Team

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Acronyms

BUSA	Business Unity South Africa
CFL	Compact Fluorescent Light/bulb
CGE	Computable General Equilibrium (model)
CIP	Critical Infrastructure Programme
COP	Coefficient of Performance
CPI	Consumer Price Index
DME	Department of Minerals and Energy
DSM	Demand Side Management
DTI	Department of Trade and Industry
EBIT	Earnings Before Interest and Taxes
EDI	Electricity Distribution Industry
EIA	Environmetal Impact Assessment
EITT	Economic Impact Task Team (of the NERT)
GDP	Gross Domestic Product
GJ	GigaJoules
GW	Gigawatt
GWh	Gigawatt Hour
HSRC	Human Sciences Research Council
HVAC	Heating, Ventilation and Air Conditioning
IPP	Independent Power Producer
kVA	Kilovolt Ampere
kW	Kilowatt
kWh	Kilowatt Hour
M&V	Measurement and Verification
MTEF	Medium-Term Expenditure Framework
MVA	Megavolt Ampere
MW	Megawatt
MWh	Megawatt Hour
NERSA	National Energy Regulator of South Africa
NERT	National Electricity Response Team
PCP	Power Conservation Programme
PFC	Power Factor Correction
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
RoD	Record of Decision
SAM	Social Accounting Matrix
SANRAL	South African National Roads Agency Limited
SIC	Standard Industrial Classification
SMEDP	Small and Medium Enterprise Development Programme
SPA	Special Pricing Agreement
StatsSA	Statistics South Africa
SUT	Supply Use Table
UPS	Uninterruptible Power Supply
VSD	Variable Speed Drive

Executive summary

This report assesses the economic impact of electricity cuts on the South African economy. The study investigates the potential economic impact of differently distributed pricing or rationing options aimed at reducing peak electricity usage and electricity consumption. More specifically, the objective was to:

- Assess the economy-wide impact of a reduction in electricity use of up to 10%, differently distributed across the main economic sectors and users.
- Assess the potential for short- and medium-term improvements in energy use by large consumers.

The study also considers the potential impact of different pricing proposals on Eskom itself.

The project was led by the Centre for Poverty, Employment and Growth at the HSRC, in collaboration with the Energy Management Division at WSP Consulting Engineers. We gratefully acknowledge the financial support of ComMark, on the motivation by the Sector Strategies Co-ordinator in the Presidency. The views contained in this report are those of the authors only, and do not represent the views of ComMark or the Presidency.

The project involved a number of methodologies including economy-wide modelling, financial modelling and substantial interaction with stakeholders and experts in a range of industries. In addition, there was considerable interaction with the National Electricity Response Team (NERT), the National Energy Regulator of South Africa (Nersa) and feedback from Eskom. To some extent, the work was experimental and required strong conceptualisation. A number of iterations of the brief were required to arrive at useful methodologies and findings. Moreover, the research was done alongside a policy process (in support of the NERT) so objectives sometimes shifted.

This report is organised in three main sections. The first section analyses the potential economic impact of electricity price increases, or alternatively, electricity rationing, as a way of reducing consumption. This work confirms that, all things being equal, and if there is a choice:

- Electricity price increases are preferable to electricity rationing, that is, raising the price will reduce demand without requiring choices about the allocation of the cuts. Our model shows that an unrationed 10% cut may need a price increase of 72%, which is very close to that proposed by Eskom. This would result in the gross domestic product (GDP) falling by 0.3% in real terms. It is worth noting that in other work done for Nersa, an across-the-board 60% electricity price increase could result in a 2.1% consumer price index (CPI) increase. It is also worth noting that the price increase required if only mining and smelting were rationed is 57%, but the consequent fall in GDP would be 0.9%.
- A cut in electricity by 10% results in a 1.5% fall in low-skilled employment. High-skilled workers remain employed, albeit with a reduction in wages.

- Uncertainty around the timing of power cuts is far more damaging than are planned cuts. Planned cuts must take place as promised and according to a schedule.
- Adopting strategies that enable a period of adjustment for industry will in most cases be less pernicious than those that shock. The one obvious insight that has arisen through this process is that a 10% decline in electricity leads to a disproportionate negative adjustment in the economy, compared to a 5% decline. In other words, the economy can adjust relatively easily and with limited harm to the 5% decline, but the 10% decline has a different impact. For example, the electricity price would have to be raised by 27% to achieve a 5% cut in electricity usage, compared to 72% for a 10% cut in usage. This requires adjustment to the modelling that could not be done in a short time frame. Other than simple changes like switching light bulbs or turning down air conditioning, a change in technology is almost never immediate. The negative impact on industry will be greater in the short term than in the medium or long term. However, there may be long-term consequences of industry being forced to adjust to an immediate cut or price increase that might be difficult to undo thereafter. This raises the importance of identifying strategies that enable a phased approach (with alternatives such as improved maintenance strategies, etc.), especially for industries that may be forced to respond in ways that are not easy to reverse. Examples include the closure of marginal mines, or loss of investor confidence in property investments.

The second section of this report considers how firms in different industries might respond to electricity cuts or price increases. The central findings include:

- It is clearly possible to realise significant gains in energy efficiency in many industries and households. This means that 'all things need not be equal'. In other words, the need to implement power cuts could be made considerably less with more forceful approaches to improving energy efficiency. The quickest policy approach will involve extensions of tax allowances that are more rapidly depreciated where they are in place, but may not cover the desired investment as needed at present[1]. The second approach will involve a rapid design and implementation of incentives. Strategic price increases should also lead to changes in technology and process; however, this is more uncertain in that firms might also simply cut back production. The tax and cash incentives are meant to at least maintain output, whilst raising productivity. The main limits to this approach will be the availability of relevant equipment at the scale and time needed, as well as experienced personnel to implement it. This is the best possible way of addressing the medium- and long-term needs, as it has the effect of raising productivity.
- The need to cut electricity use by 10% will necessarily have a negative impact on investment, output and employment. However, the precise impacts will be uncertain, and in some cases may appear to be positive in the short run. For example, a shift in resources from tradable manufacturing such as smelters or

[1] We give one example in this paper, namely the potential for implementation of hard ice refrigeration technology as opposed to vacuum ice refrigeration or chilled water refrigeration plants in deep level mining (see section 3.10). Energy savings programmes in the mines are reviewed to find that they mostly have not adopted hard ice plants, which would be the more energy-efficient choice.

motors to inward-oriented activities such as construction or personal services could appear to offer employment a boost and reduce the current account deficit as imports for production exports falls. However, these may result from slowing growth and exports, which will hinder longer-run growth and development.

- The urgency of introducing new sources of power cannot be over-emphasised, whether by enabling large users to find alternatives off the grid, or by introducing new sources that are channelled onto the grid (co-generation).
- The potential for supply-side options are explored in this paper, particularly for co-generation and for taking large users off the grid. Co-generation is really a medium- or long-term option. Eskom has received about 100 co-generation projects potentially generating 5,000 megawatt (MW). Project sizes are mostly below 100 MW, with the larger providers potentially offering 400 MW. Much could be done to pick up the pace in this process. In this paper, we also discuss the potential to take large shopping centres off the grid. Many large retailers have already invested in generators for emergency use, such as lighting and refrigeration. However, generators are a very expensive option, even if Eskom is awarded a 60% price increase.
- There are many industry effects of rationing that are outlined in this document. The most important ones include:
  - ***Mining:*** It is unlikely that the mines will be able to achieve a 10% reduction in energy use in the short term. This is partly due to already implemented energy-saving programmes, but also due to the fact that the 'quick wins' are found in administration offices and hostels, which are relatively small users of electricity. The short-term impact of such a large cut is likely to be the closure of marginal mines. Unplanned cuts are dangerous in mining because of loss of ventilation and refrigeration, and the potential for trapping people underground. In addition, if power goes off for longer than 90 minutes, the slurry thickens, potentially causing damage to the stirring rakes when power is restored.
  - ***Agriculture***: There are few significant ways of immediately reducing power use in agriculture, although milling and some processing could be shifted to off-peak periods. Load shedding is extremely damaging to this already precarious sector, especially in dairy, poultry and aquaculture.
  - ***Motor industry***: As motor manufacturing involves 'jobbing', a power cut stops production but does not cause damage. However, motor manufacturing is a major source of exports and relies on timeous delivery.
  - ***Food industry***: The food and beverage industries involve batch and/or continuous processes. The critical problem arises where stocks are damaged due to loss of refrigeration. This can have uncertain knock-on effects on agriculture, and therefore on employment and rural livelihoods.
  - ***Chemicals industry***: Particularly in continuous processes, power cuts can damage equipment, and certainly cause delays. In many industries, a two-hour cut results in a disproportionate loss of production due to the need to clear machinery and re-start processes. This will be the case particularly if machinery is damaged in the process.

- ***Property***: Savings of up to 57% are possible in a 10,000m² commercial office, and can be achieved quickly. Incentives would help in this regard. The more critical concern is for the possible delay in building projects.
- ***Retail***: As with property, it should not be difficult to achieve a 10% cut in power consumption through simple changes related to light bulbs or temperature control in air conditioning.
- ***Residential***: Savings of 15% to 20% should be possible through the implementation of a range of measures outlined in this document, translating into about 26 million kilowatt hour (kWh). If radical improvements were made, up to 57% energy savings could be possible.

The third section of this report reviews the appropriate price path for the electricity price. 'Appropriate' was defined as a price that achieve a balance in respect of minimising damage to the economy, responsibly promoting energy saving and being sufficiently high to reasonably cover Eskom's financial health.

The analysis was prepared in response to Eskom's request to Nersa for a price increase above the 14.2%[2] already approved. It sought a 100% real price increase over two years. Eskom's stated objective was to cover the cost of its demand side management (DSM) and power conservation programmes, and ensure financial sustainability in light of Standard & Poor's having put it on 'credit watch'.

We considered four scenarios in our modelling: the 53/43 split proposed by Eskom (which amounts to a 119% compound increase), a three-year introduction of a 100% compound price increase (26/26/26), a four-year introduction of a 100% increase (19/19/19/19) and a five-year introduction of a 100% compound price increase (14.85/14.85/14.85/14.85/14.85).

It is important to note that our estimates relied on public information, and that they may not have the precision possible with the use of information available internally to Eskom. We made our spreadsheets available to the Eskom board and to the Chief Financial Officer (CFO) for review and comment. We did receive detailed comment from Eskom and substantially revised our submission on this basis. It should be noted that the value of the exercise was not in relation to precision, but rather in offering a technical framework upon which to judge Eskom's application.

The central arguments and findings were as follows:

- We believe that Eskom's proposed price increases enable an unnecessarily fast repayment of loan finance and exceed what is required to maintain credibility with its creditors. If no additional equity injections are made by the shareholder (other than that already committed) and if DSM is stripped out, we estimate that raising the real price by 100% over four years (19% per annum) would be sufficient to

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[2] The nominal price increase already approved is 14.2%. Eskom refers to this as equivalent to a 9% real increase. It is unclear why Eskom is assuming an inflation rate of only 5.2%. Note that the modelling used for this submission assumes an inflation rate of 7% in 2008/09 and an average of 8% per annum in subsequent years.

cover the cost of investment, provide adequate debt/equity ratios and support needed cash flow and interest cover. This includes primary energy costs forecast by Eskom for 2008/09, rising by inflation in subsequent years. The interest cover in 2008/09 is tight; however, this could be remedied with a slightly larger upfront loading of the state's R60-billion injection in 2008/09. Currently these injections are loaded in later years: weak cash flow could be remedied if the state instead loaded this funding into the earlier years, for example by shifting R3-billion to R4-billion into 2008/09 and 2009/10.

- Price determination must be made with the new levy in mind (R0.02/kW). This would add a further 10% to the average price. It is not an appropriate year to introduce this tax, and it is recommended that it not be introduced in the next two years. If Treasury does go ahead, we recommend that Eskom retain the earnings for one year at least, and that the price determination is reduced by the same amount.
- More co-ordination is needed in the decision-making process: while we make recommendations in respect of the proposed levy or the slightly higher up-front loading in the state's capital injection, these are not within the ambit of Nersa's current decision-making process.
- The price of coal and liquid fuel is uncertain, and therefore the associated price changes should be considered separately to other costs from 2009/10. We concur with Eskom's recommendation for a rule change in respect of primary energy costs, as laid out on page 27 of its proposal. Should primary energy costs rise faster than 8% per annum after 2008/09, the price may need to rise by more than 19% per annum.
- Energy-saving support measures (DSM) should be costed and paid for separately from this application. DSM objectives would be more appropriately handled through government's existing investment incentive programmes, such as the accelerated depreciation allowances or the Department of Trade and Industry's (the dti's) cash incentive programmes. We show the financial ratios with DSM included and excluded.
- Considerable savings could be made in energy use by businesses, but this would require new investments, which take time. Our research shows that with the appropriate incentives, firms could substantially reduce consumption over six to 18 months. Incentives are more likely to promote output-enhancing investments, while rapid price increases may reduce output in the process of reducing energy use. A price increase that is introduced too rapidly will have a disproportionate effect on reducing output. There are quite a number of other challenges currently facing the economy, inducing inflation and dampening growth. It is essential that where possible, the electricity price does not introduce an additional challenge.
- It is worth noting that there are other reasons to raise the price of electricity. One purpose may be to reduce peak usage and/or to reduce overall consumption. This is not reflected in Eskom's document, nor is it the purpose of its proposal. Nevertheless, it is an important consideration, as any price increase should be implemented in a way that maximises its combined impact on both peak usage and consumption. It is also worth noting that a 54% increase introduced over two years would likely reduce consumption by the sought-after 10%, ***if there were no other incentives in place***. It has been noted that other factors will also encourage

reduced consumption – such as fear of rationing and load shedding, or positive incentives to introduce energy efficient technologies. Hence, the 100% increase is needed to cover costs only, and is more than that needed to reduce consumption by the desired amount.

- We are concerned that this price determination could be made in isolation of other important related decisions that do not necessarily fall within Nersa's ambit. As examples, we refer in this document to the location of DSM, the introduction of the new levy and the timing of the state's injection.

1. Background

This is the final report for the project to assess the economic impact of electricity cuts on the South African economy. To help the reader, the initial project proposal is included at the back of this report.

The objectives of this project were to:

1. Assess the economy-wide impact of a reduction in electricity use of up to 10%, differently distributed across the main economic sectors and users.
2. Assess the potential for short- and medium-term improvements in energy use by large consumers.

This was done through a number of processes, including economy-wide modelling, interaction with the NERT and other stakeholders, insights from different sectors and feedback from Eskom. To some extent, the work was experimental and required strong conceptualisation. A number of iterations of the brief were required to arrive at useful methodologies and findings. Moreover, the research was done alongside a policy process (in support of the NERT), so objectives sometimes shifted.

This report analyses two broad scenarios. In both, we look at the consequences of a 10% fall in electricity output on a reduction in the capacity of the sector. This is a simple way of capturing the situation in South Africa, which has arisen because demand growth has outstripped capacity.

- In the ***first scenario***, we allow the price of electricity to adjust to match demand with available supply.
- In the ***second scenario***, we ration supplies to selected sectors. We consider ***two different rationing packages***:
    a. Gold and other mining plus non-ferrous metals (which includes smelters) (electricity supply to all three cut by 10%); and
    b. A range of more service-oriented sectors (wholesale and retail trade, hotels, catering and accommodation, and insurance, real estate and business services).

Section 3 of this report explores possible improvements that could be made in energy efficiency, how long these would take to implement and how much they would cost. To define immediate, medium term and long term, we used government's *National Response to South Africa's Electricity Shortage* of January 2008 (Department of Minerals and Energy, 2008), as follows:

- Immediate = within six months;
- Medium term = within 18 months; and
- Long term = longer than 18 months.

This part of the report offers an overview of considerations in mining, agriculture, manufacturing, tourism and commercial sub-sectors. We wanted to offer a concrete example, and appended a mining case study to explore the impact of vacuum ice refrigeration technology compared to hard ice refrigeration technology, where the latter does not yet appear to have diffused through the mining industry but could offer a 'quick win' opportunity.

The report offers an overview of all potential savings, particularly those that can be implemented in the immediate or medium term. For ease, all known options are listed, even those that are currently being pursued by Eskom's DSM programme, such as the replacement of light bulbs. While listing these, this investigation has not focussed on them except insofar as they aid the modelling work. The deeper insights are sought on technology and processes that appear to be off the radar, with views on cost and time frames for their potential adoption. Likewise, the report may offer insights about industry impacts and choices that have already been communicated by Eskom or industry; they are nevertheless listed here for completeness' sake. The project independently verified views put forward by Eskom and industry as much as was possible.

Although not specified in the brief, the HSRC-WSP team prepared recommendations in respect of Eskom's proposed price increases, which were submitted to the regulator Nersa and ultimately adopted. These recommendations are found in Section 4 of this report. They relied on financial and economy-wide modelling to identify an independent view of an appropriate price path, from the perspective of the impact on the market and on Eskom.

2. Economy-wide impacts of electricity cuts differently distributed[3]

In general, a shortage of electricity means that the total quantity all users would like to use exceeds the available supply. When this happens, something has to bring the two in line, as the economy cannot use more electricity than is available.

In this section we look at the impact an electricity shortage might have on the economy as a whole, depending on how use is adjusted to the shortage. We begin by restating the nature of the problem in order to set out what it is we attempt to analyse. We then look briefly at the use of electricity in the South African economy and some of the data problems involved in getting a clear picture. This is followed by a consideration of how impacts are affected by the time over which they take place. We then discuss some basic issues related to rationing. Finally, we look at the impact of an electricity price increase and of rationing that is distributed differently according to sectors.

2.1. The nature of the problem(s)

There are three dimensions to the electricity problem faced by South Africa (Department of Minerals and Energy, 2008):

- **A capacity problem**: the installed capacity is insufficient to meet peak demands;
- **A supply problem**: the desired consumption of electricity exceeds the capacity of the system to supply it; and
- **A reserve margin problem**: the margin between capacity and demand is below what is safely required to allow routine maintenance, to meet unanticipated surges in demand and to cope with unanticipated down time.

While these problems are related, they have different prime causes and may require different responses.

The capacity problem is caused primarily by the gap between the installed (or operational) generating capacity and peak demand. The solutions are, on the supply side, to increase capacity by new investment and, on the demand side, to reduce peak demand. This can be done by shifting the timing of peaks of different users, as well as by reducing those peaks through technical interventions.

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[3] This section was written by Prof. Rob Davies. He would like to thank James Thurlow, Channing Arndt and Dirk van Seventer for helping to clarify some of the modelling issues; Miriam Altman, David Fleming, Andrew Mather and other members of the WSP team for casting light on some of the more arcane aspects of electricity; members of the NERT EITT for their insights; and Kabilo Masike and Lona Manzana at Eskom for assisting with data.

The supply problem is caused by a gap between consumption levels and the ability to supply power. The latter is determined by a combination of operational capacity and the ability to run it over sustained periods. This depends in part upon technical requirements for maintenance and in part upon availability of complementary inputs, primarily coal. In South Africa there seems to be a constraint on production caused by the quality and quantity of coal supplies.

The reserve margin problem in South Africa has been caused by demand rising faster than operational capacity. It results in less time for maintenance and in equipment being run harder and longer than is optimal, and it reduces the buffer for unplanned down time, so that any such time leads to disruptions of supplies.[4] The problem can be addressed in the longer run by increasing capacity. With given capacity in the short run, the ability to meet unanticipated increases in demand depends in part on the ready availability of inputs such as coal. When stocks have been depleted, they can only be rebuilt if coal purchases exceed usage. This can be achieved in part by reducing electricity consumption.

All three problems can thus be solved by various combinations of increased supply capacity and reduced use. In the short run, the scope for the former is limited (but not non-existent), placing much of the burden of adjustment on the demand side. In broad terms, users need to be either induced or instructed to use less electricity. 'Inducements' could be targeted incentives to cut use; for example, subsidies for installing less electricity-intensive equipment, or price increases that persuade users to conserve electricity in whatever way they can. 'Instructions' covers all forms of rationing. Rationing can be direct – some explicit administrative rule which decides which users will cut back and by how much – or indirect – some process which is not based on targeting specific users but employs other criteria such as geographical area or time (such as load shedding).

The policy problem is to find ways of reducing use that impose the least cost on the economy in terms of foregone output, reduced employment and increased social disruption. While it is natural to focus attention in the short run on the lost output (and jobs), the greater cost is probably foregone growth. Lack of electricity constrains South Africa's ability to benefit from the international commodity boom. It probably also exacerbates negative influences on the economy, such as rising oil prices. While these consequences may not be completely avoidable, it is important that they are minimised as far as possible.

Both demand and consumption can be affected by price. However, they are not necessarily affected in the same way. Consumption is affected by cost to the user, although this is not the only determinant. The specifics of some uses may limit users' ability to respond to price increases. For example, the possibility of switching to other sources of energy varies across users. However, within these structural constraints, raising the price will reduce consumption. But peak demand depends not only on the level of consumption but also on its pattern. It is feasible for the level of consumption

[4] One can think of this as equivalent to carrying stocks of materials and finished product as a precaution against unanticipated disruption of supply and production. Since electricity cannot be stored easily, reserve capacity is the only way the industry can take such precautions.

to be reduced without peak demand falling. One can think of a production process as requiring two different electricity inputs, one related to starting up the process and the other to running it. For example, in mining the start and end of a shift, in which lift gear is heavily used, has a higher demand than the rest of the shift. It may well be that the best way for mines to reduce electricity consumption in response to a price increase is to reduce other consumption, but to maintain the peak demand at the start and end of shifts. A general price rise may accentuate the difference between peak and 'normal' demand, but not necessarily reduce the peak. To be certain of reducing demand through a price increase requires a time-dependent tariff structure.

The same considerations apply to using rationing to affect consumption and demand. Even when rationing reduces consumption, it may not reduce demand, and *vice versa*. To affect demand, the rationing instrument has to focus on a particular time of day or particular seasonal use.

The above discussion is intended to highlight the importance of understanding the specific problem we wish to address and the appropriate instruments for doing so. It should not be taken as suggesting that these varied instruments do not already exist in South Africa. Eskom already has mechanisms specifically aimed at peak demand. For example, large users are charged tariffs based on agreed peak usage, and pay penalty prices if they exceed these limits. In most instances such users have installed equipment to monitor peak use and automatically switch use if they are approaching the limit.[5]

The modelling we use focuses on consumption, not demand. We assume that there is a relationship between the amount of electricity a sector consumes and the output it produces over the year. While this is a reasonable assumption, it could be invalid for sectors where production processes have fixed peak demand requirements. It is possible that such an industry reduces output because capacity cannot meet its peak, even though the supply of energy to it is not cut. Our models do not capture this possibility.[6]

In the sector studies section (Section 3), we look at the scope for reducing electricity demand and consumption within different sectors, taken in isolation. We divide the impact of reduced electricity inputs on output into three phases. Initially there may be no impact (Phase I). Continued reductions beyond this point cause output to fall, probably at an accelerating rate (Phase II). Finally, we reach some point when everything shuts down, even though some electricity may be available (Phase III). These phases differ from sector to sector, as explored in Section 3.

[5] These provide excellent illustrations of the effectiveness of price-based mechanisms for inducing the desired responses from users.

[6] We could be interpreted as assuming a fixed relationship between peak demand and consumption. The figures in Table 1 suggest that this is not completely unreasonable. Between 1991 and 2008, differences in the ratio of peak MW to consumed gigawatt hour (GWh) show up only in the third decimal place (although this constancy is dependent on the units of measurement).

Table 1 – Data on South Africa's electricity production and use

	Peak demand	Installed capacity	Operational capacity	Reserve margin	Volume of electricity available for distribution	Ratio of demand to consumption	Consumption/ installed capacity
	GW	GW	GW	%	GWh	MW per GWh	GWh per MW
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
1991	22.5	33.0	29.5	32	153,776	0.146	4.66
1992	22.6	34.9	30.1	35	154,083	0.147	4.41
1993	23.1	35.9	31.1	36	159,505	0.145	4.44
1994	24.4	36.8	32.0	34	165,985	0.147	4.51
1995	25.0	36.7	32.0	32	171,401	0.146	4.67
1996	28.0	37.5	32.8	25	180,370	0.155	4.81
1997	28.1	38.0	33.2	26	187,507	0.150	4.93
1998	27.9	38.8	34.6	28	187,516	0.149	4.83
1999	28.0	39.3	35.4	29	190,120	0.147	4.84
2000	29.1	40.0	36.2	27	195,660	0.149	4.89
2001	30.5	40.5	37.1	25	196,063	0.156	4.84
2002	31.9	40.5	37.1	21	206,020	0.155	5.09
2003	32.0	40.5	37.1	21	213,461	0.150	5.27
2004	34.1	40.5	37.1	16	221,938	0.154	5.48
2005	33.2	40.5	37.1	18	223,257	0.149	5.51
2006	35.2	40.5	37.5	13	231,323	0.152	5.71
2007	37.1	41.2	38.8	10	241,414	0.154	5.86
2008	38.6	42.0	40.2	8	-	-	-

Sources: Columns [1] to [3]: Department of Minerals and Energy (2008); Column [5] Statistics South Africa (1996) and Statistics South Africa (2007)
Notes: [4] = ([2] – [1])/[2]; [6] = [1]/[5] × 1,000; [7] = [5]/[2] × 1,000

The existence of Phase I need not imply that electricity is being 'wasted'. When we measure electricity used by a firm, we include not only electricity purchased for a narrowly defined production process, but for all uses by the firm. Thus, for example, electricity inputs into mining include electricity used by hostels at mines. Similarly, a manufacturing firm might purchase electricity not only to run its plant, but also to provide air conditioning in its offices. Reducing these purchases may cause discomfort and require some adaptation, but will not necessarily cause output to decline.

In the modelling, we focus on Phase II. The production relationships in the model do not incorporate any 'waste' or slack in electricity use. In any case, there is hardly a problem if sectors are able to reduce electricity purchases without reducing output.

2.2. An overview of electricity as an input into the South African economy

To begin to understand the potential impacts, one needs a sense of usage patterns. Data on this are provided in the Supply Use Tables (SUTs) published by Statistics South Africa (StatsSA). The latest SUTs published are for 2002 (Statistics South Africa, 2005). Although these are out of date, we are concerned mainly with the structure they depict, rather than their levels. Experience elsewhere suggests that structure changes slowly.

The share of electricity in the cost structure of an industry gives some idea of its direct vulnerability to electricity shortages. Table 3 shows industries ranked according to their dependence on electricity; that is, the share of electricity in their cost structure. However, this does not tell us where most electricity is used, since a highly dependent sector could be a small user. Table 4 ranks sectors by their shares in total electricity purchases by industries. (We exclude households, whose share was 31.1%, while industrial purchases accounted for 68.9%.) It can be seen that the top 17 purchasers account for 75% of spending on electricity by industry.

These two tables provide information that would help to understand the direct impacts of electricity cuts. Table 3 shows how cuts might impact on individual sectors, while Table 4 gives some idea of the amount by which electricity demand would be reduced if particular sectors were cut.

While the SUT data are useful for understanding electricity use in South Africa and form the basis for most of the modelling we undertake later, some shortcomings need to be noted.

Differential pricing: Most importantly, these data show expenditure on electricity, rather than physical use (that is, kWh). Since users are charged different prices, physical use and expenditure are not perfectly correlated. However, to the extent that there is a tendency for big users to be charged lower prices, the figures in Table 4 will understate relative use at the top and overstate it at the bottom.

Unfortunately, detailed data on physical use by user are not publicly available. Eskom does have confidential data on usage classified at a five-digit Standard Industrial Classification (SIC) level. However, electricity supplied by municipalities is classified at the very broadest level – residential, commercial and industrial. It is therefore not possible to collate the two data sources to provide a detailed picture of physical consumption by user.[7]

Based only on the Eskom data, the price differentials cause the biggest anomaly for residential and prepaid users. They consume about 10% of Eskom's sales measured by expenditure, but only about 4% measured by kWh.

[7] We would like to thank Eskom and Electricity Distribution Industry Holdings (EDI) for supplying us with these data.

Peak demand: We have no data on peak demands by users. This is not a problem for the modelling, since we model consumption, not demand. However, such data would be useful for more rigorous modelling of production processes.

Consumption of self-generated electricity: The SUT does not record use of electricity generated by users. SUTs measure market transactions, not intra-firm activities. Where electricity is generated inside the firm using purchased inputs, we would see high purchases of, say, diesel, which is then transformed into electricity. This is no different from any other inputs that are transformed in the production process, and does not pose problems. However, when we consider changing technologies induced by the shortages and the possibilities of co-generation by private producers, we would probably wish to be able to identify the extent of own use.

2.3. Impacts and time

The size of any impact of a shock to the economy will depend in part on the period over which it is measured, for several obvious reasons. First, any cumulative impact will be bigger over longer periods, simply because it is cumulative. Second – and importantly for economy-wide assessments – the impact will be greater the more time there is for it to have knock-on effects (for the shock waves to be felt through the economy). Third, responses, whether ameliorating or aggravating, will be more significant the more time they have to be put into place.

The same shock may have different time profiles, depending on the specific measure of its impact. We are interested in the impact of the electricity shortages on, *inter alia*, output and employment. When we assess the output response, we should be more precise in specifying the period to which we refer. Obviously, we would expect the aggregate output lost to rise as time passes, allowing losses to accumulate. However, we would expect the impact on the industry's ability to produce in a given period of time, say a week, to be bigger immediately after the cuts than later, when producers have had time to respond with actions that ameliorate the impact. Indeed, there may be no discernible effect on output per week after sufficient time has passed.

However, this may not be true when we measure the impact on employment. Even if firms wish to reduce their labour force in response to the shortages, they may not be able to do so in the very short run because of contractual obligations. In this case, employment may decline only after some time has elapsed. It may never recover to its former level if the ameliorating response is to move to less labour-intensive technologies.

Impacts can be classified according to the time period in which they take effect:[8]

- ***Very short run***: No supply response is possible and demand responses are limited to adjustments within existing technology (for example, switching off lights, air conditioning, hot-water geysers, etc.).

[8] This classification is adapted from Rose and Gauri-Shankar (2004).

- ***Short run***: No supply response is possible, but a wider range of demand responses is possible, including some minor technical changes (for example, using compact fluorescent light[bulbs] or CFLs). A possible way of distinguishing between these demand responses and those in the very short run is that there is now some kind of 'capital' cost involved in making the change.
- ***Medium run***: Some supply responses are possible (for example, co-generation from existing capacity); demand responses include making 'easy' switches in technology.
- ***Long run***: The full range of supply and demand responses is possible.

These periods lie on a continuum and will differ from industry to industry – and probably from firm to firm within any industry. Nonetheless, it is useful to analyse impacts within this periodisation.

In the shortest run, when supply/capacity is fixed, some form of demand management is required. In principle, this can be done ***through the market*** (allowing prices to change and letting users respond as best they can), or by ***rationing*** (some administrative allocation), or a ***combination of the two***.

The time dimension is also important when thinking about various private agents' likely responses to the shortages. These will depend on the perceptions of agents as to whether the shortages are temporary or not: a shortage that is expected to last a few days and not be repeated will evoke a different response to one that is expected to be sustained for some time.

2.4. Administered prices, rationing and electricity in South Africa

The differences between market (price) based and rationing responses to the shortages are at the heart of our analysis below. It is therefore useful to set out some broad issues that affect the modelling strategy we have adopted.

Electricity price changes are essentially based on negotiations between Eskom and Nersa. This does not result in prices that respond to market conditions. It appears that while the regulator can consider cost-side issues, it cannot consider those on the demand side; price increases can be permitted because costs have risen, but not because there is a need to reduce demand.

Problems inherent in this procedure have been masked up to now by the fact that there has been excess supply of electricity. Effectively, Eskom has been able to meet the demands of all users at the existing price without running into a supply constraint. Increased demands from existing or new users could be accommodated within existing capacity constraints. Effectively, changes in demand have been met at a (low) fixed price by varying profits. Indeed, until recently, Eskom has attempted to encourage users to increase consumption (and users of competing energy to switch to electricity). This is entirely what one would expect from an industry which has excess production capacity and is effectively unable to vary its price.

Problems are now surfacing because the surplus capacity has disappeared. If the price is not permitted to rise in the face of this – that is, because demand exceeds supply rather than only because costs of production have risen – there has to be some other method of deciding which users will have to reduce their consumption and which will not. As indicated above, this could be through direct and/or indirect rationing. Indirect methods may be a bit haphazard in their effects on different users, unless there is a very clear geographical pattern of use. Businesses benefit by being on the same grid as users who are regarded as important enough to be exempted from load shedding, but which businesses these are has been determined by a largely random historical process.

Unless direct rationing reduces use by at least the total excess demand, other mechanisms have to be brought into play. This is difficult to ensure, even where demand is not growing (assuming that the rationers would prefer not to cut excessively). In a more dynamic setting, it is even more difficult. If demand rises over time while capacity does not, one necessarily needs to keep tightening the rationing. Given the difficulty of changing direct rations frequently, it probably becomes increasingly necessary to resort to indirect rationing – unplanned load shedding is likely to become more frequent over time.

The quantity of electricity consumed by rationed users under rationing is less than under the price increase. This is a result that applies under all rationing schemes. Under the price increase, the required aggregate cut is distributed across a wider spectrum of users than under rationing. To meet the same aggregate cut under rationing, those rationed necessarily have to reduce consumption by more. Those in favour of rationing are actually motivated by this. They feel that some users should have bigger and others smaller cuts than they would under the market solution, whether on grounds of fairness, ability to absorb cuts, economic impact or for other reasons.

2.5. Analysis of the economy-wide impacts of electricity shortages

While the figures in Tables 3 and 4 are useful for assessing electricity use by sectors taken on their own, they do not give any idea of indirect usage of electricity. Industries use electricity not only directly but also indirectly through the inputs they purchase from other sectors. To examine these we need to consider inter-industry linkages. The tables also do not show us the influence of economy-wide constraints and feedbacks. These might change the conclusions we draw from a sector-focussed study. For example, when we examine a sector in isolation, it is obvious that a cut in electricity supply can only be harmful or, at best, have no impact; it cannot be beneficial. If we reduce the availability of a necessary input, we reduce the sector's capacity to produce and, to the extent that it cannot make costless ameliorating adjustments, will reduce its output. However, when the cuts affect a number of sectors simultaneously, other factors are brought into play. As sectors cut back their output, they reduce their demand for inputs. Depending on the time horizon over which the effects are measured, this can reduce prices and costs for other firms that use them. This provides a positive impetus that counteracts the negative effects of the cuts. Whether the net effect is negative or not will depend on the importance of electricity as an input and the size of any price-reducing impacts.

Other economy-wide effects may also be important. The exchange rate may depreciate, stimulating export-oriented sectors. Labour costs may be affected as labour is shed from contracting sectors.

To examine these, we need to locate any particular sector within the whole economy. Various techniques for economy-wide analysis allow us to do this and help us to think through some of the issues. We primarily use a computer-based model – technically a computable general equilibrium (CGE) model – that captures economy-wide interlinkages between production, income distribution and consumption, and which incorporates some behavioural responses to the shocks. We supplement this with an input-output model, which assumes fixed proportions, to examine cost-push implications of electricity price increases.

We need to be clear at the outset that the approaches we use do not give us forecasts, but allow us to isolate the effects of the shortages. They do **not** give us a picture of the South African economy in, say, five years' time. Rather, they provide us with a laboratory that allows us to think about the impacts of the shortage *if nothing else changes*. We capture changes that occur as a consequence of the shortages, but not those that might occur if, for example, world commodity prices collapsed in addition to the shortages.

The CGE model we use has been used to analyse a number of issues in South Africa (see Thurlow and Van Seventer, 2002, for a full specification and discussion of the model). It is essentially a market-oriented model that assumes that prices are allowed to adjust in response to changes in supply and demand. Imposing rationing in such a model requires further model development, which is still being undertaken. Nonetheless, some preliminary lessons can be drawn from the unrefined model.

Our modelling strategy is as follows. We assume that there is a 10% fall in electricity output consequent upon a reduction in the capacity of the sector. We examine the consequences for the rest of the economy in a static, one-period model. It might be more appropriate to use a dynamic model, which tracks the path of the economy over time, with and without the constraint on electricity supply. However, to do so would require better information than we have about how investment and technology in different sectors respond to the shortages. This is important to examine, but will take more time than was available for this report. We believe that the static approach we use is a simple way of capturing the situation in South Africa, which has arisen because demand growth has outstripped capacity. It gives us useful insights while avoiding further complicating assumptions that a more dynamic analysis would require.

Within this framework, we analyse two broad scenarios. The first, a market scenario, allows the price of electricity to adjust to match demand with available supply. The second, a rationing scenario, forces selected sectors to reduce their electricity consumption. We actually run a set of these rationing scenarios, varying the selected sectors. In all of them, we allow the price of electricity to change so as to allocate electricity amongst the remaining non-rationed sectors.

Allowing prices to rise in this way may seem to miss an essential aspect of electricity in South Africa – the fact that its price is an administered rather than a market one that responds to demand changes. However, as discussed in the previous section, unless rationing reduces demand sufficiently to erase all excess demand, we need a rule for allocating the remaining excess demand. We do not know what rules are used for deciding on load shedding, or how such indirect rationing maps into different economic sectors. We have therefore not tried to simulate such rationing. Rather, we examine the extent to which rationing targeted sectors reduces the price increase that would otherwise be required. This captures part of the motivation behind rationing: by imposing a certain burden on some users, we can reduce the burden placed on others.[9]

A number of modelling concerns have to be addressed:

- ***Prices in the model are relative prices***. When we talk below of a change in the price of electricity, we mean that its price must change relative to all other prices. We keep the CPI constant. This is important when interpreting the results, and we will re-emphasise it later. It means that the modelling *per se* cannot tell us about the inflationary impact of price changes. To measure this, we insert the predicted electricity price increases into a separate model based on the same SUTs.
- ***Additional profits from electricity price increases are retained in the electricity sector***. It is reasonable to assume that the price increase will generate extra revenue for electricity producers (implicitly assuming the elasticity of demand for electricity is less than one). What happens to this revenue? This is not only a modelling issue, but also has to be addressed in the real world. In practice, Eskom's profits are either distributed as dividends to government or retained and (presumably) invested. Surpluses generated by municipalities, if any, presumably go into local government financing.[10] For the modelling, we have assumed that any additional profits are retained in the sector. They raise aggregate savings directly and thus indirectly permit aggregate investment to rise. However, since we use a static model, we do not consider the sector distribution of investment.
- ***The nominal exchange rate is kept fixed***. The shortages might be expected to affect exports and imports. We examine the impact on the current account balance, although we also consider the consequences of permitting the exchange rate to vary to maintain a fixed current account balance.
- ***The government budget balance is allowed to vary***. Electricity shortages might be expected to have direct and indirect effects on government revenue and spending. We choose not to neutralise this effect (for example, by assuming that tax rates are adjusted).

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[9] Those who are unhappy with the model permitting price changes might prefer to interpret them as indicating the pressure of unsatisfied demand remaining after rationing has been implemented. A higher price rise suggests a greater demand by non-rationed users and a greater problem for the rationing scheme.

[10] It is possible that higher revenues do not translate into higher profits/surpluses, but are appropriated as higher salaries and wages in the sector.

- ***Equality between aggregate savings and investment is maintained through a 'balanced closure'***. We assume that investment is a constant proportion of domestic absorption and that savings rates adjust to maintain the equality between savings and investment that is required for macroeconomic consistency.
- ***There is unemployment and no skills shortage***. We have assumed that there is unemployment in the model, and that there is no shortage of skilled labour. This allows us to focus on what happens to the demand for labour and the potential for creating or losing jobs.

In each of the experiments that make up the set of rationed scenarios, we target different sectors for rationing. While we have selected sectors partly on the basis of those that have already been targeted for rationing (gold and other mining, smelters, commercial businesses and households), our main interest is to understand how the impact of rationing is affected by the characteristics of the targeted sectors so as to draw out some broad lessons.

We have to make a decision on the extent of the rationing we should model in each sub-scenario. The initial discussions about rationing did specify targets for the cuts in the targeted sectors. For example, one suggested set of cuts (not implemented) was that industrial users would be cut by 10%; commercial users by 15%; hotels, resorts and shopping malls by 20%; large office buildings, government, municipal and electricity offices by 15%; agriculture by 5%; residential users by 10%; and large users by 10%; and that coal mining, electricity and water would not be rationed at all (Neva Makgetla, personal communication, 19 March 2008). These targets were probably set on the assumption that direct rationing would be required to reduce consumption by the full expected shortfall of 10%. However, as it turned out, responses of users to the threat of rationing meant that such drastic direct rationing was not required. Furthermore, the targets were also probably set on the assumption that they did not exceed what we have termed Phase I cuts for most users; they could be made without affecting output drastically. This being the case, it does not make sense to implement them in a model that analyses Phase II cuts.

Thus, although there may be apparent merit in replicating actual or proposed rationing schemes, it does not make sense to model these early proposals.[11] More importantly, there is not a lot to be learned from implementing such cuts. More can be learned by simulating rations targeted at different sectors or groups of sectors, comparing the impacts and trying to understand why there might be differences. To do this, we need to eliminate certain obvious reasons for the differences. For example, the same percentage reduction in sectors that consume very different quantities of electricity will obviously have very different impacts. We need to set the rations so that we compare like with like. To do this, we have assumed that the aim of rationing is to reduce the initial excess demand for electricity by a given amount, regardless of which sectors are rationed. When there is a group of sectors targeted, we assume that they are all cut by the same per cent. For comparative purposes, we also apply uniform 10% cuts in electricity use by rationed sectors.

[11] While some sectors are being rationed at present, we do not have detailed information on what the rationing strategy is.

Table 2 – Summary of selected impacts of alternative allocative schemes

		Market solution	Rationing solutions			
			Mining and smelters		Commercial	
		1	2A	2B	3A	3B
	Cut		10.0%	4.3%	10.0%	15.7%
1	Electricity price increase	71.3%	53.8%	65.0%	37.0%	13.9%
2	Impact on GDP	-0.9%	-1.6%	-1.1%	-5.9%	-10.1%
3	Employment	-1.4%	-1.9%	-1.5%	-7.9%	-13.9%
4	Household income	-1.2%	-0.5%	-0.9%	-6.8%	-11.5%
5	Impact on CPI	2.5%	1.86%	2.25%	1.28%	0.48%

Note: 'Mining and smelters' = gold mining, other mining and non-ferrous metals; 'commercial' = financial services, real estate, business services and other services, excluding health

The target we select for the rationing exercises is to reduce the excess demand for electricity by 10%. This is a relatively small target, but is predicated on the relatively small electricity consumption of most sectors. Since most sectors consume considerably less than 10% of total electricity, trying to recover all of the shortage from a small sub-set of them would entail closing them down.

Table 2 summarises some of the impacts of five different schemes: a market solution plus two rationing schemes, targeted at different groups of sectors. For each of these, we show uniform cuts in the targeted sectors, both by 10% (columns 2A and 3A) and by a percentage that reduces overall excess demand by 10% (columns 2B and 3B). Thus, because the 'mining and smelter' sectors are such large users relative to the 'commercial' sectors, we would need to cut their use by only 4.3% to achieve the same overall reduction in demand, as against a 15.7% across-the-board cut in the 'commercial' sectors.

2.5.1. The electricity price

The price of electricity would have to rise by 71.3% if it was relied on to bring demand in line with the reduced supply (the 'market solution').[12] As expected, this increase is mitigated when various rationing schemes are introduced, with the required increases varying between 13.9% and 65.0%. There is thus scope for rationing to mitigate price increases.

Why is there such a difference in the price impact of different rationing schemes? The differences in the inter-industry linkages of the sectors are at the heart of the

[12] Recall that this is a *relative* price, meaning that the electricity price would have to rise by another 71.3% over and above any underlying rate of inflation. If the rate of inflation is 10%, the price of electricity would have to rise by 88%.

explanation. The targeted 'commercial' sectors have more significant linkages to other industries than do the 'mining and smelting' sectors. This means that the reduction in commercial output consequent upon the rationing has a larger (negative) knock-on effect than does the reduction in mining and smelting. For example, the output multiplier derived from the SUT is 3.0 for Other Mining, whereas it is 4.2 for Business Services. The decline in Business Services thus has a bigger initial impact on outputs of other sectors. This not only feeds into bigger reductions in demand for electricity by other sectors, but also (through its greater impact on employment and household income) a greater decline in demand for electricity by households. Although we have cut the demand for electricity by the same amount in both rationing schemes 2B and 3B, the secondary consequences of 3B are such as to induce a bigger further reduction in demand, thereby requiring a smaller price increase to restore the balance between supply and use.

By this token, other things being equal, we would prefer to target 'commercial' sectors for rationing. More generally, targeting sectors with greater linkages to the rest of the economy will provide more effective rationing, insofar as our aim is to mitigate price increases. Unfortunately, there is a cost to this: the output and employment impacts are commensurately worse.

2.5.2. Macroeconomic outcomes

With full price adjustment, GDP falls by 0.9% in real terms. The rationing schemes worsen this impact. However, rationing commerce has a much bigger negative impact than rationing mining and smelting: when we compare the two equivalent schemes (2B and 3B), we see that the negative impact on GDP of rationing commerce is almost 10 times that of rationing mining and smelting. Similarly, the impact on employment is much greater.

The reason for this is the same as the reason why the electricity price does not rise as much. The stronger linkages of the commercial sectors to the rest of the economy induce a stronger (negative) output effect. This simultaneously means that there is less need for a price increase to cope with excess demand **and** that GDP and employment fall more.

There are several reasons why all the rationing schemes lead to a larger output and employment decline than price adjustment. When a lower electricity input reduces the output of a using sector, it can raise its price. This will offset somewhat the contractionary effect of the electricity shortage, providing an inducement to produce more. With price adjustment, sectors are able to balance these two effects and decide how far it is profitable to reduce output (if at all). We thus get a smoother adjustment across the economy, with a number of sectors making small cuts in electricity usage. In principle, sectors where cuts have the least impact on profits make the most adjustment. Rationing imposes large cuts on a few sectors and does not allow them to respond (in the short run) to offset the effects.

The sectoral output changes shown in Table 5 illustrate the problem. In the un-rationed scenarios where firms adjust to a price increase, the output of non-ferrous metals falls by 3.3%, gold mining by 1.8% and other mining does not change. They are able to absorb the electricity price increase with relatively little adjustment to their output. In the rationed scenario, however, we impose a 10% cut on their output. Although this releases more electricity, ameliorating the rise in the market-clearing price of electricity, it is a much bigger cut than would otherwise have occurred.

We have assumed that the exchange rate adjusts to keep the current account of the balance of payments stable. Although the impact on the exchange rate is small (well within the margin of error), it is instructive to look at it. With un-rationed adjustment, a slight appreciation occurs. This surprising result is a consequence of the shrinking GDP, causing a fall in import demand that outweighs the decline in exports. However, with rationing, the exchange rate depreciates. We are rationing export sectors, forcing their output (and exports) to fall more than they would have without rationing.

The larger decline in GDP with rationing also occurs because of the loss of markets for some sectors. The enforced decline in the rationed sectors spills over into reduced demand for outputs from sectors supplying them with intermediate inputs.

We have assumed that all labour is relatively abundant, so that changes in demand for it are met by changes in supply, with no increase in wages. In both the un-rationed and the rationed scenarios, employment falls. As should be expected, it falls less in the market solution than in any of the rationed solutions.

Household income also falls. However, unlike the impact on other variables (where rationing has a bigger impact than the market solution), household income falls by a smaller percentage in some of the rationing solutions than in the market solution. The higher rise in the price of electricity in the market solution simultaneously raises Eskom's profits and squeezes other sectors' profits more than under rationing. Recall that we assume that Eskom retains its capital income. Household income depends on capital income in other sectors, and since these are squeezed less under rationing than the market solution, it is possible that more capital income is distributed to households. There will not necessarily be the same outcome across all rationing scenarios, since other factors affect capital income. In particular, profits in the rationed sectors are affected, and this may offset the foregoing effect.

This is a complex story, and is clearly driven by the assumptions of the model. It does suggest, however, that the management of Eskom's profits when electricity prices are raised will have an important impact on overall outcomes.

2.5.3. Sector changes

One of the concerns informing the management of the shortages has to be the impact on different sectors. The database underlying our analysis covers 110 sectors and thus provides a mass of data. At the risk of over-burdening the reader, we present detailed impacts on sector outputs under the different scenarios in Table 5.

A number of 'patterns' are apparent in the table.

- The effects of the shortages are negative on all sectors.
- The effects are bigger the stronger the rationing.

- As measured by the unweighted average impact, the market solution has a smaller impact than any of the rationed solutions. However, the median impact for 2B is much the same as for the market solution.
- The two schemes rationing mining and smelters seem to have a much more varied impact on sectors than the market solution, which is more varied than the two commercial rationing schemes (as indicated by the coefficients of variation). This is probably for the same reason that the commercial rationing has a bigger impact on output: the inter-industry linkages are stronger and thus generate a larger, but more uniform impact.
- The impacts of the different schemes on the different sectors vary considerably. While the correlation between the ranking of the impacts is reasonably strong within each broad scheme, it is low across schemes. Thus the correlation coefficient between rankings under the two equivalent schemes (2B and 3B) is 0.47. Coal Mining is the worst affected sector under the market solution, simply because it is a major input into electricity. Under rationing of mining, we see that the Jewellery sector is worst hit, while it is Office Equipment under the commercial rationing scheme. Indeed, output in these sectors falls even more than the fall in the output of the rationed sectors.

2.5.4. Other considerations

The results presented above are based on a particular set of assumptions embodied in the model. It is useful to consider how these affect the results. Two sets of considerations are of particular relevance: the elasticities used and the assumptions about exchange rates. Here we consider briefly how different assumptions would affect the results.

We have discussed earlier how the impacts of shortages depend on the time period over which they are measured (see Section 2.3). One way to capture the effects of time is through the elasticities which govern how producers respond to changes in prices. For the above results we have assumed that the elasticities are low, in an attempt to measure short-run impacts. With a higher set of elasticities, we find that the price effects are somewhat ameliorated, while the output effects are worsened. Thus, in the market solution, raising elasticities of substitution from 0.3 to 1.2 across the board reduces the required electricity price rise from 71.3% to 56.8%, but increases the drop in GDP from -0.9% to -1.8%. Similar patterns are found in the rationing schemes.

We have also assumed in our results above that the exchange rate is kept fixed, with the current account balance adjusting. If instead the exchange rate is flexible and adjusts to maintain a constant current account balance, we find a similar effect to raising elasticities: the price effect is ameliorated and the output effects are worsened. GDP would fall by several percentage points more.

Table 3 – Cost structure and electricity usage by industry (ranked by share of electricity in costs [column 2])

		Cost structures (%)					
		Intermediates		Wages	Gross operating surplus	Taxes/ subsidies	Total
		Excl. electricity	Electricity				
		[1]	[2]	[3]	[4]	[5]	[6]
1	Non-ferrous metals	57.8	11.1	5.8	25.0	0.3	100.0
2	General hardware	55.1	6.8	24.3	13.1	0.7	100.0
3	Knitting mills	66.7	6.1	18.0	9.1	0.0	100.0
4	Other textiles	69.7	5.5	17.6	7.3	-0.1	100.0
5	Tyres	70.6	5.3	17.7	7.1	-0.7	100.0
6	Water	59.9	4.9	11.0	25.1	-0.9	100.0
7	Electricity	40.5	4.9	20.8	33.1	0.7	100.0
8	Gold	34.4	4.8	32.2	27.6	1.0	100.0
9	Soap	76.0	4.1	9.4	10.4	0.1	100.0
10	Pharmaceuticals	74.5	4.0	9.8	11.5	0.1	100.0
11	Accommodation	57.7	4.0	15.1	22.1	1.1	100.0
12	Fish	49.1	2.8	22.7	24.7	0.7	100.0
13	Other chemicals	70.4	2.5	19.0	7.6	0.5	100.0
14	Treated metals	62.2	2.4	26.1	8.4	0.8	100.0
15	Gears	66.0	2.3	27.5	3.5	0.7	100.0
16	Lifting equipment	81.4	2.3	9.9	5.9	0.4	100.0
17	Machine tools	58.1	2.1	30.7	8.7	0.3	100.0
18	Cement	47.4	2.1	5.3	45.0	0.2	100.0
19	Office machinery	71.4	2.0	14.8	11.2	0.6	100.0
20	Petroleum	74.0	1.8	2.3	21.7	0.2	100.0
21	Structural ceramics	67.4	1.8	15.1	15.1	0.6	100.0
22	Meat	95.5	1.8	0.2	2.5	0.0	100.0
23	Handbags	70.7	1.7	21.0	7.1	-0.5	100.0
24	Grain mills	79.4	1.6	4.9	13.7	0.3	100.0
25	Accumulators	71.7	1.6	16.5	9.6	0.5	100.0
26	Other mining	43.7	1.5	15.4	38.9	0.5	100.0
27	Bakeries	64.3	1.4	23.9	9.7	0.7	100.0
28	Oils	84.4	1.4	4.6	9.4	0.1	100.0
29	Food machinery	72.4	1.4	21.7	4.3	0.3	100.0
30	Coal	51.5	1.3	17.3	28.9	0.9	100.0
31	Carpets	82.7	1.3	9.7	7.0	-0.7	100.0

		Cost structures (%)					
		Intermediates		Wages	Gross operating surplus	Taxes/ subsidies	Total
		Excl. electricity	Electricity				
		[1]	[2]	[3]	[4]	[5]	[6]
32	Transport services	57.2	1.2	18.1	22.7	0.7	100.0
33	Pumps	72.0	1.2	21.7	4.5	0.5	100.0
34	Fruit	73.2	1.1	13.6	11.8	0.2	100.0
35	Other non-metallic	76.8	1.1	9.5	12.3	0.4	100.0
36	Confectionery	61.8	1.1	25.3	11.4	0.4	100.0
37	Dairy	76.2	1.1	12.3	10.2	0.3	100.0
38	Communications	57.2	1.1	13.6	27.8	0.3	100.0
39	Textile articles	75.3	1.0	17.4	5.9	0.3	100.0
40	General machinery	73.4	1.0	16.6	8.3	0.8	100.0
41	Glass	64.9	1.0	16.7	17.3	0.1	100.0
42	Iron and steel	80.1	1.0	6.5	12.3	0.2	100.0
43	Other rubber	71.1	1.0	17.9	7.9	2.1	100.0
44	Animal feeds	87.5	0.9	4.1	7.3	0.3	100.0
45	Paints	82.2	0.9	10.8	5.7	0.4	100.0
46	Furniture	67.6	0.9	23.0	7.8	0.6	100.0
47	Activities/services	37.2	0.9	51.7	9.0	1.2	100.0
48	Optical instruments	69.2	0.8	12.9	16.2	0.9	100.0
49	Paper	70.0	0.8	8.6	20.4	0.2	100.0
50	Primary plastics	77.4	0.8	7.3	14.2	0.2	100.0
51	Electric motors	75.5	0.8	22.4	0.8	0.5	100.0
52	Basic chemicals	72.8	0.8	12.7	14.3	-0.5	100.0
53	Leather	86.3	0.8	3.8	8.9	0.3	100.0
54	Fabricated metal	73.5	0.7	14.8	10.8	0.3	100.0
55	Lighting equipment	77.0	0.7	15.3	6.7	0.3	100.0
56	Real estate	35.4	0.7	3.9	53.5	6.5	100.0
57	Non-structural ceramics	61.9	0.7	20.5	16.1	0.8	100.0
58	Jewellery	88.8	0.7	8.7	1.4	0.4	100.0
59	Other transport	70.3	0.6	22.9	6.0	0.3	100.0
60	Beverages and tobacco	65.0	0.6	9.5	24.0	0.8	100.0
61	Trade	46.8	0.6	24.7	26.7	1.1	100.0
62	Health and social work	58.5	0.6	20.0	19.6	1.3	100.0
63	Agriculture	48.1	0.6	12.5	39.8	-0.9	100.0
64	Fertilizers	81.4	0.5	3.1	12.6	2.3	100.0
65	Wood	68.4	0.5	21.9	8.7	0.5	100.0

		Cost structures (%)					
		Intermediates		Wages	Gross operating surplus	Taxes/ subsidies	Total
		Excl. electricity	Electricity				
		[1]	[2]	[3]	[4]	[5]	[6]
66	Sugar	66.4	0.5	14.3	18.4	0.4	100.0
67	Textiles	82.8	0.5	8.6	8.2	-0.1	100.0
68	Household appliances	82.3	0.5	8.4	8.7	0.1	100.0
69	Electricity apparatus	66.7	0.5	17.1	15.4	0.4	100.0
70	Wearing apparel	70.9	0.5	21.6	6.8	0.2	100.0
71	Footwear	74.8	0.3	11.8	12.5	0.5	100.0
72	Publishing	62.4	0.3	32.9	3.9	0.5	100.0
73	Electrical equipment	75.2	0.3	18.2	6.2	0.1	100.0
74	Other manufacturing	56.5	0.3	8.9	34.4	-0.1	100.0
75	Radio and television	69.5	0.3	17.2	12.9	0.1	100.0
76	Containers of paper	78.7	0.3	13.6	7.0	0.4	100.0
77	Mining machinery	84.9	0.3	9.8	4.9	0.1	100.0
78	Engines	77.0	0.3	15.1	7.3	0.5	100.0
79	Other construction	68.1	0.3	16.6	14.5	0.5	100.0
80	Insurance	40.7	0.3	23.5	33.9	1.7	100.0
81	Structural metal	75.6	0.2	17.8	6.0	0.3	100.0
82	Agricultural machinery	69.4	0.2	22.7	7.0	0.7	100.0
83	Motor vehicle parts	67.6	0.2	20.6	11.6	0.0	100.0
84	Plastic	67.8	0.2	23.5	8.4	0.1	100.0
85	General government	34.2	0.2	56.8	7.9	0.9	100.0
86	Buildings	80.2	0.1	11.8	7.4	0.4	100.0
87	Other paper	80.7	0.1	11.3	7.5	0.3	100.0
88	Business activities	59.1	0.1	28.1	12.4	0.3	100.0
89	Pesticides	78.4	0.1	13.5	9.1	-1.1	100.0
90	Other food	66.3	0.1	16.7	16.5	0.4	100.0
91	Wire and cable	80.3	0.0	10.7	8.3	0.6	100.0
92	Special machinery	66.3	0.0	21.3	11.7	0.7	100.0
93	Motor vehicles	88.9	0.0	5.2	6.0	-0.1	100.0
94	Recorded media	56.9	0.0	20.6	22.0	0.6	100.0
95	Total industry	56.7	1.1	20.7	20.7	0.9	100.0
	Household expenditure		1.7				

Source: Calculated from Statistics South Africa (2005)

Table 4 – Sectors ranked by shares in electricity purchases

Rank	Sector	Share	Cumulative share	Rank	Sector	Share	Cumulative share
1	Non-ferrous metals	11.3	11.3	48	General machinery	0.3	95.2
2	Gold	8.0	19.3	49	Wearing apparel	0.3	95.4
3	Electricity	7.2	26.5	50	Fish	0.3	95.7
4	Transport services	6.7	33.2	51	Fertilizers	0.3	95.9
5	Trade	5.6	38.8	52	Animal feeds	0.2	96.2
6	Other mining	4.9	43.7	53	Furniture	0.2	96.4
7	Petroleum	4.2	48.0	54	Other transport	0.2	96.6
8	Accommodation	4.1	52.1	55	Publishing	0.2	96.8
9	Communications	3.9	56.0	56	Motor vehicle parts	0.2	97.0
10	Soap	2.9	58.9	57	Textiles	0.2	97.2
11	Pharmaceuticals	2.9	61.7	58	Plastic	0.2	97.4
12	Real estate	2.7	64.4	59	Glass	0.2	97.5
13	Iron and steel	2.5	66.9	60	Confectionery	0.2	97.7
14	Water	2.4	69.3	61	Accumulators	0.1	97.8
15	Activities/services	2.0	71.3	62	Containers of paper	0.1	98.0
16	Meat	1.9	73.2	63	Textile articles	0.1	98.1
17	Coal	1.9	75.1	64	Structural metal	0.1	98.3
18	Agriculture	1.8	76.9	65	Sugar	0.1	98.4
19	General government	1.6	78.5	66	Gears	0.1	98.5
20	Insurance	1.6	80.2	67	Electric motors	0.1	98.6
21	Health and social work	1.3	81.5	68	Optical instruments	0.1	98.7
22	Other chemicals	1.2	82.7	69	Leather	0.1	98.8
23	Tyres	1.2	83.9	70	Pumps	0.1	98.9
24	Grain mills	0.9	84.8	71	Machine tools	0.1	99.0
25	Beverages and tobacco	0.8	85.6	72	Electrical equipment	0.1	99.1
26	General hardware	0.8	86.4	73	Jewellery	0.1	99.2
27	Primary plastics	0.7	87.1	74	Other rubber	0.1	99.3
28	Knitting mills	0.7	87.7	75	Mining machinery	0.1	99.4
29	Fabricated metal	0.5	88.3	76	Radio and television	0.1	99.5
30	Paper	0.5	88.8	77	Household appliances	0.1	99.5
31	Basic chemicals	0.5	89.3	78	Electricity apparatus	0.1	99.6
32	Other manufacturing	0.4	89.7	79	Carpets	0.1	99.6
33	Dairy	0.4	90.2	80	Food machinery	0.0	99.7
34	Bakeries	0.4	90.6	81	Lighting equipment	0.0	99.7
35	Treated metals	0.4	91.0	82	Footwear	0.0	99.8
36	Cement	0.4	91.4	83	Handbags	0.0	99.8

Rank	Sector	Share	Cumulative share	Rank	Sector	Share	Cumulative share
37	Other construction	0.4	91.7	84	Other food	0.0	99.9
38	Wood	0.3	92.1	85	Other paper	0.0	99.9
39	Paints	0.3	92.4	86	Office machinery	0.0	99.9
40	Business activities	0.3	92.8	87	Engines	0.0	99.9
41	Oils	0.3	93.1	88	Non-structural ceramics	0.0	99.9
42	Lifting equipment	0.3	93.4	89	Motor vehicles	0.0	100.0
43	Other non-metallic	0.3	93.7	90	Pesticides	0.0	100.0
44	Buildings	0.3	94.0	91	Agricultural machinery	0.0	100.0
45	Other textiles	0.3	94.3	92	Wire and cable	0.0	100.0
46	Structural ceramics	0.3	94.6	93	Special machinery	0.0	100.0
47	Fruit	0.3	94.9	94	Recorded media	0.0	100.0

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Table 5 – Sectoral changes in output (%)

Market solution			Rationing schemes											
			Mining and smelters						Commercial					
[1]			[2A]			[2B]			[3A]			[3B]		
Shortage sector														
Electricity	-10.00		Electricity	-10.00		Electricity	-10.00		Electricity	-10.00		Electricity	-10.00	
Rationed sectors														
			Gold	-10.00		Gold	-4.33		Insurance	-10.00		Insurance	-15.70	
			Other Mining	-10.00		Other Mining	-4.33		Real Estate	-10.00		Real Estate	-15.70	
			Non-Ferrous Metals	-10.00		Non-Ferrous Metals	-4.33		Business Activities	-10.00		Business Activities	-15.70	
									Activities/ Services	-10.00		Activities/ Services	-15.70	
Non-rationed sectors														
Summary characteristics														
Mean	-0.74			-1.11			-0.83			-4.52			-8.19	
Coefficient of variation	62.7			118.8			77.8			50.1			48.2	
First quartile	-0.93			-0.26			-0.38			-2.61			-5.12	
Median	-0.68			-0.82			-0.67			-4.70			-8.39	
Third quartile	-0.40			-1.51			-1.14			-5.97			-10.73	
Individual sectors														
Sector	**%**	**R**	**Sector**	**%**	**R**	**Sector**	**%**	**R**	**Sector**	**%**	**R**	**Sector**	**%**	**R**
Coal	-2.13	1	Jewellery	-10.73	1	Jewellery	-4.40	1	Office Machinery	-15.68	1	Office Machinery	-26.75	1
Tyres	-1.95	2	Mining Machinery	-3.62	2	Coal	-2.31	2	Confectionery	-8.08	2	Health & Social Work	-15.19	2
Electricity Apparatus	-1.91	3	Pumps	-3.58	3	Electricity Apparatus	-2.24	3	Health & Social Work	-7.65	3	Confectionery	-14.21	3
Gold	-1.85	4	Gears	-3.51	4	Electric Motors	-2.06	4	Knitting Mills	-7.61	4	Knitting Mills	-13.06	4
Knitting Mills	-1.79	5	General Machinery	-3.13	5	Tyres	-2.02	5	Accumulators	-7.26	5	Household Appliances	-12.96	5
Electric Motors	-1.68	6	Electric Motors	-3.00	6	Gears	-1.94	6	Other Construction	-7.18	6	Machine Tools	-12.94	6
Lighting Equipment	-1.67	7	Electricity Apparatus	-3.00	7	Mining Machinery	-1.91	7	Buildings	-7.18	7	Pharmaceuticals	-12.91	7
General Hardware	-1.67	8	Other Chemicals	-2.67	8	General Hardware	-1.88	8	Pharmaceuticals	-7.13	8	Buildings	-12.80	8
Non-Ferrous Metals	-1.63	9	Coal	-2.67	9	Lighting Equipment	-1.80	9	General Government	-7.08	9	Textiles	-12.79	9
Soap	-1.61	10	General Hardware	-2.39	10	Pumps	-1.76	10	Textiles	-7.06	10	Other Construction	-12.77	10

Other Textiles	-1.41	11	Accumulators	-2.36	11	Other Chemicals	-1.69	11	Machine Tools	-7.04	11	General Government	-12.70	11
Accommodation	-1.36	12	Other Transport	-2.33	12	Accumulators	-1.58	12	Gears	-7.03	12	Accumulators	-12.64	12
Accumulators	-1.33	13	Lighting Equipment	-2.27	13	Treated Metals	-1.50	13	Structural Ceramics	-6.94	13	Structural Ceramics	-12.29	13
Pharmaceuticals	-1.32	14	Fabricated Metal	-2.19	14	Knitting Mills	-1.48	14	Household Appliances	-6.89	14	Gears	-12.24	14
Treated Metals	-1.32	15	Engines	-2.17	15	Wire & Cable	-1.46	15	Tyres	-6.67	15	Accommodation	-11.99	15
Wire & Cable	-1.28	16	Iron & Steel	-2.14	16	Soap	-1.42	16	Other Textiles	-6.63	16	Carpets	-11.90	16
Other Construction	-1.22	17	Tyres	-2.14	17	Engines	-1.33	17	Publishing	-6.62	17	Food Machinery	-11.77	17
Water	-1.15	18	Electrical Equipment	-2.08	18	Other Construction	-1.33	18	Lighting Equipment	-6.59	18	Other Textiles	-11.72	18
Other Chemicals	-1.13	19	Machine Tools	-2.06	19	Machine Tools	-1.32	19	Accommodation	-6.57	19	Structural Metal	-11.38	19
Gears	-1.12	20	Wire & Cable	-2.04	20	Other Textiles	-1.30	20	Carpets	-6.49	20	Tyres	-11.29	20
Machine Tools	-1.09	21	Treated Metals	-1.95	21	Electrical Equipment	-1.30	21	Food Machinery	-6.36	21	Publishing	-11.27	21
Buildings	-1.07	22	Structural Metal	-1.84	22	Accommodation	-1.23	22	Soap	-6.33	22	Lighting Equipment	-11.10	22
Activities/ Services	-1.04	23	Other Construction	-1.73	23	Other Transport	-1.23	23	Structural Metal	-6.32	23	Soap	-10.97	23
Electrical Equipment	-1.00	24	Special Machinery	-1.72	24	General Machinery	-1.19	24	Electric Motors	-6.32	24	Glass	-10.89	24
Structural Ceramics	-0.96	25	Other Rubber	-1.65	25	Structural Metal	-1.17	25	Electricity Apparatus	-6.11	25	Optical Instruments	-10.88	25
Mining Machinery	-0.95	26	Structural Ceramics	-1.61	26	Fabricated Metal	-1.15	26	Treated Metals	-5.99	26	Electric Motors	-10.86	26
Engines	-0.95	27	Other Non-Metallic	-1.51	27	Structural Ceramics	-1.15	27	Glass	-5.97	27	Lifting Equipment	-10.73	27
Structural Metal	-0.93	28	Motor Vehicle Parts	-1.51	27	Other Rubber	-1.12	28	Lifting Equipment	-5.93	28	Other Non-Metallic	-10.65	28
Pumps	-0.89	29	Transport Services	-1.48	29	Pharmaceuticals	-1.10	29	Wire & Cable	-5.85	29	Treated Metals	-10.27	29
Other Rubber	-0.88	30	Wood	-1.43	30	Buildings	-1.09	30	Optical Instruments	-5.85	30	Agricultural Machinery	-10.26	30
Other Non-Metallic	-0.87	31	Non-Structural Ceramics	-1.43	31	Activities/ Services	-1.09	31	Other Non-Metallic	-5.83	31	Wire & Cable	-10.24	31
Non-Structural Ceramics	-0.84	32	Buildings	-1.33	32	Water	-1.07	32	Electrical Equipment	-5.62	32	Special Machinery	-10.24	32
General Government	-0.82	33	Lifting Equipment	-1.31	33	Iron & Steel	-1.06	33	Paints	-5.60	33	Other Transport	-10.21	33
Handbags	-0.81	34	Cement	-1.27	34	Other Non-Metallic	-1.06	34	Engines	-5.59	34	Engines	-10.18	34
Bakeries	-0.80	35	Household Appliances	-1.26	35	Non-Structural Ceramics	-1.03	35	Textile Articles	-5.53	35	Electrical Equipment	-10.09	35
Lifting Equipment	-0.78	36	Basic Chemicals	-1.25	36	Transport Services	-0.97	36	Wearing Apparel	-5.52	36	Electricity Apparatus	-10.03	36
Confectionery	-0.78	37	Paints	-1.25	37	Special Machinery	-0.94	37	Mining Machinery	-5.51	37	Wearing Apparel	-9.98	37
Other Transport	-0.77	38	Activities/ Services	-1.22	38	Lifting Equipment	-0.92	38	Other Paper	-5.50	38	Textile Articles	-9.93	38

Textiles	-0.76	39	Food Machinery	-1.20	39	Wood	-0.90	39	Other Transport	-5.49	39	Mining Machinery	-9.91	39
Household Appliances	-0.76	40	Other Textiles	-1.20	40	Cement	-0.86	40	Agricultural Machinery	-5.48	40	General Machinery	-9.90	40
Health & Social Work	-0.76	41	Soap	-1.11	41	Business Activities	-0.86	41	Special Machinery	-5.42	41	Other Paper	-9.83	41
Business Activities	-0.75	42	Business Activities	-1.11	42	Paints	-0.85	42	Other Rubber	-5.37	42	Dairy	-9.78	42
Food Machinery	-0.74	43	Accommodation	-1.04	43	Motor Vehicle Parts	-0.85	43	Dairy	-5.37	43	Other Rubber	-9.77	43
Carpets	-0.73	44	Primary Plastics	-1.01	44	Food Machinery	-0.84	44	Pumps	-5.17	44	Paints	-9.71	44
Oils	-0.72	45	Plastic	-0.99	45	Household Appliances	-0.82	45	Primary Plastics	-5.12	45	Pumps	-9.44	45
Glass	-0.72	46	Motor Vehicles	-0.96	46	Basic Chemicals	-0.77	46	Non-Structural Ceramics	-5.10	46	Primary Plastics	-9.42	46
Textile Articles	-0.70	47	Knitting Mills	-0.95	47	Glass	-0.77	47	Cement	-4.99	47	Paper	-9.41	47
Cement	-0.70	48	Fertilizers	-0.94	48	Trade	-0.73	48	Bakeries	-4.96	48	Cement	-9.19	48
Publishing	-0.69	49	Glass	-0.94	49	Primary Plastics	-0.72	49	Paper	-4.94	49	Non-Structural Ceramics	-9.13	49
Motor Vehicles	-0.69	49	Water	-0.93	50	Motor Vehicles	-0.72	50	General Hardware	-4.81	50	Bakeries	-8.79	50
Special Machinery	-0.68	51	Agricultural Machinery	-0.91	51	Plastic	-0.71	51	Other Chemicals	-4.77	51	Motor Vehicles	-8.77	51
Paints	-0.68	52	Trade	-0.89	52	Handbags	-0.68	52	General Machinery	-4.76	52	Containers Of Paper	-8.45	52
Wood	-0.68	53	Forestry	-0.83	53	Publishing	-0.68	53	Containers Of Paper	-4.70	53	Radio & Television	-8.39	53
Fabricated Metal	-0.68	54	Office Machinery	-0.81	54	Textiles	-0.66	54	Motor Vehicles	-4.69	54	Trade	-8.35	54
Wearing Apparel	-0.68	55	Radio & Television	-0.79	55	Textile Articles	-0.66	54	Trade	-4.59	55	Furniture	-8.33	55
Fishing	-0.67	56	Containers Of Paper	-0.78	56	Agricultural Machinery	-0.66	54	Plastic	-4.55	56	Plastic	-8.30	56
Trade	-0.66	57	Pharmaceuticals	-0.75	57	Containers Of Paper	-0.65	57	Fabricated Metal	-4.50	57	Iron & Steel	-8.29	57
Dairy	-0.64	58	Petroleum	-0.73	58	Oils	-0.64	58	Radio & Television	-4.43	58	Other Chemicals	-8.25	58
Transport Services	-0.63	59	Publishing	-0.69	59	Carpets	-0.63	59	Iron & Steel	-4.42	59	Fabricated Metal	-8.24	59
Jewellery	-0.63	60	Optical Instruments	-0.62	60	General Government	-0.62	60	Wood	-4.35	60	General Hardware	-8.23	60
Agricultural Machinery	-0.62	61	Other Manufacturing	-0.62	61	Bakeries	-0.61	61	Furniture	-4.28	61	Wood	-7.93	61
Plastic	-0.61	62	Textile Articles	-0.60	62	Confectionery	-0.61	62	Basic Chemicals	-4.24	62	Basic Chemicals	-7.91	62
Primary Plastics	-0.61	63	Carpets	-0.58	63	Health & Social Work	-0.58	63	Oils	-4.04	63	Recorded Media	-7.89	63
Containers Of Paper	-0.60	64	Other Paper	-0.54	64	Forestry	-0.58	64	Fruit	-3.94	64	Leather	-7.83	64
Other Paper	-0.60	64	Textiles	-0.52	65	Other Paper	-0.57	65	Motor Vehicle Parts	-3.86	65	Oils	-7.42	65
Motor Vehicle Parts	-0.59	66	Handbags	-0.51	66	Fertilizers	-0.56	66	Leather	-3.81	66	Fruit	-7.38	66
Optical Instruments	-0.57	67	Oils	-0.51	67	Optical Instruments	-0.55	67	Transport Services	-3.73	67	Motor Vehicle Parts	-7.31	67

Meat	-0.56	68	Communications	-0.47	68	Wearing Apparel	-0.54	68	Forestry	-3.73	68	Forestry	-7.18	68
Iron & Steel	-0.56	68	Paper	-0.41	69	Radio & Television	-0.54	69	Gold	-3.72	69	Footwear	-6.95	69
Footwear	-0.55	70	Other Food	-0.39	70	Fishing	-0.52	70	Pesticides	-3.70	70	Pesticides	-6.87	70
Communications	-0.54	71	Insurance	-0.34	71	Communications	-0.51	71	Footwear	-3.66	71	Transport Services	-6.81	71
Basic Chemicals	-0.54	72	Leather	-0.33	72	Dairy	-0.47	72	Coal	-3.63	72	Handbags	-5.99	72
Grain Mills	-0.52	73	Confectionery	-0.33	73	Petroleum	-0.43	73	Recorded Media	-3.43	73	Grain Mills	-5.99	73
Furniture	-0.50	74	General Government	-0.31	74	Meat	-0.43	74	Communications	-3.30	74	Meat	-5.87	74
Fruit	-0.49	75	Wearing Apparel	-0.31	74	Office Machinery	-0.42	75	Grain Mills	-3.17	75	Communications	-5.86	75
Radio & Television	-0.49	76	Health & Social Work	-0.31	76	Grain Mills	-0.41	76	Handbags	-3.16	76	Gold	-5.57	76
Forestry	-0.49	77	Bakeries	-0.29	77	Other Manufacturing	-0.39	77	Meat	-3.09	77	Fertilizers	-5.28	77
Poultry	-0.47	78	Pesticides	-0.28	78	Paper	-0.39	78	Fertilizers	-2.84	78	Coal	-5.28	78
Fish	-0.44	79	Fishing	-0.26	79	Other Food	-0.38	79	Other Manufacturing	-2.61	79	Beverages & Tobacco	-5.12	79
Other Food	-0.42	80	Animal Feeds	-0.26	79	Insurance	-0.38	80	Beverages & Tobacco	-2.55	80	Other Manufacturing	-5.07	80
Insurance	-0.41	81	Grain Mills	-0.22	81	Fruit	-0.37	81	Other Food	-2.52	81	Poultry	-4.86	81
Leather	-0.40	82	Meat	-0.21	82	Footwear	-0.36	82	Poultry	-2.52	82	Cotton & Tobacco	-4.81	82
General Machinery	-0.40	83	Dairy	-0.20	83	Leather	-0.36	83	Non-Ferrous Metals	-2.51	83	Jewellery	-4.77	83
Paper	-0.38	84	Cotton & Tobacco	-0.19	84	Poultry	-0.35	84	Water	-2.49	84	Other Food	-4.62	84
Animal Feeds	-0.38	85	Fruit	-0.19	85	Fish	-0.34	85	Cotton & Tobacco	-2.49	85	Dairy	-4.45	85
Dairy	-0.38	86	Poultry	-0.17	86	Animal Feeds	-0.33	86	Dairy	-2.32	86	Animal Feeds	-4.21	86
Office Machinery	-0.36	87	Fish	-0.17	87	Pesticides	-0.31	87	Jewellery	-2.25	87	Fishing	-4.07	87
Cotton & Tobacco	-0.36	88	Dairy	-0.15	88	Cotton & Tobacco	-0.29	88	Animal Feeds	-2.25	88	Water	-3.97	88
Pesticides	-0.34	89	Vegetables	-0.14	89	Dairy	-0.29	89	Fishing	-2.23	89	Non-Ferrous Metals	-3.56	89
Fertilizers	-0.33	90	Fodder Crops	-0.14	90	Furniture	-0.28	90	Sugar	-1.82	90	Sugar	-3.53	90
Other Manufacturing	-0.31	91	Other Horticulture	-0.13	91	Vegetables	-0.23	91	Petroleum	-1.54	91	Petroleum	-3.13	91
Vegetables	-0.28	92	Wheat & Winter Cereals	-0.13	92	Wheat & Winter Cereals	-0.22	92	Wheat & Winter Cereals	-1.54	92	Citrus Fruit	-3.01	92
Wheat & Winter Cereals	-0.27	93	Oil-Seeds & Legumes	-0.12	93	Fodder Crops	-0.22	93	Citrus Fruit	-1.52	93	Wheat & Winter Cereals	-3.01	93
Fodder Crops	-0.27	94	Other Livestock Products	-0.12	94	Subtropical Fruit	-0.20	94	Fish	-1.50	94	Subtropical Fruit	-2.70	94

Subtropical Fruit	-0.26	95	Maize & Summer Cereals	-0.11	95	Other Horticulture	-0.20	94	Subtropical Fruit	-1.40	95	Fish	-2.70	95
Beverages & Tobacco	-0.26	95	Livestock Sales	-0.11	96	Livestock Sales	-0.20	96	Fodder Crops	-1.36	96	Livestock Sales	-2.60	96
Petroleum	-0.26	97	Subtropical Fruit	-0.10	97	Sugarcane	-0.17	97	Livestock Sales	-1.32	97	Fodder Crops	-2.58	97
Livestock Sales	-0.25	98	Sugarcane	-0.08	98	Maize & Summer Cereals	-0.17	97	Sugarcane	-1.24	98	Sugarcane	-2.33	98
Other Horticulture	-0.24	99	Dec. Fruit & Viticulture	-0.07	99	Beverages & Tobacco	-0.17	99	Vegetables	-1.12	99	Maize & Summer Cereals	-2.14	99
Other Mining	-0.24	100	Real Estate	-0.06	100	Other Livestock Products	-0.17	100	Maize & Summer Cereals	-1.10	100	Vegetables	-2.06	100
Sugarcane	-0.23	101	Citrus Fruit	-0.03	101	Oil-Seeds & Legumes	-0.17	101	Other Horticulture	-0.90	101	Oil-Seeds & Legumes	-1.67	101
Sugar	-0.21	102	Footwear	-0.03	102	Citrus Fruit	-0.13	102	Oil-Seeds & Legumes	-0.89	102	Other Horticulture	-1.62	102
Maize & Summer Cereals	-0.21	103	Beverages & Tobacco	-0.02	103	Dec. Fruit & Viticulture	-0.10	103	Other Livestock Products	-0.78	103	Other Livestock Products	-1.41	103
Other Livestock Products	-0.20	104	Furniture	0.05	104	Real Estate	-0.07	104	Other Mining	-0.70	104	Other Mining	-1.25	104
Oil-Seeds & Legumes	-0.19	105	Sugar	0.16	105	Sugar	-0.07	105	Dec. Fruit & Viticulture	-0.37	105	Dec. Fruit & Viticulture	-0.65	105
Citrus Fruit	-0.19	106	Recorded Media	0.34	106	Recorded Media	0.34	106						
Dec. Fruit & Viticulture	-0.12	107												
Real Estate	-0.08	108												
Recorded Media	0.34	109												

Note: Sectors are ordered in each scenario according to the size of the impact

Table 6 – Sectors used in the analysis

Description	SIC	Description	SIC	Description	SIC	Description	SIC
Maize & Summer Cereals	11	Sugar	304	Tyres	337	Wire & Cable	363
Wheat & Winter Cereals	11	Confectionery	304	Other Rubber	337	Accumulators	364
Oil-Seeds & Legumes	11	Other Food	304	Plastic	338	Lighting Equipment	365
Fodder Crops	11	Beverages & Tobacco	305-306	Glass	341	Electrical Equipment	366
Sugarcane	11	Textiles	311	Non-Structural Ceramics	342	Radio & Television	371-373
Cotton & Tobacco	11	Textile Articles	312	Structural Ceramics	342	Optical Instruments	374-376
Vegetables	11	Carpets	312	Cement	342	Motor Vehicles	381-382
Citrus Fruit	11	Other Textiles	312	Other Non-Metallic	342	Motor Vehicle Parts	383
Subtropical Fruit	11	Knitting Mills	313	Iron & Steel	351	Other Transport	384-387
Deciduous Fruit & Viticulture	11	Wearing Apparel	314-315	Non-Ferrous Metals	352	Furniture	391
Other Horticulture	11	Leather	316	Structural Metal	354	Jewellery	392
Livestock Sales	11	Handbags	316	Treated Metals	355	Other Manufacturing	395
Dairy	11	Footwear	317	General Hardware	355	Electricity	41
Poultry	11	Wood	321-322	Fabricated Metal	355	Water	42
Other Livestock Products	11	Paper	323	Engines	356	Buildings	5
Fishing	13	Containers of Paper	323	Pumps	356	Other Construction	5
Forestry	12	Other Paper	323	Gears	356	Trade	61-63
Coal	21	Publishing	324-325	Lifting Equipment	356	Accommodation	64
Gold	23	Recorded Media	326	General Machinery	356	Transport Services	71-74
Other Mining	22/24/25/29	Petroleum	331-333	Agricultural Machinery	356	Communications	75
Meat	301	Basic Chemicals	334	Machine Tools	356	Insurance	81-82

Description	SIC	Description	SIC	Description	SIC	Description	SIC
Fish	301	Fertilizers	334	Mining Machinery	357	Real Estate	81-82
Fruit	301	Primary Plastics	334	Food Machinery	357	Business Activities	83-88
Oils	301	Pesticides	335	Special Machinery	357	General Government	91, 94
Dairy	302	Paints	335	Household Appliances	358	Health & Social Work	93
Grain Mills	303	Pharmaceuticals	335	Office Machinery	359	Other Activities/Services	92, 95-96, 99
Animal Feeds	303	Soap	335	Electric Motors	361		
Bakeries	304	Other Chemicals	335	Electricity Apparatus	362		

3. Potential energy savings[13]

This section reviews the potential for energy savings in the different sectors of the economy to establish the possible impact of electricity rationing approaches. It is organised in the following way: the first section offers background to the two goals being sought when targeting savings. The first is to reduce demand and the second is to reduce overall consumption. Before exploring the potential for saving, it is necessary to analyse the difference between these goals. The subsequent subsections then review the potential impact in a range of sectors across the economy. The final subsection reviews the approach to demand side management.

3.1. Demand and energy usage

It is essential that a clear distinction be made between ***electricity demand*** and ***energy usage*** when exploring responses to the electricity shortage, and particularly when thinking about the stated need that South Africa reduce its electricity consumption by 10%.

Consumption of electricity is broken down into two categories:

Energy usage is the amount of kWh or MWh used by the consumer during the course of the day, week, month and year. For example, if you leave your 3 kW stove on for three hours when you could have turned it off after one hour, you would have used three times the energy, but the electrical demand would still be the same, that is, 3 kW.

Electrical demand (instantaneous demand) is the amount of kVA (or kW) that is connected onto the grid at any one time (that is, the power that is being used by consumers at any one time).

Eskom has a current installed capacity of 42,000 MW and an operational capacity of between 38,000 MW and 40,000 MW. In normal circumstances, to allow for unplanned and planned maintenance, it is necessary to have a 15% reserve margin below the operational capacity. If the demand from consumers exceeds the operational capacity of the grid, it would shut down.

Demand is therefore one of the issues that drives Eskom to require a reduced level of consumption from consumers to be able to secure the supply.

[13] This section was primarily written by Andrew Mather, Dave Fleming and Howard Harris of WSP. They would like to acknowledge the support of Miriam Altman, Rob Davies, the members of the EITT in the NERT, and the many companies who shared their insights in the preparation of this report.

- Under normal circumstances, the combination of all users on the grid leads to a demand curve (the number of kW or MW used at any time over a prescribed period) that exhibits three distinct daily peaks and one distinct annual peak.
- The daily peaks roughly occur at 6am to 8am, 12pm to 2pm and 5pm to 8pm. During the rest of the period the power consumption is much lower.
- The annual peak roughly occurs during winter, from June through to August, with a much lower peak occurring during summer (January to March).
- The daily peak profile does not change shape from summer to winter; however, the height of the peaks increase by as much as 10% to 15% during winter.

If the daily peak starts to approach the operational peak capacity of the Eskom grid, it puts the national supply at risk and Eskom would have to shut down various industries, local authorities or residential areas to minimise this risk.

The present course of action is to institute managed load shedding of supplies, which allows Eskom to control this risk at a much lower point on the demand curve. Eskom would institute load shedding on the grid if national demand approached a reduced level below operational capacity, calculated at the 15% reserve margin level below such capacity. This type of load shedding would only be instituted during peak hours and definitely not on weekends and public holidays.

If consumers were able to shift their load usage into different times of the day, the peaks could be reduced and the load curve could be substantially flatter – which would immediately reduce the risk to the grid on the demand side. This could be accomplished by industry rescheduling shifts, office and retail rescheduling normal office hours and opening hours, and residential consumers moving the use of their high consumption appliances away from the peak periods, installing timers on geysers and pool pumps, using gas stoves, etc.

Although this would reduce demand, it would not affect the amount of energy consumed, as we would only be moving our loads into different parts of the day – reducing peaks and filling in the troughs or low points. This would mean, however, that load shedding during peak hours could be stopped or at least significantly reduced, and if still required, could be of much shorter duration.

However, this is not the only problem Eskom faces. The amount of energy consumed during a day, week, month and year is also an issue.

The cost and consumption of resources needed to generate electricity at each power station are increasing. If faced with a resource shortage, power stations are unable to generate to their full capacity, which means that the operational capacity Eskom documents as being available could, in fact, be lower. A shortage of coal, poor coal quality or wet coal are factors that dictate whether Eskom can achieve its stated operational capacity.

Under normal circumstances, the effects of these issues would be dealt with within the 15% reserve margin. However, as the reserves were severely depleted and compromised for a number of months in early 2008, Eskom's ability to produce the energy for which it has capacity has been seriously reduced.

In this case, the simple measures of reducing demand peaks and moving load consumption to other parts of the day will not solve Eskom's problem fully.

To reduce energy demand to a level where the resources can cope, Eskom needs to induce consumers to lower their usage over the whole day, week, month and year. Managing the peak demand helps to meet the demand target, but not the consumption target. Reducing the peak demand together with shifting it would help to reduce the consumption target.

This can only be achieved by increasing the efficiency and reducing the operating time and capacity of all equipment/appliances connected to the grid, hence the need to implement energy-efficient lighting, solar water heaters, gas cooking and the myriad of other solutions currently being instituted by industry and consumers to address the problem. However, as such a process takes time to show effect, Eskom has been forced to implement load shedding at all times of the day, regardless of whether the peak operational capacity was being threatened or not.

It is also important to review the supply situation during the winter months.

- The demand and energy consumption increase during winter by as much as 10% above the 'summer' level.
- If the peak operational capacity is at risk during the summer period, that risk is significantly increased during winter if no new capacity is added to the grid.
- If the availability of resources to generate power are constrained and cannot be improved during the summer period, there can just not be enough energy generated in winter to cope with the increased usage, despite the fact that we may have the capacity to generate this energy.
- It is possible that Eskom could produce enough energy from all its existing power stations to cope with the winter loads, but this would mean that all operating capacity would need to be available, and the stockpile of coal significantly increased and the quality improved. If this is not possible, we could be left with major power outages, prolonged load shedding and industry being forced to close sections of plant or whole plant just to keep sufficient power available to run the rest of South Africa during winter.

2008 projections

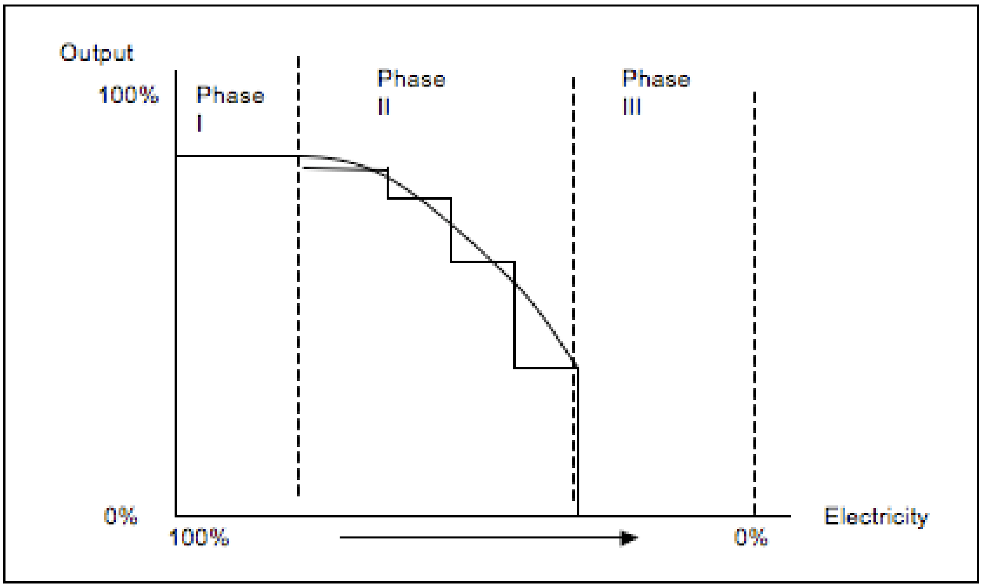
Installed capacity	42,000 MW
Operational capacity	40,000 MW
Reserve margin level	34,000 MW
Current summer peak load	32,000 MW
Projected winter peak load	36,000 MW – higher than the reserve margin level
Actual operational capacity	we are not certain of this figure

These projections are based on the profiles available from the papers titled *National Response to South Africa's Electricity Shortage*, published in January 2008 (Department of

Minerals and Energy, 2008) and *Demand Side Management*, published on the Eskom website in February 2007 (Eskom, 2007).

The extent to which there is inefficient use of electricity – or 'slack' – in the system, is a critical concern affecting the ease with which a cut can be absorbed without output being reduced. We can think of electricity and output being related in the way shown in Figure 1. Output is at full capacity on the left. Initially, as we reduce electricity input, there may be no impact (Phase I). Continued reductions beyond this point cause output to fall (Phase II). These reductions might be smooth, but are more likely to follow the step function shown, essentially breaking Phase II into smaller phases. It is almost certain that the rate of reduction accelerates. Finally, we reach the point where everything shuts down (Phase III), which is likely to be at a point where we have not removed all electricity. The practical question is how different sectors fit into these phases. For some of them, Phase I will be short and they will be less able to absorb reductions in power. We analyse this for the different sectors.

Figure 1 – Phases of electricity reduction



3.2. The mining sector

3.2.1. Power utilisation

Power on the mines is primarily used for the following activities:

- Refrigeration and ventilation;
- Compressed air generation;
- Pumping;

- Vertical transportation / hoisting;
- Conveying of materials;
- Milling;
- Processing;
- Arc furnaces;
- Hostels – lighting / heating and cooling; and
- Administration offices.

Pumping, cooling and ventilation consume about 50% of the total power used by mining.

Referring to Figure 1, one can say that the mining sector has a relatively short Phase I – it cannot absorb a large reduction in power supply before production output is affected.

3.2.2. Opportunities for power saving

a. Immediate-term savings

In the very short term it is only really possible to make savings without affecting production in the last two areas mentioned above – hostels and administration offices. Yet these two areas constitute a relatively small percentage of the total power used. It is therefore highly unlikely that a 10% saving could be achieved in the short term without affecting production.

Total consumption in the mining sector is 33,529 GWh/annum, with an average load of 5,700 MW. Hostels and administration offices account for about 9% of this figure. Approximately 30% savings are possible by applying DSM technologies in these areas, which means there is the potential to save about 905 GWh/annum consumption or see a 154 MW load reduction in the immediate term.

If forced to achieve a 10% saving in the short term, the mines will most probably stop working those shafts with a lower ore grade. This means closing a whole shaft, and since most of the unskilled and semi-skilled workforce are on contract or paid according to production achieved, this would entail a loss of income and/or employment for such staff.

The other short-term possibility is the introduction of power factor correction (PFC), but most mines have installed this already.

b. Medium-term savings

Medium-term savings in the mining sector could be achieved in the following ways:

- Some of the mining houses have embarked on programmes to remove their hostels and housing compounds from the grid and supply these with power derived from bio-energy plants and photovoltaic cells. This would reduce demand by up to 4.5 MW per shaft.

- Use of pelton wheel turbines to utilise the energy from water coming down the shaft.
- Use of the three-chamber pipe feed system to move hot water up and out of the mine.
- Use of mill power optimisation technology.
- Implementation of a variable speed drive (VSD) programme for appropriate motor technology.
- Use of electric drilling programmes, which reduces the compressed air component significantly.
- Remote sensing to reduce light usage on the plant.
- Waste heat capture to produce hot water for the ablution facilities.
- Motor efficiency programmes can be (and are) implemented by developing an *in situ* monitoring and diagnostic programme and a core replacement programme .
- Bulk energy storage on site, which can act as a security power supply as well as displacing load during peak periods.
- Load shifting programmes are a major contributing factor to reduce the current strain on the generation base and significant savings have and can be achieved in this area.
- The use of ice plants in lieu of chilled water refrigeration plants can reduce the energy requirements in refrigeration and pumping. Because of the latent heat in the ice, more cooling is obtained from less ice. And because ice has a larger volume than water, significantly less water needs to be pumped out. Moreover, using hard ice technology is even more energy efficient than vacuum ice technology. Most of the mining groups have started to use vacuum ice technology sporadically, but there is very limited use of hard ice technology.

  To show what can be done, we explored a case study of the use of vacuum ice and hard ice plants to reduce power consumption (see Appendix A). Each vacuum ice plant can potentially save 3.9 GWh/annum, a reduction in demand of 350 kW. There is potential to install at least 50 such plants. At the current cost of electricity, the payback period would be more than 10 years, which means mines would not readily install these plants without some support, such as a tax incentive. It is worth noting that this area of investment is not covered by the current accelerated depreciation allowance for the mining industry. The reduction in the payback period will vary linearly with an increase in the cost of electricity.

Table 7 – Potential savings in mining

		% of total demand that can be saved	Time to implement (months)
Pumping	Efficient pumps	3.75	12 - 18
Compressed air	Hilti electric drills and lead reduction	5.25	24
Ventilation	Energy saving off shift	1.08	6
Gold plants	Independent compressors	1.09	6

Refrigeration	Thermal ice storage	1.30	12 - 18

Source: Estimates from a shaft at one South African mining house

c. Drivers for power saving

Factors preventing mines from adopting the above energy-saving measures include:

- Shortage of specialist skills;
- High capital cost of some of these plants;
- Low cost of electricity;
- The ore grade of the particular mine; and
- Ice plants are only viable for deep level mines because of the increased pumping costs.

Factors that could accelerate the adoption of this technology include:

- DSM subsidies for the capital cost.
- A streamlining of the DSM approval process.
- Tax write-off in the first year of the capital cost. The current 100% depreciation allowance for new production plant should be changed to include any plant that is installed with a view to reducing electricity demand.
- An increase in the cost of electricity.

Table 8 shows an analysis of which mining groups are adopting some or all of these energy-saving measures.

Table 8 – Current adoption of energy saving initiatives by mining houses

Mining house	Have energy reduction programme	Utilise vacuum ice plants	Utilise hard ice plants	Utilise pelton wheel turbines	Utilise mill power optimisation technology
Anglo American	Yes	Yes	No	Yes	Yes
Goldfields	Yes	Yes	No	Yes	Yes
BHP Billiton	Yes	Yes	No	Yes	Yes
Lonmin Plat	Yes				

3.2.3. Effects of unscheduled power cuts

Unscheduled power cuts can have severe implications for the mining industry, including:

- Loss of production, although this will occur whether the power cut is scheduled or unscheduled.
- Loss of ventilation and refrigeration, which causes great discomfort to people underground, requiring their quick evacuation from the mine. Evacuation efforts are hampered by the lack of power.
- Potential for people to get trapped underground temporarily.
- Damage to thickeners in the reduction plant. If power goes off for longer than 90 minutes, the slurry thickens to such an extent that it will damage the stirring rakes when power is restored.

3.3. The manufacturing sector

The manufacturing sector is highly diverse, and it is not possible to tease out all the variations in this short project. Below we identify some areas of commonality, as well as critical areas that need attention in select sub-sectors.

3.3.1. Potential for power savings

a. The extent of potential power savings

The extent of potential power savings in manufacturing depends on:

- The extent to which DSM schemes have already been implemented.
- The type of process, whether batch, jobbing or continuous.
- Whether the manufacturing process is energy intensive, such as in smelters, or labour intensive, such as in apparel. Potentially it is possible to achieve a greater percentage saving in consumption in a labour-intensive industry, although the absolute saving may not be as high as for an energy-intensive plant.
- The amount of waste produced and its suitability for co-generation projects.

The aim should be to reduce power consumption without affecting production outputs, as a drop in production will have the same negative consequences as for mining. As discussed in Section 2 of this report, GDP, employment and the balance of payments can be affected negatively.

b. Opportunities for power savings

Some of the clear opportunities for power savings include:

- Installation of bulk check metering and sub-metering;
- Installation of PFC;
- Installation of remote motion sensing connected to the lighting component in plant and buildings;
- Energy-efficient lighting in the plant and administration areas;

- Changes in the load profile if possible, that is, running energy-intensive processes at night or during off-peak periods;
- Develop motor efficiency programmes in an *in situ* diagnostic monitoring programme and a core replacement programme; and
- Co-generation opportunities (as discussed in Section 3.3.1.c).

c. Factors that could accelerate the number of co-generation projects

Appendix B shows the minimum requirements to make co-generation feasible. Co-generation is widely practised in the sugar and pulp & paper industries, and to a lesser extent in the petro-chemical industry. Less than 300 MW of electricity is currently produced through co-generation; however, we believe that 2,000 MW is achievable within two years. It takes about two years to design and build a co-generation plant and to get the necessary Eskom approvals. Factors that could accelerate the number of co-generation projects include:

- Streamlining the current Eskom approval process.
- Allowing a full write-off for tax of the capital cost in the first year.
- Higher prices for electricity produced through co-generation that is sold back to the grid. The principle of contracting at the utility's full avoided cost is sound, as the co-generator offsets its higher cost of capital and higher return required against efficiency improvements. There is currently an apparent disconnect between Eskom's calculation of its avoided cost and sellers' expectations. A number of co-generation schemes have been planned and are 'ready to go', but are awaiting Eskom approval. Other co-generation schemes are planned, but the current price paid for supplying electricity to the grid does not make these projects viable. An increase in the price paid for electricity could make more of these schemes feasible.
- Publishing co-generation feed-in tariffs will assist in expediting the process and incentivising potential co-generators.
- Streamlining of the current 100-page Power Purchase Agreement (PPA).
- Resolution of the asymmetry of risk uptake that exists in proposed PPAs between the seller and buyer.
- Environmetal Impact Assessment (EIA) Records of Decision (RoDs) need to be fast-tracked for co-generation projects.
- Defined rules between co-generation and Power Conservation Programme (PCP) requirements.
- Independent Power Producers (IPPs) should receive a production tariff (premium) that will ensure commercial viability over the lifetime of a project, and this should be unique to each project.
- Eskom's single buyer model should be extended to RE generators.

d. Time frames for power savings

Immediate opportunities for power saving in the short term:

With the exception of co-generation, all of the above-mentioned potential power-saving measures can be achieved in the short term.

Tables 9, 10 and 11 are sourced from Howells (2006).[14] Table 9 shows the percentage usage of electricity by the industrial sector for the various components that make up the plants.

Table 10 shows the percentage savings that can be achieved for each of the potential DSM measures that can be implemented.

Table 11 shows the energy-saving potential for each sector if a full suite of DSM measures were implemented.

Table 9 – Percentage usage of electricity by industrial user

	Food & beverages (%)	Textiles (%)	Wood & wood products (%)	Chemicals (%)	Iron & steel (%)	Non-ferrous metals (%)	Basic metals (%)	Manu-facturing (%)
Indirect uses boiler fuel	2	1	3	1	0	0	0	1
Process heating	4	5	6	3	39	1	17	10
Process cooling	24	7	0	6	1	0	0	5
Compressed air	8	10	38	10	8	0	11	9
Other machine drive	44	50	38	53	40	2	56	47
Electro-chemical processes	0	0	0	18	2	95	17	11
Other process uses	0	1	1	0	1	0	0	1
HVAC	8	15	4	4	3	1	0	8
Lighting	7	10	7	3	4	1	0	7
Facility support	2	2	1	1	1	0	0	2
Transportation	0	0	0	0	0	0	0	0

Source: Howells (2006)

[14] It should be noted that some industry stakeholders believed that some of Howell's figures were ambitious and potentially not reflective of energy-efficiency measures implemented since the article was written. Howell's figures are based on what is potentially possible. The WSP team believes, based on its extensive experience working in mining and manufacturing industries, that the figures are achievable and therefore wanted to ensure the reader was aware of them.

Table 10 – DSM interventions and their potential (stand-alone) savings by end use

	Steam system	Thermal measures	Efficient motors	VSDs	Efficient lighting	Compressed air savings	HVAC	Refrigeration	Load shifting
Indirect uses boiler fuel	15%	5%							
Process heating		5%							
Process cooling				10%					20%
Compressed air			5%	5%		15%		15%	
Other machine drive									
Electro-chemical processes									
Other process uses									
HVAC			5%	10%			30%		20%
Lighting									
Facility support					40%				
Transportation									

Source: Howells (2006)

Table 11 – Energy saving DSM potential based on current electricity consumption

Sector	Potential saving in GWh	Typical payback period in years
Iron & steel	2,289	2.3
Wood & wood products	1,458	2.2
Chemicals	1,370	2.7
Food & beverages	605	2.4
Rest of manufacture	542	2.6
Textiles	67	2.6

Source: Howells (2006)

Medium-term opportunities for power saving:

Co-generation is the main medium-term opportunity, and Table 12 shows the potential co-generation capacity that is available. This information has been provided by Business Unity South Africa (BUSA) members in the sector. Some of key insights include:

- Co-generation opportunities exist within the motor industry, with particular reference to wind generation at industry sites in the Eastern Cape.
- Co-generation opportunities exist in the brewing industry where methane from waste water plants which is currently flared can be used in gas reciprocating engines to generate electricity.

- Eskom is budgeting for at least 3,500 MW of co-generation.
- Eskom has received proposals for approximately 100 co-generation projects with a total generation capacity of 5,000 MW.
- The largest are between 300 MW and 400 MW, while the majority of the projects are below 100 MW.
- Sasol Secunda has approved a co-generation plant of 280 MW.
- ArcelorMittal is proposing a 110 MW plant at its Vanderbijlpark Works.
- Tongaat-Hulett is in the planning stages of its 60 MW plant.

Table 12 – Co-generation potential capacity available

Industry	Additional potential	Remarks
Sugar industry	150 MW - 200 MW	Blue sky potential of 1,000 MW
Oil refining industry	150 MW - 250 MW	
Synthetic fuels industry	400 MW - 800 MW	280 MW in process, a further 100 MW possible in the short term, the rest only after 2012
Iron & steel	100 MW	
Food processing	75 MW	
Pulp & paper		
Waste industry		Blue sky potential of 500 MW

3.3.2. Effects of unscheduled power cuts

Unscheduled power cuts can have varying implications for the manufacturing industry, depending on the nature of production. One cross-cutting impact may be that an unfair distribution of load shedding or cuts may create competitive advantage or disadvantage for some manufacturers relative to others.

We briefly assess the impact of unscheduled power cuts in the motor, food & beverages, chemicals and iron & steel industries.

Motor industry

- Referring to Figure 1, the motor industry has a longer Phase I, which means it is less sensitive to a reduction in electricity supply.
- The motor manufacturing production process is a 'jobbing' process, therefore an unscheduled power interruption will cause jobs to be stopped, but no materials or products will be damaged. The effect of such a disruption will therefore be limited to a reduction in output.
- The unfair distribution of load shedding or cuts which affects some manufacturers and not others may lead to skewed competition in the market.

Food & beverage industry

- Referring to Figure 1, the food & beverage industry has a relatively short Phase I, which means it is relatively sensitive to a reduction in electricity supply.
- The production processes within the food & beverage industry are generally either batch or continuous processes. In either case, an unscheduled power interruption will not only result in a reduction in output, but also in damaging the batch of material that is in production. This can have relatively severe financial implications. In the case of a continuous production process, there is normally a further delay following the power interruption, as the whole process needs to be 'started up again'. This not only has the effect of a longer power outage, but additional resources and costs are also incurred to bring the plant on-line.
- Processes in this industry are often biological in nature and temperature control is essential for successful operation. In some cases it is not only the production run that is lost but also the seed micro-organisms.

Chemical industry

- Referring to Figure 1, the chemical industry has a relatively short Phase I, which means it is relatively sensitive to a reduction in electricity supply.
- As with the food & beverage industry, the production processes within the chemical industry are generally batch or continuous processes. An unscheduled power disruption therefore results not only in a loss in production output, but also in a loss of batches in production. In some cases it can take several hours to clear the 'damaged batch' following the power interruption. In continuous processes, it can also take several hours to 're-start' the process. This not only has the effect of a longer power outage, but additional resources and costs are also incurred to bring the plant on-line.
- In some cases, damage to equipment can occur when a batch is left standing midway through the batch process, as some materials can solidify.
- Another challenge in the chemical industry is that of health and safety. Start-up and stop are the most dangerous parts of process operations, and unexpected stops and starts increase the risk of accidents.

Iron & steel industry

- Referring to Figure 1, the iron & steel industry has a relatively short Phase I, which means it is relatively sensitive to a reduction in electricity supply.
- The production processes within the iron & steel industry are generally batch or continuous processes. An unscheduled power disruption therefore results not only in a loss of production output, but also in a loss of batches in production. In some cases it can take several hours to clear the 'damaged batch' following the power interruption. In continuous processes, it can also take several hours to 're-start' the process. This not only has the effect of a longer power outage, but additional resources and costs are also incurred to bring the plant on-line.
- In some cases, damage to equipment can occur when a batch is left standing midway through the batch process, as some materials can solidify.

- Another challenge in the iron & steel industry is that of health and safety. Start-up and stop are the most dangerous parts of process operations, and unexpected stops and starts increase the risk of accidents.
- One of the largest manufacturers in this sector reports a reduction of 26,000 liquid steel tons per month, or 15% of total capacity, due to load shedding.

3.4. The property sector

3.4.1. Potential for power savings

The different property classes – retail, commercial and institutional – will by design all consume different amounts of power. In all cases though, fairly significant savings can be achieved through a combination of the following:

- Good façade design – orientation, type of glass, shading, etc.;
- Good heating, ventilation and air conditioning (HVAC) design – use of chilled beam solutions, or the utilisation of a thermal source;
- Use of natural light and energy-efficient lights; and
- Use of solar panels for water heating and photo-votaic cells for energy generation.

Appendix C shows the possible savings that can be achieved by a 10,000m^2 commercial office development. Savings of up to 57% are possible, or 6.9 MWh per building per day.

There is an opportunity for central and regional government, local authorities and Eskom to work together with private property developers to assist with 'self-supply' schemes. These would involve setting up independent power sources financed by the developers through purchase from or lease agreements with plant suppliers. The option of selling spare capacity back into the grid needs to be addressed, or selling it off to adjacent communities who are being compromised by the lack of capacity on the grid. All this needs to be done in line with supply authority rules and regulations. As and when the grid stabilises and can accommodate additional load, the continuing viability of the self-supply schemes can be addressed against the revised cost of supply of electricity and reduced to just standby capacity, if required. Developers who undertake this type of scheme will be looking to some form of incentive via tax rebates, reduced connection costs on finalised schemes, good rates for repurchase of electricity into the grid, etc.

3.4.2. Opportunities for power savings

a. Immediate opportunities

Immediate savings can be achieved by the introduction of low-energy light fittings and the remote sensing and switching of these lights, so that they only come on when the space is occupied. Similarly, outside lights could be changed to energy-efficient fittings, with switching either through 'daylight' switches or through remote sensing.

The set points for HVAC plants can be increased in summer and reduced in winter, which would result in significant energy savings.

Table 13 shows a case study of the costs and savings that can be achieved for an office campus occupied by a mobile Telecoms network provider.

Table 13 – Immediate energy savings achievable in a commercial office campus

Description	Factor
Lettable m² area	± 30,000m²
Capital cost to fit low-energy lights and remote switching	± R8-million
Power reduction	± 1 MW
Electricity cost saving	
Payback period at current electricity prices	Three years, with period reducing linearly as electricity price increases

This sector consumes 22,697 GWh per annum of electricity. By applying the DSM measures described above, it could reasonably save 3,404 GWh per annum, and potentially save 11,000 GWh per annum.

b. Medium-term opportunities

Medium-term opportunities for power saving can be found mainly in co-generation and self-supply schemes, as described above, as well as in the energy-efficient design of new buildings.

3.4.3. Effects of unscheduled power cuts

The effect on the property sector is less direct than for mining and manufacturing, as properties can 'make a plan' with standby generators and uninterruptible power supplies (UPSs).

The effects of rolling black-outs have been experienced through the entire value chain in the sector, resulting in significant delays to construction programmes. This can be demonstrated by the delays experienced on the Gautrain tunnelling programme.

3.4.4. Impact of Eskom delaying approvals for new developments by six months

Before a new development will proceed, a developer will assess the following:

- The financial feasibility of the development;
- The marketability of the development; and
- The availability of services – electricity, water, sewage and telecoms.

Should any of these be negative, the developer will not proceed with the development. The effect of delaying the approval by six months is the same as there being no available services, as the developer will not be prepared to pay the upfront design costs, which can run into several million rand if there is not absolute certainty that services will be available when needed. The development will therefore not go ahead.

3.5. The hospitality sector

There are opportunities for saving energy in the hospitality sector, including:

- Using solar power for heating hot water;
- Using solar power for lighting;
- Using solar power for cooling in conjunction with triple-effect absorption chillers;
- Using micro wind turbines on high-rise hospitality sites;
- Using HVAC condenser water to 'pre-heat' hot water;
- Using low-energy light fittings and motion sensors to switch off lights/air conditioners/TVs when there is no motion;
- Using electronic card key systems which switch off lights and air-conditioning when rooms are not occupied;
- Using gas for cooking;
- Encouraging guests to reuse towels, which reduces laundry and results in energy saving; and
- Changing all lifts to a merit system.

3.5.1. Immediate opportunities for power saving in the short term

- Immediate savings can be achieved by the introduction of low-energy light fittings and the remote sensing and switching of these lights so that they only come on when the space is occupied. Similarly, outside lights should be changed to energy-efficient fittings, with switching either through 'daylight' switches or through remote sensing.
- Immediate savings can also be achieved through the introduction of solar power for water heating and waste heat recovery technology for water heating.
- Where electric geysers are maintained, they should be fitted with geyser blankets and be connected to a geyser monitoring system.
- Key card systems to switch off all electrical devices when a room is not occupied can be introduced relatively quickly.
- Migrating the kitchens to gas.
- Adjusting the set points on HVAC systems to be higher in summer and lower in winter, which can result in substantial savings.

- An average three-star hotel room is designed for 3 kVA per room, and a five-star for 5 kVA per room. It is immediately possible to save about 0.5 kVA per room.

3.5.2. Effects of unscheduled power cuts

The following are potential consequences of unscheduled power cuts on this sector:

- Guests getting trapped in elevators;
- HVAC systems not working, causing discomfort to guests and conference delegates;
- Inability to cook food (this is limited, as most hotels cook with gas);
- If at night, no light for guests to move around;
- Hospitality industry response depends on the nature of the business. Many restaurants have lost business. This is a sub-sector with very tight margins and many go out of business for a variety of reasons; this year, higher numbers than usual have been reported as a result of load shedding. Unscheduled power cuts particularly affect restaurants when patrons are nervous to venture into dark restaurants at night because of the risk of crime. This is especially true when the restaurant is not situated in a mall.
- The impact on malls is less severe, but less passing trade as a result of no shoppers has an impact.
- Hotels appear not to have lost sales over the initial period, but are unlikely to sustain that situation over a longer period. Patrons will only bear so much inconvenience. There is also the question of patron migration from a place with high load shedding to one with less, which is a similar competition issue to that identified in the automotive sector.

Whilst these consequences may not appear to be severe in the short term, it could affect South Africa's attraction as a tourist destination if guests are repeatedly inconvenienced.

Service levels have been negatively impacted by the power interruptions. A number of establishments have also incurred significant expense in installing and operating back-up power generation equipment.

3.6. The retail sector

3.6.1. Immediate opportunities for power saving in the short term

It should be possible for shopping centres to achieve a 10% reduction in power consumption relatively easily.

- Immediate savings can be achieved by the introduction of low-energy light fittings and the remote sensing and switching of these lights so that they only come on when the space is occupied. Similarly, outside lights could be changed to energy-efficient fittings, with switching either through 'daylight' switches or through remote sensing.

- HVAC systems can be set at 1ºC or 2ºC warmer (in winter) or colder (in summer). This will not have a very noticeable effect on shoppers, but can make a significant contribution to power saving. In Australia, the by-laws dictate that no shopping centre shall have its target temperature set to less than 24ºC in summer. HVAC and ventilation systems can also be linked to timers and monitoring systems to reduce the overall HVAC energy load during peak periods.
- All escalators can be retrofitted with timers and sensors to ensure optimum energy efficiency.

3.6.2. Effects of unscheduled power cuts

The following are potential consequences of unscheduled power cuts on this sector:

- Shoppers getting trapped in elevators;
- HVAC systems not working, causing discomfort to shoppers;
- Potential security breaches due to lights going off;
- Inability of customers to pay for transactions;
- Customers not wanting to visit the centre due to reduced lighting and therefore less security;
- Inability to cook food in restaurants;
- Escalators and elevators not working; and
- Spoilage of frozen foods and fresh produce.

Effectively, the result of all this is a loss of income to retailers, which can be particularly serious if the power interruptions take place at week-ends.

3.6.3. Feasibility of taking shopping centres 'off grid'

As a rule of thumb, the bigger the shopping centre, the more viable it is to take it off the national grid. Table 14 offers a rough estimate of costs.

Table 14 – Costs of generation versus taking shopping centres off the grid

Type of centre	m^2 area	Approximate installed power	Approximate emergency power	Approximate generator cost	Approximate Eskom cost to supply off-grid
Suburban centre	30,000	4 MVA	1.5 MVA	R1.5-million	R1.0-million
Large centre, e.g. Sandton	150,000	18 MVA	7.5 MVA	R7.5-million	R1.5-million

Note: The Eskom costs will depend on the proximity of the closest supply point

The feasibility of taking shopping centres off grid in return for achieving a 10% saving in power will depend on how a particular centre currently receives its power. If the centre is fed from a Municipal Ring Feed, it would be possible to change it to a spur feed directly from Eskom. The following is necessary to achieve this:

- An Eskom sub-station in close proximity; alternatively, a new sub-station will need to be constructed.
- New cables will need to be laid from the sub-station to the shopping centre in-take sub-station.
- The cables at the in-take sub-station will need to be re-terminated. This will result in a power outage for the centre of three to four hours.

The potential extent of savings also depends on the extent to which retailers or centres have turned to generators as an alternative source of power. A number of retailers already have generators or are in the process of installing them. Woolworths has generators for all its stores nationally. Shoprite has generators in most of its stores, and has placed orders for those that do not have. Growthpoint and Liberty have also placed orders for generators for their centres. It must be noted, however, that generators only cover the 'emergency' load – lighting and refrigeration – and not HVAC (air conditioning).

Even at 60% higher electricity prices, electricity would still be cheaper than generation. The cost of generation is about R2.30/kWh, as opposed to the current cost of electricity, which varies between 14 cents and 30 cents per kWh. Therefore, even those retailers that have generators will only run them during black-out periods.

3.7. The agricultural sector

3.7.1. Potential for power savings

Power usage in the agricultural sector is primarily for pumping for irrigation and for material conveying. There is not much opportunity for energy saving in this sector other than perhaps using diesel-driven pumps, but that has environmental impacts. Some minor savings can be achieved at the homestead.

- Micro anaerobic digester units can supply gas for heating and cooking;
- Solar water pumping is an ideal application for the agricultural sector; and
- Solar and wind generation, together with large energy storage, can render some sectors of the agricultural sector self-sufficient.

It is possible, however, for this sector to re-look load shifting so that the load is taken off the peak periods, reducing the impact.

Few of these opportunities will be utilised without some form of financial incentive, such as a DSM subsidy, a tax incentive, or both.

3.7.2. Opportunities for immediate power saving

No significant opportunities exist in this sector, although milling and some processing can be shifted into off-peak periods.

3.7.3. Effects on this sector of rolling black-outs

The effects of rolling black-outs on this sector have and can be severe. This is particularly the case in the dairy, poultry and aquaculture sectors. Industry-wide rolling black-outs have disrupted irrigation cycles, while the refrigeration chain across the sectors has been affected, which contributed to significant losses due to spoilage.

- *Milling companies, abattoirs and processing plants have and will be affected negatively.*
- *Irrigation*. Farms under irrigation generally draw irrigation from state irrigation schemes in terms of a permit. Irrigation schedules are spread over 24 hours to ensure balanced use of the water. Interruption of power disrupts the schedules and may result in farmers not being able to draw water in terms of their schedule.

  Specific tariff schemes to incentivise irrigation outside of normal peak times are already in place.
- *Maintenance of the cold chain from farm to retail*. A wide range of agricultural products has to be maintained at a low temperature from the farm to retail. Any disruption in this cold chain can destroy the produce. Examples of such products are milk, meat, and some fruit and vegetables. The same applies to the fishing industry.
- *Biological processes*. Most biological processes require specific temperatures to be maintained for the duration of a particular process. Again, disruption of the temperature chain destroys a batch, which in the case of some products like wine can result in the loss of a whole crop.
- *Automated feeding systems*. Automated feeding systems can generally not be used manually and unplanned disruptions here can result in large-scale deaths of livestock.

The agriculture industry recognises the need to make a contribution to the current energy situation, but needs load shedding to be well scheduled and advance warnings to be reliable. It is recognised that the current approach to load shedding is an improvement on the earlier efforts. It is imperative that the sector monitors the impact with better advance warning and makes adjustments where necessary.

3.8. The residential sector

3.8.1. Potential for power savings

Although individual residential consumption is quite small, the aggregate consumption is significant. There are a number of opportunities for power saving in this sector, especially in the higher income group. Savings of 15% to 20% should be possible through the implementation of some or all of the following measures:

- Use of solar panels for water heating, with electrical geysers used to supplement this heating if required, but on time switch control to keep this load off peak;
- Use of insulating geyser blankets to reduce heat loss;
- Use of low-energy light fittings;
- Use of motion sensors to turn off lights when there is no movement, and photo-electric cells to switch off external lights during the day;
- Use of gas for heating and/or cooking;
- Reducing the 'filter-off' time on swimming pools and water features;
- Use of micro wind turbines in appropriate areas; and
- Use of geothermal heating and cooling.

Appendix D shows a maximum potential saving for a medium to large household of 57% by applying all the above measures. Accepting that it is not possible for all households to apply all measures, we would suggest that, conservatively, at least 20% can be saved by most households.

Taking the historical Eskom sales and municipal data from EDI, the residential sector consumes about 41,209 GWh per annum. A 20% saving would therefore equate to savings of 8,241 GWh per annum.

This sector would be sensitive to electricity pricing, and therefore a tiered increase in tariffs would motivate a strong reduction in demand.

3.8.2. Opportunities for immediate power saving

- Immediate power saving can be achieved through a co-ordinated national programme where current lighting systems are replaced with low-energy light bulbs.
- A national domestic geyser programme should be implemented in which geyser blankets and geyser monitoring systems can render significant power savings.

3.9. Encouraging energy efficiency in industry (DSM)

There is much evidence to show that substantial energy-saving DSM projects are possible, especially in the mining and manufacturing sectors. Most of these initiatives require an initial capital investment.

There are a number of ways to encourage improvements in energy efficiency by users. In some cases, as in mining, firms have already implemented programmes to explore and implement improvements. However, to promote a faster rate of adoption across the economy, it is recognised that some support will be required.

Although Eskom's DSM programme intends to offer this support, it has a number of serious problems, particularly in a context where rapid take-up is sought. For example, the average time from proposal to contract placement is approximately one year in the

Eskom system, while in some cases it can extend to 18 months or longer. Only after the DSM agreement is signed and the Eskom contract placed does the measurement and verification (M&V) begin. This M&V baseline study can take another two to four months before the actual work can commence on the project. Another major problem is the costing differential on components associated with the programme, taking into account inflation and the exchange rate. This in turn poses a serious constraint and highlights the model's shortcomings.

It is unclear whether Eskom need to manage a DSM programme. But whether it is managed by Eskom or some other entity, it is clear that the processes need to be streamlined and decentralised. First, any M&V process could be outsourced to a designated list of accredited consultants. Second, support for demand-side improvements might be better achieved as a result of tax breaks and the proposed dti electricity incentive targeted for this purpose. For example, it should be possible to process work retrospectively, with the demonstrated savings being reimbursed to the initiator of the project by a tax incentive.

Howells (2006) shows the following potential savings of applying a suite of DSM measures in each sector, as well as the typical payback periods for these measures.

Table 15 – Energy saving DSM potential based on current energy consumption and typical payback periods (based on 2006 consumption figures)

Sector	GWh per annum equivalent saved	Typical payback period in years
Mining	4,779	2.4
Iron & steel	2,289	2.3
Wood & wood products	1,458	2.2
Chemicals	1,370	2.7
Food & beverages	605	2.4
Rest of manufacture	542	2.6
Textiles	67	2.6

Source: Howells (2006)

The DSM measures referenced in Howells (2006) include efficient motors, VSDs for fans and pumps, compressed air, load shifting, lighting, steam and thermal measures. The potential of each of these interventions is gauged for each industry against the energy usage in that sector, providing the *potential* energy saving of each intervention for the industry sector; or what is technically possible. The actual implementation of these savings will depend on a range of factors.

Table 16 has been compiled from discussions with industry personnel and energy efficiency and industry experts, whose views show that:

- There is little information regarding the energy usage in each industry and projects to improve the supply of information to industry organisations are long overdue;
- Little can be done over a period of 18 months (the short term) without loss of production;
- Government intervention is required to stimulate the DSM process; and
- Less than a half, or even a fifth, of what is technically possible would be implemented in the absence of DSM support by government.

Table 16 – Potential savings achievable in different time frames

Sector	**Phase 1**	**0 - 18 months**	**Phase 2**	**> 18 months**
	Demand (MW)	**Consumption (GWh/annum)**	**Demand (MW)**	**Consumption (GWh/annum**
Mining	250	875	750	2,625
Iron & steel	100	700	100	700
Petrochemicals	100	700	900	6,300
Sugar	200	350	800	1,400
Wood	50	350	200	1,400
Food & beverages	50	350	100	350
Rest of manufacturing	200	350	200	350
Waste industry			400	3,000
Commercial	250	1,750	250	1,750
Residential	600	4,200	600	4,200
Total	**1,800**	**9,625**	**4,300**	**22,075**

3.10. Appendix A – Energy efficiency case study of mining vacuum ice refrigeration technology compared to hard ice refrigeration technology

This case study looks at the potential energy efficiency gained by changing refrigeration technology in the mining industry. More specifically, the coefficient of performance (COP) between vacuum ice and hard ice is compared, expressed as kW output against kW input. More efficient plants will have a higher COP number. The comparison is based on an article by IDE Technologies on the Mponeng Plant of Anglo American (IDE Technologies, 2008).

The COP number is substantially influenced by the ambient conditions, which means the lower ambient temperatures in winter will result in a higher COP than in summer.

Vacuum ice COP

The Mponeng case study uses a COP 1 as well as a COP 2. For comparative purposes one should use COP 2 only, as this includes all process energies – also the ice slurry and coolant pumping. It does not refer to the cooling tower fans nor to the vacuum pump required to remove the non-condensables from the condenser system. This equipment will lower the COP.

The plant performance for COP 1 was guaranteed at 3.9, whereas the calculated value was 4.34. The guaranteed value for COP 2 is some 0.32 lower (see Table 17). We can therefore conclude that the guaranteed value for COP 2 would be 3.58, still excluding cooling tower fans and vacuum pumps. It is this value that will be used for the comparative performance of the hard ice plant.

Hard ice plant COP

The guaranteed performance of the plant was based on cooling tower water temperatures of 22^{o}C in and 27^{o}C out. Under these conditions, the hard ice plant will operate on a condensing temperature of 30^{o}C.

This will result in a COP of 3.79 for ice delivered at the shaft, including all losses, compared to the guaranteed COP figure of 3.58 for vacuum ice (excluding cooling tower fans and vacuum pumps).

Table 17 shows the motor schedule and absorbed power for various operating conditions of the hard ice plant. The COP figure is for ice delivered to the shaft.

Table 17 – Motor schedule and absorbed power in hard ice plant

	Size connected kW	No.	Summer absorbed kW peak	Winter absorbed kW peak	Design condition +30°C condensing	Anticipated annual average at 25.5°C condensing
Ice compressors	1,250	2	2,070	1,520	1,962	1,748
Compressor oil pump	11	2	18	18	18	18
Cooling tower fans	45	2	80	80	80	80
Condenser pumps	110	2	200	200	200	200
C.W. pumps	37	2	68	68	68	68
Screw conveyors	15	5	13	13	13	13
Belt conveyors	15	2	24	24	24	24
Vent fans	11	4	18	18	18	18
Total kW absorbed			2,493	1,943	2,383	2,169
▪ Ice delivered to shaft kg/sec (94% ice fraction)			23.65	23.65	23.65	23.65
▪ Ice energy at shaft (kW) (including warming up to 16.2°C), i.e. 381.8 kJ/kg of ice			9,030	9,030	9,030	9,030
▪ Ice COP delivered to shaft			3.62	4.65	3.79	4.16

Ice fraction

The ice fraction of the hard ice (made from typical mine water) delivered to the shaft is 94% and 70% for the vacuum ice.

This entails that for every kilogram of hard ice at 94% ice fraction, one needs to deliver 1.266 kilograms of slush ice at 70% concentration.

The equation is 0.7 x 334 x y + 4,186 x 16.2 x y = 381.8 kJ
y = 1,266 kg

As seen in Table 17, to achieve 9,030 kW, an additional 23.65 x 0.266 = 6.29 kg/second of water would need to be pumped from a depth of 2,500m. Assuming a pump efficiency of 75% and a motor efficiency of 92%, an absorbed power of 227 kW is required to pump this additional water to the surface, over a height of 2,500m.

This will lower the vacuum ice plant overall guaranteed COP from 3.58 to 3.29.

Annual operating cost of vacuum and hard ice plants for ice delivered to shaft

It is assumed that the delivered ice quantity to the shaft is 23.65 kg/second for 24 hours a day and 350 days a year. The COP for the hard ice plant is taken at the average calculated condition of 4.16.

On the same basis, the COP of the vacuum ice plant would now be 3.61 (the same percentage improvement as for hard ice), from 3.29. We arrive at rhis figure using Table 17, which compares cooling water temperatures and relative COPs.

The comparative electricity costs for the two types of ice are tabulated in Table 18.

Table 18 – Comparative electricity costs using vacuum ice and hard ice

	Vacuum ice	Hard ice
kVA	2,633	2,283
kWh per 350 days	22.1 x 10^6	18.2 x 10^6
Network demand and access charge	12 x 14.37 x 2,633 = R454,035	12 x 14.37 x 228 = R393,680
kWh charge: low season (33 weeks)	0.0906 x 2,501 x 24 x 33 x 7 = R1,256,218	0.0906 x 2,169 x 24 x 33 x 7 = R1,089,459
kWh charge: high season (17 weeks)	0.188 x 2,501 x 24 x 17 x 7 = R1,342,857	0.188 x 2,169 x 24 x 17 x 7 = R1,164,596
Total annual cost of electricity	R3,053,109	R2,647,735

(The kWh unit cost is derived as an average of the weekly peak, standard and off-peak charges for Megaflex tariffs, which comes to R0.0906/kWh for low season and R0.188/kWh for high season. It is assumed that the plants operate seven days a week and 24 hours per day.)

Initial capital cost

At present we do not have accurate capital costs of the vacuum ice plant, but we understand it to be more expensive.

General

As the term indicates, vacuum ice plants are operated under almost complete vacuum. Any small leak such as via shaft seals of compressors, valve glands and the like will result in the ingress of air and decreased efficiency.

In addition, the process is dependent on the addition of salt to the watery solution to form ice crystals. The salt concentration is critical to the operation of the plant. Inevitably, salt is carried over with the ice, which in turn causes an environmental problem.

The water vapour compressors used for the vacuum ice plants are of specialised design, which is still in development. And since only one factory in Israel manufactures these components, one is entirely dependent on a single source of supply.

3.11. Appendix B – Typical requirements for co-generation plants

Industry can use co-generation plants to augment its power supply from the grid, saving on the cost of power and in some cases improving the reliability of supply. Co-generation plants can be connected to the grid so that they can 'sell' electricity back to Eskom in periods of low demand, or they can be designed to supply a specific load only. A pre-requisite for the establishment of a co-generation plant is either:

- An available source of gas of sufficient quantity and with a high enough methane content; or
- The availability of bio-degradable waste in sufficient volume.

The minimum design criteria for a co-generation plant are as follows:

Bio-gas fired plants

Modules of 1 MW to 3 MW constitute economically viable plants. 265m^3 of biogas is required per MW per hour, and the methane concentration should be at least 55% to 60%.

Bio-waste to energy plants

These plants would typically be 5 MW or larger. 10 kilo tons to 12 kilo tons of bio-mass are required per MW per annum, at an assumed moisture content of 20% to 40%. The Cv of the bio-mass must be at least 15 GigaJoules (GJ) to 20 GJ per ton.

Drivers for co-generation plants

- Plants can reduce their total energy cost;
- Plants can improve the reliability of their electrical supply;
- Carbon credits can be obtained; if one is also reducing the release of methane into the atmosphere, additional credits can be obtained;
- DSM subsidies can be obtained to offset some of the capital cost; and
- As the price of electricity goes up, these plants become more viable.

Barriers to co-generation plants

- Lengthy approval processes for DSM subsidies;
- High capital costs; and
- Shortage of appropriate skills.

3.12. Appendix C – Potential for energy saving in commercial buildings

No	Device(s)	Power rating	Load factor	Actual power	Hours of operation per day	Total energy usage per day kWh	Savings possible	Savings as a % of total usage	How saving achieved
		kW		kW		kWh	kWh/day		
1	Lights – internal	200	0.9	180	24	4,320			Low energy lamps
	Internal lighting after savings	100	0.6	60	10	600	3,720	86	Reduce time on Switch off lights when office not in use
2	Lights – external	40	0.9	36	11	396			Low energy lamps
	External lights after savings	20	0.9	18	10	180	216	55	Daylight switches
3	Small power	300	0.6	180	11	1,980			Switch off devices not in use
	Small power after savings	300	0.4	120	8	960	1,020	52	
4	HVAC	500	1	500	11	5,500			Switch off a/c units when office not in use
	HVAC after savings	500	0.7	350	10	3,500	2,000	36	Encourage open windows in lieu of a/c
	Total daily usage					**12,196**			
	Total possible daily saving						**6,956**		
	Possible % daily saving							**57**	

Notes: This reflects maximum power saving, as not all the savings measures are possible.
This is based on a medium-sized commercial building of 10,000m².
It is assumed that a console-type HVAC unit is used.

3.13. Appendix D – Potential for energy saving in residential households

No.	Device(s)	Power rating	Load factor	Actual power	Hours of operation per day	Total energy usage per day kWh	Savings possible	Savings as a % of total usage	How saving achieved
		kW		kW		kWh	kWh/day		
1	Lights – internal	8	0.7	5.6	5	28			Low energy lamps
	Internal lighting after savings	4	0.6	2.4	5	12	16	57	Reduce time on
2	Lights – external	1	0.9	0.9	11	9.9			Low energy lamps
	External lights after savings	0.5	0.8	0.4	10	4	5.9	60	Daylight switches
3	Small power	12	0.5	6	13	78			Switch off devices not in use
	Small power after savings	11	0.4	4.4	13	57.2	20.8	27	
4	Underfloor heating	4	1	4	11	44			Use gas heating
	Heating after savings	0	0	0	0	0	44	100	
5	Geysers	3	1	3	4	12			Use solar geysers
	Geyser after savings	0	0	0	0	0	12	100	
6	Stoves	4.4	0.8	3.52	2	7.04			Use gas stoves
	Stove after savings	0	0	0	0	0	7.04	100	
7	Swimming pool	1	1	1	12	12			Reduce running hours
	Pool after savings	1	1	1	8	8	4	33	
	Total daily usage					**190.94**			
	Total possible daily saving						**109.74**		
	Possible % daily saving							**57**	

Notes: This reflects maximum power saving, as not all the savings measures are possible, for example, gas stoves are not always possible. It is based on a medium to large home.

3.14. Appendix E – Summary of impacts of unscheduled load shedding

	Mining	Manufacturing			Property	Hospitality	Retail
		Jobbing process	Batch process	Continuous process			
Normal production losses	Yes	Proportional to time off	Proportional to time off	Proportional to time off	Yes	Proportional to time off	Proportional to time off
Additional production losses		None	Loss of material caught in cut	Loss of material caught in cut. Long restart time after power restored.	None	None	None
Health & safety	Loss of ventilation and refrigeration requires quick evacuation from mine. Evacuation efforts hampered by lack of power. Potential for people being temporarily trapped underground.		Starting up and shutting down are dangerous parts of process	Starting up and shutting down are dangerous parts of process	Guests trapped in elevators	Security risks Guests trapped in elevators	Security risks Customers trapped in elevators
Risks to plant	Damage to thickeners in reduction plant if power off for > 90 mins		Material caught in the process may damage plant	Material caught in the process may damage plant	None	None	Perishable goods will be damaged

4. Identifying an appropriate path for the electricity price[15]

This section is the submission made by the HSRC to Nersa in respect of the price determination for electricity in May 2008. While not strictly speaking part of the project brief, the project team was able to deliver these insights as a result of the background work that had been done, in addition to the team's own contribution of financial modelling and assembly of the arguments. We therefore believed the client would be interested to have this submission. Nersa's determination was very similar to the recommendations made by the team.

Two submissions were made to Nersa. The first was submitted in April and the second in May 2008. The initial document and the underlying spreadsheets were shared with Eskom, Nersa, the Presidency and Treasury, as well as a number of experts and stakeholders. We particularly received invaluable detailed comments from Eskom. Feedback received and revisions made to this document are summarised in Appendix F.

This final submission to NERSA reflects on:

1. The financial implications of alternative pricing scenarios.
2. The implications of Eskom's proposals for the economy – for firms, and for growth, inflation and employment more generally.
3. Comments on the approach to a price increase given multiple objectives.

4.1. Financial implications for alternate pricing scenarios

Eskom made a request to Nersa for an electricity price increase above the nominal 14.2% increase Nersa had already approved, seeking a 100% real price increase over two years. It provided five scenarios, but recommended the scenario with a 53% real price increase in 2008/09 and 43% in 2009/10, and then 'marginally above inflation' thereafter (we call this 'Scenario A'). Its financial analysis already incorporated government's R60-billion loan. It is worth noting that Eskom's proposal would result in a 118.8% compound price increase.

Below, Eskom's proposal is evaluated against three others. This includes a second scenario ('Scenario B') that introduces a real price increase of 100% over three years (26/26/26), and a third scenario ('Scenario C') that introduces a real 100% compound

[15] This section was written by Miriam Altman. She acknowledges extensive support of Howard Harris at WSP who prepared the financial modelling. She also acknowledges the advice of Dave Fleming, the EITT in NERT and Nazmeera Moola, and detailed feedback from Eskom. This section is largely based on a submission that was made to Nersa as part of its review process in 2008.

price increase over four years (19/18/19/19). The fourth scenario ('Scenario D') introduces a real 100% compound price increase over five years (14.85/14.85/14.85/14.85/14.85).

4.1.1. Financial objectives

Eskom's stated objective was to:

1. Cover the cost of its expansion programme.
2. Cover rising primary energy costs – coal and liquid fuel in particular.
3. Cover the cost of its DSM and power conservation programmes.
4. Ensure financial sustainability in light of Standard & Poor's having put it on 'credit watch'.

Eskom's financial viability needs to be assured to enable it to undertake and finance the proposed generating expansion successfully. It is recognised that the electricity price has been kept artificially low, and as a result, Eskom has not accumulated cash and resources ahead of the anticipated expansion projects. Moreover, the costs of the capital investment and of primary energy inputs have risen faster than anticipated. It is therefore recognised that above-inflation price increases are needed, as are special shareholder injections to support the company's financial position. For any entity to undertake an expansion of the size Eskom is envisaging, substantial shareholder contribution would be required.

Government's approach to state-owned enterprise finance is that it should work on the basis of cost recovery. In this special case, government has made available R60-billion in the form of semi-equity, which National Treasury has informed us would be treated by financial institutions as an equity injection.

The importance of meeting all of these objectives is recognised. Two central questions must be answered:

1. What is the required quantum and time span over which these increases are introduced to ensure that these objectives are met?
2. Is it appropriate that the price increase incorporates DSM?

Our modelling focused on identifying the potential impact of four different scenarios on profitability, interest cover and debt/equity ratios. We have received information from Eskom in respect of its view on performance required to maintain its credit rating. It should be noted that the targets identified by Eskom are also those appropriate for a public listed company. If Eskom is able to achieve these financial ratios, it should be seen as more than adequate for a state-owned monopoly with virtually guaranteed demand. In this case, we focused on the following financial targets:

- That Eskom would earn a net profit in the majority of years over the course of its expansion. It is not unusual for a private company to earn very low profitability in some years over which it is embarking on a major investment or expansion. We did not seek to achieve the profit rate allowed by Nersa.

- Eskom's CFO has confirmed that Eskom is targeting an interest cover of 3.0 in its effort to maintain its credit rating.[16]
- Eskom's CFO has confirmed that Eskom is targeting a debt/equity ratio that is below 200% in most years.

We make the following assumptions in respect of Eskom's costs (also see notes in the appendix):

- Some R10-billion of the requested additional revenue (a 25% price increase in itself over end-March 2007 figures) will be expended on securing coal at the new higher prices, and the cost of running Open Gas Cycle Turbine generation plants for extended periods. To be financially prudent, all primary energy costs should be a pass through and should be recovered in price increases. We sourced these energy costs from Eskom's proposal, where its primary energy costs rise from R13-billion in 2006/07 to R23-billion in 2008/09. In subsequent years, we assume that primary energy costs rise by inflation (estimated at 8%).
- We show the financial results if government's R60-billion contribution over the Medium-Term Expenditure Framework (MTEF) is treated as equity. We were assured by Treasury that financial institutions would treat it as equity, and that the contribution would be interest-free over the period under consideration. This will impact favourably on Eskom's debt/equity ratio.
- We consider the possibility of rising cost of finance. Provision is made for an adjustment of interest rates at above inflation and to reflect the premium which might be charged if the debt/equity (d/e) ratio exceeds 1.0 and then again 2.0. The premium has been set at 10% if the d/e ratio is over 1.0 and 20% if the d/e ratio is over 2.0.
- We look at alternatives with DSM included or excluded.
- Eskom informed us that its calculations in respect of its price proposal included losses from derivatives valued at R3.8-billion. Our calculations do not include this item in our scenarios: these revenues are uncertain, as evidenced by the large earnings in the previous two years.

4.1.2. Alternate pricing scenarios considered

We review the financial impact of the four pricing scenarios.

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[16] Interest cover is the ratio used to determine how easily a company can pay interest on outstanding debt. The interest coverage ratio is calculated by dividing a company's earnings before interest and taxes (EBIT) of one period by the company's interest expenses of the same period. The lower the ratio, the more the company is burdened by debt expense. A public or listed company might seek an interest cover of 3.0 to 5.0 or more. When a company's interest coverage ratio is 1.5 or lower, its ability to meet interest expenses may be questionable. An interest coverage ratio below 1 indicates the company is not generating sufficient revenues to satisfy interest expenses. A state-owned monopoly might set a lower target than a listed company.

Scenario A shows Eskom's recommendation that the electricity price be increased by 53% in 2008/09 and then by 43% in 2009/10, amounting to a 119% real price increase. Prices are increased by 1% above inflation thereafter.

Scenario B reviews the impact on Eskom of a 26% per annum real price increase implemented for three years. This amounts to a 100% compound increase.

Scenario C reviews the impact on Eskom of a 19% per annum real price increase, implemented for four years. This amounts to a 100% compound price increase.

Scenario D reviews the impact on Eskom of a 14.85% per annum real price increase, implemented for five years. This amounts to a 100% compound price increase.

The four scenarios are summarised in Table 19.

The Eskom application price increase (***Scenario A***) is intended to achieve a turn-around of Eskom's finances in a short period of time. Eskom will make an estimated R27.4-billion profit (after taxes and interest) in 2009/10, rising to R48.5-billion in 2012/13. Net profit before tax to total assets rises from 5.2% in 2009/10 to 15.9% in 2012/13. The debt/equity ratio falls below 200% in all years. Interest cover (calculated as operating profit divided by interest) is also in excess of what the market would require; in most years it exceeds 5.

Scenario B shows what would happen if the real price increased by 26% per annum for three years, amounting to a total compound increase of 100%. This price increase would enable Eskom to achieve profitability in every year, rising from R1.3-billion in 2008/09 to R24.1-billion in 2012/13. Interest cover is low in 2008/09 but then recovers. If DSM is stripped out, interest cover is 2.0 in 2008/09 and then well above 3.0 in every other year.

Scenario C shows what would happen if the price were raised by 100% over five years, with the real price rising by 14.85% per annum. This price increase would result in a loss of R0.8-billion in 2008/09. However, this would recover from 2009/10, rising from R7.0-billion to R12.3-billion in 2012/13. Interest cover is extremely low in 2008/09, but returns to acceptable levels by 2010/11. If DSM is excluded, interest cover is low in 2008/09, but then sufficient (although tight) in subsequent years.

Scenario D shows what would happen if the price were raised by 100% over five years, with the real price rising by 14.85% per annum. This price increase would result in a loss of R2-billion in 2008/09. However, this would recover from 2009/10, rising from R0.9-billion to R1.6-billion in 2012/13. Interest cover is extremely low for three years, but returns to acceptable levels by 2012/13. If DSM is excluded, Eskom breaks even in 2008/09, and profitability rises thereafter. Interest cover is very low in 2008/09, but then recovers to 1.9 in 2009/10 and improves in subsequent years.

As a reminder, we have identified financial ratios as indicated by Eskom, which are also appropriate to public and listed companies. It is presumed that credit rating agencies and creditors would apply less onerous requirements to a state-owned monopoly with a guaranteed consumer base. This needs to be established.

From this we find that Eskom's proposed price increases enable an unnecessarily fast repayment of loan finance and exceed what is required to maintain credibility with its creditors. If no further equity injections are made by the shareholder, and if DSM is stripped out, we estimate that raising the real price by 100% over four years (19% per annum) would be sufficient to cover the cost of investment, provide adequate debt/equity ratios and support needed cash flow and interest cover. This includes primary energy costs forecast by Eskom for 2008/09, and then rising by inflation in subsequent years. While cash flow would be tight in 2008/09, this could be remedied with a slightly larger price increase in the first year, or a slightly larger upfront loading of the state's R60-billion injection in 2008/09. For example, raising the first-year injection from R6-billion to approximately R9-billion or R10-billion would make a big difference.

Eskom's recommendation for a rule change in respect of primary energy costs (page 27 of Eskom's pricing proposal) seems sensible and fair.

The price determination must be made with the new levy in mind (R0.02/kW). This would add a further 10% to the average price. It is not an appropriate year to introduce this tax, and it is recommended that it not be introduced in the next two years. If Treasury does go ahead, we recommend that Eskom retain the earnings for one year at least.

More co-ordination is needed in the decision-making process: while we make recommendations in respect of the proposed levy or the slightly higher up-front loading in the state's capital injection, these are not within the ambit of Nersa's current decision-making process.

Table 19 – Three pricing scenarios compared

Year ending…	Mar.07	Mar.08	Mar.09	Mar.10	Mar.11	Mar.12	Mar.13
Scenario A – Eskom application							
Application - real unit price increase (%)			53.0	43.0	1.0	1.0	1.0
Net profit after tax and interest (Rbn)	3.2	-0.8	6.7	27.4	35.3	42.2	48.5
Net profit before tax to Turnover	12.8	-1.9	15.1	38.0	37.7	40.2	40.3
Net profit before tax to Total Assets	5.7	-0.7	5.2	15.3	15.5	15.7	15.9
Increased borrowings (Rbn)	-8.4	-30.9	-53	-36	-16	4	-5
Interest cover by profit before tax & interest	3.4	0.5	3.5	5.7	5.6	5.0	6.1
% Interest bearing debt over equity	58.3	114.4	196.3	189.5	165.2	134.2	106.2
Scenario B – Double price over three years							
Real unit price increase (%)			26.0	26.0	26.0	0.0	0.0
Net profit after tax and interest (Rbn)	3.2	-0.8	1.3	13.6	17.5	20.9	24.1
Net profit before tax to Turnover	14.3	-1.9	2.4	17.2	15.6	15.6	15.7
Net profit before tax to Total Assets	6.3	-0.7	0.7	5.2	5.3	5.3	5.4
Increased borrowings (Rbn)	-8.4	-30.9	-58.3	-49.4	-34.2	-17.0	-29.1
Interest cover by profit before tax & interest	3.4	0.5	1.3	2.5	3.3	3.2	3.5
Interest cover if no DSM	4.8	0.5	2.0	3.3	4.0	3.9	4.5
% int. debt over equity	58.3	114.4	193.2	193.2	162.9	131.6	130.3
Scenario C – Double price over four years							
Real unit price increase (%)			19.0	19.0	19.0	19.0	0.0
Net profit after tax and interest (Rbn)	3.2	-0.8	-0.8	7.0	9.0	10.7	12.3
Net profit before tax to Turnover	14.3	-1.9	-1.4	9.7	9.3	8.5	8.1
Net profit before tax to Total Assets	6.3	-0.7	-0.4	2.7	2.7	2.7	2.8
Increased borrowings (Rbn)	-8.4	-30.9	-60.4	-56.0	-42.7	-27.2	-40.8
Interest cover by profit before tax & interest	3.4	0.5	0.8	1.7	2.1	2.8	3.3
Interest cover if no DSM	4.8	0.5	1.4	2.4	2.8	3.2	3.9
% int. debt over equity	58.3	114.4	203.3	225.1	204.5	176.5	188.9
Scenario D – Double price over five years							
Real unit price increase (%)			14.9	14.9	14.9	14.9	14.9
Net profit after tax and interest (Rbn)	3.2	-0.8	-2.0	0.9	1.2	1.4	1.6
Net profit before tax to Turnover	14.3	-1.9	-3.8	1.4	1.3	1.3	1.1
Net profit before tax to Total Assets	6.3	-0.7	-1.1	0.4	0.4	0.4	0.4
Increased borrowings (Rbn)	-8.4	-30.9	-61.6	-62.1	-50.5	-36.5	-51.6
Interest cover by profit before tax & interest	3.4	0.5	0.5	1.1	1.4	1.8	2.5
Interest cover if no DSM	4.8	0.5	1.1	1.9	1.9	2.4	3.3
% int. debt over equity	58.3	114.4	209.6	257.6	253.3	233.9	273.9

Notes:

1. *The Eskom CFO says that Eskom's credit rating could fall if debt/equity rises above 200% or interest cover below 3.0.*
2. *The government injection is treated as equity by financial institutions, and is interest-free over this period.*
3. *Borrowing costs are assumed to be 2% above inflation and have the following premiums depending on debt/equity ratios: 20% premium if D/E is higher than 100% and 40% if D/E is greater than 200%, but with an average rate which is never greater than the average rate of inflation.*
4. *DSM costs are assumed to rise from R2.5-billion in 2008/09 to R2.8-billion in 2009/10, R3.2-billion in 2010/11 and R3.5-billion from 2011/12.*
5. *Inflation is 7% in 2008/09 and at an average of 8% in other years: this is much higher than the one used by Eskom. It has the impact of raising costs of borrowing relative to Eskom.*
6. *Primary energy costs are included in 2008/09, as estimated by Eskom; thereafter these costs increase by inflation.*
7. *We assume that, on average, each day 77% of the projected usable generating capacity does produce energy, all of which is sold. (In 2008/09, this results in a 5% reduction in real sales, which is approximately what Eskom has suggested to us.)*

4.1.3. Demand side management

In Eskom's application, it notes that it requires a 6% real price increase to cover the R2.5-billion cost of DSM in 2008/09. It is noted that DSM is unlike investment costs, as it should ideally be recovered in the year expended.

Eskom currently budgets to pay approximately R3,000/kW for savings. We believe that this may be sufficient to cover the cost of the easier savings, but will not be sufficient to cover the next round of savings. New investments may well need more generous support, perhaps double that currently paid by Eskom.

We recommend that DSM should ideally be stripped from the calculation of Eskom's pricing. There are three main reasons for this:

- DSM is not core to Eskom's business and should rather be implemented by agencies set up for this purpose.
- Eskom's approach barely touches what is possible on the industrial side over the medium term. The HSRC is producing a study that reviews potential savings in different industries and indicates how a change in price or the provision of incentives might encourage their adoption.
- The inclusion of DSM complicates the financial picture.

It is recommended that DSM incentives be aligned to existing industrial cash and tax incentives available to firms and consumers. Examples of these programmes include the accelerated depreciation allowances on manufacturing equipment, mining, bio-waste and small-medium enterprises. These typically run over three to four years and do not necessarily apply to the required investments. They could be made relevant for a given period on a more accelerated basis (for example, two years) to offer a meaningful incentive to firms to adjust more quickly.

In addition, the dti's Small and Medium Enterprise Development Programme (SMEDP) subsidises the capital investment of new and expanding firms in a range of sectors. Only small changes to its specifications would be required to enable the programme to cover the kinds of investments aimed at saving energy in the production process.

The dti's Critical Infrastructure Programme (CIP) is a non-refundable cash grant that is available to the approved beneficiary upon the completion of an infrastructure project that can be shown to underpin a group of further investments in a location. The scheme covers between 10% and 30% of the total development costs of the qualifying infrastructure.

A defined, managed programme is not necessary to effectively implement these incentives. A programme simply needs clear guidelines and rules against which the firm's accounts can be audited, or, in the case of cash incentives, against which applications can be approved.

The proposed revisions to building codes should have an impact on new buildings. For low-cost building programmes, government could introduce energy-saving provisions to its procurement requirements, with some top-up in contract amounts for additional costs associated with energy-saving additions.

We analysed the impact on Eskom's financial position if DSM were taken out from 2009/10, simply because we are concerned that the implementation of any alternative may take time. However, if government were able to fast-track small extensions to existing programmes, it is recommended that DSM be removed in 2008/09. Eskom has verbally noted that, aside from the distribution of light bulbs, it has curtailed its DSM programme due to lack of funding.

4.2. Impact on the economy

Eskom's proposal says that it would be preferable to implement the required price increases rapidly, as consumers will adjust their behaviour in response to being charged the true economic costs. It may be that households can adjust fairly quickly, with limited impact on the economy. This is not the case for firms. Some immediate savings are possible, but the larger electricity savings generally require the installation of new equipment, which can take six to 18 months to implement. If the price were increased faster than firms can adjust, it will result in falling output.

Therefore a slow introduction of a price increase is preferable to a faster one. Our modelling shows the following:

1. We compared a one-year 27% price increase to a 72% price increase. The effects of this are not proportionate. A 72% price increase would lead to a 2.5% rise in inflation, a fall in GDP by 0.3% (or about R67-billion) and a reduction in low-skill employment by 1.4% (about 55,000 jobs). If the electricity price increases by 27%, inflation rises by 0.9%, GDP falls by 0.1% and low-skill jobs shrink by 0.3%.

2. Note that a 27% price increase could cause electricity consumption to fall by 5%, whereas the 72% price increase would be required to reduce consumption by 10%. This assumes that price is the only consideration, and that there are no incentives. This shows how difficult it can be to rapidly reduce consumption past the first phase of 'low hanging fruit'.

4.3. Approach to price increases given multiple objectives

It must be remembered that four main concerns currently need consideration when raising the price. These include:

1. The aim of covering the cost of opex and capex in a way that maintains Eskom's credit rating.
2. The aim of reducing energy consumption.
3. The aim of reducing peak demand usage.
4. The impact on the economy – inflation, production and employment.

Ideally, any price increase will be introduced in a way that optimises the overlap between the solutions to these four problems, while also seeking to minimise damage to the economy.

1. Eskom says it needs a 100% increase in the electricity price to cover its costs. We find this to be more than adequate if spread over five years, with some adjustment for future primary energy costs if needed.
2. Eskom seeks to reduce consumption, although it has not specified by how much. As noted, a 72% price increase in one year, or a 54% price increase implemented over two years would reduce consumption by 10%. Eskom has not communicated or justified precisely what consumption savings are needed over what time frame. It should be noted that the consumption problem is directly linked to the availability of coal.
3. Eskom seeks to reduce peak usage by 10%, and has recently reported that there has already been a 7% saving. It is worth noting that a general price increase does not necessarily reduce peak usage, since savings might be made at other times of the day.
4. In industry, the major energy savings can not be implemented within very short periods of time. New equipment and machinery must be identified, then ordered either locally or overseas, delivered, and installed. We estimate that substantial savings in both peak usage and consumption could be made in a wide range of sectors if the right incentives are put in place. However, the minimum period of adjustment is approximately six to 18 months. Therefore, a large sudden price increase can result in falling consumption, as a result of a contraction in output rather than as a result of productivity improvements.

To achieve these goals, tariffs need to be structured in a way that offers the right incentives and disincentives. For example, maximum demand prices would encourage reduced consumption, whereas time of use tariffs would reduce peak demand.

We have modelled the impact of price increases on consumption, assuming no positive investment incentives to encourage changed behaviour. We find that substantial energy savings could be possible over a two-year period, and than many firms have not implemented them due to cost of investment. Two factors will impact on this decision-making framework. First, a rise in price will raise the return on these new investments. Second, the application of investment incentives to the relevant category of investments could halve the amortisation period.

4.4. Appendix F – Comments received on the HSRC modelling and revisions made to the April draft

4.4.1. Handling of government injection

In the initial document, the modelling presented mainly reflected results when government's R60-billion injection was treated as a loan. However, it was confirmed that this injection would be seen as equity by financial institutions, and that it would be interest free over the period. We now use this as a standard way of measuring government's injection in all the scenarios.

4.4.2. The price increases reviewed

In the previous draft, Scenarios B and C had price increases of 28% per annum x three years, and 14.85% per annum x five years. This draft shows a price increase of 26% per annum x three years so that it compares directly with the 100% real compound price increase in Scenarios C and D.

In the previous draft, Scenario C had a price increase of 100% over five years. In this draft, Scenario C shows the impact of a price increase of 100% over four years, and Scenario D of 100% over five years.

4.4.3. Financial ratios and Eskom's credit rating

The Eskom CFO has noted that it is targeting debt-equity ratios below 200% and interest cover of 3.0 or more in an effort to maintain its credit rating. We spoke to a range of financial institutions to obtain their views. These views were widely divergent and inconclusive. This is also reflective of the Standard & Poor's report on Eskom, which compares Eskom to other similar institutions in South Africa and abroad. From that comparison it appears that the general health of the company is sought, and not specific ratios.

One leading bank economist noted:

"… numbers from our bankers on other planned projects in South Africa:

For an accommodation public-private partnership (PPP) with a government underpin:

Gearing ratio of approximately 85%
Minimum senior interest cover ratio of approximately 1.5x to 2x

Average profit before tax/revenue of about 30% to 40% over a 25-year project

For a toll road with recourse to the South African National Roads Agency Limited (SANRAL):

Gearing ratio of approximately 70% to 85%
Minimum senior interest cover ratio of approximately 1.5x to 2.3x
Average profit before tax/revenue of about 44% over a 30-year project."

4.4.4. Eskom's comments

a. Energy consumption

"Our revenue assumes a reduction of 10% in consumption of energy. This is based on the power conservation programme (PCP) that was initiated by Eskom and government to reduce consumption. After taking into account the growth in 2008/9, the net reduction approximates 5%."

In the HSRC report, we assume that on average, each day 77% of projected usable generating capacity does produce energy, all of which is sold. In 2008/09, this results in a 5% reduction in real sales, which is approximately what Eskom has suggested to us.

b. Inflation

The Eskom figures account for a very low inflation rate in the region of 4% or 5%. We assume an inflation rate of 7% in 2008/09 and 8% in subsequent years. Inflation will probably be higher in 2008/09 than the HSRC's estimate. The inflation path over the next five years is uncertain. However, the rate used by Eskom in its pricing proposal does seem very low.

c. Cost of borrowing

"The finance charges in our model exceed those in the 'Base' (HSRC) model by approximately R2-billion. We assumed finance charges of approximately 9% over the five year planning window."

We have revised our estimates for cost of finance so that it rises by 2% more than inflation. The average borrowing cost is negatively affected by Eskom's entry into financial markets now, as the cost of capital has risen. It should be noted that the HSRC estimates have higher finance charges than does the Eskom model, as we use higher inflation rates. Naturally, this also affects other estimates, most notably revenue.

It is also worth noting that Eskom is working to an annual R30-billion borrowing limit, which is what it believes can realistically be raised in the market. We have adjusted accordingly.

d. Depreciation

"Over the period 2008/09 to 20012/13, the depreciation differential is approximately R47-billion, with Eskom reflecting the lower cost. This represents additional cash resources as depreciation is added back in the determination of cash flows. The higher depreciation is a result of assuming all capital expenditure is depreciated."

We have revised our depreciation figures to be in line with Eskom's. We had originally calculated depreciation to cover capital investment as it happened. We have revised this in our final report so that depreciation is now calculated from the time that the plant is complete and operational.

e. Items included in revenue calculation

"The Eskom revenue consists of sales from standard customers, revenue from exports and revenue generated from special pricing agreements (SPAs), also referred to as Commodity Linked Agreements. The revenue from exports and SPAs is contractually based and is not regulated by the National Electricity Regulator of South Africa (Nersa). Therefore applying the general price increases would be incorrect for these two categories of revenue…

"…we recommend that for modelling purposes the above growth on standard energy sold is used and add the other revenue categories to get to the total revenue for Eskom. The 2008 standard revenue is R39,928-million."

Eskom's total revenue was R43-billion in 2007/08, and the HSRC uses this as the revenue base for its 2008/09 calculations. It would only be appropriate to cut revenue for non-regulated sales if it were possible to also cut associated costs. At the moment, this is not possible.

f. Derivatives

Eskom's calculations "take into consideration an embedded derivative cost of R3.8-billion". We excluded this from our scenarios, since this income is inherently uncertain.

Eskom earned R12.3-billion from derivatives in 2006/07 and 2007/08, and projects a loss of R3.8-billion in 2008/09. Thereafter, it expects little impact on its balance sheet.

However, earnings on derivatives are uncertain. There is a probable inverse relationship between Eskom's earnings on derivatives and the electricity price increase, and also some relationship to the price of aluminium. Eskom's projection might be seen as the highest potential once-off loss from derivatives associated with a very large price increase. A lower price increase may result in much smaller losses, or even a neutral impact.

g. Deferred tax

"The application of deferred tax is not shown in tax computation of the 'Base' (HSRC) scenario." In Eskom's calculation, this adds R3.3-billion to its balance sheet. We do not include this, as it is a deferred tax credit and a non-cash item. However, if we had added it, it would have improved the financial ratios shown in the HSRC modelling.

h. Operating costs

"Operating costs calculated in the Eskom scenario exceed those calculated in the 'Base' (HSRC) scenario by R2.4-billion. These costs are based on the sum of operating costs submitted by the various divisions within Eskom based on their plans."

The HSRC calculations use a reconciliation of the disclosed operating cost figures available at the time. Our revisions, as explained above and based on Eskom's comments, bring our opex estimates closer to Eskom's estimates.

5. Terms of Reference: the impact of a 10% cut in electricity usage in the South African economy

Proposal for:
The Office of the Presidency
Administered by TIPS
Prepared by the HSRC

12 February 2008

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Background

All observers of the current electricity crisis in South Africa recognise that it is having a negative effect on current output and growth. While some newspaper reports have also noted there are already job losses, these employment consequences have been less widely commented on.

Given that Eskom predicts that the electricity shortages will last until 2012 and beyond, there are likely to be consequences for meeting 2014 employment targets.

The impact on employment will depend, inter alia, on

a. The extent of energy cuts ultimately required;

b. The relative pattern of initial sector impacts;

c. Linkages between firms and sectors, which will determine knock-on effects;

d. Mitigating strategies and the responses to them;

e. Coping strategies of firms and sectors; and

f. Macroeconomic impacts, on exchange and interest rates, investment plans, etc.

The inter-industry linkages point to the need for an economy-wide approach to analysing the impacts. This is reinforced by the likelihood that the effects may be large, suggesting feedback effects through both demand and macroeconomic consequences.

While the impact effects can be analysed relatively easily through a static economy-wide model (an input-output or Social Accounting Matrix [SAM] multiplier analysis or a CGE model), it seems likely that the shocks may have an effect on the path that the economy takes. In other words, the shocks have a permanent effect on the economy. This will be determined by the nature of not only the shocks but also the responses.

All of this suggests that some kind of dynamic economy-wide model would be a useful approach to helping think through issues. However, such an approach by itself will not give the insights needed. We do not fully understand the microeconomics of the shocks and and responses. What are the possibilities of substitution by other power sources? How efficient are alternatives? Do coping strategies – for example, replacing grid electricity with individual generators – push up costs? Are such effects permanent? Can these private choices be influenced by public policies?

Moreover, it is possible that the low historical electricity price has encouraged wasteful practices in industry and households. What potential is there for more energy efficient practices and equipment that would enable reduced energy use without reducing output?

A well-designed project trying to address the question as comprehensively as possible would there entail both microeconomic investigation and economy-wide modelling.

The microeconomic side requires some level of empirical fieldwork, since much of the data do not exist in secondary sources. This will require time to do properly.

The economy-wide analysis can be divided into two parts, the first looking at static impact effects, the second examining dynamic implications. It is possible to make a first initial assessment since we already have models and data that could be used. There is also a dynamic model we could use, although it is not clear that it captures anticipated path dependence effects.

The nature of the crisis suggests that it would be useful to have quick results, even if they are 'dirty'. However, if we are right in thinking that there are permanent long term effects that will be influenced by policy responses, it would also be useful to have a more finely honed tool for analysis and monitoring.

It is therefore proposed that the project should be undertaken in two phases.

Project objectives

The objectives of this project include:

1. Assessing the economy-wide impact of a reduction in electricity use of up to 10%, differently distributed across the main economic sectors and users.
2. Assessing the potential for short- and medium- term improvements in energy use by large consumers.

Project phases

We have been asked to prepare very quick, preliminary estimates of potential economy-wide impacts of either electricity rationing or price increases. This needs to be assessed within status-quo decision-making and input-output relationships. While the HSRC model does specify these relationships, it is possible that certain sectors behave differently to how they are modelled currently (for example, where they generate their own energy). However, it is also possible that firms react differently to shocks and 'crises' – perhaps identifying new sources of energy efficiency that they were not searching for previously.

There is an immediate need for information and insights to support policy-making, but it must be understood that a close assessment will require some time and probably constant monitoring, as behaviour is likely to change as the processes unfold.

Phase one: preliminary estimates

The first phase will last approximately two weeks, and will offer a preliminary assessment of economy-wide impacts of electricity rationing and/or price increases. It will also offer an initial assessment of potential electricity savings amongst the largest users and what these would entail from time and cost perspectives.

The first phase modelling will focus on using input-output supply use table of initial impacts. Some preliminary insights into using our CGE model will be offered (moving to the use of CGE modelling is more complex, but offers more important insights as it enables an understanding of potential 'feedback' effects). We will ask: if price were allowed to rise sufficiently to enable a 10% cut, what would be effects on level and pattern of production across sectors. What is the market clearing price. It is probable that the price – output relationship will not be as strong as found in the model, and in phase 2 there will be interaction between the modellers and the WSP to establish more precise estimates of potential responses.

The first phase sector insights will offer preliminary views on potential energy savings amongst the largest users. This will focus on potential "quick wins", that could be achieved within the year through simple innovations.

The PCAS has agreed to arrange a workshop where Phase 1 findings can be presented to stakeholders for feedback. Recommendations will be made for Phase 2 thereafter.

Phase two: deeper assessments

In Phase 2, more specific modelling of different rationing and pricing options will be prepared. We will also improve the database and SAM to reflect learning from WSP interaction and Phase 1 workshop in respect of potential industry responses to changes in price and rationing.

We already have a range of methods and data available that will allow us to analyse the impact effects quickly. However, even in a quick analysis, we would like to modify these in a number of ways:

- The energy inputs in our data are not sufficiently aggregated to allow us to look at substitution between different sources properly. We would like to disaggregate somewhat. This would essentially require modifying the SAM that we work with.
- Related to this, the modelling requires some understanding of the parameters governing choices among these alternative sources.

There are two possible ways of dealing with the first of these tasks and this will be recommended from the Phase 1 process.

- There has already been recent work involving disaggregated energy inputs, undertaken by the Energy Research Centre (ERC) at the University of Cape Town. The ERC may allow us to access its database.
- Alternatively, we can construct our own data set, either in-house or by sub-contracting Quantec to do so.

It will also be important to have some intuition about various behaviours of firms and sectors to shocks.

It is important to note that the modelling process can be uncertain. There will be regular interaction with the client to ensure that expectations are met.

In Phase 2, a deeper assessment will be made by WSP on potential electricity savings possible in the major energy users. This will offer a broader range of possibilities, with some view on potential savings that could be implemented over the coming years (and not simply the 'quick wins').

The HSRC will organise a workshop, in consultation with the client, to review and verify findings.

A final overview report will be prepared, with recommendations for a more substantial 'Phase 3' project.

6. 15-sector aggregation used by the HSRC model

	New activity code	Description	Old activity code	Old description	SIC
1	AAGR	Agriculture	AAGRI	agriculture	1
2	AMIN	Mining	ACOAL	coal	21
			AGOLD	gold	23
			AOTHM	other mining	22/24/25/29
3A	ALIG	Labour intensive intermediate goods	ATEXT	textiles	311-312
			ALEAT	leather products	316
			AWOOD	wood products	321-322
			APAPR	paper products	323
			APRNT	printing and publishing	324-326
			AOCHM	other chemical products	335-336
			ARUBB	rubber products	337
			APLAS	plastic products	338
			AGLAS	glass products	341
			ANMMP	non-metallic metal products	342
			AMETP	metal products	353-355
			AELMA	electrical machinery	361-366
			ASCIE	scientific equipment	374-376
3B	ALIG-T	Labour intensive intermediate goods – transport	AVEHI	vehicles	381-383
			ATRNE	transport equipment	384-387
4	ALCG	Labour intensive consumer goods	AFOOD	food processing	301-304
			AAPPA	wearing apparel	313-315
			AFOOT	footwear	317
			AFURN	furniture	391
			AOTHI	other industries	392-393
5	ALKG	Labour intensive capital goods	AMACH	machinery	356-359
			ACOME	communication equipment	371-373
6	AKIG	Capital intensive intermediate goods	APETR	petroleum products	331-333
			ABCHM	chemical products	334

			AIRON	basic iron and steel	351
			ANFRM	non-ferrous metals	352
7	AKCG	Capital intensive consumer goods	ABEVT	beverages and tobacco	305-306
8	AELW	Electricity and water	AELEG	electricity and gas	41
			AWATR	water	42
9	ACON	Construction	ACONS	construction	5
10	AUIS	Low skill intensive intermediate services	ATRAD	trade services	61-63
			ATRAN	transport services	71-74
			ACOMM	communication services	75
11	AUCS	Low skill intensive consumer services	AHCAT	hotels and catering	64
			AOTHP	other producers	92, 95-96, 99
12	ASIS	Skill intensive intermediate services	AFINS	financial and real estate services	81-82
			ABUSS	business services	83-88
13	ASCS	Skill intensive consumer services	AMAOS	medical and other services	93
14	AGOV	Government services	AGOVS	government services	91, 94

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