Electricity consumption growth in newly electrified settlements

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1. Introduction

Eskom embarked on its electrification programme in 1991. Since then over one million new connections have been made, at a cost of R2.25 billion in capital investment (Eskom 1995a; du Plessis 1995). As is well known, connection and tariff policies have been to charge a nominal connection fee and to attempt to recover the cost of the investment through the tariff, consisting of only an energy charge. This practice has been closely associated with the use of electronic prepayment meters which were introduced to simplify and secure revenue collection and to provide a metering system whereby consumers can monitor and regulate their consumption.

Given these connection and tariff policies, Eskom's rate of return on investment is sensitive to five critical variables: the cost per connection, support costs, consumption, revenue losses and tariff levels. Given a rate of return requirement and assumptions regarding the first four variables, it is a simple procedure to calculate the required tariff level. Average capital costs to date have been in the region of R3 000 per connection (Eskom 1995a), and with present tariffs and other supply and maintenance costs, this means that average consumption levels must be over 350 kWh per month in order to achieve Eskom's required nominal financial return of 17.8% (the real discount rate used is 6%). At the start of the electrification programme, average consumption was predicted to reach 525 kWh/month in urban areas and 350 kWh/month in rural areas within three years of connection (Berrisford 1990). To date average sales have been way below these initial estimates and have been in the order of 80 kWh/month (Eskom 1995b).

Although consumption levels are expected to grow over time, there is no certainty regarding growth rates. The picture is also complicated by excessive revenue loss through theft and meter failures. Although it is widely considered that most of the technical problems associated with the earlier models of prepayment meters have now been solved, there continue to be high levels of 'non-technical' losses. Calculations of the financial impact of electrification on utilities are sensitive to estimates of consumption growth and the extent to which losses can be controlled. In addition, Eskom has raised over R1.7 billion through the issue of Electrification Participation Notes (EPNs) (Eskom 1995a), special financial instruments where the return is related to consumption growth (Potgeiter 1994). Although the conditions of EPNs were modified to remove the effect of losses (returns were made dependent on consumption rather than sales), Eskom's investors have a direct interest in monitoring consumption growth.

The importance of monitoring consumption and demand growth is emphasised by the growing significance of newly electrified households in Eskom's consumption profile. These customers now account for 5% of Eskom's total electricity generated and 9% of peak demand (Eskom, 1994c). As electrification progresses, and as average consumption rates grow over time, the size and importance (in load terms) of this section of Eskom's customer base will further increase.

This document reports on an analysis of electricity consumption growth in newly electrified settlements, including a review of other work and a focus on predominantly rural areas in the country.

2. Data sources and data problems

The data used in this analysis covers settlements electrified by Eskom in the Eastern Cape, including the former Ciskei and Transkei, settlements administered by Eskom's Pretoria office, which include rural areas of Mpumalanga, North-West and the Northern Province, and Eskom areas of KwaZulu/Natal (which excludes most urban centres, notably Durban).

One of the main difficulties of examining consumption growth in newly electrified settlements is that most of them have only recently been electrified. Hence, the

history of consumption growth is limited. For this reason, only those settlements with at least 18 months of sales records were selected for analysis. There is also a danger associated with using only settlements which were electrified some time ago as the history of electrification has been that wealthier and more established settlements have been electrified earlier. As the electrification programme progresses and more remote and lower income communities obtain electricity, consumption growth patterns may change.

Sales data is captured by Eskom's sales system. Each prepayment meter and each electrification project has a code and can be used to sort the data. However, there have been a large number of 'unaccounted sales' – that is, revenue from electricity sales which cannot be allocated to an individual meter or project. Although it is possible for electrification managers to allocate these sales to projects, knowing where vending stations are situated, in practice this has not happened in all regions.

Revenue losses due to a combination of electricity theft, unallocated sales, and meter failures have been high. Across a sample of 27 Eskom projects, revenue losses were found to be 34% of energy delivered in 1994 (Bezuidenhout 1995). As a result, sales data may seriously under-represent actual consumption. In order to resolve this problem and determine actual consumption, it is necessary to either (1) use bulk-metered figures and correct for technical losses; or (2) use sales and correct for revenue losses. Since revenue losses may vary significantly between projects and regions, the first option is felt to be more reliable where data is available. However, technical losses may themselves be difficult to determine as they depend on distribution line lengths, transformer size and loading, and reticulation layout. Bezuidenhout (1995) calculated losses for 27 electrification projects and found losses in urban projects to be 7-8% of energy delivered, and 14-16% in rural projects, and 10% overall.

It is likely that households which steal electricity consume more than other households; however, it is difficult to quantify this difference. Constraints on appliance acquisition may be more effective limits to consumption growth than the effective price of electricity. If full payment were effected, the possible decline in overall consumption may be partially offset by projected real decreases in the price of electricity. However, the price elasticity of demand in low-income households has not been investigated.

Unfortunately, reliable bulk-metered data stretching back for two years and more was only available in the Eastern Cape sample. For settlements in this region, technical losses of 10% were used to calculate consumption. For other regions, where only sales figures were available, it was necessary to obtain estimates of revenue losses from averages calculated for the Sales and Customer Services (SACS) regions during 1995. Clearly this is a simplification of actual losses as these will vary significantly from site to site. However, given current information constraints, it was the most accurate method that could be employed.

In the Eastern Cape a total of 45 settlements were selected. Data was made available by Eskom's regional office in East London and included prepayment meter sales as well as bulk-metering on a monthly basis. In the former Transvaal, a total of 108 settlements were selected and data included prepayment meter sales in these settlements, as well as loss figures for each SACS region. In KwaZulu/Natal a total of 177 settlements were selected, with loss figures for the two SACS regions in this province.

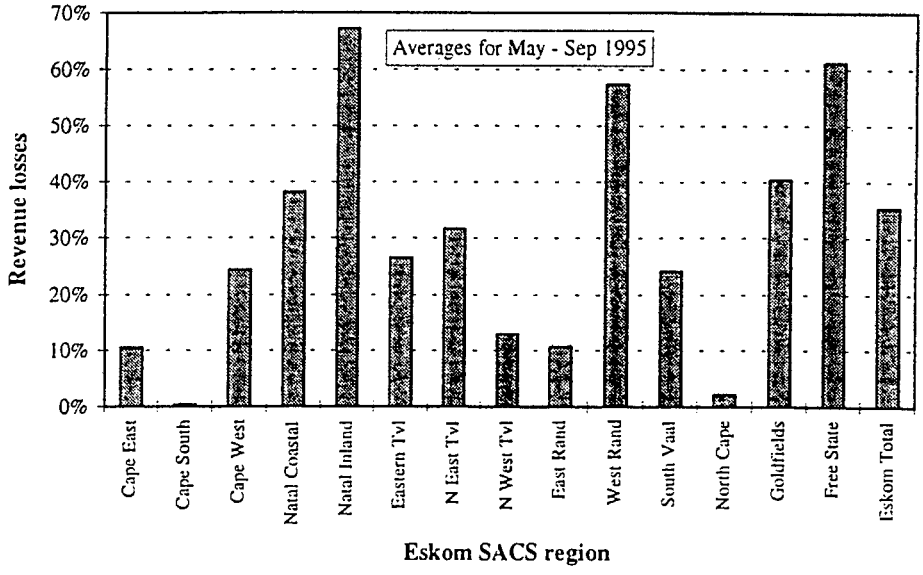

FIGURE 1: Revenue losses in Eskom SACS regions
Source: Bezuidenhout 1995

Although bulk-metering provides accurate records of consumption, prepayment sales for any one month may not accurately represent the actual consumption for that month. Electricity consumption in one month may have been paid for in a previous month, and sales in one month may only be used later. This complicates the calculation of losses, and it is necessary to take averages over a number of months to obtain an accurate picture.

Attempts to estimate growth trends are also complicated by seasonal effects. These are more strongly felt in some areas that in others. Winter heating loads have a greater effect in the interior of the country and places where the switch from wood, coal and paraffin has been more pronounced. In cases where seasonal effects are evident, presenting consumption as a function of time since connection may be misleading unless appropriate corrections are made. Alternatively, growth rates can be calculated from changes in summer or winter levels, or calculated by comparing averages over twelve-month blocks.

The approach taken in this analysis has been to look at consumption with the 'settlement', or electrification project, as the unit of analysis. Figures may be presented as 'kWh per customer', but it must be recognised that this is an average for the whole settlement. Within each community there will be some variation in consumption levels from low- to high-level consumers. However, for the purpose of understanding the effects of consumption and sales on the financial impact of electrification projects, settlement averages are the most appropriate measures.

3. Review of previous work

The monitoring of consumption levels is clearly of paramount importance to Eskom and investors. Hence, this is not the first study of consumption growth records. Eskom's electrification monthly reports include sales figures for each engineering region (the former Eskom distributors). Since these figures include all settlements, including those only very recently electrified, they do not accurately reflect the rate at which consumption may be growing. As the electrification programme has accelerated, so the proportion of very recently electrified settlements has increased. Since consumption increases with time, this effect will depress average figures. Also, where revenue losses are high, sales figures will not accurately reflect consumption.

Average sales [kWh/month]	1992 (Dec)	1993	1994	1995 (to date)
Bloemfontein	138	76	79	78
Cape Town	201	137	123	124
Durban	105	73	88	83
Johannesburg	53	70	67	83
Pretoria	32	51	55	59
Total	**96**	**75**	**80**	**83**

Note: Figures for 1992 are for December only, not averaged across the entire year. Since there is usually a December peak in sales, the 1992 figures may over estimate the annual averages.

Note: Nationally, revenue losses have been found to be in the order of 34% of total consumption (Bezuidenhout 1995). Consequently, actual consumption has probably been in the order of 125 kWh/month.

TABLE 1: Sales levels since 1992
Sources: Eskom 1992; Eskom 1993; Eskom 1994a; Eskom 1995b

Much of the early work around electricity consumption and load growth was conducted in Soweto and other townships in Gauteng. Table 2 presents the results, from Berrisford (1990), for seven urban townships. The results seem exceptionally high given the figures shown in Table 1. Possible reasons for this may be that many electrified households supply electricity to 'back yard shacks', and so the average per household can be expected to be lower than that reported. Secondly, it is possible that commercial enterprises were included in the figures, although this is not made clear by Berrisford.

	Average annual consumption kWh per customer	Average annual ADMD kW
Soweto	660	2.2
Sebokeng	543	1.4
Kagiso	965	3.5
Mabopane	950	2.9
Tembisa	562	1.7
Katlehong	940	3.0
Mohlakeng	601	1.8

Note: ADMDs in other areas have been found to be as low as 0.5 in KwaNobuhle and 0.6 in Mohlakeng (Surtees 1993)

TABLE 2: Consumption and After Diversity Maximum Demand (ADMD) for seven Gauteng townships
Source: Berrisford 1990

Not only were consumption levels found to be high, but growth in consumption was rapid. Berrisford (1990) reports that 'usage grows quickly once electricity becomes available, and within a year the household is using over half of its ultimate consumption'; even in the low-income village of Bapong monthly electricity consumption was found to be 400 kWh per customer nine months after electrification.

Surtees et al (1994) comment that the high levels of consumption experienced in early electrification projects in Gauteng townships may not be an accurate indicator of future trends elsewhere. Two factors are suggested as being important: (1) the number of unofficial connections – for example backyard shacks being supplied from other meters, and (2) the high level of non-payment and the use of cheap 'flat-rate' tariffs. Surtees et al suggest that consumption would be reduced by about 25% if full payment were effected. However, there exists no sound statistical support for this assertion.

Table 2 shows that the ADMD in the seven Gauteng townships monitored was found to be between 1 and 3 kW. Research conducted by Eskom (1994c) has also shown that there is a linear relationship between ADMD and consumption. These

results indicate that where consumption is less than 300 kWh/month, the ADMD will be less than 1 kW. However, where consumption is significantly less than this, demand may well be even lower. In Ivory Park, where consumption is in the order of 80 to 120 kWh/month, the ADMD was found to be 0.48 (Surtees 1994). However, the diversity factor is significant and maximum demand (measured over five minute intervals) at one low-consumption household has been found to be between 2.5 and 4 kW (Surtees 1994). Probert (1992) has constructed a model to determine ADMD as a function of appliance penetration and Surtees (1994) speculates that it should be possible to model appliance ownership as a function of community and household characteristics, and so model ADMD growth in a newly electrified community.

The Palmer Development Group (1993) looked at electricity consumption in a selection of South African townships. Many of the localities selected have had access to electricity for over twenty years. As in the Gauteng townships, average monthly consumption was found to be high – over 500 kWh per household.

Thorne and Qangule (1994) report on an analysis of electricity consumption growth in urban townships in the Western Cape. In the recently electrified areas of Khayelitsha, electricity sales were observed to increase over a two-year period until they reached a plateau of around 200 kWh/customer/month. However, since 1993 the number of customers has increased dramatically (from 6 000 to 10 000 in Khayelitsha) and so average sales figures decreased to around 100 kWh/month in 1994. There are clear winter peaks around 50% higher than the summer minimum average. Langa and Guguletu, which have had electricity for longer and where the growth in the number of customers has not been as high, experience much higher consumption levels (450–550 kWh/month).

Table 3 presents the distribution of consumption in Khayelitsha for February 1994. Although there are many customers who do not purchase any electricity, this is because many households do not purchase every month, and not only because some meters have been by-passed. Table 3 also presents the size of electricity purchases in Khayelitsha. It can be seen that the vast majority of households purchase in small amounts (80% of households buy cards of value R10 or less).

Consumption group	% of all customers	Size of purchase	% of all purchases
0 kWh	15	R0 ≤ R5	45
0–40 kWh	7	R5 ≤ R10	35
40–80 kWh	17	R10 ≤ R20	15
80–120 kWh	16	R50 ≤ R50	5
120–160 kWh	11	> R50	0
160–200 kWh	10		
200–250 kWh	10		
> 250 kWh	14		

TABLE 3: Consumption and electricity purchases in Khayelitsha
Source: Thorne & Qangule (1994)

Domestic load profiles are known to be exceptionally 'peaky' with fairly low load factors. Off-peak loads are very low – 20W per customer in Ivory Park (Surtees et al 1994) – and the evening peaks are narrow. Seasonal variations in peak demand have been found to be significant for the Gauteng region (Surtees et al 1994) and related to ambient temperature (Nyikos 1994). The Palmer Development Group (1993) found winter peaks of 20% for coastal areas and 100% for interior localities.

A recent analysis by Simonsen (1995) has attempted to model consumption growth in newly electrified communities. The model developed has two components: one part estimates consumption in the initial year using an income elasticity equation; a second part estimates annual growth rates thereafter. Simonsen and Conway (1995) suggest that this model can be calibrated for different housing types in each region of the country and demonstrate its use in the Eastern Cape. Inadequacies in the model include (1) the absence of the effects that electricity price changes may have;

(2) the exclusion of effects related to changing income over time; and (3) the use of parameters developed to model *energy* use rather than *electricity* consumption.

As with all models of this nature, there are difficulties in obtaining adequate data to perform the necessary calibration and in demonstrating the validity of the model. Since large-scale electrification of low-income household has only been in progress since 1991, the long-term accuracy of any modelling technique simply can not be determined. However, it is important to attempt to validate the model using existing data. The results of Simonsen's model for the Eastern Cape show average consumption reaching a plateau five years after connection, averaging at 280 kWh/month for all households. Scattered rural households and farmworkers are estimated to consume less than half of this average amount. Econometrix (1995) suggest that the growth generated by the model in the first few years is too high.

In addition to Simonsen's work, Eskom Marketing Intelligence has recently commissioned two statistical analyses based on data from an extensive national household energy survey, the Omni-survey, commissioned by Eskom. The two studies have adopted different approaches. Higgs (1995) has attempted to construct a scoring procedure, based on socio-economic variables, which would allow a household to be ranked according to its rate and level of consumption – high consumption/high growth obtains a high score, and low consumption/low growth households are scored low. Presumably the scores for a community can be averaged to indicate the viability of electrification. Preliminary results indicate that the scoring system is dominated by measures of affluence, with three-quarters of the total maximum score made up of income, expenditure, employment and house-type variables.

Galpin (1995), also using data from the Omni-survey, has attempted to design a system whereby households can be classified according to electricity consumption groups. Again, a set of socio-economic variables were used to construct 'definitions' for each group. Galpin found that expenditure on electricity appeared to stabilise after three years, although the sample of low-income households which have had electricity for more than three years was small. Again, affluence-related variables appear to dominate the classification system.

Stavrou et al (1993) report on a detailed analysis of electricity use in four settlements in KwaZulu. It was found that households spent, on average, R30 per month on electricity, corresponding to 150 kWh per month. The study found that electricity consumption in the first few months after electrification was very low, but increased rapidly, doubling over a six-month period. Thereafter, growth in electricity consumption was found to increase in steps as appliances were acquired. The time between each step increase was quite long and was found to be related to the time taken to pay for appliances on hire-purchase terms. Often one of the first appliances purchased is a television, which takes the household some time to pay for, yet consumes only a small amount of electricity. Householders who had purchased electric hotplates found that in winter they were forced to either purchase an electric heater, or switch back to using another fuel which would both cook food and heat the home.

Stavrou et al (1993) found that the major factors determining electricity use were the physical structure and size of the home, how long the house had been electrified, the practice of keeping spare cards, and the 'various costs' associated with the consumption of electricity. Installation costs were regarded as cheap, and the cost of electricity cards was found to be less important than might be supposed. The most important costs affecting electricity use were found to be the costs of appliances, finance (hire-purchase) charges, appliance repair, and costs associated with extending wiring to other rooms in the house. The study suggested that various marketing strategies, including finance for appliances and training of technicians to wire houses and fix appliances would significantly increase consumption levels.

Eskom's Load Research group, commenting on the variables which influence demand, state that 'appliance penetration has some influence on consumption but is not a primary determinant' and that primary variables are level of urbanisation,

income, housing type and size, and availability of other fuels (Eskom 1994c). Surtees (1994) states that income is the dominant factor affecting electricity consumption in newly electrified households and illustrates this with a statistically significant regression between electricity consumption and income in a newly electrified Gauteng community.

Viljoen and Kidgell (1994) examined electricity consumption growth in 20 settlements in the former Transvaal, eight of which had had electricity for more than one year. Monthly sales figures varied from 20 to 80 kWh per customer. However, bulk meters indicate consumption figures of between 45 and 300 kWh per month. Although some of this difference may be due to technical losses and possibly consumption in streetlights, the figures indicate that losses are in excess of 50%. In contrast to figures obtained from Eskom's sales database, domestic consumption in rural areas of former Venda is 250 kWh per month (Viljoen & Kidgell 1994).

Most studies indicate that electricity consumption grows over time with a rapid increase in the early months. A study conducted by Eskom (1994) attempts to determine the correlation between age of connection and consumption. The results indicate a positive and significant correlation. Average monthly consumption levels were found to be 50 kWh per customer, and the average growth rate was 18 kWh per year, equivalent to a growth of 36% per annum. These figures group all prepayment customers throughout the country, based on sales records and not bulk metering.

Eskom region	Range in consumption	Annual growth	
	kWh/customer/month	kWh/customer/year	% per year
Bloemfontein	50–90	10	14
Durban	30–100	15	23
Cape Town	60–150	25	28
Pretoria	10–70	15	38
Johannesburg	65–100	10	18

TABLE 4: Sales and sales growth
(based on an analysis of consumption against time since connection – April 1994)
Source: Eskom 1994b

In summary, early work on electricity consumption levels tended to focus on formal urban settlements, mostly in Gauteng, which had had electricity for many years. Consequently, consumption levels were found to be much higher than those currently experienced in the electrification programme. Subsequent studies have found monthly consumption levels in the region of 80-150 kWh per customer. Given the importance of electrification programme, and the sensitivity of financial impacts to revenue, it is important to attempt to gain an overall picture of consumption growth. In addition, since much of Eskom's electrification programme will probably be conducted in rural areas, and residential areas close to small towns, it is important to examine consumption growth in localities outside of the major cities. The following sections look at consumption growth in three of Eskom's engineering regions which have involvement in non-metropolitan areas, namely the Eastern Cape, Pretoria region, and KwaZulu/Natal.

4. Eastern Cape

All electrified settlements in this region with a sales history of 18 months or more were selected. A total of 45 settlements were arrived at in this way. The majority of these settlements are residential areas close to small towns in the Eastern Cape. In addition, there are a number of rural settlements in the former Transkei and Ciskei and peri-urban locations around East London. Settlement sizes varied between 100 and 7 000 connections with most settlements in the range 100–1000 connections.

Average monthly consumption in the majority of settlements, based on bulk metering, is in the range 50–150 kWh/customer. Less than 7% of settlements consume more than this. A number of settlements exhibited seasonal differences with winter peaks approximately 20% higher than the annual average, particularly in the higher consuming settlements. This peak is lower than that found in other urban townships (Palmer Development Group, 1993).

Almost all settlements exhibited a December sales peak, although the corresponding consumption peak was much smaller. A similar December sales peak was observed by Viljoen and Kidgell (1994) in their study in the Transvaal and they suggest that the cause is the increased number of people resident in the household at this time. Although this may be important, the difference between the sales and consumption peak suggests that the availability of cash at this time of year may be a more important factor.

In most cases consumption increased rapidly during the first three to four months, thereafter settling into a much slower growth pattern. The average annual growth has been 10 kWh per customer, equivalent to 14% per annum. Table 5 presents growth rates for each consumption band.

Ave consumption	Percentage of sample	Growth rate	
kWh/month	%	% per year	kWh per year
> 150	7	25	38
100–150	24	16	15
75–100	22	9	1
50–75	38	14	7
0–50	9	14	4.5
All	**Ave consumption = 90 kWh**	**14%**	**10**

TABLE 5: Growth rates for different consumption groups – Eastern Cape

Figure 2 presents the consumption history for the five consumption groups. Winter peaks can be observed for all but the lowest consumption group. Since each group contains settlements which have had electricity for different time periods, this figure partially masks the growth rates on a *per settlement* basis. The most notable features of this graph are:

- Consumption growth is highest for the highest consumption group
- Seasonal differences are most marked for the highest consumption group, and this is most likely a consequence of heater ownership. No seasonal variations can be detected for the lower consumption groups.
- There is a noticeable December peak in consumption (this peak is more pronounced for sales).

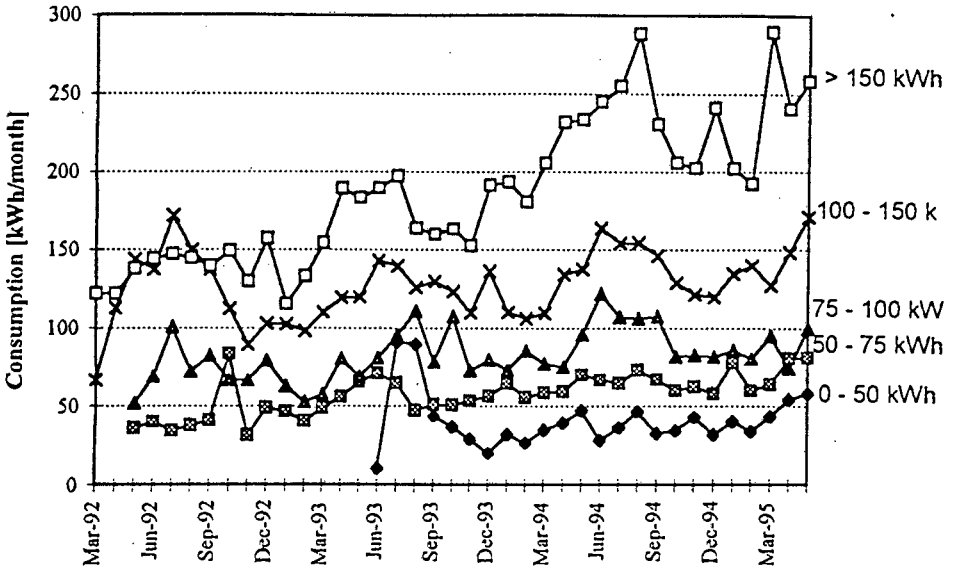

FIGURE 2: Average consumption against time for each consumption group – Eastern Cape

On average, total losses have been in the region of 20–25%. A portion of this, around 10%, will be due to technical losses in the distribution system and the rest can be termed revenue loss due to either faulty meters or theft. Although no clear time-trend can be observed, losses have been lower than average during the most recent six months.

Eleven of the settlements were identified by Eskom personnel as being 'rural'. However, no significant differences in consumption or growth rates from 'non-rural' sites could be identified.

Attempts were made to investigate correlations between average consumption, settlement size, growth rates, losses and time since connection. The only result that could be observed was a very weak correlation between average consumption and time since connected, as shown in Figure 3. The effect of time since connection on consumption growth may be influenced by the tendency for more established and higher income settlements to have been electrified earlier in the programme. This influence can be seen by the fact that the average growth rate represented in the trend line drawn in Figure 3 is over three times the average growth found in the analysis.

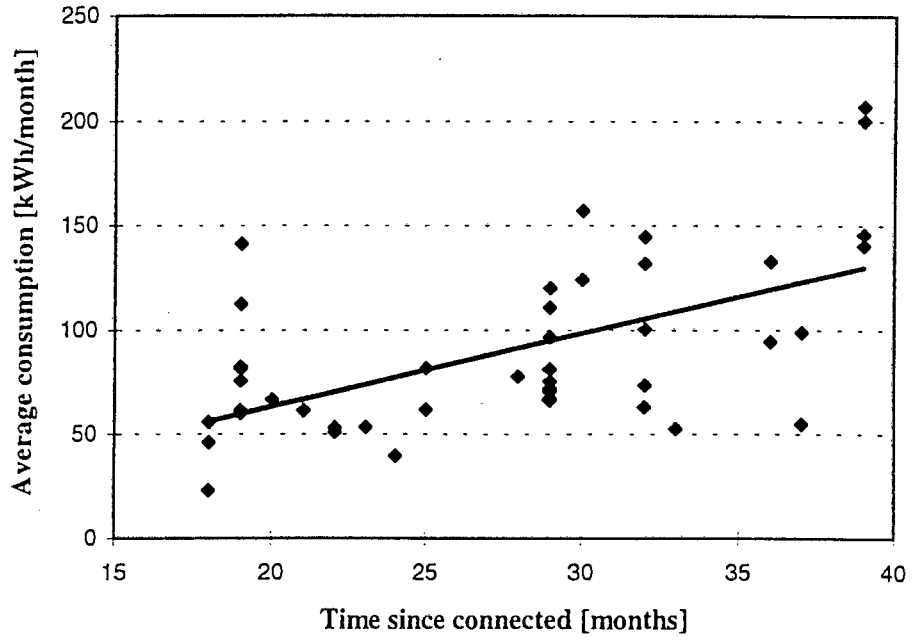

FIGURE 3: Average consumption against time since connected – Eastern Cape

Figure 4 presents a plot of annual growth rates (expressed as the increase, in kWh, in monthly consumption per customer over a year) against average consumption. Although there are no clear trends evident, higher consumption settlements experience higher growth in terms of kWh per month, which translates to a percentage growth similar to that for lower consumption settlements.

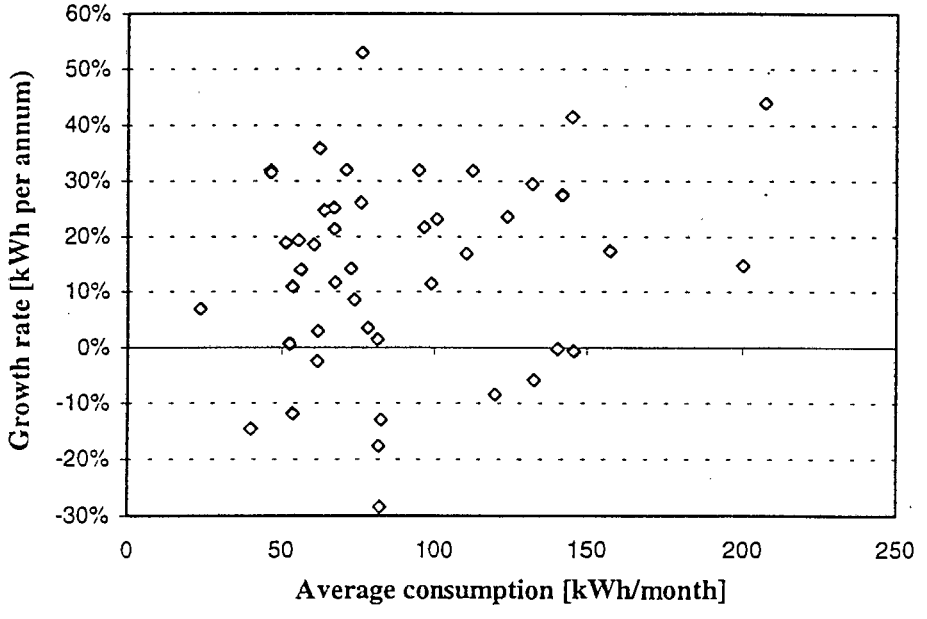

FIGURE 4: Average growth rate against average consumption – Eastern Cape

5. Mpumalanga, North West and Northern Province

All electrified settlements in this region with a sales history of 18 months or more were selected, giving a total of 108 settlements. The majority of electrification projects undertaken by Eskom in these provinces are categorised as 'rural' by

Eskom, although it is possible that this includes residential areas close to urban centres. A number of farmworker settlements were included in this sample and their consumption history is discussed separately. Settlement sizes ranged from fewer than ten customers to more than 10 000. The mean and median settlement sizes were 817 and 475 respectively.

Sales figures had to be corrected for revenue losses to arrive at actual consumption. For 18 of the 108 settlements, average losses were calculated from bulk meter records (from January to August 1994) and applied to data for that settlement. For other settlements, averages losses for the relevant SACS area were available and used.

Average monthly consumption for the entire sample was 89 kWh/customer and the median was slightly less than this (72 kWh). Only 6% of settlements have average monthly consumption greater than 150 kWh/customer. As much as 63% of settlements fell in the 50–100 kWh/customer band.

Average annual growth in consumption has been high in the low consumption groups (26% for those consuming less than 75 kWh/customer) and low and even negative for high-consumption groups. It should be noted that for any one group the range and standard deviation of growth rates is exceptionally high.

Ave consumption	**Percentage of sample**	**Growth rate**	
kWh/month	%	% per year	kWh per year
> 150	6	-17	-38
100–150	17	1	2
75–100	25	8	7
50–75	28	16	10
0–50	25	37	15
All	**Ave consumption = 89 kWh**	**15%**	**7**

TABLE 6: Growth rates for different consumption groups – Pretoria region

Figure 5 presents the consumption history for each consumption group. Since the graph presents averages for each group, growth trends may be masked. The highest consumption group (>150 kWh) has been excluded since this is such a small sample. The 100–150 kWh group is also a small sample and the averages may present a misleading result. The notable features of the graph are:

- there are small winter peaks, which are most notable for the higher consumption groups;
- growth rates appear low, but this may be masked by the averaging effect;
- there is a December peak in consumption.

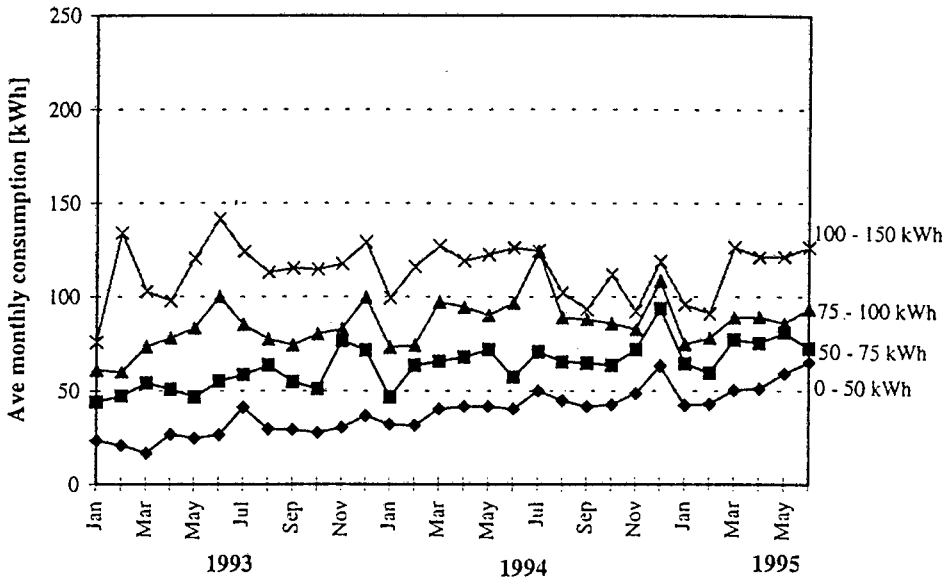

FIGURE 5: Average consumption against time since connected for each consumption group – Pretoria region

Figures 6 and 7 present plots of average consumption against time since connected, and growth rates against average consumption. No clear trends can be observed.

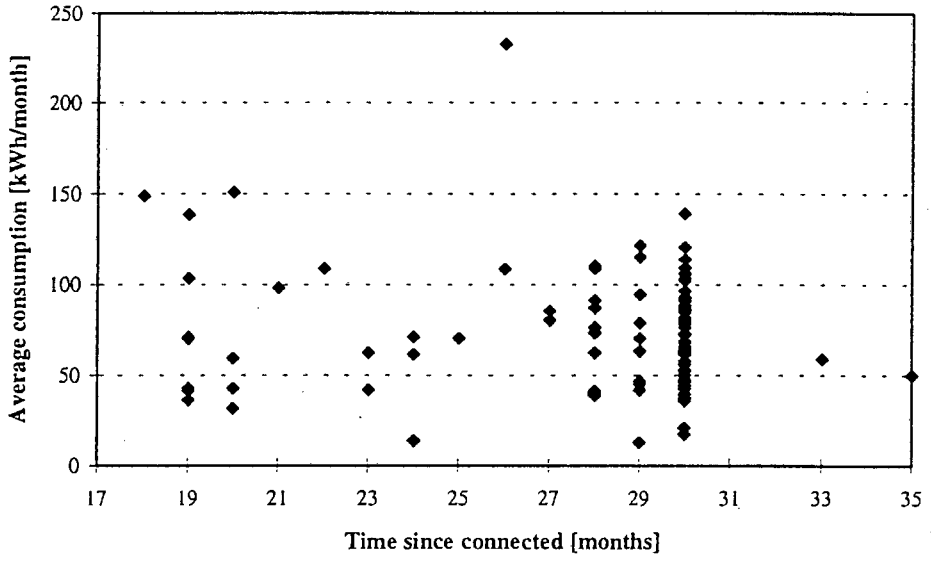

FIGURE 6: Average consumption against time since connected – Pretoria region

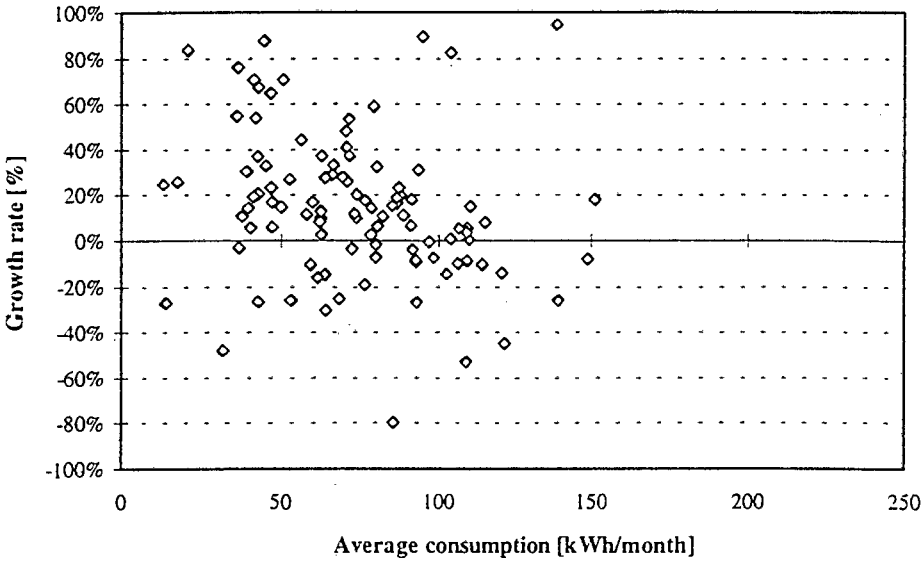

FIGURE 7: Average growth rate against average consumption – Pretoria region

A total of eight farmworker projects were included in the sample, with the number of customers in each project less than 30, with one exception. Average consumption is very low (28 kWh/customer). Growth rates have been very variable, ranging from 67% to -27% per annum.

6. KwaZulu/Natal

All electrified settlements with a sales history of 18 months or more were selected, giving a total of 177 settlements. Data provided covered sales per customer and this was converted to consumption using average loss figures for the region. Losses in KwaZulu/Natal are particularly high – 38% for the coastal SACS region and 67% for the inland SACS region. Applying these average loss figures to all the settlements clearly distorted the picture, giving very high consumption to some settlements. The top 3%, measured by household consumption, were removed as outliers.

Average monthly consumption for the entire region was 154 kWh/month, considerably higher than other regions. This discrepancy can probably be attributed to the high loss figures, which may be inaccurate or may encourage high consumption. Compared with other regions, the distribution in consumption bands is skewed to the higher bands.

Average annual growth is slightly lower than in other regions: 10% overall. This may be attributed to the higher base off which such a growth rate comes from. The growth measured in kWh per year averaged at 7 kWh/month – similar to that found in other regions.

Ave consumption	Percentage of sample	Growth rate	
kWh/month	%	% per year	kWh per year
> 150	35	-1	-3
100–150	34	11	13
75–100	15	15	13
50–75	11	27	16
0–50	5	24	10
All	**Ave consumption = 154 kWh**	**10%**	**7.7**

TABLE 7: Growth rates for different consumption groups – KwaZulu/Natal region

Figure 8 presents the consumption history for each group. Similar features to those in other areas can be noted. Figures 9 and 10 present plots of average sales against time since connected; and growth rates against average consumption. No clear trends can be observed.

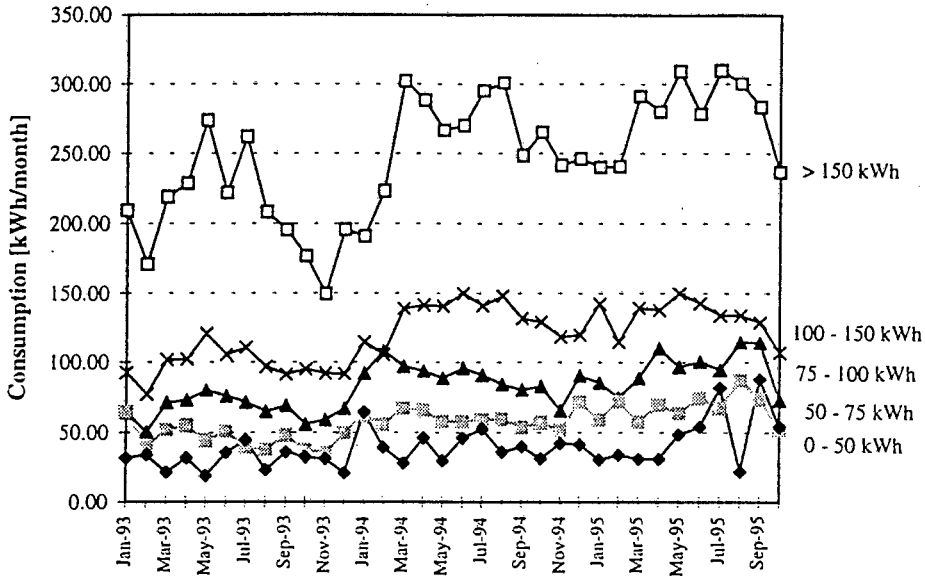

FIGURE 8: Average consumption over time for each consumption group – KwaZulu/Natal

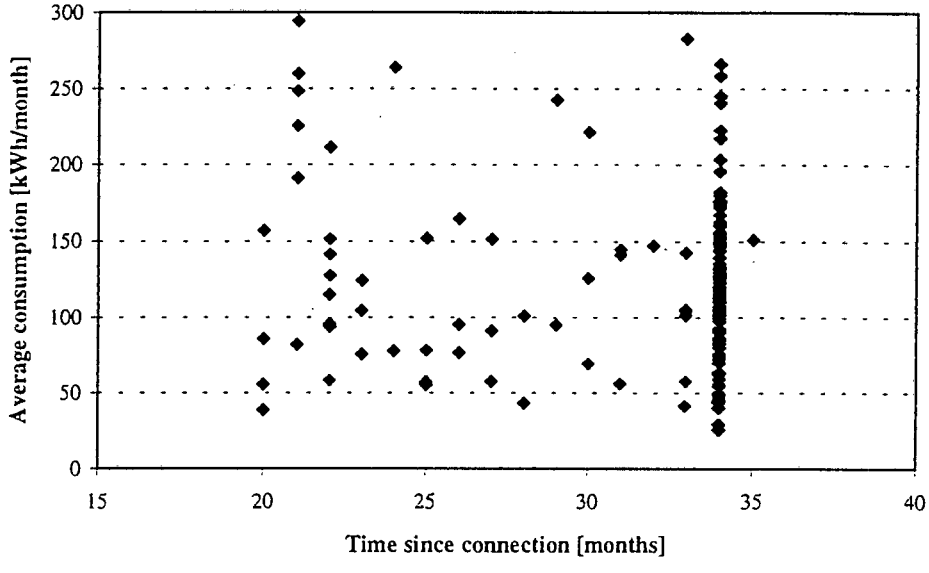

FIGURE 9: Average consumption against time since connected – KwaZulu/Natal

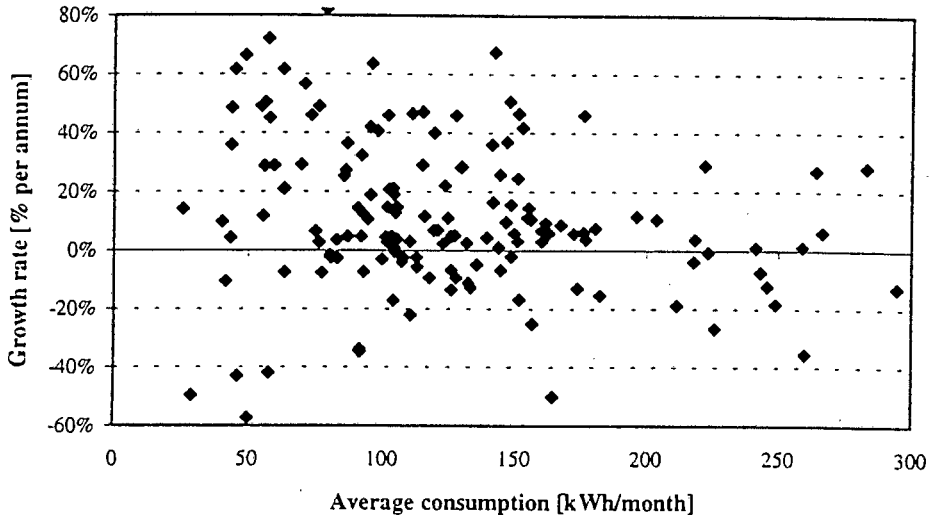

FIGURE 10: Average growth rate against average consumption – KwaZulu/Natal

7. Summary and discussion

This paper has attempted to present the consumption growth patterns in newly electrified communities, over the period 1992–1995. Table 8 summarises some of the main results. It should be noted that high revenue losses mean that sales are considerably below these levels. Particularly high average losses in KwaZulu/Natal, which were applied to all settlements in the regions included in this analysis, may mean that consumption in this province is over-stated.

Table 9 shows that over 50% of settlements have average household consumption less than 100 kWh/month. However, these figures are strongly influenced by the KwaZulu/Natal figures, and in other areas it was found that 70-80% of settlements had average consumption below this level.

Region	Ave consumption	Growth rate	
	kWh/month	% per year	kWh per year
Eastern Cape	90	14%	10
Mpumalanga, N-W, N prov.	89	15%	7
KwaZulu/Natal	154	10%	7.7
Weighted average	**124**	**12%**	**7.8**

TABLE 8: Summary of results – I

Consumption [kWh/mth]	E Cape [%]	Former Tvl [%]	K/Natal [%]	Weighted ave [%]
> 150	7	6	35	21
100–150	24	17	34	27
75–100	22	25	15	19
50–75	38	28	11	20
0–50	9	25	5	12

TABLE 9: Summary of results – II

Estimates of consumption growth made near the start of the electrification programme were clearly much higher than current experience indicates. In

addition, the existing high levels of revenue losses were not predicted. Consequently early electrification planning and pricing, based on these figures, has overestimated the revenues and underestimated the required cross-subsidy. Figure 11 shows the required cross-subsidy for different consumption levels, based on an analysis of costs and revenue attributable to one household. At a consumption of 100 kWh, the required cross-subsidy is in the order of 32c/kWh, equivalent to R32 per customer per month.[1] These cross-subsidies would naturally decline over time were sales levels to increase, and the graph indicates the sensitivity to consumption growth.

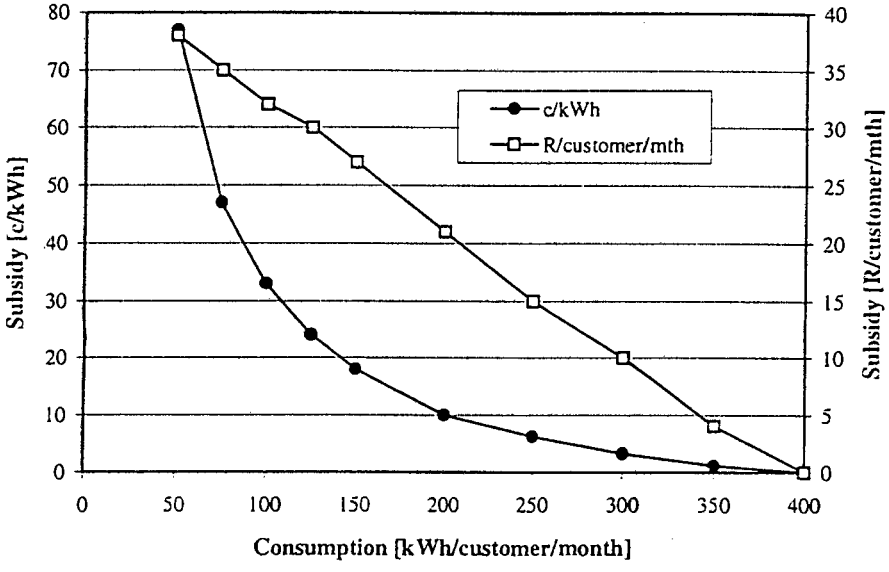

FIGURE 11: Subsidy levels for different consumption rates

Although the results of this analysis indicate that consumption levels are low, growth rates have been relatively high – in the order of 10–20% per annum. However, past experience may not be a reliable guide to future growth. In particular, as the electrification programme reaches more remote and poorer communities, consumption levels may decline. It is generally accepted that a plateau exists at which consumption growth is low, at which stage the extent of appliance ownership in a community is fairly high and static. With the exception of the Eastern Cape (where the sample size was very small), growth rates for communities consuming more than 150 kWh per month were low, indicating that this may represent a levelling out of consumption growth.

There are two effects which may act to alter consumption growth in the future. Firstly, if Eskom and other utilities manage to reduce revenue losses, it is likely that this may act to depress actual consumption levels. Alternatively, projected real decreases in the price of electricity (in line with Eskom's price compact) may act to stimulate demand. Without much information on the price elasticity of electricity demand in newly electrified communities, it is difficult to quantify these effects in any way.

There are two areas where this research may be pursued further. Firstly, this analysis has focused on a community level, and has grouped communities on the basis of the average consumption in each settlement. It would be useful to know the diversity of consumption within a settlement and how it differs from low- to high-consumption localities. Secondly, a more detailed analysis of the factors

[1] Analyses of this nature are sensitive to the assumptions used. To generate this graph, it was assumed that revenue losses would decline from 35% to 15% over five years, initial capital costs were R3 000 per connection, support costs were R25 per month, bulk supply costs were based on marginal costs and tariff changes were in line with Eskom's pricing compact. A real discount rate of 6% was used.

which affect consumption growth would be useful and an attempt should be made to correlate socio-economic indicators with average consumption levels, on a settlement basis. Although work to date indicates that income, and income-related variables, are important in predicting consumption levels, a dependence on affluence related variables may over-simplify the factors which influence growth in electricity consumption.

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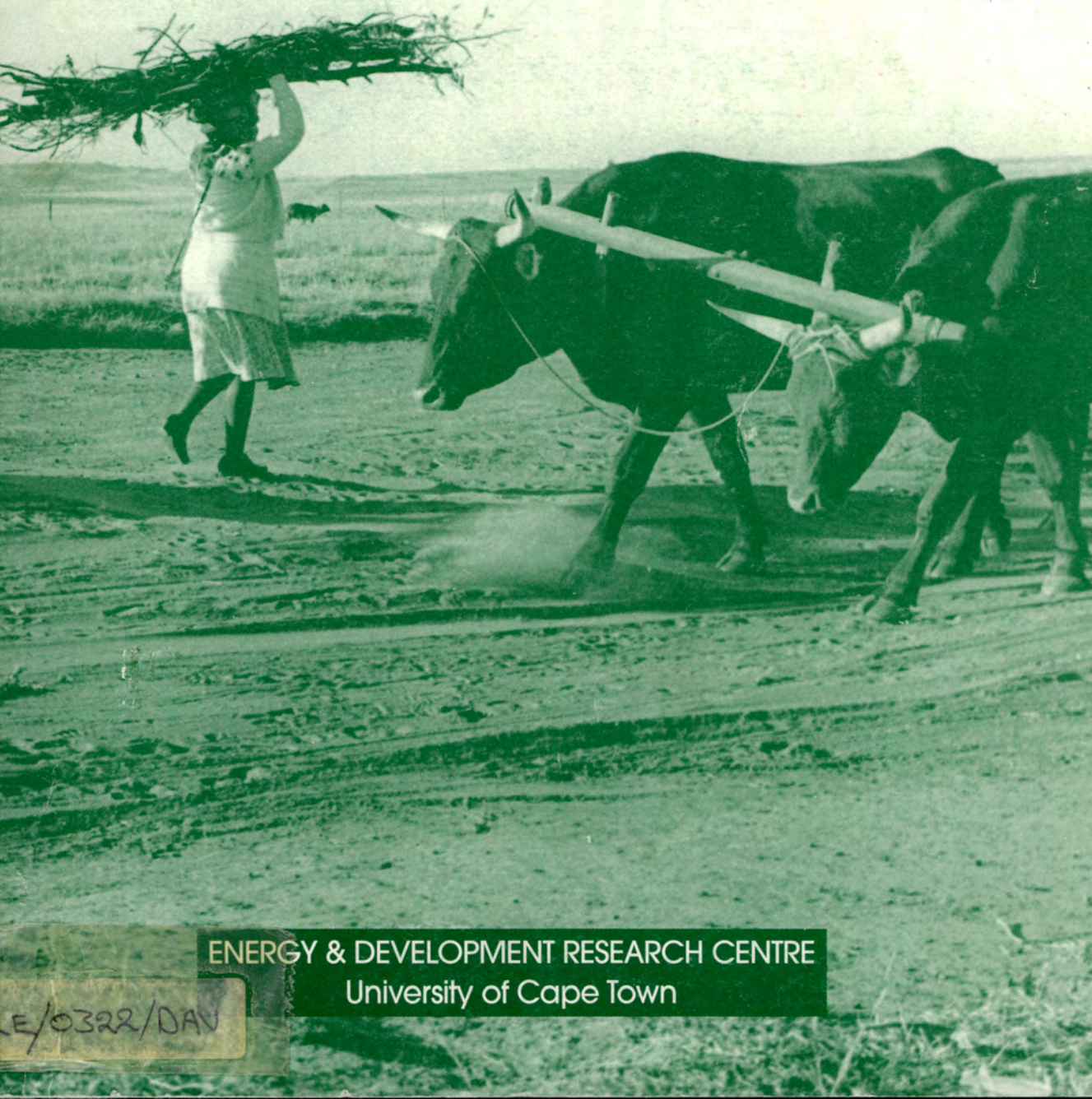

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