Contributing to Access to Household Electrification for Sustainable Development – A Partnership Between Eskom and the University of Cape Town

August 2002

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Preface

Energy is essential for development, yet two billion people currently go without, condemning them to remain in the poverty trap. We need to make clean energy supplies accessible and affordable. We need to increase the use of renewable energy sources and improve energy efficiency. And we must not flinch from addressing the issue of over consumption – the fact that people in the developed countries use far more energy per capita than those in the developing world. (Kofi Annan, Secretary General, United Nations.)

The United Nation's General Assembly in its Millennium Declaration resolved to take special measures to address the challenges of poverty eradication/reduction and to promote sustainable development in Africa, including debt relief/cancellation, improved market access for African products, enhanced official development assistance and increased flows of foreign direct investment to the continent, as well as the transfer of environmentally-sound technologies. Energy projects within a well-planned programme are a critical basis for socio-economic development in Africa. Such projects should aim at improving access to modern energy services in an equitable manner, so that the essential services, which support a reasonable quality of life, are available to the majority, and at the same time assist African countries to follow the sustainable development pathway in satisfying their socio-economic aspirations.

Presently, access to electricity is low in many African countries, ranging from 4% to 30% on average. Hence, South Africa's achievements in meeting the challenge of electrification in the last five years are noteworthy, with the South African government reaching their target of 2.5 million households electrified by the year 2000. This target figure was met and, in fact, exceeded. Since the inception of Eskom's electrification programme in 1991, a total of 2 601 210 homes have been electrified, bringing a range of socio-economic benefits, such as improvements in quality of life, improvement in indoor air quality, reduction in air pollution and increased business development. These positive results could be replicated by other countries undertaking development projects in the continent and they could benefit from the experience Eskom has gained in combining development priorities and commitment with good business sense. The total percentage of people in South Africa who now have access to electricity is approximately 66% of the population.

This achievement was made possible by the commitment and participation of a number of bodies, including government, business, academic institutions and NGOs. These partnerships were a key mechanism for the effective implementation of South Africa's electrification programme. The collaboration between Eskom and the University of Cape Town and supported by the South Africa Department of Minerals and Energy outlined in this document, is one of many that were formed in order to meet the electrification objectives. This body of work highlights the importance of adapting and modifying electrification programmes through a targeted research and investigation programme. The results of this work not only improved business efficiency and equitable distribution, but also ensured that benefits were identified and maximised as far as possible.

The final objective for each person in South Africa to have access to electricity remains a primary driver. However the success of the South African process thus far should be shared with other African countries and implementation agencies in order to make a contribution to the global effort of access to modern energy services. This document shares some of that experience and other such initiatives should be encouraged and supported, to not only profile the South African initiative, but to also pass on the benefit of our experience and knowledge.

THULANI S. GCABASHE
ESKOM CHIEF EXECUTIVE

Background on the partners

PARTNERS

Eskom

Eskom's strategic intent is to be the pre-eminent African energy and related services business, of global stature.

Eskom's mission is to grow shareholder value by exceeding its local and international customers' needs for energy and related services.

Eskom is a vertically integrated operation that generates, transmits and distributes electricity.

Eskom Enterprises, the wholly owned subsidiary of Eskom, together with its subsidiaries, serves as a means by which all the non-regulated activities of Eskom, both inside and outside South Africa, are carried out. Eskom Enterprises' core lines of business are infrastructure development, energy business operations, specialised energy services and the pursuit of key opportunities in related or strategic businesses, such as information technology and telecommunications.

The operations of Eskom are located in South Africa. Eskom Enterprises has operations on the African continent, with its head office located in Johannesburg, South Africa, and other offices in Uganda, Nigeria and Mali.

The ownership of Eskom vests in the South African government.

Electricity is sold to industrial, mining, commercial, agricultural and residential customers and re-distributors.

Eskom, South Africa's electricity utility, is among the top seven utilities in the world in terms of generation capacity, and among the top nine in terms of sales. The majority of the sales are in South Africa, with only a small percentage of sales being in the southern African region.

Key Eskom statistics are as follows:

- has 24 power stations with a nominal capacity of 42 011 megawatts;
- has 316 634 kilometres of power lines spanning the entire country and transporting power to neighbouring countries;
- supplies approximately 95% of the country's electricity requirements, which equals more than half of the electricity generated on the African continent;
- is a responsible corporate citizen, integrating environmental sustainability and socio-economic improvement into its business;
- supports the development of an interconnected African grid to encourage co-operation whilst accelerating economic growth in the region.

University of Cape Town

The University of Cape Town (UCT) is a major research institution in South Africa that recognises the importance of undergraduate training in the provision of much needed manpower in all fields including that of science and technology, and also the vital role postgraduate training plays in the research enterprise of South Africa.

The mission of the University of Cape Town is to aim to be an outstanding teaching and research university, educating for life and addressing the challenges facing our society.

Educating for life means that our educational process must provide:

- a foundation of skills, knowledge and versatility that will last a life-time, despite a changing environment;
- research-based teaching and learning;
- critical enquiry in the form of the search for new knowledge and better understanding; and
- an active developmental role in our cultural, economic, political, scientific and social environment

The University of Cape Town recognises that in order to address the challenges facing the society of South Africa it must come to terms with the past, be cognisant of the present, and plan for the future.

In this, it is central to our mission that we:

- recognise our location in Africa and our historical context;
- claim our place in the international community of scholars;

- strive to transcend the legacy of apartheid in South Africa and to overcome all forms of gender and other oppressive discrimination;
- be flexible on access, active in redress, and rigorous on success;
- promote equal opportunity and the full development of human potential;
- strive for inter-disciplinary and inter-institutional collaboration and synergy; and value and promote the contribution that all our members make to realising our mission.

To equip people with life-long skills we must and will:

- promote the love of learning, the skill of solving problems, and the spirit of critical enquiry and research; and
- take excellence as the bench-mark for all we do.

We are committed to academic freedom, critical scholarship, rational and creative thought and free enquiry. It is part of our mission to ensure that these ideals live; this necessarily requires a dynamic process of finding the balance between freedom and responsibility, rights and obligations, autonomy and accountability, transparency and efficiency, and permanence and transience; and of doing this through consultation and debate.

The Faculty of Engineering and the Built Environment comprises seven departments and institutes and is one of the eight university faculties. This faculty has had a long relationship with Eskom in undertaking research and development and also in providing policy advice. Such activities involve most of the departments of the faculty.

THE NATURE OF THE ESKOM-UCT PARTNERSHIP

The Eskom-UCT partnership goes back a number of years and consists of many projects and programmes in a number of faculties and departments. The body of work reported here is only a small sub-set of such activities and in no way encompasses the myriad of initiatives that have taken place between Eskom and UCT (not even those undertaken in this specific area). Both institutions have forged partnerships with many other tertiary education bodies, organisations and government departments, both nationally and internationally. This document strives to summarise almost a decade of research work that has been undertaken in technical, socio-economic and environmental aspects of electrification and related areas – undertaken as one part of a more comprehensive Eskom and national research and investigation programme.

The research and development partnership between Eskom and UCT, as the work goes beyond the merely technical, into economic, social and environmental areas. Eskom initiates the partnership process through consultation with UCT, and then under a contractual arrangement, UCT embarks on the research programme. Programme results are handed over to Eskom for further development; this may require the results to be documented in an appropriate format for implementation. Further areas of research and development are established with customers and clients through an ongoing feedback system of collaboration between all parties concerned. The nature of this partnership ensures that both theoretical and practical approaches combine to ensure that projects are completed successfully and to improve their overall feasibility.

One of the special features of this document is the focus on the impact of electrification at the household level, in both rural and urban areas of South Africa. This is important, because it is this level of operation that has to be satisfactory in order to ensure that other areas of the economy function effectively, although in most cases these impacts are indirect.

Some of the projects highlighted in this document were co-funded by contributions from other parties. In particular, the work highlighted in Chapters 5 and 6 was co-funded by the Norwegian Overseas Development Agency (NORAD) and the South African Department of Minerals and Energy. These contributions are gratefully acknowledged.

STRUCTURE OF THE DOCUMENT

Chapter 1 introduces the topic of electrification, providing background information and an overview of the challenges, drivers and opportunities of electrification initiatives in general, and in South Africa in particular.

Chapter 2 describes the energy planning and modelling work undertaken by Eskom and the Energy Research Institute (ERI), University of Cape Town. This is only part of more extensive work that has been undertaken by the two institutions in this area, and, due to the focus of this body of work, relates specifically to the residential sector.

Chapter 3 presents the results of various pieces of work that assisted with the mapping out of the technical parameters regarding electrification programmes, ensuring that more people are connected using improved cost-effective methods and management tools.

Chapter 4 assesses some of the issues of financing relating to rural electrification in South Africa.

Chapters 5 and 6 detail the specific socio-economic impacts of electrification, especially in rural households in South Africa. These chapters explore ways of assessing the non-quantifiable benefits of these impacts.

Chapters 7 and 8 highlight the issues related to demand-side management in electrified households, both as a support mechanism for the affordability of electricity and the necessity for monitoring and verification for such programmes.

Chapter 9 concludes the document, with a discussion and a summary of the main findings and identification of major lessons learnt and possible future work that needs to be undertaken.

Chapter 1

Sustainable Development & Electrification: Issues, Challenges & Opportunities for Africa

Ogunlade Davidson[1] and Wendy Poulton[2]

[1] University of Cape Town [2] Eskom

Electrification can be a significant driver for the social and economic progress of nations all over the world, provided that appropriate technologies, along with the necessary support systems, are in place to ensure technical, economic and environmental feasibility.

INTRODUCTION

One of the key issues for sustainable development is access to essential services for improved quality of life. These services include access to improved health services, clean water, adequate food, and modern energy. Electricity plays a key role in the delivery of all these services. It is estimated that two billion people around the world do not have access to electricity. Exploring ways to improve this situation is one of the focus areas for the World Summit on Sustainable Development (WSSD) to be held in Johannesburg, South Africa in August/September 2002. The complete text from the third preparatory meeting for the WSSD is as follows:

Launch an action programme to reduce by half the number of people who currently lack access to modern energy services. This would include international, regional and national actions to:

- *Utilize financial instruments and mechanisms to provide financial resources to developing countries to meet their capacity needs and strengthen national institutions involved with energy, including promoting energy efficiency, advanced fossil-fuel technologies and renewable energy.*
- *Improve access to energy services in rural and semi-urban areas through rural electrification and decentralized energy systems, by intensifying regional and international cooperation in support of national efforts.*
- *Develop regional plans of action to facilitate cross-border energy trade, including the interconnection of electricity grids and oil and natural gas pipelines.*
- *Develop and utilize locally available and indigenous energy sources and infrastructures for various local uses, where considered more environmentally sound, socially acceptable and cost-effective, with increasing use of renewable energy resources, including through community-based development methods, with the support of the international community, to meet the daily energy needs and to find simple and local solutions. Improve access to modern biomass technologies and fuelwood sources and supplies, and commercialise biomass operations, including the use of agricultural residues, where such practices are sustainable.*
- *Strengthen and, where appropriate, establish policies on energy for rural development, including, appropriate, regulatory systems to promote access to energy in rural and semi-urban areas.*
- *Enhance international and regional cooperation to improve access to energy services, as an integral part of poverty-reduction programmes.*

History has demonstrated that electricity underpins the economic and social development of many countries all over the world, as well as providing the support infrastructure for such development to occur. Therefore, for any nation or region to move forward and become competitive in the global market, the provision of reliable and affordable electricity is crucial. This is very true for countries in Africa, where it is estimated that, as a continent, only 17% of the population have access to electricity, as compared to other developing regions of the world, where over 80% or more of their population have access to electricity, with the exception of South Asia. Hence, the provision of electricity in African countries is crucial to not only improve the quality of life for its people, but also to improve its overall net productivity and become competitive with other developing regions of the world.

The provision of electricity in Africa however, has to be integrated with other aspirations of the continent, as there are major challenges to be faced. These aspirations, which have been advocated collectively in the recently formed African Union, and individually in national country plans, include the reduction of poverty and the fulfilment of basic human needs for the majority of the continent's inhabitants, in a sustainable manner. The fulfilment of these aspirations is synergetic with the challenges and primary objectives of sustainable development in Africa. Undoubtedly, the provision of electricity will greatly assist countries in Africa to not only fulfil their needs but also to significantly advance movement towards a sustainable development path.

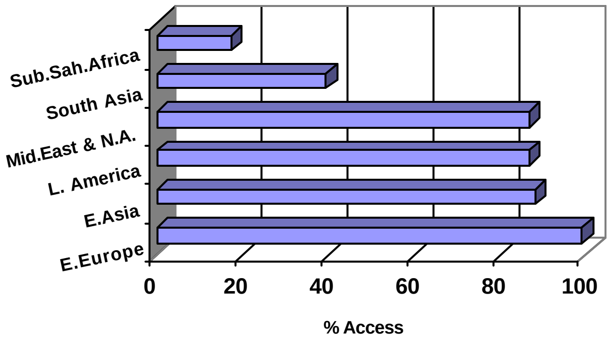


Figure 1: Population with access to electricity in developing regions, 2000
Source: O'Sullivan & Hamaide (2002)

As can be seen from Figure 1, access to electricity in sub-Saharan Africa was only about 17% in 2000 as opposed to other developing areas, which were in excess of 80%, and that of South Asia of 40%. Hence, for countries in sub-Saharan Africa to compete with other developing regions, access to electricity has to be substantially increased. However, this data for the region also hides the differences between countries, which are quite significant, and as Figure 2 shows there is significant variation among countries in the region.

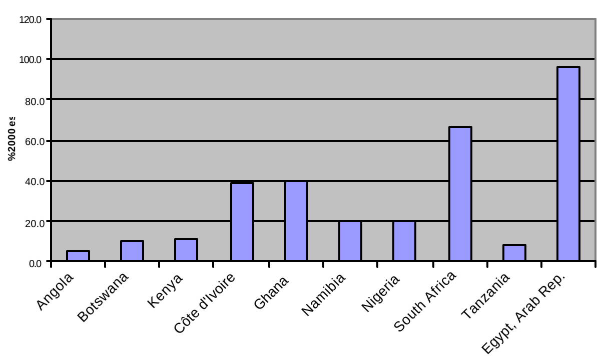


Figure 2: Population with access to electricity (% 2000 est)
Source: O'Sullivan & Hamaide (2002)

Another key issue for electrification in developing countries is that of affordability. Most of the available literature tends to discuss cost in terms of comparing absolute cost, without discussing the disparity in disposable incomes. Historically, Countries have initially set low electricity prices to stimulate socio-development until a strong middle-income earner class develops, and have then embarked on a variety of schemes to maintain access. These schemes have demonstrated that the role of the government has been central. The cost of electricity in South Africa, relative to other selected countries, is low, as shown in Figure 3 below. When considering the electricity price, it must be compared to disposable income or GDP per capita.

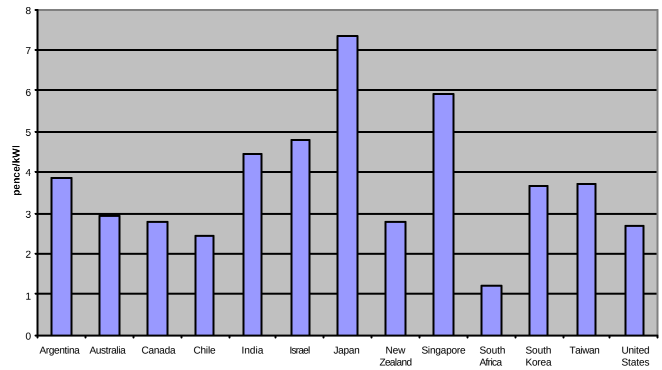


Figure 3: Price of electricity in selected countries
Source: EAS

Apart from the provision of electricity for economic development, which was discussed above, the provision of electricity also advances social development and progress, as well as environmental protection. These two issues usually fall under the domain of central and municipal governments, especially at the early stage of development in a country. This explains governments' intervention in the electricity sector world-wide. Further, maintenance of this service requires government, and a well-regulated system, because of national interests. The situation in Western Europe, which is shown in Figure 4, clearly demonstrates the role of government in electricity supply and use.

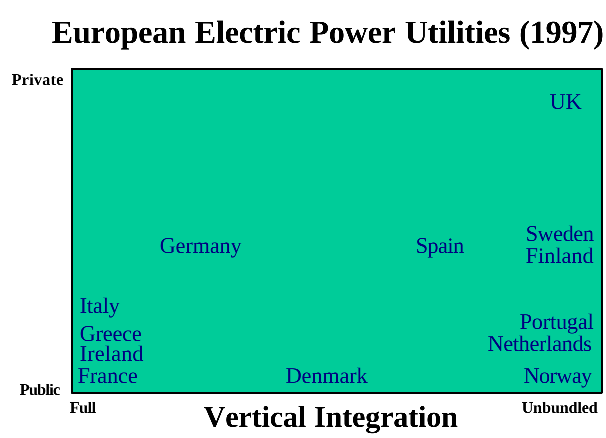


Figure 4: The state of ownership of power utilities in Western Europe
Pers.Comm. Abeeku Brew-Hammond, KITE, Ghana.

THE SITUATION IN SOUTH AFRICA

The Energy Policy of South Africa, as clearly advocated in the Government's White Paper, provides valuable high-level guidance regarding the priorities related to the energy sector. The five priority areas for South African energy policy are:

- increasing access to affordable energy services;
- improving energy governance;
- stimulating economic development;
- managing energy-related environmental impacts; and
- securing supply through diversity.

In 1992, 6% of the rural population had access to electricity, as did 60% of the urban population. Total overall access was therefore 39%. (Eberhard & van Horen 1995). The importance of electricity, as previously mentioned, was recognised in South Africa, hence at independence in 1994, electrification was identified as a priority in the country and this is also recognised within the Southern African region (SADC) as a whole. During the deliberations of the National Electrification Forum (NELF) in 1993 and 1994, some scenarios were developed for the implementation of a national household electrification programme that would involve the entire electricity-distribution industry. Eskom and other distributors, as well as the South African Reconstruction and Development Programme, finally adopted the mid-range scenario as a set of targets. The aim was to connect 2.5 million homes from 1994 to 1999. Eskom committed itself to connecting 1.75 million homes as part of this programme (Steyn 1996).

ESKOM'S ELECTRIFICATION PROGRAMME

Eskom's commitment had the following implications:

- a new connection every 30 seconds;
- a pole every ten seconds;
- 200m cable per minute;
- payment and invoice of R6 000 per minute;
- 1 000 projects every year, with 200 running simultaneously, had to be managed.

The results achieved are detailed in Figure 5 below:

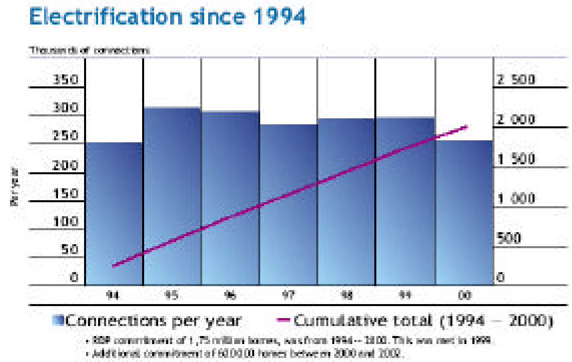


Figure 5: Eskom's electrification results

This was obviously a substantial commitment, as Eskom had previously undertaken no electrification project on this scale. Thus, the process was continuously adapted and refined over the implementation period, in order to reduce timelines and costs, to carry out the process more efficiently, and to implement lessons learnt on a project level at a company level. It was therefore identified that various projects needed to be carried out in order to research specific technological and operational aspects in order to effect improvements and support the overall implementation of the commitment. In addition, it was also identified early on that it was critical to monitor the impacts of this increasing access to electricity, not only on the end-use customer and the environment, but also on Eskom's business. Some of these projects were undertaken by the University of Cape Town at Eskom's request and are highlighted in this document.

This document also seeks to provide information to a wider audience on what was accomplished, not only on a business level, but also from a research perspective. This includes the lessons learnt on an operational level, as well as the research methodologies and process that were evaluated and assessed. It is hoped that the findings outlined in this document will assist policy and process for electrification programmes in other developing countries.

The document also aims to expose the linkages between electrification and socio-economic benefits. This is a critical aspect of sustainable development, as, once access is achieved, the resultant benefits can include the following:

- job creation through foreign direct investment in energy intensive manufacturing;
- new employment opportunities;
- small business development;
    - ✓ appliances

    - ✓ shops
    - ✓ welding
    - ✓ hair salons
- change of lifestyle;
    - ✓ refrigeration
    - ✓ extended hours
    - ✓ access to communications
- improved security;
- improved education levels;
- rural development;
- GDP increases;
- knock-on impacts;
- improved quality of life;
- access to modern technology;
- reduced local air pollution levels;
- major health benefits through fewer paraffin burns and poisoning, as well as vaccine refrigeration, water pasteurisation and a decrease in respiratory disease.

Electrification may not bring about immediate results, as improvements take place over a number of years.

REFERENCES

Electricity Association Services Limited, International Electricity Price (Issue 28).

Eberhard, A & van Horen, C 1995. Poverty and power: Energy and the South African state. London: Pluto.

O'Sullivan, K & Hamaide, M 2002. Calculation sheet of access to electricity by country used for business renewal strategy preparation in March 2001. World Bank, Washington.

Pers. Comm. Abeeku Brew-Hammond. Kumesi Institute of Technology and Environment, Kumesi, Ghana.

Steyn, G 1996. Rural electrification: delivery or development? REIPERA project. Energy & Development Research Centre, University of Cape Town.

UNDP/UNESOC/WEC, 2000. World Energy Assessment, UNDP. http://www.undp.org/seed/eap/activities/wea

Chapter 2

Energy Modelling as a Tool to Assist with Electrification

Mark Howells[1], Mavo Solomon[2], Andrew Kenny[1] and Zaheer Kahn[2]

[1] University of Cape Town [2] Eskom

Energy modelling is an important tool that translates and contextualises energy needs and requirements in terms of economic, environmental and technology data. This allows policy makers to make quantitative assertions to optimally meet developing country needs.

OVERVIEW OF THE ENERGY SECTOR IN SOUTH AFRICA AND RESIDENTIAL ENERGY

The South African economy is energy intensive, using a large amount of energy for every Rand of value added. South African energy is dominated by coal, which contributes 70% of primary energy. It is low cost and this results in low energy costs, particularly for electricity, which is among the cheapest in the world. South Africa has little oil and most of her crude is imported. She obtains useful amounts of energy from biomass and nuclear power, with smaller amounts from hydropower, natural gas, solar and wind. The potential usage of hydropower and natural gas is largely constrained by the availability of these resources. Figure 1 shows the types of primary energy consumed in South Africa in 2001 (total: 4064 PJ).

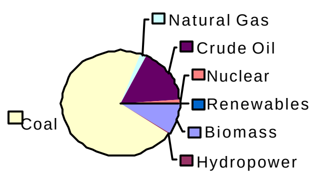


Figure 1: South African primary energy in 2001

Much of the primary energy is transformed into final energy, such as electricity and liquid fuels. South Africa's final energy demand in 2000 was 3054 PJ, consisting of electricity (20%), coal (32%), liquid fuels (31%), biomass (13%), crude oil (1.7%), other fuels (2%), with natural gas and renewables less than 1%.

Figure 2 shows South Africa's final energy demand by sector in 2000.

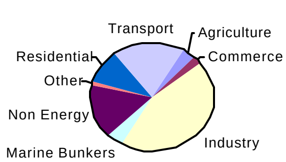


Figure 2: South African final energy in 2000

Residential energy accounted for 284 PJ in 2001, which included electricity (38%), coal (20%), wood (30%), paraffin (8.9%), LPG (1.6%) and vegetable wastes (1.5%). The main uses of residential energy are cooking (40%), space heating (32%), water heating (10%), lighting (5.4%) and refrigeration and electrical appliances (12%). There is a movement from traditional fuels such as dung and wood, through transitional fuels such as coal, LPG and paraffin, to electricity.

STRATEGIC ELECTRICITY PLANNING AT ESKOM AND ENERGY MODELLING AT UCT

It is essential for Eskom to forecast future electricity demand so that it can plan its required generation and distribution. It also needs to forecast electricity peaks so that it can deal with them by storage schemes and load shifting. For this purpose, it has its Integrated Strategic Electricity Planning department (ISEP). ISEP collects information about energy consumption in general and electricity in particular, keeps in touch with trends in industrial, commercial and residential energy usage, and forecasts how much the demand for each type of energy will grow and in what areas the growth will take place. It then recommends when new power stations should be built and what type they should be. It advises whether the new station should be for base-load or for meeting peak loads. At the heart of the ISEP process are a series of computer-based models of the 'electricity economy', including an electricity expansion-planning optimisation tool, EGEAS.

South African electricity consumption is not uniform over 24 hours but has peaks at about 7am and 7pm, due mainly to residential consumption. It is expensive to build new generating plant just to meet these peaks. Load management programmes are implemented aimed at reducing the peaks by shifting demand away from these times. Other DSM initiatives promote: strategic load growth, for example low cost projects for fully controllable geysers; energy-efficiency schemes; and interruptible electricity-supply contracts on selected customers or, by substituting other energy forms for electricity. On the supply side, the most usual scheme for managing these peaks is pumped storage. In off-peak times, electricity is used to pump water from a lower dam to a higher one; in on-peak times the water runs back down, generating electricity through a turbine. Electricity could also be used to make a cooling medium such as ice slush or liquid nitrogen off-peak, which could them be used for chilling or freezing on-peak.

The Energy Research Institute of the University of Cape Town is currently analysing the South

African Energy Sector using sophisticated modelling techniques. It has set up an energy model using MARKAL programme software, supported by the LEAP model. These models describe South Africa's energy supply, energy transformation and energy demand. Energy transformation is the conversion of primary energy such as coal and crude oil into final energy such as electricity and/or petrol, using conversion technologies such as power stations or oil refineries. Energy demand is divided into the following sectors: industry, commercial, transport, residential and agriculture, and these in turn are divided into sub-sectors. For example, industry is divided into mining, iron and steel, chemicals and petrochemicals, non-ferrous metals, non-metallic minerals (mainly cement, bricks and glass), pulp and paper, food and tobacco, and 'other' (which includes manufacturing).

The MARKAL model considers the energy now used, such as coal, oil, gas, nuclear, biomass, solar and wind, and the present and future technologies to harness them. It provides an extra degree of freedom in terms of electricity-demand forecast, as the effect of fuel switching is now taken into account in the optimisation analysis. In the residential sector, the energy used may be 'traditional' (wood and dung), 'transitional' (coal, paraffin, candles and LPG) or 'modern' (electricity and piped gas).

Energy use in households is divided into cooking, lighting, water heating, space heating and other (which includes refrigerators, radio, television, power tools and other appliances).

The MARKAL energy model has been set up using predictions of future cost and performances criteria at current prices and incorporates all the available data about energy supply, transformation and use. To gain insight into the future, the models have run a series of scenarios, which explore different ways in which energy supply and demand might develop.

Scenarios are not predictions. They simply give outcomes for different assumptions about the future, but they are extremely useful for planners and policy makers.

Each scenario depends upon variables put into it. These are the 'drivers', 'elasticities' and 'scenario assumptions'. The drivers are the primary assumptions that affect the entire model. In the scenarios developed thus far, the drivers have been economic growth (annual increase in GDP) and population growth (annual increase). Elasticities give a measure of the increase of a particular demand compared with one of the drivers. For example, if the demand for chemicals increased at twice the rate of GDP growth, the elasticity would be 2. If it were half the rate, it would be 0.5. Scenario assumptions are other variables, which might not be numerical, which can affect part of or all of the scenarios.

Examples are the inflation rate, the discount rate, the degree of regional co-operation in southern Africa, the oil price, environment issues, and the penetration of new technologies. There is no clear dividing line between drivers and scenario assumptions, and it is often not clear which is the cause and which is the effect. GDP growth will affect energy consumption but the energy supply will affect GDP. The impact of AIDS must be considered when estimating the future population growth.

The drivers, elasticities and assumptions have been drawn from various authorities and experts in their fields.

MODELLING ENERGY DEMAND

The LEAP model is only a simulation model. It can only give results for the future, calculated from data and assumptions fed into it. The MARKAL model can optimise. It can calculate the best selection of energy technologies so as to give the lowest total energy costs.

In order to establish what future technologies and practice may be used to meet energy demand, it is important to determine how energy is currently being used and what service it provides. This service is termed the energy service, and examples include cooking, space heating, process heating and pumping.

For the residential sector, the following table summarises energy services and some appliances modelled in MARKAL and LEAP used to meet this demand.

Table 1

Service	***Appliance***							***Comments***
Cooking	Electric hot plate	Electric stove	Kerosene primus	Kerosene wick	Coal brazier	Coal stove	Wood stove	Other devices modelled but not included in the table are LPG-ring stoves and electric microwaves. Provision is made for natural gas-ring stoves in the future. In this round, devices were modelled to only supply one energy service. This is an artificial simplification, as stoves often supply the service of cooking, space heating and water heating.
Lighting	Electric CFL	Electric fluorescent	Electric incandescent	Kerosene pressure	Kerosene wick	LPG pressure light		
Space heating	Anthracite heater	Dung open fire	Electric heater	Kerosene heater	LPG heater	Wood fire		Refer to the note under 'Cooking'.
Water heating	Electric geyser	LPG geyser	Solar	Agricultural waste	Coal	Wood		Refer to the note under 'Cooking'.
Other	LPG	Electricity						This energy service refers to items such as refrigerators, televisions, hi-fis etc. It is assumed to grow with electrification over the period. It should be noted, however, that demand levels are likely to be related not only to access but also expendable income.

Energy service requirements are then projected as a function of the drivers considered. The sector can be split into different sub-sectors, which differ in terms of their energy usage. Current work now considers the following classifications: rural, peri-urban, low-cost housing and urban.

For each appliance used, costs, energy service, time-of-use-curve and atmospheric emissions are estimated per unit of energy service delivered. Also included is the cost of energy distribution. Estimates can then be established of the effects of interventions, such as electrification.

As the time-of-use curve (that is when most of the cooking, water heating, etc is done) is determined by cultural and social habit, it is characteristically 'peaky'. That is, most people cook, use heat and lighting at the same time. Therefore, during the morning and evening there are significant peaks in demand. This poses a problem in terms of electrical supply, as the supply system must have capacity for these peak demands, which occur for only short periods. In terms of other fuels this is not currently an issue, as it is simply burned when required. The result of the electricity-supply industry having to carry the extra capacity to meet these peaks, is an increase in running and capital costs.

In order to minimise costs, various load-management options are considered. In terms of the residential sector, demand-side-management or DSM options can be divided into four broad categories.

Residential DSM options

Various load-management options are illustrated graphically in the figure below, and fall into the following categories:

- **Interruptible supply**. Where electricity is restricted during times of peak demand. A typical example of this, are the interruptible supply agreements with particular large industrial customers.

- **Load shifting**: Shifting electrical load is often done either by attempting to change habits, or by storing energy at off-peak times for use during peak times. An example of this would include the use of night- time heat storage for peak-time use.
- **Strategic load growth**: Of special interest when electrifying households, is the question of encouraging the demand for electricity during off-peak times, when the electricity supply system is under-utilised.
- **Energy efficiency and fuel switching**: Implementing economic energy-efficient practice and technologies, switching fuel sources away from electricity, can; decrease demand growth and delay the construction of more expensive new plant; and reduce peak demand and extra peaking capacity that must be supplied by the electricity supply system.

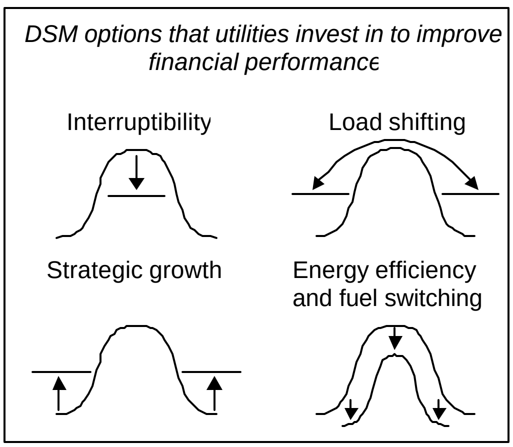


Figure 3: Demand-side management options

ENERGISATION AND ENERGY EFFICIENCY

It is important to note that much of the peaky residential heat-energy demand may be safely met using fossil fuel. An example would include the use of liquid petroleum gas (LPG) for cooking and water heating while using electricity for lighting and refrigeration. Power plants that would have been run to meet peak electricity demand (some use oil for this purpose) need not be constructed. The oil (that may have been used to power the peaking electricity plant at a low efficiency) could be used to provide the energy service in the household at much higher system efficiency. It is important to ensure that fuels which are used directly in the household, are used safely. This method of reducing the system costs, while encouraging electrification, is known as 'energisation'.

The reduction in the cost of the system by allowing fuel switching is optimised in MARKAL.

Energy efficiency is often an economic method of saving energy, reducing greenhouse gases and benefiting the environment at the same time. An aspect of this, and other DSM measures, is that this helps reduce the need to build new electrical plant and can save on household energy bills. When existing power-plant capacity becomes insufficient to meet an increasing electrical load, the marginal cost of electricity increases. The system, as modelled in MARKAL, has the choice of investing in a new power plant or energy-efficient technologies. In terms of the system, the latter generally costs less. Thus the cost of supplying electricity is reduced, and as less energy is used to supply the same service.

SOME MODELLING RESULTS ENERGY USE IN THE RESIDENTIAL SECTOR

The following graph (Figure 4) indicates the useful energy required by the entire residential sector for a business-as-usual growth over a twenty-year period. It is the challenge of the modeller to meet this demand in a cost- effective, clean and sustainable manner. Data is drawn from case studies described in this book and then fed back into the model to develop scenarios to inform policy.

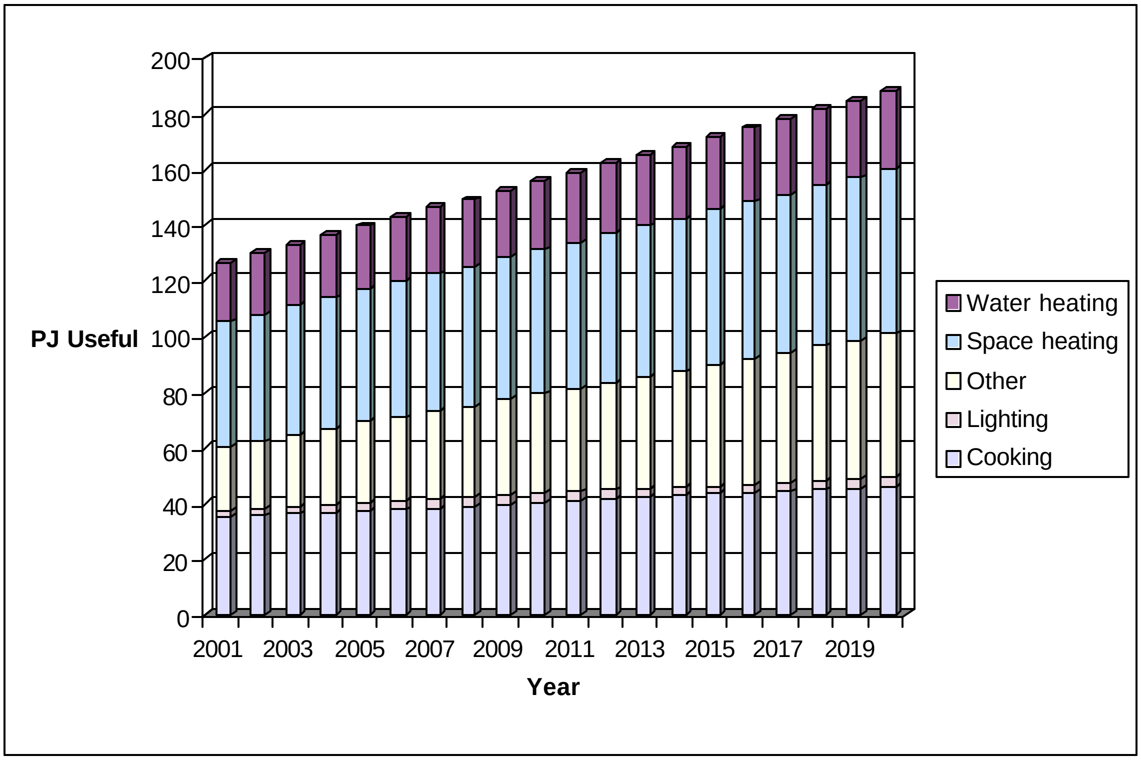


Figure 4: Residential energy service requirements

FUTURE MODELLING WORK

Future modelling work includes extending this analysis into other Southern African countries, and including macro-economic feedback. More detailed models are currently being developed by the Energy Research Institute, the International Energy Agency's (IEA) lead energy technology systems analysis program (ETSAP), programmer and model developer, Stanford University, and with Eskom, to develop a detailed least-cost blueprint for electrification, including distributed generation, in the residential sector with reference to development economics. The latter is being carried out using the IEA's MARKAL upgrade, TIMES.

ELECTRIFICATION AND FUTURE ENERGISATION IN THE RESIDENTIAL SECTOR

South Africa, has followed a vigorous programme of electrification. From 1994 to 1999, about 450 000 households a year were electrified, 300 000 of them by Eskom.

As the above results suggest, there are great benefits in providing households not just with a single energy source such as electricity, but with an energy service that gives them various types of energy to meet their requirements. For households far from the national electricity grid, photovoltaic electricity is suitable for lighting, radio and television, but may not be suitable for heating and cooking. A much better energy source here may be LPG. In this case, energisation would provide electricity and LPG.

Providing an energy service by energisation holds out much promise for clean, safe and affordable energy to households off the grid. Energy modelling is the perfect tool for exploring these options so as to give the most cost-effective solution.

Chapter 3

Policy Economic and Technical Aspects of Electrification

Charles Dingley[1] and Rob Stephen[2]

[1] University of Cape Town [2] Eskom

International experience can be used in planning national electrification programmes. It is also necessary to adapt and develop existing distribution technologies in order to carry out programmes in the most cost-effective way.

INTRODUCTION

This chapter presents a summary of the joint research work carried out by Eskom and the Department of Electrical Engineering at UCT into the policy, economic and technical aspects of the proposed national electrification programme. This work is focused on grid electrification, and relates to both urban and rural areas.

SETTING THE PARAMETERS OF A NATIONAL ELECTRIFICATION PROGRAMME

Research was conducted to assist in speeding up the launch of South Africa's national electrification programme, by gathering as much information as possible about electrification policy, technology and experience in various other countries (see Dingley, 1988). To do this, visits were made to utilities and policy-making bodies in Brazil, Costa Rica, Greece, Hong Kong, Thailand and the United States (where the rural electric co-operatives set up by President Roosevelt in 1935 still supply 75% of the area of the country). This report provided a detailed account of the findings, covering the following topics:

- the role of government in the formulation of electrification policy;
- the perceived benefits of electrification;
- achieved rates of electrification (as they related to population);
- institutional frameworks for electrification;
  the rural electric co-operative structure in the USA;
- consumer to employee ratios in utilities;
- consumer densities and maximum demand data;
- technical aspects (single-phase systems, earthed centre-tap LV systems, house wiring, electrification of shanty areas);
- appliance usage and domestic consumption levels;
- domestic tariffs and metering and billing systems;
- capital costs and financing of electrification projects.

Tobich (1989) conducted a case study of the electrification of underdeveloped rural areas for the area then known as the Ciskei. This had two components.

The first was an extensive survey to ascertain householders' attitudes towards the possibility of having access to electricity, and the second was a macro design of a network covering a major part of the then Ciskei, so as to obtain a more accurate costing for rural electrification.

A report by Dingley (1990a) made three major recommendations. The first was that South Africa should aim to connect 350 000 houses a year to the grid, so as to achieve virtually complete electrification within 20 years. The second was that the programme should be formulated and driven by a national electrification board, which is the role now played by the National Electrification Advisory Board. The third was that urgent attention be given to rationalising the structure of the distribution industry, so as to overcome certain obstacles to electrification that had their roots in the fragmented nature of the electricity distribution industry.

As part of the Nedcor-Old Mutual scenario planning study of the South African economy, Dingley (1990b) carried out an investigation into how rapidly South Africa's national electrification programme could proceed. The study identified and assessed possible constraints on achieving an electrification target of up to one million new household connections a year. The study concluded that local suppliers of electrical equipment could increase their output over a year or two to meet even a target of a million connections a year. The only constraint that might prevent such a high target being reached (apart from the obvious one of finance) was the probable lack of availability of project managers to run a programme of this scale.

A subsequent paper by Dingley (2000a) extended the earlier work from a South African to a Southern African context. This paper reviewed present electricity usage in sub-equatorial Africa, and provided an estimate of the overall cost of the electricity infrastructure needed for a 25-year comprehensive electrification programme in the region. The study showed that, even assuming per capita usage for the region in 2025 of only slightly more than present per capita usage in Asia, the region would need some 80 000 MW of new generating capacity. The cost of a programme on that scale would be of the order of US$150 billion.

MANAGEMENT OF THE OF THE ELECTRIFICATION PROGRAMME

In the early 1990s, Eskom's Distribution group faced a daunting task of electrifying some 300 000 houses per year to achieve around 1,5 million house connections by the year 2000. The company had limited experience in this field. The figure of 300 000 was based on a total connection rate of 450 000 per year, with 150 000 being done by the municipal structures.

It was not clear where to start – was this part of normal business or should it form a totally separate business? Only one aspect was very clear – there was expectation that Eskom had to deliver effectively and efficiently at a pace that was never before achieved.

The programme had to be tackled on a number of fronts – the process had to be formulated and the technology had to be perfected. The project management aspect was key. In order to meet the target it meant that a connection had to be made every 30 seconds for five years. A pole had to be placed in the correct position every ten seconds. Two hundred meters of cable had to be strung and attached every minute. In addition, invoices and payments had to be made to the value of South African Rand (R) 6 000 per minute, or approximately R300 000 per day. In the course of one year, over 200 individual electrification projects had to be planned, designed and executed with precision.

The process and means by which this is achieved is covered in the following sections.

ELECTRIFICATION PROCESS

In order to meet the challenges as described above, a process needed to be developed whereby the electrification of rural communities could be realised. In the initial stages, the planning progress from electrification of the areas to switch-on was too short, being only six to nine months. This led to designs not being fully optimised and costs escalating. In 1994 most of the lucrative high-density areas were electrified and the less dense areas remained. The cost per connection was escalating in the areas to R6 000 or more. As Eskom was financing the programme, it was essential that the cost be rapidly brought under control. A total cost of R1 billion per year was the maximum that could be tolerated. The cost per connection therefore had to be reduced by about 40% in order for the programme to be successful. If this was not achieved, it meant that either fewer connections would be done or more funds had to be raised. Neither option was acceptable.

The process developed therefore, focused on a two-year lead-time. Villages earmarked for possible electrification were identified 24 months in advance. The expected number of connections and estimated costs were allocated accordingly. A set of indicators was developed to assess whether the stated cost per connection was in line or inflated.

These indicators included the density in connections/km of line, sizes of transformers, number of connections per transformer and the cost/km of line. From this analysis, an objective cost per connection target was established, as well as steps that needed to be taken to meet the target. These steps led to refinement of the technical standards as well as the construction methods required.

Once the number of connections and cost per connection was established for the next 24 months, detailed planning could commence. In most cases, Eskom was dealing in areas that had no formal settlements. This implies no neatly laid out roads or street addresses. Communities were also volatile, with numbers of houses varying with time. This required detailed discussions with the community. The area also had to be over-flown and aerial photography used to identify connections and terrain.

From this information, it was possible to start placing villages into identifiable projects. The network planning of a particular region with a number of villages could commence at a high level.

Senior management then approved this plan in the region and the network plan was finalised. Detailed planning of the villages was now possible. The high level plan was also divided into smaller projects.

It should be noted that Eskom did not have the resources to execute the design and construction of all the projects. It was essential that consultants and contractors were brought on board to assist in this work. It is in partnership that the electrification programme was achieved.

Each project was then taken to the detailed design stage where local capital investment committees approved expenditure. The approval of the programme was thus achieved at a national level with the regions being allocated funds and connections to be delivered. Projects were approved at the local regional level. This enabled regions to manage their own projects rather than request permission for each project separately at a national level. To manage in excess of 200 projects in any twelve-month period from a central point is not feasible and would have lead to a large amount of 'red tape' and delays.

In addition, there was no roll over of funds allowed. What was not spent in the allocated year was lost. Regions could not only aim to spend on budget but had to deliver the required number of connections as well. This led to unique challenges, which had to be overcome.

In order to manage the volatile situation whereby the number of connections may vary monthly, political pressures may focus on certain strategic areas and costs and design may vary, it is possible that projects are deferred or cancelled in the early design phase. It is critical that these changes are managed during the year of implementation, to ensure that the overall number of connections at the target cost is met. In order to achieve this, a quarterly rolling-plan review was introduced. Numbers of connections and associated costs are presented quarterly per region. In addition the political and other requests from stakeholders are obtained and incorporated. The cost per connection and number of connection targets are then reassigned and funds allocated to regions accordingly.

In this manner it has been possible for Eskom to meet or exceed both the cost per connection and connection number targets. This is in spite of the cost per connection being reduced by 50% over five years and the connection numbers forcing the connections to be made in more and more remote areas.

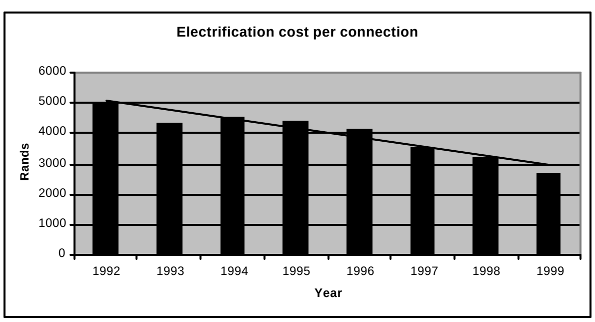


Figure 1: Reduction in cost per connection

TECHNOLOGICAL DEVELOPMENTS

In addition to the process development, which was mentioned in the previous section, it was necessary to develop technical standards and indicators that needed to be applied in electrification projects. In addition, guidelines as to how to apply the standards also had to be developed.

Scott (1992) evaluated a range of line designs with the aim of reducing the cost of rural lines as far as possible, while remaining within acceptable performance limits. A key finding was that the widely-used spacing of 100 metres between poles could in many cases be extended considerably, up to about 160 metres, with the potential for a reduction of perhaps 20% in medium-voltage line construction costs.

Initially Eskom a series of structures and conductor or cable types that were readily available and allowed for easy construction at lower cost. Detailed manuals were produced for this purpose in record time, making use of experts in all regions. Past practices were reviewed and standard practices and designs agreed to. This was no simple task, as those who have been involved in writing the standards would understand. In the Eskom Distribution case, designs and practices that were in place for many years had to be questioned and, where necessary, changed. The end result was a range of 'building blocks', which could be used to design and construct electrification projects as in a production line.

Michie (1995) conducted an investigation into optimal conductor sizes and optimal transformer designs, in order to arrive at a minimum life-cycle cost, when taking into account the cost of losses over the life of a project. The study showed clearly that South African distribution utilities did not place sufficient value on the use of high-quality core steel in the manufacture of small transformers.

Type of electrical supply

With any electrification it is important to create the correct technical options or building blocks to ensure optimal designs are achieved. In Eskom, although each supply was at low voltage and had to comply with 230V +/- 10%, the technology to supply the LV from the transformers could vary from three-phase to dual- and single-phase. It is not the purpose of this paper to describe the detailed differences between the systems, it suffices to state that the three-phase was the most expensive, followed by the dual- or bi- phase and then the single-phase supplies were the lowest cost. The three-phase technology can be utilised in designs of 1,5kVA to 3kVA per household. It is suitable for higher loads but expensive for lower loads, as in the case of electrification. The aim was therefore to reduce the amount of three-phase circuitry to an absolute minimum. Supplies into villages were designed as dual- or single-phase or single-wire earth-return (SWER) systems.

The difference in the three phases to SWER line costs was six to one. Although the three-phase supply could transfer more power, the SWER is in most cases adequate for the load.

In large electrification programs it is not unusual to have up to 200 projects being implemented at the same time. In order to evaluate the designs, which are normally compiled by consultants and contractors, it is essential to have a set of indicators that can rapidly determine if the cost per connection quoted is the optimum level, or if it can be improved upon. In Eskom Distribution, a set of such indicators were derived and used. This enabled a saving of around US$60 per connection, as well as a vastly improved throughput of designs. It was possible to allow only seven staff to assess up to 50 or 60 designs at one time. The indicators catered for the type of supply provided, as well as the utilisation of equipment, which is described in the next section.

Wyatt (1995) carried out an important technical and economic evaluation of various existing technologies for reaching small, scattered loads in rural areas. He came to the interesting conclusion that for a wide range of loads, a two-phase system appeared to be superior to the standard phase-and-neutral design used throughout the rural areas of the USA.

Badenhorst et al (1995) undertook a technical and economic evaluation of using voltages between standard low- and medium-voltage levels (for example, 3.3 kV) to reach scattered homesteads found in settlement patterns in some parts of South Africa. The evaluation showed that the use of an intermediate voltage would be marginally better economically for a certain range of housing and power densities, but that its application would not be sufficiently widespread to justify the introduction of a new technology for those cases.

From the points of view of aesthetics and long-term maintenance costs, underground cables are by far superior to the less costly aerial bundled conductor technology widely used at present. Blignaut and Dingley (1996) looked at whether there are conditions in which the cost difference would be low enough to justify the use of underground cables in place of aerial bundled conductors. Their conclusion was that conditions would sometimes be encountered (for example, in soft sandy soil such as that found on the Cape Flats) in which designers could consider the use of underground cables.

The sizing of low-voltage feeders so as to achieve the lowest life-cycle cost is a surprisingly difficult aspect of electrification planning and design. Ferguson (1999) and Ferguson and Gaunt (2001) studied the tools and methods available to Eskom for solving this problem, and concluded that the so-called Herman Beta method was the most appropriate. This recommendation was accepted by Eskom, and this method of sizing LV feeders has been in use since that time.

Once the building blocks were established, based in part on the research performed jointly, it was necessary to define the parameters by which the networks were to be designed. Initially, the design load used was similar to that used in the previously supplied urban areas. It was soon evident that the load demanded by the inhabitants of electrification areas was far less than initially assumed. The designs had thus moved from 1,5kVA initially to 0,6kVA in 1996 to 0,4kVA in 1998. Obviously some areas are still designed at 0,8kVA or higher, depending on the income in the area.

In addition to the guidelines, it was necessary to devise measures to assist the designers in assessing designs provided by consultants for suitability. At any one time, Eskom staff were required to assess up to 20 different projects. It is not possible to do this without some form of standard guideline.

To this end, a further series of design indicators were introduced. Examples of these were the distance between poles or ‘span length’, the number of connections divided by the installed transformer capacity or the ‘design-demand load’. This linked in with the research results of Scott (1992). These and other indicators enabled assessors to quickly determine whether a design and associated cost provided by the consultant was on target or needed reworking. It is estimated that these measures reduced the cost per connection by approximately 20%. Once these measures were in place, it made the achievements possible.

Continual advances in materials technology change the economic balance between, on one hand, the cost of using higher standard voltages for transmission and distribution lines, and, on the other hand, the advantages of higher line voltages, such as reduced losses and voltage drop. Morarjee and Dingley (2001) describe a computer model that they developed to calculate the life-cycle costs of rural distribution systems as a function of the specified medium-voltage level. The more specific purpose of the work was to assist in determining whether 22 kV or 33 kV should be the standard for rural MV lines in South Africa. The study suggested that consideration should be given to the adoption of 33 kV as the rural medium-voltage standard in South Africa. Results from the model strongly favoured 33 kV for new rural electrification schemes in areas where population (and hence power) densities are relatively high. The longer reach of 33 kV (as compared to 22 kV) lines means that far fewer high-voltage to medium-voltage sub-stations are required, while line losses at 33 kV are less than half those using the same conductor at 22 kV.

Pitamber (2001) used the PBIL algorithm (an advanced form of genetic algorithm) in a computer model designed to find the economically optimum number and placement of sectionalising switches on a given rural network. This type of algorithm is based on simulating genetic mutation. Apart from demonstrating that genetic algorithms can be used to solve optimisation problems across a wide range of fields, this work has provided a tool that can assist distribution-system planners by rapidly producing solutions corresponding to any set of trial parameters.

Revenue management and metering

Before any electrification programme is undertaken it is important that the revenue management and metering technology and systems are decided upon. If this is uncertain, it is important that pilot projects are undertaken to assess the success or failure of a proposed system. One of the main concerns at the start of a programme for rural areas is the ability to bill customers and receive payment for service. In Eskom Distribution it was soon realised that with the low demand of the customer at 30kWH initially, revenue collection needed to be kept to a minimum. The cost of sending and processing a bill by mail would in many cases exceed the revenue collected. In addition, most rural areas have no roads or postal addresses. To mail a bill was impossible. This meant visiting each customer at least once a month in order to deliver the bill and at the same time obtain the revenue. The problem with this was that the customers were seldom at home and repeat visits were required.

In response to a request from the World Bank, Dingley (1991) compiled a report on the functional design, operation and benefits of the electricity prepayment systems that had been developed in South Africa. The submission of this report was followed by a visit to the World Bank, with presentations by one of South Africa's leading prepayment system suppliers. This resulted in South African prepayment system suppliers being awarded contracts for World Bank sponsored projects in various African countries.

In response to proposals made by a national working group in terms of which there would be different tariff structures for low- and high-usage residential customers respectively, Dingley (1996) presented the view that, for a variety of reasons, it would in fact be undesirable for low-usage and high-usage households to be on different tariff structures. This issue is likely to be resolved only with the formation of regional electricity distributors in South Africa.

It was clear early on in the programme that any method of billing was not feasible. A method of prepayment was thus developed with a magnetic card being issued from a vendor that enabled an amount of units to be purchased as and when the customer could afford it. The card could only be used for a particular meter. In this way it was possible to determine which customers had not purchased power for a while, and they could be visited to ensure that no bypassing of meters was taking place. In addition, meters were installed at each village to determine the technical losses and to balance the remaining energy transmitted with the energy purchased. It was thus possible to determine the percentage of non-technical losses in the village.

In spite of these devices, non-technical losses still pose a problem. Different technologies such as remote metering, split meters or placing meters on the outside of houses need to be looked into.

Safety issues

Dingley (2000b) undertook an international review of approaches among other utilities to the problem of ‘low-hanging conductors’. This research was motivated by Eskom's commitment to high levels of public safety. It addressed the difficult problem of reducing the possibility of accidents caused by contact with wood-pole lines that have been blown over but are not touching the ground, a condition that cannot be detected by conventional protection equipment. This is a particular problem in newly electrified rural areas, where people are unfamiliar with electricity, and the lack of telephones makes it difficult to report faults quickly. This international review indicated that no technical solution had been developed elsewhere, and that the usual approaches to this problem are regular inspection of wood-pole lines, and high-profile public education programmes to warn people of the dangers of touching power lines.

Appliances for customers

As input to Eskom's Efficient Lighting Initiative (subsequently implemented by Bonesa,) Kika et al (1999) looked at various technical aspects of compact fluorescent lamps (CFLs), (such as the generation of harmonics and the performance of CFLs under varying voltage conditions), as well as at the economics of the use of CFLs in low-income households. High-order harmonics (up to the 31st) were detected. The study included work on the theoretical aspects of harmonics, but was unable to predict what the effect of the harmonics would be on a distribution system. The economic study showed that clear savings were available through the use of CFLs.

Dingley and Bredenkamp (2001) took this work further in a paper that presented projections of the cost of a programme for the widespread household use of CFLs in the countries of sub-Saharan Africa. They also analysed the benefits in terms of reduced energy consumption and generating capacity requirements as domestic electrification proceeds in the region. They showed that a large-scale programme aimed at all households in the region could at present reduce the region's peak demand by 2 000 to 3 000 MW. The cost of the CFLs would be considerably less than the saving in generating-plant costs.

The inability of many households to afford all but basic appliances means that they cannot fully benefit from their access to electricity. Dingley (1999) reported on refrigerators in particular, as they offer significant benefits in terms of diet, expenditure on food, and quality of life. A major finding was that basic units were more expensive in South Africa than elsewhere. The lowest retail price of a basic 55-litre model in South Africa was almost exactly twice the price (at the then exchange rate) at which similar units were available from a retail chain in the US. Arising from discussions with the appliance industry, the report proposed an initiative to make available basic units for the low-income market. There is currently consideration of such an initiative.

A significant contributor to electricity wastage is so-called 'electricity leakage', that is, the drawing of power by electronic appliances while in standby mode (such as television sets with remote-control circuitry that remains energised). The work of Mawasha and Dingley (2000) tied in with studies being undertaken by the US Department of Energy into this problem. Those studies showed that a US household could typically draw some 50 watts of standby power, and about double that if a computer was left powered on, suggesting a total standby load in the US upwards of 5 000 MW. In response to this situation, the US DoE has embarked on a 'one watt' campaign to encourage energy-efficient design of standby circuitry. (Designers are being encouraged to design circuitry that draws no more than one watt when in standby mode, which is a fraction of the current norm.) Although conditions in South Africa are obviously somewhat different to those in the US, the study showed that some South African households would draw a similar level of standby power to that drawn by US households, and that the standby load in South Africa could be of the order of 100 MW.

CONCLUSION

In summarising the practices of the past, it was the introduction of a detailed planning, design and project-management process as well as detailed standard technical building blocks and indicators, that have made the achievement of 1,5m connections in five years with an accompanying 50% reduction in cost possible.

Eskom therefore have built on their experience to identify the following process to assist with future electrification programmes:

- The first step is to develop processes for the industry, to ensure the up-front planning, critical to electrification, is in place.
- The second step is to work with the standards organisations to ensure the technology is in place.
- The third step is to ensure the tariffs are in place to enable the poorest of the poor to afford electricity. It should be noted that this does not mean a free supply, but a supply tailored to the needs and means of the customer.
- The fourth step is to embrace and investigate the introduction and use of non-grid as a supply option.

This process has been successfully implemented and refined and now forms the basis for future electrification programmes.

REFERENCES

Badenhorst C, Dingley CE and Ferguson I (1995). *An investigation into the use of an intermediate voltage for rural electrification.* SA Universities Power Engineering Conference, Pretoria.

Blignaut CG and Dingley CE (1996). *A comparison of aerial bundled conductor and underground cable for low-voltage mains in urban electrification projects.* SA Universities Power Engineering Conference, Johannesburg.

Dingley CE (1987). *Some issues related to the electrification of the underdeveloped areas of South Africa.* SAIEE Conference on Cost Effective Power Distribution and Reticulation, Pretoria, August.

Dingley CE (1988). *A review of electrification programmes in six countries.* University of Cape Town. ISBN 0 7992 1245 8.

Dingley CE (1990a). *Electricity for all in South Africa: the need and the means.* University of Cape Town. ISBN 0 7992 1262 8.

Dingley CE (1990b). *A rapid electrification programme for South Africa: an exploration of the constraints.* Report prepared for Nedcor and Old Mutual.

Dingley CE (1991). *Electricity pre-payment metering systems using encoded tokens.* Report prepared for the World Bank.

Dingley CE (1994). *South Africa's electrification programme: design approaches and new technology.* Conference of the Association of the Electricity Supply Industry of East Asia and the Western Pacific, Christchurch.

Dingley CE (1996). *Tariff options for domestic users.* Conference on the Domestic Use of Electricity, Cape Town.

Dingley CE (1999). *An investigation into the availability of low-cost domestic refrigerators*. Report prepared for Eskom.

Dingley CE (2000a). *What will it take to meet the need for electricity in sub-equatorial Africa?* Power Economics 4(5).

Dingley CE (2000b). *An international review of the problem of low-hanging conductors on overhead lines.* Report prepared for Eskom.

Dingley CE and Bredenkamp B (2001). *The potential impact of an efficient lighting programme in Sub-Saharan Africa.* Conference of the International Electrical Research Exchange, Cape Town.

Ferguson IA (1999). *Exploring the relationship between cost-effective rural electrification and low-voltage network sizing tools in South Africa.* MSc thesis, University of Cape Town.

Ferguson IA and Gaunt CT (2001). *LV network sizing in electrification projects - replacing a deterministic method with a statistical one.* Distribution 2001 Conference, Brisbane.

Kika J, Umley H and Dingley CE (1999). *An investigation into the technical and economic aspects of compact fluorescent lamps.* SA Universities Power Engineering Conference, Potchefstroom.

Mawasha B and Dingley CE (2000). *Standby power consumption of electronic appliances.* SA Universities Power Engineering Conference, Durban.

Morarjee N and Dingley CE (2001). *Determination of the optimum voltage level for rural medium-voltage distribution systems.* SA Universities Power Engineering Conference, Cape Town.

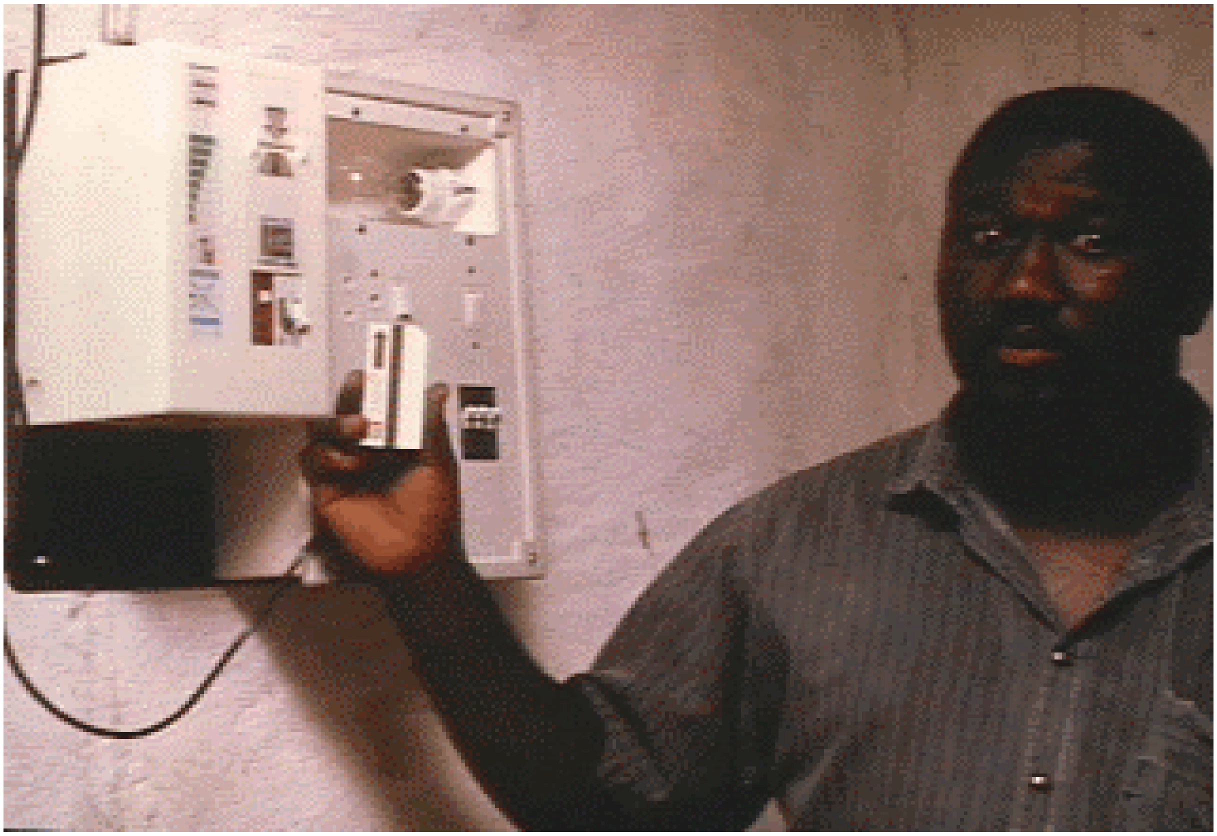
Michie SD (1995). *A study of the life-cycle costs of distribution transformers and low-voltage feeders in urban electricity distribution systems.* MSc thesis, University of Cape Town.

Pitamber N (2001). *The optimal placement of switching devices on rural medium-voltage systems.* MSc thesis, University of Cape Town.

Scott RA (1992). *Evaluation of pole-top designs for 22 kV rural distribution lines.* MSc thesis, University of Cape Town.

Tobich RG (1989). *The electrification of underdeveloped areas: a case study in Ciskei.* MSc thesis, University of Cape Town.

Wyatt GM (1995). *An investigation into optimal medium-voltage system design for rural electricity distribution in South Africa.* MSc thesis, University of Cape Town.



Chapter 4

Financing Electrification Schemes

This report has been compiled from reports by M. Davis[1]

[1] Formerly University of Cape Town

Financing rural electrification is a complex problem, influenced by many factors, including the economic status of the community and the cost of connections.

THE FINANCIAL AND ECONOMIC VIABILITY OF ELECTRIFICATION PROJECTS

The paper *A financial and economic analysis of two electrification projects* by Davis (1997), details the results of financial and economic analyses of two rural electrification projects undertaken by Eskom. It provides insight into the financial viability of rural electrification projects.

Two electrification sites were chosen for a detailed financial and economic analysis. Loskop, in KwaZulu/Natal, is a community of around 1000 households and has been completely electrified over the past few years. The electrification project has primarily been reticulation infrastructure. Mafefe, in the Northern Province, is a dispersed area containing over 30 villages. Of these, four settlements were electrified in the first phase of the project by means of a 22km extension of the grid. Approximately 650 households received electricity as a result.

The methodology used for the financial and economic analysis was a cash-flow model, which calculates the net present value (NPV) of annual cash flows, taking into account a range of costs, revenue and other benefits. In the economic model, additional benefits incorporated into the analysis were the consumers' surplus, as well as health and safety benefits associated with reduced fire hazards and paraffin poisoning. Additional economic benefits may well exist, but these have not been incorporated into the model. The results indicate that the projects are not financially viable for the utility, and that the total net present value of required subsidies is in the order of R2 000 and R4 000 per household (for Loskop and Mafefe respectively). In the case of Loskop, the prepayment meter option appears to require the lowest subsidies, while all three options produce similar results in Mafefe. The difference between the two sites can be mainly attributed to the 22km grid extension required at Mafefe and the fact that the community is significantly smaller.

Table 1: Financial and economic net present value of the projects

Source: Davis (1997)

	Financial NPV per connection		Economic NPV per connection	
	Loskop	Mafefe	Loskop	Mafefe
Prepayment	(R2 200)	(R4 100)	R3 000	R2 100
Load-limited*	(R2 500)	(R4 000)	R1 600	R1,000
Solar systems	(R3 950)	(R3 950)	(R1 350)	(R1350)

Note (*): a. Refer to chapter 5 for a discussion of the load-limited option piloted in Mafefe.

The economic analysis reveals that both projects are economically viable for grid electrification, with high rates of return. This can mainly be attributed to the estimation of fairly substantial positive externalities, primarily health and safety benefits, as well as a consumer's surplus. It can be seen that for both projects the prepayment system generates the most economic value, due to the greater benefits associated with the use of a wider range of end uses/services.

The analysis of the conditions under which each supply technology is optimal, has shown that load-limited supplies are preferred, from the utility's perspective, at consumption levels of less than 150 kWh/month per customer and relatively short distances from the grid. For consumption levels higher than this, prepayment systems generate fewer losses. At low consumption levels (less than 50 kWh/ month), off-grid supplies are optimal for even very short distances from the grid (as little as 20m per connection). Where consumption is higher, off-grid systems only become financially attractive to the utility in the case of communities which are further from the grid. If the same analysis is performed from an economic perspective, it is apparent that prepayment metered supplies are optimal over a much greater consumption and distance range, that the niche for load-limited systems is restricted to lower consumption levels, and that off-grid systems are optimal at only much greater distances from the grid.

THE FINANCIAL OF RURAL ELECTRIFICATION

The paper *The financial impacts of rural electrification* by Davis (1996), reports on a modelling exercise undertaken to investigate the financial impacts of the national rural electrification programme. It details the levels of subsidy required to sustain the programme.

The results from a modelling of future capital costs were used, together with the connection profile and assumptions regarding tariffs, other costs and consumption growth, to construct a cash-flow model of rural electrification for the country. The resulting cash-flow was then used to analyse the net present value and required subsidy for rural electrification. The key results are:

- If the proposed connection targets are met outside main urban areas, then access to electricity in these areas will reach 50% by the year 2000, and 67% by 2010.
- Average capital costs are R4 740 per connection, and there is a clear trend towards higher costs as the programme progresses. If capacity-differentiated supplies are not used, capital costs increase, on average, by 30%. The cost penalty is particularly severe towards the end of the programme as more remote locations are reached.
- The NPV of the programme is highly negative at negative R13.8 billion, which is equivalent to negative R3 500 per connection. A sensitivity analysis showed that this result is strongly sensitive to capital costs, although the NPV remains negative even if capital costs decline by 30%.
- If all financing requirements are met through debt, then the total accumulated debt in 2011 will be R38 billion, equivalent to R9 500 per connection. This debt is over three times the depreciated value of assets at this time (where assets are depreciated over twenty years).
- An average subsidy of 17c/kWh, or R32 per customer per month, would suffice to keep debt within acceptable levels. If no debt is allowed at the end of the programme, then much higher subsidies are required – in the order of R1.2 billion per annum.
- Financial indicators for urban areas show a 20-30% improvement over those for non-urban areas, as shown in the table below.

Table 2: Comparison of urban and rural electrification

Source: Davis (1996)

	Rural	Urban	Difference
Ave capex/connection	R 4 740	R3 850	20%
NPV/connection	R3 500	R2 280	35%
Subsidy/connection	R32/month	R22/month	30%
Subsidy/kWh	17c/kWh	11c/kWh	27%

As is widely believed, rural electrification is not financially viable, and extensive subsidies are required to cover losses. This analysis has quantified the extent of these subsidies, and has shown that it is capital costs, rather than operating losses, which drive the financial impact of the programme. This suggests that major cost-saving gains are to be made in considering innovations in supply technologies rather than in operating procedures.

CONCLUSION: THE NEED OF A NEW FINANCING MECHANISM

While rural electrification has the potential to offer net economic benefits, it is clear that at existing tariffs most projects are not financially viable. The viability of rural electrification to date has hinged on extensive cross-subsidisation within Eskom. Not only is the continuation of cross-subsidies questionable in the context of market liberalisation and Eskom restructuring, but proposals to restructure the distribution industry into a small number of regional electricity distributors threatens to strand certain REDs in financially unviable positions. For electrification to continue beyond 1999 new financing arrangements need to be established which do not prejudice industry restructuring initiatives. However, the new electrification planning and management system, which provides for subsidies from government, has probably addressed this.

The above work was carried out in 1996 and the recommendations were taken into account. Eskom became a tax paying company in 2000. Funding is now entirely from the fiscus for the capital portion of the electrification programme. Investigations are also currently underway on an electrification levy to be used to compensate service providers (and hence the customers) for losses that may be incurred with regards to operating costs.

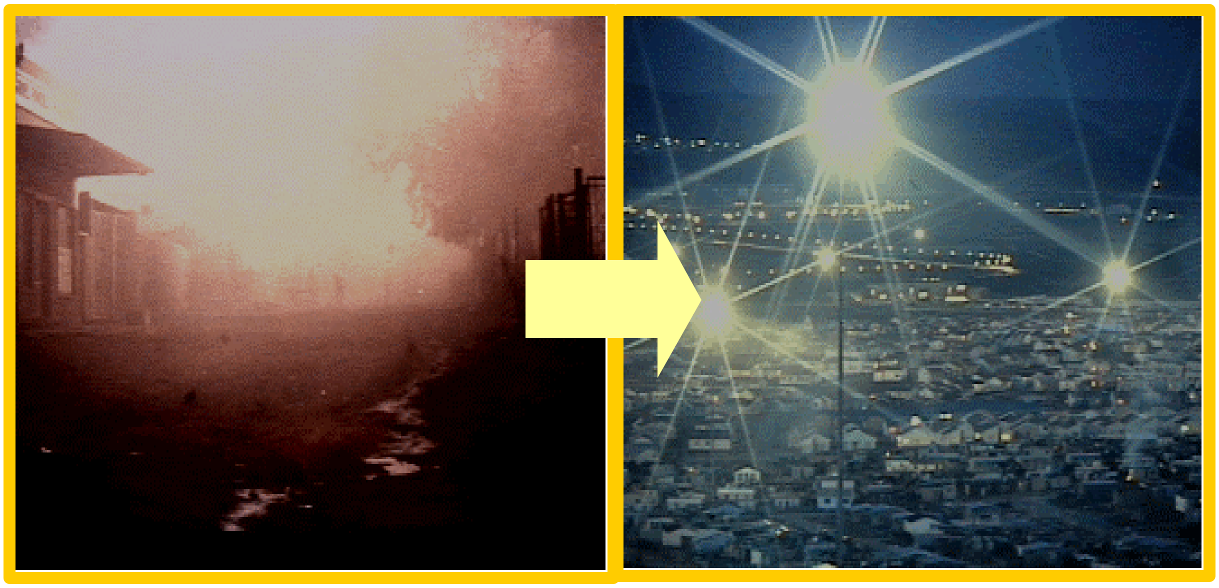
REFERENCES

Davis, M 1996. The financial impacts of rural electrification. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Davis, M 1997. A financial and economic analysis of two electrification projects. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Davis, M 1998. Cross-subsidies and sensitivities: Further analysis of sustainable financing of electrification in South Africa. Accompanying paper to Van Horen & Thompson (1998). REIPERA project. Energy & Development Research Centre: University of Cape Town:

Van Horen, C & Thompson, B 1998. Sustainable financing of electrification in South Africa. REIPERA project. Energy & Development Research Centre: University of Cape Town.



Chapter 5

Impacts of Electrification: Maximising the benefits of rural electrification

Cecile Thom[1] and Bronwyn James[2]

[1] University of Cape Town [2] Formerly University of Cape Town

While electrification can make a substantial contribution to rural development, its full benefits may not be realised. Interventions are necessary to enhance the impact of electrification, including greater coordination with other services and productive sectors.

INTRODUCTION

South Africa embarked on a large-scale rural electrification programme in the early 1990s. As discussed in Chapter 1, Eskom and other distributors had adopted and met the target to connect 2.5 million homes from 1994 to 1999. Eskom committed itself to connecting 1.75 million homes as part of this programme. More than 400 distributors were supplying grid electricity in South Africa in the mid-1990s. Most of these were municipal electricity departments.

The years 1995 to 1998 were important in terms of formulating a new energy policy for democratic South Africa. Research was required to inform government policy on rural electrification. For this purpose, a three-year research project called *The role of electricity in the integrated provision of energy to rural areas (*REIPERA) was undertaken by the EDRC from 1995 to 1998.[1] The main funder of the project (providing about 50% of the funds) was the Norwegian Agency for International Development Co-operation (NORAD), while Eskom and the South African Department of Minerals and Energy (DME) each funded about 25% of the project.

One of the aims of the REIPERA project, was to establish what the objectives of the South African rural electrification programme should be, and what strategies were needed to achieve these objectives – that is, to maximise the benefits of the rural electrification programme. This chapter presents a summary of the findings of the project in this regard. It draws on a large number of research papers written as part of the project, which are listed under References.

Defining 'rural' areas

As this chapter is specifically concerned with rural electrification, it is necessary to explain briefly what is meant by the term 'rural'. At the time of the first democratic elections in 1994, the official definition of 'urban' areas in South Africa included proclaimed urban areas only, thus excluding most informal settlements (that is, areas often referred to as peri-urban in nature), even those bordering on proclaimed urban areas. Many fairly large and densely populated settlements, particularly in the former 'independent' homelands, were also excluded from the definition of urban areas. As a result the term 'rural' as used in this chapter refers to areas that vary greatly in size and density, including informal settlements that border on small towns, large sprawling peri-urban settlements located in the homelands, remote rural villages, and scattered homesteads on tribal land in the homelands and on commercial farms (Thom 1997).

[1] This chapter is an expanded version of a paper by Thom (1998).

ELECTRIFICATION OF HOUSEHOLDS

In this section the findings of research on household-level impacts during this project are summarised. The impacts of electricity at a household level are discussed in more detail in Chapter 6, based on research conducted in two rural areas after the completion of the REIPERA project.

Eskom's approach to household electrification

Eskom has been responsible for most of the electricity connections in rural areas. An important characteristic of Eskom's electrification programme has been the fact that the majority of households in a settlement are typically electrified because of the relatively low connection fee charged. The connection fee for a standard connection (currently 20A) is much lower than the actual cost of providing the connection. All households in a settlement who pay the connection fee and fall within the boundaries of the project (that is, those who can be electrified at a reasonable cost) are provided with an electricity connection.

Since 1999, Eskom has further widened access by providing households that are unable to pay the connection fee with a 2.5A supply, which enables them to use electricity for lighting, radios, television and refrigeration. Although no connection fee is charged for a 2.5A supply, the energy charge is the same as for a 20A supply, but there are no fixed monthly charges for either a 2.5A or 20A supply and both levels of supply are provided with a prepayment meter. This approach has meant that many poor households have been able to benefit from an electricity supply. It has also meant that all households in villages can be provided with an electricity supply at a lower cost per connection (Pers comm Rob Stephen).

Household use of electricity in rural areas

Appliance ownership in rural areas

Data on the ownership of electrical appliances in rural areas is presented in Table 1. This has been drawn from an analysis done during this project on data collected in the *Project for statistics on living standard and development* (PSLSD) (Davis & Ward 1995).

Some information on electrical appliance ownership and use was obtained in a post-electrification study in Loskop (a rural settlement in KwaZulu-Natal), conducted as part of this project (Hansmann et al 1996). A small quantitative survey was undertaken in an area where households had been electrified for two years or more. The information pertaining to electrical appliances is presented in Table 2. It is particularly interesting to compare the percentage of households that use appliances frequently with the percentage that own the appliances concerned. A significant percentage of households that own an electric stove or hotplate do not use these frequently for cooking purposes. The difference is even more striking in the case of electric heaters.

[1] Research done concerning the 2.5A supply is discussed later in this chapter.

[1] Some of the information presented here has been published in an article by Thom (2000).

Table 1: Appliance ownership among electrified households in rural areas
Source: Davis and Ward (1995)

	% of all households	% of households with per capita[a] monthly income of:		
		<R130	R130-270[b]	>R270
Geyser	5	0	2	8
Stove/hotplate	37	10	27	53
Kettle	32	12	25	45
Fridge	43	12	28	65
Television	47	19	33	67
Radio/hi-fi	87	79	85	91

Notes: a.Average household size was about 5.5. b. Estimated minimum monthly expenditure to satisfy basic needs was about R270 per capita. c. R = South African Rand

Table 2: Ownership and use of electrical appliances by households in Loskop electrified for 2 years or more[a]
Source: Compiled from Hansmann et al (1996)

Service	Households using it frequently (%)	Households using it occasionally (%)	Households using it (total) (%)	Households owning appliance (%)
Lighting	94	0	94	-
Radio/hi-fi	77	0	77	84[b]
Refrigeration	48	0	48	48
Television	42	3	45	52[b]
Ironing (iron/hotplate)[c]	61	10	71	65 (electric iron)
Water heating (kettle/hotplate)[c]	32	16	48	45 (electric kettle)
Cooking (hotplate/stove)	29	13	42	3 (stove) 45 (hotplate)
Space heating	3	3	6	16 (heater)

Notes: a. A sample of 30 was used, chosen randomly as far as possible within practical constraints. b. These figures may include some radios and televisions operated with batteries – for example, 3% of the sample (one household) indicated that they frequently used car batteries to operate a television. c. The percentage of households using electricity for ironing and water heating probably include households using a flat-iron and simple stove-top kettle respectively, heated on a hotplate.

Use of electricity for lighting

Electrified households commonly use electric lighting. However, research done in this project indicates that a significant percentage of electrified households continue to use other fuels – particularly candles, and to a lesser extent paraffin lamps – for lighting purposes. Davis and Ward (1995) found that as much as 60% of the electrified sample in rural areas used candles and paraffin for lighting in addition to electricity, while about 20% used electricity only, and about 18% used candles and/or paraffin only (no electric lighting).

A number of factors have an impact on the use of electric lighting, as indicated by some qualitative post-electrification studies conducted during this project. At both Tambo village in the Eastern Cape and the Mafefe Tribal Area in the Northern Province where a 2.5A supply was piloted, candles and paraffin were still being used substantially for lighting about six months after electrification (Wentzel et al 1997; James & Ntutela 1997). The main reason for this was that electric lighting was not available in all the rooms in houses (James 1997). Eskom generally provides households with a 'ready board' comprising a light fitting and some sockets, which allows households immediate access to electricity without the expense of formal house wiring, while reducing the reticulation cost to the utility. The disadvantage of this approach is that the light fitting and sockets are located in a specific room. Households unable to extend wiring to other rooms themselves have to employ someone with the necessary skills to do this. They are not provided with any assistance as far as house wiring is concerned – for example, in the form of information brochures or training. Extension cords are often used to 'wire' houses informally.

A survey conducted at Tambo found that about 76% of households had electric lighting in one room only, while about 14% had lights in two rooms, and only about 10% had lights in more than two rooms (James & Ntutela 1997). This was apparently because of the cost of materials for informal wiring, as well as the cost of installation and the limited availability of people with the necessary skills. In very poor households at both Tambo and Mafefe, no wiring of additional rooms had occurred (James 1997). The placement of the ready board in the home clearly becomes an important consideration under these circumstances. In some cases, electrification contractors consult households about the placement of ready boards, but this is not always the case.

The research in Tambo and Mafefe was conducted about six months after the electrification of these villages. The findings therefore need to be compared with studies done in areas which had been electrified for a longer period. In a longitudinal study on energy use in Kameelrivier B – a peri-urban area in Mpumalanga province – Palmer (1999) found that 79% of households relied solely on electricity two years after electrification, while 21% were using it in conjunction with other fuels. The main reason for continuing to use other fuels, and candles in particular, seemed to be that not all rooms had been provided with electric lighting, thus confirming the findings in the Tambo and Mafefe studies.

As shown in Table 2, about 6% of households in Loskop (KwaZulu-Natal) that had been electrified for two years or more showed that they did not use electric lighting at all. The majority of the sample (94%) all used electric lighting frequently. More information on households' use of electric lighting emerged from qualitative interviews undertaken in Loskop.[2] Electric lights were generally available in all rooms of the main dwellings (as opposed to additional outbuildings that form part of the homestead) of the households included in the qualitative sample. Most of these households also had an outside electric light. Candles, and occasionally paraffin lamps, were used in outbuildings and when power failed (Annecke 1996). The wiring of the houses was in most cases done by family members and sometimes by neighbours, and was therefore probably not very costly to households.

Use of electricity to power radios

A large percentage of rural households own radios. For example, Davis and Ward (1995) found that 74% of unelectrified households and 87% of electrified households in the PSLSD sample owned radios. In the absence of grid electricity, radios are mostly powered with dry-cell batteries. It seems that unelectrified households generally buy radios that can be operated on batteries only, without the option to use grid electricity. At both Tambo and Mafefe, none of the households interviewed in the qualitative research were able to power their small radios with electricity (James 1997). For example, in Tambo eight households included in the qualitative sample (a total of seventeen households) owned radios in working condition, none of which could be operated with grid electricity (James & Ntutela 1997). Only hi-fis could be operated from the grid.

Findings in metropolitan areas in the Western Cape have been similar, with significant

[2] The qualitative sample was smaller and differed substantially from the quantitative sample (Thom 2000).

percentages of electrified low-income households using dry-cell batteries to power radios. The use of dry-cell batteries in these electrified households occurs because ownership of battery-operated radios dates back to the pre-electrification period (Mehlwana & Qase 1999).

In Loskop the majority of households in the quantitative sample (77%), which had all been electrified for more than two years, were using radios and/or hi-fis operated on grid electricity. Nevertheless, a significant percentage of households (32%) still used battery-operated radios, with 19% using them frequently, and the rest using them only sometimes (see Table 2). About 10% of households indicated that they did not own a radio or hi-fi. Clearly there were people who used both batteries and electricity to operate their radios – one reason is probably that batteries are needed if radios are used a distance away from available sockets (outside of houses, for example).

The cost of dry-cell batteries is extremely high in relation to the energy delivered, and some studies have found that dry-cell batteries form a significant component of households' energy expenditure (up to 30-40% in some unelectrified villages) (Griffin et al 1992). Furthermore, James and Ntutela (1997) found that the energy expenditure of households in Tambo that got a 2.5A electricity supply (for which they had to pay a fixed charge of R15 per month) had increased significantly in cases where electricity had not displaced other fuels for lighting, or batteries for radio and television. Dry-cell batteries for radios seemed to have the greatest impact on household budgets under these conditions, because of their expense.

Research among farm workers in the Free State found that in addition to not having mechanisms to run their radios on electricity, farm workers did not realise that they might be able to power their radios with electricity, nor did they have the money to buy new radios, which could run on electricity (Hofmeyr 1996, cited in James 1997). The expenditure on batteries was found to be high, especially when considered as a proportion of wages.

Use of electricity for cooking

Qualitative studies done during this project indicate that cooking with electricity is important to many rural households, even if cooking is not done exclusively with electricity. The study in Tambo indicated that many people value the use of electricity for cooking. For example, some women in Tambo saved money from their earnings under difficult conditions in order to purchase cooking appliances, thereby demonstrating their determination to cook with electricity. Furthermore, 75% of the households in the quantitative sample in Tambo that chose a 20A supply, did this because they wanted to be able to use electricity for services not available with a 2.5A supply, such as cooking (James & Ntutela 1997). They therefore prioritised the expenditure on the connection fee (R200 in Tambo village in 1996) for the 20A supply. Similar cases were found in Mafefe in spite of the fact that households had to pay a connection fee of R450 and a monthly service charge of R37 in order to obtain a level of supply that would enable them to use electricity for cooking (James 1997). These households did not necessarily belong to a high-income group. In fact, in Tambo, households reliant on one pension or less per month also prioritised expenditure on hotplates or stoves, so that electricity could be used for cooking (James 1997). James and Ntutela (1997) point out that, even in cases where a hotplate is used only for food which can be cooked speedily, the service of cooking with electricity can be highly valued.

The importance attached to cooking with electricity was also evident in Loskop, where only two of the thirteen households included in the qualitative sample had no electric stove or hotplate (Hannsman et al 1996). A significant number of these households (seven) had bought electrical cooking appliances before any other appliances, and in two cases, hotplates were the first and only appliances bought by households. Households with a variety of demographic and gender characteristics (for example, male and female household heads and/or income-earners) as well as incomes were included in this sample.
Nevertheless, while many households regard cooking with electricity as a priority, it is true that those who purchase electric hotplates and stoves often do not use these for all or even most of their cooking activities. Davis and Ward (1995) found that a third of electrified households in the rural PSLSD sample used electricity for cooking (also see Table 1). Only higher-income households however, were likely to use electricity as the sole fuel for cooking (26% of these households). Most of the middle- and lower-income households used electricity in combination with other fuels such as wood and paraffin. The quantitative survey in Loskop found that 29% of households used electricity frequently for cooking, while an additional 13% occasionally used electricity to cook (see Table 2). Although most households in the qualitative sample in Loskop owned electric cooking appliances, there did not seem to be much evidence of the displacement of other fuels by electricity (Annecke 1996, cited in James 1997). It was found that stoves used before electrification (utilising wood, paraffin or gas) were still in use in all the households. Similar results were found at both Tambo and Mafefe in

households which had acquired hotplates and stoves. None of the households had switched entirely to electricity, and other fuels were still used in conjunction with electricity (James 1997). It should be pointed out that not all households want to cook with electricity. In Loskop, the households which consisted of men only, tended not to have electric stoves, as well as households which considered themselves to be too poor or did not like electricity for cooking (Annecke 1996, cited in James 1997). Some people in Tambo also indicated that they were not interested in cooking with electricity, but were happy with wood and paraffin (James & Ntutela 1997). This attitude was prevalent among older women pensioners and households that consisted of men only.

Multiple fuel use

Multiple fuel use – the use of more than one fuel for household purposes – is a key feature of energy use among lower-income households in South Africa, including electrified households. The National Domestic Energy Use Database indicates that about 68% of all households (electrified and unelectrified) use combinations of two or more fuels, with many households (about 30%) using three fuels (Afrane-Okese 1999). Davis and Ward (1995) found that most electrified households (39%) in rural areas use three fuels in combination to meet their energy needs (mostly wood, paraffin and electricity), while the use of four or more fuels is also very common (29%). As most unelectrified rural households use two or three fuels (34% and 56% respectively), it would seem that electricity does not always replace other fuels, but generally adds to the fuels used by rural households.

It is further likely that most electrified rural households will remain heavily dependent on fuels other than electricity (particularly wood and paraffin) for thermal purposes in the foreseeable future. One of the most interesting phenomena in post-electrification energy use among low-income households is the persistence of paraffin as a fuel, particularly for purposes other than lighting. One of the factors contributing to the continued use of paraffin is the view that it is cheaper than electricity for cooking and water heating.

A general trend towards using paraffin for time-consuming cooking processes has been found in areas such as Loskop and Tambo. Cooking processes such as simmering were seen as expensive by households in Loskop, and paraffin was preferred, because it was regarded as cheaper than electricity (Hansmann et al 1996). By comparison, the speed of cooking food was regarded as one of the main advantages of cooking with electricity – it was thus sometimes used exclusively for dishes that require quick, intense heat inputs such as frying (Hansmann et al 1996; James & Ntutela 1997). Coupled with this, were some forms of behaviour that probably added to the experience that electricity is expensive for cooking purposes. For example, some people tended to use electric hotplates on the highest setting all the time, without reducing the heat once the food is boiling. One of the reasons given for this was that they thought it was more expensive to use all the settings on the hotplate (Annecke 1996).

The impact of electricity at a household level

Annecke (1998) conducted an analysis of the impact of electrification at a household level, based on household studies done in South Africa during this project. She considered a range of potential benefits, which have been identified in the international literature. Her assessment of the contributions made by electricity to rural people's lives is summarised in Table 3.

Table 3: Contribution of electricity to people's lives in rural areas
Source: Adapted from Annecke (1998)

Potential benefit	*Does electricity contribute to this?*
Improved living standards	Qualified yes
Improved quality of life	Yes or a qualified yes
Reduced domestic burden for women	Uncertain, likely for some
Time saving	Uncertain
Improved communication	Uncertain
Lighting for 'longer days'	Qualified yes
Improved education through providing lighting for evening study for school children and adult learners alike	Uncertain, towards positive
Improved education and educational services	Uncertain
Lowered fertility rates	Uncertain
Reduced crime rates / improved safety (perceptions)	Qualified yes
Environmental benefits, such as alleviating the pressure on local wood resources	Uncertain, dependent on income
Reduced urban migration	Uncertain, unlikely
Improved political stability and security of rural communities	Uncertain
Improved health and safety	Qualified yes

In addition, Rogerson (1997) found that electrification seems to result in an initial boost of 'survivalist'[3] micro-enterprises (generally in the retail and services sectors), which is often linked to the use of refrigeration. These micro-enterprises may form an important element of some households' strategies to reduce vulnerability under circumstances of extreme poverty (Moser cited in Thom (1997)).

Both Annecke (1998) and Rogerson (1997) also point out some potentially negative effects of electrification; for example, the dangers of shocks or electrocution when people do their own wiring with no training, and the burden placed on limited household budgets by appliance hire- purchase schemes.

Finally, an interesting perspective is provided by Crawford Cousins (1998), who argues that electrification has considerable symbolic value in South Africa.

> Electrification is a potent symbol of access to 'development' and 'modernity'. The perception of being valued enough to be electrified – with the implicit promise of other improvements to follow – should not be underestimated. The belief that change is possible, and that its symbol is the delivery of household electrification, may be of great psychological benefit to Mrs Mohlamonyane[4] in her 'difficult' life. Rural household electrification, then, may be an important investment in the 'politics of hope'; that which sustains people and continues to encourage positive action towards social transformation. (Crawford Cousins 1998)

While we do not yet know exactly what all the impacts of electricity on households are, and are not able to quantify many of the impacts, both the direct and symbolic value of electricity seem to be significant.

Enhancing the impact of household electrification

A crucial point that emerged from this project is that the potential benefits of electricity for rural households may not always be fully realised. This is evident from the discussions in previous sections. As a result much of the work done during the project was aimed at developing policy and strategies to address this situation.

Enabling greater use of electricity services

As discussed above, many changes that seem reasonable to expect as a result of household electrification, such as the replacement of candles and paraffin lamps with electric light, and the use of electricity rather than dry-cell batteries to power radios, are occurring to some degree only. The reasons for this seem to be a lack of information, know-how and financial resources. This is of concern, particularly because of the extremely high costs of dry-cell batteries and to a lesser extent paraffin, which will continue to impact on the monthly energy expenditure of poor households.

If this problem is to be addressed, it needs to be specifically targeted. One of the objectives of a rural electrification programme therefore, needs to be to ensure that as many electrified households as possible gain access to the most basic benefits of electricity – the use of electric lights and radios. Although poverty presents a serious obstacle to realising all the benefits of electricity, there are some mechanisms – some of a very basic nature – that could serve to facilitate a more significant conversion to electric lighting and grid-operated radios among poor households in the immediate future. For example, the conversion to electric lighting could be facilitated through the training of community-based organisations or informal entrepreneurs, including local women, to do the basic wiring of houses (Thom 1998).

The conversion to electricity for cooking and heating purposes is a much more complex problem for poor households than the conversion to electric light. An important finding of this project is that, contrary to the general perception, many poor rural households do regard the use of electricity for cooking purposes as very important, even if cooking is not done exclusively with electricity. Furthermore, the impact of electricity at a household level – particularly on women and girls – is likely to increase considerably if electricity is used for cooking and other domestic work, and not only for lighting and media.[5] The electricity supply options provided to poor households, need to be designed to facilitate as far as possible the use of electricity for domestic work by poor households who desire this.

3 Refer to discussion on the role of electricity in the development of the SMME sector.

4 Mrs Mohlamonyane is a hypothetical poor rural woman used by Crawford Cousins to discuss issues concerning household electrification in a more personalised way.

5 James (1997) argues in this regard that it is important to meet women's practical needs in the process of development and empowerment, even though this may seem to support unequal gender relations.

While the impact of electrification on rural people could be enhanced by various measures, it is nevertheless expected that most electrified rural households can remain heavily dependent on fuels other than electricity (particularly wood and paraffin) for thermal purposes in the foreseeable future. It is therefore crucial that initiatives to address the problems of rural households around the use of fuels such as wood, paraffin and liquid petroleum gas (LPG) for thermal purposes, and to find ways to reduce the consumption of these fuels while achieving the same cooking objectives, be given specific attention in energy policy.

Providing appropriate supply options and tariffs

Eskom introduced the 2.5A electricity supply option, because of the reduction in capital costs that it offers in rural areas. It effectively limits the power that can be drawn by a user, to about 560W. This prevents the use of most thermal appliances, although kettles and irons that can be used with a 2.5A supply are available. As electricity consumption is effectively limited by the 2.5A circuit breaker, the option was originally introduced without any metering. Instead, households paid a fixed monthly fee.

Eskom piloted the 2.5A supply in 1995 in Mafefe and Tambo. Research was done on the social impacts of implementing the 2.5A supply in Tambo and Mafefe (James & Ntutela 1997; Wentzel et al 1997). It was concluded that the 2.5A supply is a suitable option for the very poor, as long as it is provided with a prepayment meter, and does not require fixed monthly payments. The research found that the fixed payment resulted either in households being unable to use their electricity supply or in stress on household budgets. Very poor households who could not afford the connection fee for other supply options were paying more per month for the same electricity service (for example, lighting) than other households who had been able to pay for a supply option with a prepayment meter (James 1997). People in the pilot areas expressed a distinct preference for prepayment meters, as they enable people to control their monthly expenditure on electricity.

It was also found that the connection fees charged for higher levels of supply at Tambo and Mafefe restricted the number of people opting for them.. Although many households could not afford the once-off payment for a connection, it is quite feasible that households could manage to pay off the connection fee in instalments (James 1997).

It is further imperative that the technical design of electrification projects makes allowance for the need to upgrade (James 1997). The circumstances and needs of households are not static, and it is essential that there is the potential to upgrade, particularly where current-limited supplies are implemented that are very restrictive, as in the case of the 2.5A supply.

The following guidelines regarding grid supply options and tariffs, which meet the requirements of poor households, have thus been developed in this project.

Level of supply

In terms of the level of supply of electricity to the rural poor, the principles of appropriateness and informed choice are proposed. Specific recommendations include the following (Wentzel 1998; James 1997):

- A range of supply options (with different levels of supply) needs to be provided to all households electrified with the grid, including the poor. Households should be able to decide which supply level is most appropriate for their purposes.
- Opportunities to upgrade to another level of supply need to be available to households.

Adequate and appropriate information should be widely disseminated, to enable households to make appropriate choices regarding their required level of supply.

Tariffs and connection fees

It is recommended that policies regarding tariffs and connection fees should adhere to the principles of affordability, flexibility, as well as freedom of choice. Specific recommendations include the following (Wentzel 1998; James 1997):

- A variety of tariffs and connection fees, linked to specific supply levels, should be available to increase affordability and allow a larger range of choice. Differences between connection fees for various supply options should be relatively small so that people do not feel trapped in a specific choice.
- There needs to be a relationship between the consumption of electricity and expenditure on the service, as well as a link between the perceived benefit of electricity and expenditure.
- Payment arrangements for connection fees should be flexible to reduce the barriers to poor households – for example, an extended time period should be allowed for

households to make small deposits until the total connection fee is paid.
- Adequate and appropriate information should be available to inform choice.

Policy regarding upgrading should adhere to three principles: affordability, effectiveness and transparency. Specific recommendations include the following (Wentzel 1998; James 1997):

- A well-managed, transparent system of upgrading to a higher level of supply should be in place.
- Upgrading should be affordable and flexible – for example, the required fee should be payable in instalments.
- Adequate and appropriate information should be available to enable upgrading.

Building human capacity while delivering electricity services[6]

Existing community consultation and education practices

Liaison takes place with community representatives during the planning and implementation of electricity projects, while mass meetings are used to disseminate information about projects, as well as for user education.

It has been found that the use of mass meetings alone for information dissemination and user education is not effective: few people attend them and, where they do, the language used at these meetings is not always well understood, especially when technical concepts are discussed. The implications of this is that rural people do not have sufficient information or understanding of project plans; thus expectations are raised, and people are unable to make informed choices or participate in activities which arise.

User education approaches need to encourage the participation of local people. Education materials further need to be developed in consultation with adult education specialists. These should use indigenous languages, and symbols that reflect local knowledge.

It is also important not to view communities as homogenous entities with a unified set of interests and needs, and to recognise that community representatives may not adequately represent the diversity of needs and interests in a community.

Power relations within communities, such as those of class and gender, operate in ways which exclude people from participating in community processes in various ways. The closer people are to the centre of power, the more likely they are to have access to information and the more able they are to participate actively in activities such as mass meetings.

It is likely that bringing electricity to resource-poor areas will lead to some sort of jostling or struggle for power and control over the process and outcome of delivery. Failure to understand power relations which operate in communities can result in the exacerbation of power struggles within communities.

Improving practice: the promise of participatory development

James (1998) argues that a participatory approach is needed to community education and consultation practices and processes.[7]

Participatory development offers a way of improving the approach to working with communities, while there are various participatory approaches and methods that are effective for user education and information dissemination. Participatory group processes are better able to reach people, and in addition, the learner-centred approach enables better understanding than the didactic approach of the mass meeting.

Improved education of electricity users is also likely to enhance the impact of electricity at a household level, as it would make more informed decisions possible. Furthermore, participatory approaches can and do build human capacity, which in turn contributes to the empowerment of people – for example, by enabling community representatives to make meaningful contributions to the planning of electrification projects.

It is important, however, to stress that participatory approaches do not offer a simple solution to transforming power relations within communities, as well as those between communities and electricity distribution agencies. Participation cannot miraculously deliver empowerment. However, participatory approaches can and do build human capacity

6 This section was drawn from James (1998).

7 James' work is supported by that of Crawford Cousins (1998), who concludes that the focus of the rural household electrification programme needs to 'change and broaden in order to recognise, in its method of implementation, electrification as a social process'. She makes a number of valuable suggestions on the way in which such a human-centred and socially transforming approach could be implemented.

for transcending behavioural patterns, and investment in human development is essential.

There are also a number of powerful reasons why adopting a participatory approach to working with communities also benefits development agencies and utilities. Where projects have focused on building the capacity of people, there is more likelihood of effectiveness, sustainability and efficiency, resulting in better planning and execution, a greater sense of ownership, and the securing of local management and maintenance.

The following approach is therefore suggested (James 1998):

- Staff should develop an awareness of the complex power relations within communities, as well as between the implementing agency and communities. This requires that appropriate social analysis and research is undertaken prior to project initiation, as well as ensuring that processes are inclusive.
- Staff should be equipped to work with conflict in communities.
- Mass meetings for information dissemination and user education should be accompanied by group processes that aim to reach as many people as possible, as well as ensuring an appropriate learning environment.
- Materials and tools should be appropriate and facilitate the active learning and participation of rural people.
- Rural people should be enabled (through the process described in the previous two points) to make informed choices about their electricity supply, particularly in the context where different levels of supply (e.g. 20A and 2.5A) are provided.
- Evaluation and self-reflection of work with communities should be established as a normal practice of staff working with communities.

It is critical for the success of a participatory approach, that it is undertaken by organisations with the necessary understanding and skills. The above strategies need to be implemented within a framework of participatory development, where investment in human development is prioritised. In the context of rural electrification in South Africa, partnerships with rural communities need to be developed so that decisions can be made jointly. The social analysis and research must necessarily inform the technical delivery. A community facilitation agency could be appointed to facilitate these processes.

Finally, as the resources for the implementation of electrification projects will always be limited, it is suggested that the possibility should be investigated of using funds from sources outside of the electricity sector for the participatory community processes to take place as part of electrification projects. Examples of such funding sources are donor and government funding for community development, capacity building and empowerment.

ROLE OF ELECTRICITY IN IMPROVING SERVICES IN RURAL AREAS

Health

Health can be seen primarily as an outcome of interactions and decisions made at the household level, which are constrained by external factors (Ross et al 1997). Rural electrification can potentially play a role in improving health at the household level – for example, in reducing domestic air pollution and thus the incidence of acute respiratory infection (ARI), as well as in reducing the incidence of burns and paraffin poisoning. However, the majority of poor households with grid electricity do not convert to electricity as their only, or even major, source of energy, but continue to use an array of fuels. Problems like ARI, burns and poisoning are therefore not resolved by electrification, although access to electricity probably reduces the incidence of these problems.

Public services can also play a role in improving health in rural areas. For example, the provision of water and adequate sanitation at a household level has been shown to be the most effective infrastructural intervention in the promotion of health (Ross et al 1997). Furthermore, primary health care (PHC) is seen as the most suitable way of providing health services in rural areas. Although PHC is most effective when implemented at a household level, within the national health plan of South Africa, clinics are the major vehicles for PHC in rural areas (Ross et al 1997).

Electricity has the potential to improve both the range and quality of services provided by rural clinics. The potential benefits of electrifying rural clinics include the ability to use better technologies, to offer longer opening hours (including 24-hour or emergency services), to ensure better maintenance of the vaccine cold chain, to offer educational opportunities to visitors and patients, to increase clinic security, and to more effectively attract staff (Borchers & Hofmeyr 1997). As in the case of its potential role at a household level, however, this may not be realised as a result of other factors. For example, many clinics do not have all the equipment on the national Department of Health's essential equipment list, or additional equipment such as communication technology.

Nevertheless, it should not be assumed that the provision of suitable technology and an appropriate energy supply are the major factors in improving the services provided by clinics (Ross et al 1997). For example, it seems that vaccination programmes are more likely to fail because of human behaviour (such as the failure of parents to bring children for vaccination, and the inadequate maintenance of fridges, infrequent testing of fridge temperatures, and the storage of staff goods in fridges) than because of technical problems in the vaccine cold chain process (such as a failure of the energy supply). Therefore the technical components of the programme are only effective insofar as equipment is adequately maintained, and the people who are implementing the programme are well trained and have adequate facilities for their own use (Ross et al 1997). The provision of an adequate electricity supply to clinics is therefore merely one input into facilitating improved services at clinics, and is typically not the most important input.

The electrification of rural settlements – not only clinics – is probably an important rural health strategy in the longer term (Thom 1997). Its impact on health in rural areas will, however, depend on the extent to which the following recommendations are implemented (Ross et al 1997):

- Electrification needs to happen as part of a broader co-ordinated and community-based programme, which addresses infrastructural deficiencies that affect rural households as well as clinics, including water supply and sanitation, telecommunications, roads, and energy supply more broadly.
- It should, further, happen as part of a broader co-ordinated and community-based rural development programme which addresses poverty, violence, illiteracy, the status of women, etc.
- Broader problems experienced at clinics, which are not related to the availability of electricity supply, need to be addressed.
- Health interventions should take place at the household level and not only at clinics.

Clinic electrification programme

The following institutions were involved in clinic building and electrification programmes: the Departments of Health (national and provincial), the Independent Development Trust (IDT), and Eskom. The IDT implemented the off-grid component of the clinic electrification programme, while Eskom undertook grid extensions to clinics. The IDT funded the installation of PV systems for clinics further than five kilometres from the national electricity grid, genset-plus-battery systems for clinics between one and five kilometres from the grid,[8] and grid extension for clinics closer than one kilometre to the grid (Borchers & Hofmeyr 1997).

Borchers and Hofmeyr (1997) found that the IDT clinic electrification programme addressed rural health care priorities reasonably well. All the rural health care service priorities – vaccine refrigeration, two-way radios, indoor and outdoor lighting, staff lighting, a television plug point, and a medical examination light – were catered for in the PV, grid and genset-plus options provided. Nevertheless, it was recommended that the national Department of Health establish a policy that clearly sets out the role of electrification in improving health in rural areas. This would better equip the department to drive and take ownership of the clinic-building and electrification programmes (Ross et al 1997).

The range of services provided by rural clinics is likely to be extended in future to include 24-hour emergency services, in-patient facilities, and adequate neo-natal care. This implies extended lighting hours and power for a greater range of medical appliances such as incubators and sterilisers, and possibly extra staff facilities. The ability of the power supply to accommodate such upgrading may thus be important. It is well within the capability of the grid systems to handle substantial increases in service provision at clinics, but it is far beyond what a PV system could be expected to provide at reasonable cost. PV systems could thus become inadequate electricity supply systems over the longer-term for rural clinics which are upgraded to 24-hour health centres. However, while such an upgrading of rural clinics is a logical target given the national health priorities, whether and when this may be done is unclear, and thus it is far from certain that PV systems will ever in practice be a constraint to such upgrading (Borchers & Hofmeyr 1997).

Education

A central part of the new education and training system envisaged in South Africa is the restructuring of the curriculum, using an outcomes-based approach to education. One of the critical outcomes of the new system,

[8] The genset-plus system was intended as an interim solution for areas where grid extension was anticipated in the short to medium term.

amongst many others, is the ability to use science and technology. Furthermore, a number of areas of emphasis in the new education system are in particular need of equipment requiring electrical power. These include (Gordon 1997):

- Adult basic education and training (ABET), which would require indoor and security lighting to enable night classes.
- Technology enhanced learning (TEL), involving the use of computers and audio as well as audio-visual equipment (television/VCR).
- Improvements in science teaching, which requires energy supply.
- Basic office equipment to enable governing bodies and staff to fulfil existing and additional administrative functions effectively.

It can be argued that it is particularly important that learners in rural areas are exposed to modern technologies and new approaches to learning at school, as they have less opportunity to experience first-hand many of the concepts taught in science and technology subjects than their urban peers (Gordon 1997). As the job market becomes more sophisticated, rural learners may become even further marginalised in terms of access to income opportunities in the future.

Nevertheless, sophisticated equipment only contributes to teaching in a meaningful way when appropriate educational material is available, where the capacity exists to utilise the technologies effectively, and when teachers can adequately integrate the services provided by the technology into education. Studies that have dealt with electrification impact at schools indicate that these impacts are highly dependent on the context and complimentary measures surrounding electrification, including the quality if teaching and learning (Borchers & Hofmeyr 1997) (Gordon 1997). The electrification of schools and other educational facilities in rural areas is important in the longer term (Thom 1997).

If the impact of electrification on the quality of education is to be significant, the following conditions at least, have to be met (Gordon 1997; Borchers & Hofmeyr 1997):

- Electricity needs to be provided to schools as part of an integrated package of services, which includes water supply and sanitation, telephones, and improved transport facilities for learners.
- The lack of educational resources at schools needs to be addressed.
- School staff and governing bodies need to have the capacity to manage and use the electricity systems and equipment.
- The security problems at schools should be addressed, both for the purpose of safeguarding equipment, and to enable women to attend night classes where this is provided.

Schools electrification programme

Eskom was the implementing agency for both the grid and off-grid components of the schools electrification programme. The programme made provision for extending the grid to schools within three kilometres of the existing (or planned) grid, and beyond this distance a PV system was installed (Borchers & Hofmeyr 1997).

Borchers and Hofmeyr (1997) found that the Eskom grid-electrification programme made provision for immediate education priorities at schools – that is, indoor and outdoor lighting, and plug points for appliances (the latter are not provided) – while the supply capacity should be adequate to meet all long-term energy requirements. The PV electrification of schools by Eskom provided for some of the immediate education priorities, in the form of indoor lighting, a television set, and a video machine (VCR). However, no outdoor lighting was provided where schools were supplied with PV systems. This should be reconsidered, as outside lighting is seen as important for security purposes and for facilitating access to schools at night, particularly for women participating in ABET activities. Regarding the design of equipment packages, there seems to be a need to provide different options, rather than one standard package only. The resources required at different schools and other teaching centres are likely to differ, and need to be considered in the design of packages (Gordon 1997).

Gordon (1997) recommended that the national and provincial departments of education needed to play a key role in formulating policy on the role of electricity in supporting key education priorities. Furthermore, a range of directorates in the provincial departments of education – for example, those responsible for curriculum development, teacher upgrading, ABET, and school management – needed to be involved in the planning of electrification services at schools, and not only those responsible for school building and maintenance (Gordon 1997). They should take part in the selection of schools to be electrified, the choice of supply technology, and the design of equipment packages provided to schools. Schools' governing bodies also need to be involved in these decisions concerning particular schools.

The PV systems at schools could be upgraded in future to allow the use of additional appliances such as computers, although this would involve substantial added expense and effort. Costs associated with upgrading PV systems to a point where they could supply the longer-term needs of schools are likely to be prohibitive. It is thus possible that they may constrain the services offered by rural schools in the long term. Nevertheless, since it is unclear how and when schools will receive all the sophisticated equipment envisaged, PV systems can be appropriate choices for schools (Borchers & Hofmeyr 1997).

Domestic water supply

Electricity from the grid and from PV panels, as well as direct-drive diesel pumping (generally not electric) can all be appropriate pumping power supply options. Grid powered pumping is generally considered the most versatile, reliable and maintenance free, and often also the most cost-effective (depending on the required grid extension distance) (Borchers & Hofmeyr 1997).

Grid electricity is generally used for water pumping in bulk regional water supply schemes typically serving 20 000 to 30 000 people, which are undertaken by the Department of Water Affairs and Forestry (DWAF). DWAF insists on the use of grid electricity in bulk regional water supply schemes because of the high reliability and cost-effectiveness of the supply (DPR 1998).

If the grid is not available in the areas where bulk water supply schemes are implemented, DWAF funds the extension of the grid to these areas. It is also the preferred energy option for stand-alone water schemes (as opposed to regional schemes) undertaken by DWAF, typically serving more than 5 000 people. Stand-alone water schemes comprised the majority of rural water supply schemes undertaken with RDP (Reconstruction and Development Programme) funds. In these cases grid electricity was only used if it was already available in the area concerned, or if Eskom planned to electrify the area while the water project was being implemented (DPR 1998).

While there are many instances where grid electricity is used for water pumping in DWAF water schemes, it is unlikely that the potential is being fully realised. It has been estimated that there were about 1 350 rural communities with a population of 4 000 or more people without adequate water supply in 1998 (about 13% of the 10 800 communities without adequate supply nationally). It is unlikely that all of these communities could be electrified with the grid, but this gives some indication of the potential role of grid electricity in water pumping amongst larger communities.

Another potential role for grid electricity in water pumping is the replacement of diesel pumps, which serve relatively large communities, with electrical pumps in areas which are electrified, or are being electrified.

ROLE OF ELECTRICITY IN SUPPORTING PRODUCTIVE ACTIVITY IN RURAL AREAS

Small-scale agriculture

Tapson (1998) argues that electricity has an important and irreplaceable role to play in small-scale agricultural development in South Africa. While electricity does not of itself generate agricultural development, under the right conditions it can greatly increase agricultural productivity, and create possibilities for value-adding activities. The necessary agricultural policy framework to ensure that electricity will play a successful role in small-scale agriculture is in place in South Africa. Considerable progress has been made in directing public sector support to small-scale and resource-poor farmers.

Furthermore, many small-scale agricultural projects exist where a range of conditions is met that are regarded as prerequisites for the electrification to impact significantly on agricultural development. These include access to profitable markets, access to land, access to the basic inputs that support any agricultural enterprise, and the necessary skills to utilise the available inputs (Tapson 1998).

Two broad categories of such projects have been identified: ‘less formal’ and ‘more formal’ projects (Tapson 1998). The less formal projects are usually small, depend on local consumption or markets and are institutionally simple, involving either households or small groups of people. They typically involve vegetable gardens, small-scale pig and poultry enterprises and water pumping for cattle watering. The power consumption, whether for pumping, cooling or heating, would usually be less than 1kW. The value of the output is often very high – for example, vegetables produced either for home consumption or for sale. Many of the characteristics of projects in this category make them candidates for diesel or solar power.

The more formal projects typically produce for distant markets and, often, for export. They are institutionally complex, involving collectives of growers managing a single scheme, which supports their own individual enterprise. Schemes producing sugar cane, cotton, citrus and other cash crops are typical. Power consumption varies greatly with circumstances, but installations drawing from 50 to 250 kW are common. The need for substantial funding and the installation of large-scale infrastructure means that support from the public sector is essential. For reasons of cost and complexity of operation, there is no practical alternative to grid electricity for these schemes. This category presents the greatest opportunities to expand electricity use in small-scale agriculture (Tapson 1998).

Three energy sources were considered in the analysis by Tapson (1998): grid electricity, diesel and photovoltaic technology. He argued that grid electricity has the advantage of being a mature and universal technology, with well-developed end-user technology and delivery systems and is, within the constraints of the extent of the grid, the cheapest of all the available sources. In the developing areas of the country, the technical and economic advantages of grid electricity are considerably reinforced by the fact that only rudimentary institutions are needed to ensure its sustainable delivery. The other options require robust and sustainable institutions in order to be effective. By virtue of electricity's cheapness, agriculture based on the use of other energy sources has effectively been rendered uncompetitive.

Diesel is more expensive than grid electricity – it was estimated that, for irrigation purposes, it was as much as four times more expensive. Greater skills are required in the maintenance and operation of the plant, and robust institutional capacity is needed to ensure that supplies of fuel are on hand when needed (Tapson 1998).

PV systems are characterised by high initial costs and very low running costs, which makes them favourable where welfare demands are high and grant funds can be justified. For applications such as refrigeration, pumping and small tools they are particularly efficient. On a life-cycle cost basis they are cheaper than diesel and grid electricity where, for example, the link to the grid exceeds two kilometres in length, and more than 10 kWh per day is required. PV systems have the peculiar advantage that small installations can be as cost-effective as larger ones, which is not true for either of the alternatives. This is particularly important for small-scale agriculture. If they are carefully matched to the end-user technology, they are efficient and economic for a range of light load functions. They have the disadvantage however, of being vulnerable to vandalism and theft (Tapson 1998).

The appropriate power sources for the categories of 'less formal' and 'more formal' small-scale agricultural projects identified earlier are as follows (Tapson 1998): The power consumption of less formal projects, whether for pumping, cooling or heating, are usually less than 1 kW. Many of the characteristics of projects in this category make them candidates for diesel or solar power. The power consumption of more formal projects varies greatly with circumstances, but installations drawing from 50 to 250 kW are common. For reasons of cost and complexity of operation, there is no practical alternative to grid electricity for these schemes.

The analysis by Tapson (1998) leads one to conclude that changing the present way in which electrification planning is conducted to ensure that the electricity requirements of small-scale agricultural projects, such as collective irrigation projects, are included, could have a significant impact on small-scale agricultural development in South Africa.

Small, medium and micro-enterprises

Three types of enterprises can be distinguished in the small, medium and micro-enterprise (SMME) economy (Rogerson 1997):

- **Survival enterprises** of the informal economy: A set of non-lucrative activities undertaken primarily by people unable to find regular employment, with limited impacts on employment or wealth creation. There exist scant prospects for opportunities for upward growth into viable small business enterprises.
- **Micro-enterprises**: Small enterprises often involving the owner, some family members and at most, one to four employees. Although frequently they are not formalised, many of them will become viable formal small businesses.
- **Small and medium enterprises**: These constitute the basis of the formal SMME economy, and employ between five and 200 people.

Rural SMMEs in South Africa are overwhelmingly of a survivalist nature. In fact, the majority of activities generate meagre incomes. They are, further, narrowly concentrated in a limited number of activities, particularly in the overtraded retail sector. There is thus a serious lack of diversity in the rural SMME economy, as well as 'a virtual absence of small-scale rural industries' (Rogerson 1997).

A key development objective with respect to the rural SMME economy in South Africa is to encourage the development of micro-enterprises and formal SMMEs (Rogerson 1997). The core policy inputs required to encourage the establishment of commercially viable SMMEs in South Africa are improving access to finance/credit, markets, training as well as information. In some areas, infrastructural deficiencies – including shortcomings in telecommunications, postal services, sewerage, roads as well as electricity provision – are extremely problematic for rural SMMEs, particularly small-scale manufacturers.

Electrification has an impact on SMMEs, even if this is modest (Rogerson 1997).

- Electrification results in the 'modernisation' of existing rural SMMEs. By 'boosting' survivalist enterprises (for example, spaza shops) in this way, electricity probably makes an important contribution to the livelihood strategies of rural people vulnerable to extreme poverty (Moser cited in Thom 1997).
- In most cases, electrification exerts a modest stimulus for the growth of new enterprises. New businesses that are formed when an area is electrified are most likely to be survivalist retail and service enterprises (such as small retail shops, bars, or provision of personal services). This is often linked to the use of electricity for refrigeration. New micro-enterprises, which have a better prognosis in terms of secure incomes as well as becoming viable in the future, are much less common, especially those in the production/manufacturing sphere.
- Access to electricity can impact significantly on some small-scale manufacturing enterprises in particular – for example, garment makers, and work requiring welding equipment and power tools – by enabling them to upgrade to more effective technology and thus improve their productivity. However, these comprise a very small percentage of SMMEs in rural areas.

The impact of electricity is likely to be greater if it is not provided to small businesses in isolation, but as part of a larger package of complementary inputs, such as the extension of rural credit and greater access to markets.

Supply options[9]

As the SMME sector is overwhelmingly survivalist in rural areas, and many rural small businesses operate from households, SMME electrification is closely linked with household electrification.

PV systems could provide the power needs of many survivalist businesses, although the refrigeration needs may well require a system too expensive for many small spaza shop owners. Because of the high energy demand and thus PV system cost, it is also unlikely to be a suitable system for businesses requiring any substantial refrigeration or freezing requirements, or running any workshop equipment. Its use for SMMEs is therefore likely to be restricted to lighting applications, running small motor-driven appliances such as sewing machines, televisions, and possibly limited refrigeration. Since the vast majority of small businesses in rural areas are survivalist, PV systems may have substantial application here, although capital costs of these systems may be prohibitive. Without financing, PV systems are therefore likely to be unaffordable to many small businesses.

While a 2.5A grid electricity supply would limit appliance use in a similar way to PV, the larger capacity grid supplies would be able to provide the requirements of even substantial workshops. Grid supplies of 60A capacity and three-phase electricity is only likely to be required by large established businesses using heavy-duty equipment, and thus is unlikely to be a common need of the rural SMME sector.

Gensets are often the only option for businesses requiring any substantial amount of power where the grid is far away. They are, however, often inappropriate because of the need for continual fuel supply, regular maintenance and occasional repair, while their fixed supply capacity can also limit business growth.

Grid supply has the advantage that it is usually easy and relatively cheap to upgrade, and thus can accommodate business growth. PV systems or genset systems would normally accommodate expansion less easily. In general a grid connection is likely to be the most convenient, cost- effective and versatile option where extension distances are not too great.

Many enterprises in rural areas have difficulty accessing support regarding appropriate electricity or energy supplies for their needs, and this will need to be addressed given the

[9] The section was drawn from Borchers and Hofmeyr (1997).

importance of SMMEs in national development plans.

CONCLUSIONS

This research project has shown that electricity can make a substantial contribution to rural development (Thom 1998). However, it was consistently found that the full benefits of electricity are not being realised in rural areas. This was found in all the sectors that were investigated, including the household sector. Nevertheless, it is clear that, while poverty is an obstacle to realising the full benefits of electricity, there are many ways in which the impact of electricity on the lives of rural people can be enhanced. Some of these have been discussed above.

A key issue which has emerged from this work, is the importance of greater integration and co-ordination of the rural electrification programme with programmes to provide water, health and education services, and to develop small-scale agriculture and small businesses, if the contribution of electricity to these sectors is to be more significant (Thom 1998).

SUMMARY OF RECOMMENDATIONS

The main recommendations which arose from the REIPERA project are the following (Thom 1998):

- Electrification policy should take a long-term view of rural electrification, and should ensure that electrification of rural areas continues at a steady pace.
- Electrification policy needs to ensure that, at the very least, the most basic benefits of access to electricity – the use of electric lighting and radios – are realised in as many electrified households as possible.
- Electrification policy needs to facilitate as far as possible the use of electricity for cooking purposes by poor households who desire this.
- Initiatives to address the problems of rural households concerning the use of fuels such as wood, paraffin and LPG for thermal purposes, and to reduce the consumption of these fuels while achieving the same cooking objectives, should be given specific attention in energy policy.
- Broad guidelines regarding appropriate electricity supply options and tariffs should be included in electrification policy to guide the development of supply/tariff options by utilities.
- Guidelines to provide for improved community participation practices in electrification projects should be included in electrification policy.
- The national electrification programme currently targets households, clinics and schools. Community water supply schemes and small-scale agricultural projects should be included among the priorities of the national electrification programme, however, as electrification can make a contribution to the development of both sectors in the immediate future.
- Each of the government departments or agencies responsible for development in the various sectors, and the utilities responsible for electrification, should establish a joint policy regarding co-operation between their regional staff, and encourage its implementation.

FURTHER RESEARCH

After the completion of the REIPERA research project a need for further research on the impact of electrification in rural areas was identified. In particular, the lack of qualitative data of a longitudinal nature – that is, data collected over a period of time, not only on a once-off basis – limited the understanding of the impact of electrification on households. A research project to collect such information was commissioned in 1999 by Eskom. Some of the findings of this project are discussed in Chapter 6.

REFERENCES

Afrane-Okese 1999. National domestic energy-use database system as a tool for integrated energy planning. Pretoria: Department of Minerals and Energy.

Annecke, W 1996. Post-electrification study of Loskop – synthesis report. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Annecke, WJ 1998. The role of electricity in integrated energy supply. REIPERA project. Energy & Development Research Center

Banks DI 1998a. Criteria to support project identification in the context of integrated grid and off-grid electrification planning. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Banks, DI 1998b. Off-grid electrification for the poor: constraints and possibilities. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Bedford, L 1998a. Electrification of clinics in Region E, Eastern Cape. Post-electrification study in AmaNtshangase, AmaNdengane, Ludeke and follow-up in Mnceba. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Bedford, L 1998b. Electrification of schools in Region E, Eastern Cape. Post electrification study in Ludeke and follow-up in Mnceba. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Bedford, L 1998c. Electrification of schools in non-grid areas in Region E, Eastern Cape. Post-electrification study in AmaNstshangase and AmaNdengane. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Borchers, M & Hofmeyr, I-M 1997. Rural electrification supply options to support national health, education and SMME development. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Crawford Cousins, C 1998. A question of power: the electrification of rural households. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Davis, M & Ward, S 1995. Household energy-use patterns in rural areas: the effects of access to electricity. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Davis, M 1996. The financial impacts of rural electrification. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Davis, M 1998a. Cross-subsidies and sensitivities: Further analysis of sustainable financing of electrification in South Africa. Accompanying paper to Van Horen & Thompson (1998). REIPERA project. Energy & Development Research Centre: University of Cape Town.

DPR (Development Planning & Research) 1998. The role of electricity in the integrated provision of water in rural areas of South Africa. REIPERA project. Energy & Development Research Centre: University of Cape Town.

EDRC 1998. Rural electrification in South Africa: Summarised research from the project *The role of electricity in the integrated provision of energy to rural areas*. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Gordon, A 1997. Facilitating education in rural areas of South Africa: The role of electricity and other sources of energy. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Griffin, NJ, Banks, D, Mavrandonis, J, Shackleton, SE & Schackleton, CM 1992. Household energy and wood use in a peripheral rural area of the eastern Transvaal lowveld. Pretoria: Department of Minerals and Energy.

Hansmann, C, Van Gass, M, Annecke, W, Despins, PM & Kargas, S 1996. Post-electrification study of Loskop –Appendices. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Hofmeyr, I-M 1996. A comparative study of the access to and use of electricity by farmworker households in the Free State. REIPERA project. Cape Town: Energy & Development Research Centre: University of Cape Town.

James, B & Ntutela, P 1997. Rural households' response to the 2.5A electricity supply option in the Tambo village pilot project. REIPERA project. Energy & Development Research Centre: University of Cape Town.

James, B 1997. Current-limited supplies of electricity in the context of South African rural areas. REIPERA project. Energy & Development Research Centre: University of Cape Town.

James, B 1998. Community participation in rural electrification: Building human capacity through the delivery of electricity to rural areas. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Mehlwana, M & Qase, N 1999. The contours of domesticity, energy consumption and poverty: the social determinants of energy use in low-income urban households. Pretoria: Department of Minerals and Energy.

Palmer, R 1999. The impact of domestic electrification on household hydrocarbon fuel consumption. Pretoria: Department of Minerals and Energy.

Rogerson, C 1997. Rural electrification and the SMME economy in South Africa. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Ross, F, Matzopoulos, R & Phillips, R 1997. The role of rural electrification in promoting health in South Africa. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Steyn, G 1996. Rural electrification: delivery or development? REIPERA project. Energy & Development Research Centre: University of Cape Town.

Tapson, DR 1998. The role of electricity in the development of small-scale agriculture in South Africa. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Thom, C, Davis, M & Borchers, M 1995. Review of South African experience in rural electrification. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Thom, C 1997. A development framework for rural electrification: some preliminary findings.

REIPERA project. Energy & Development Research Centre: University of Cape Town.

Thom, C 1998. Rural electrification policy: some key recommendations. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Thom, C 2000. Use of grid electricity by rural households in South Africa. *Energy for Sustainable Development*. Vol. IV, No. 4, December 2000.

Van Horen, C & Thompson, B 1998. Sustainable financing of electrification in South Africa. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Wentzel, M, Manzini, M, Mudlaudzi, C, Sehlapelo, D & Wood, C 1997. A post-electrification study of the Mafefe electrification project. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Wentzel, M 1998. Recommendations on electricity supply options for the rural poor. REIPERA project. Energy & Development Research Centre: University of Cape Town.

Chapter 6

Use of Electricity by Rural Households

Cecile Thom[1]

[1] University of Cape Town

The use of electricity by rural households is restricted by many factors, including conditions of poverty. However, some problems can be addressed by utilities, including erroneous perceptions that result from a lack of information, and problems with appliance quality.

INTRODUCTION

After the completion of the REIPERA research project discussed in Chapter 5, a need for further research on the impact of electrification in rural areas was identified. In particular, the lack of qualitative data of a longitudinal nature – that is, data collected over a period of time, not only on a once-off basis – limited the understanding of the impact of electrification on households. A research project to collect such information was commissioned in 1999 by Eskom Resources and Strategy (Research, Development and Demonstration department).[10] It is entitled *Case studies on the impact of electrification in rural areas.* This chapter presents some of the findings of this project thus far, drawn from the research reports on the first two phases of the project (Thom et al 2000b; Thom 2002).[11]

The main aims of the project are the following:

- To assess the impacts of electrification on energy-use patterns, the domestic work burden of women, the quality of life of people, their access to information and education, and economic opportunities.
- To understand the factors that influence household electricity consumption and demand growth, particularly in rural areas with very low consumption levels at present, in order to assist with load forecasting.
- To identify obstacles to the greater use of electricity in rural areas, including problems such as a lack of information, and difficulties faced by small businesses.

These are important both from a national policy perspective – for example, assessing in what ways electrification is contributing to national development – as well as from the utility's planning perspective – for example, the optimal design of networks in rural areas.

A unique characteristic of this project is the fact that in-depth social research is being conducted among households whose electric load is being recorded on a continuous basis as part of Eskom's Load Research Studies project.[12] This makes it possible to link detailed data on these households – for example, demographics, electricity and fuel-use behaviour, and income and expenditure – to measured load and consumption data.

As this was a requirement from the outset of the project, the research sites had to be selected from those included in the load-monitoring project. The two sites chosen for the social research purposes are discussed in the next section.

RESEARCH SITES

Garagopola-Legabeng

Garagopola and Legabeng are two villages in the GaMaroga Tribal Authority in the Northern Province. It falls under the jurisdiction of the Greater Tubatse Local Municipality in the Sekhukhune Cross Boundary District Municipality shared between Mpumalanga and the Northern Province. The villages are located about 200km south east of Pietersburg along the main road to Lydenburg (R37).

Information prepared for the Mvula Trust in 1996 indicated that the number of households in Garagopola-Legabeng was 353, while the population was estimated at 2 500. The older of the two villages is Legabeng. People settled there in the early 1940s. Garagopola was only established in the 1970s when people were forcibly removed from the surrounding areas.

10 The research in the villages Antioch and Maganxosini was conducted with additional funding received from the Department of Trade and Industry's THRIP programme.

11 The project is still underway.

12 See, for example, the report by Dekenah (2000).

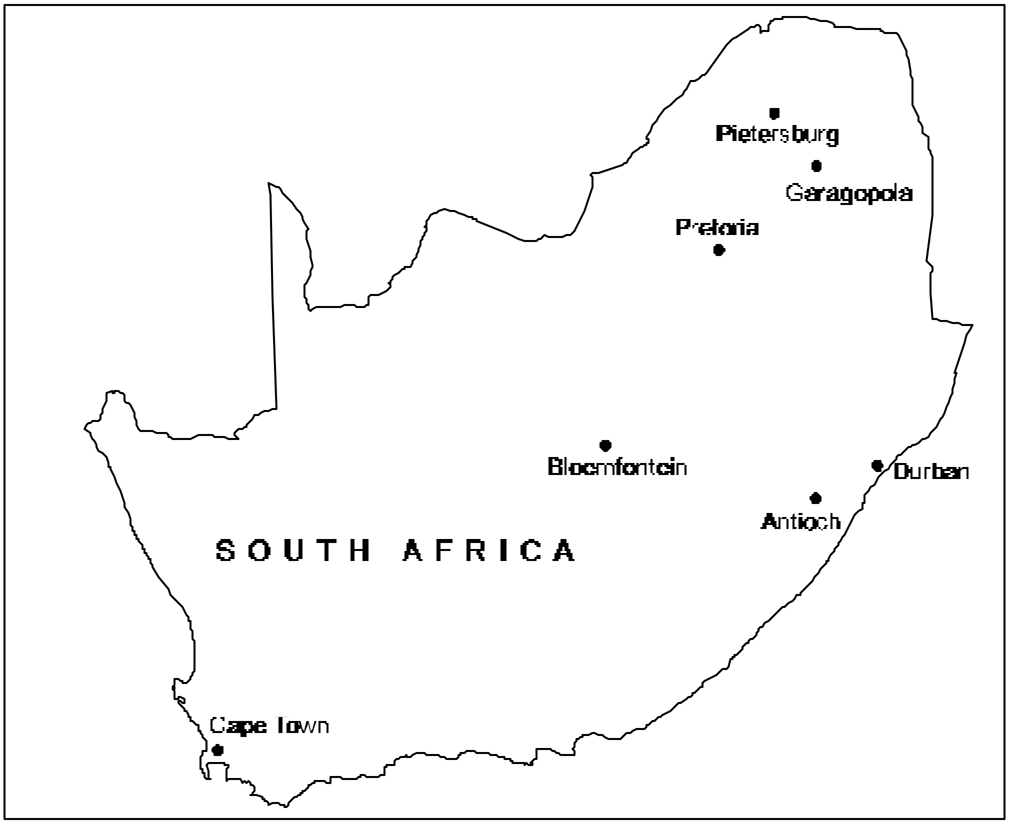


Figure 1: Location of research sites

Garagopola-Legabeng is located at the base of the Maadimo Mountain where people gather wood. Most of the households have relatively large plots and many of them undertake some subsistence farming, particularly growing maize. Many households own small livestock such as chicken and goats, and some own cattle. The nearest urban centres, Steelpoort and Burgersfort, are about twenty kilometres away and this is where residents in Garagopola-Legabeng tend to buy food and other necessities. People in the area, therefore, have relatively good access to commercial goods and services. The lifestyles and values of people in the area reflect a mix of traditional and modern influences.

A number of chrome mines, as well as industries related to mining, such as smelters, are located in the area surrounding Steelpoort. One of these is located only a few kilometres from Garagopola-Legabeng. Many men living in Garagopola and Legabeng are employed in the mines and industries. As a result, the percentage of wage income-earners who live locally is relatively high. There is also potential for further job creation in the area.

Nevertheless, some of the households interviewed as part of this study have been affected by the retrenchment of income earners.

There are three schools in the area – two primary schools and a secondary school. There is a post- office in the nearby village of Driekop on the road to Burgersfort. The closest health centre is a clinic in Gowe village, which also forms part of GaMaroga.

In 1997 and 1998 the Department of Water Affairs and Forestry (DWAF) implemented a water project in nine villages, including Garagopola and Legabeng. Because of the problem of non-payment for water in the area, a new water project was initiated in 2001 by the Greater Tubatse Municipality to ensure cost recovery.

Fixed-line phones were installed in Garagopola and Legabeng in 2001, as well as a implemented a monthly billing system. However, the community has requested that this be replaced with a prepayment system. During household interviews in 2001, a number of households indicated that their phones had been disconnected, as they had been unable to pay the monthly bills.

Antioch-Maganxosini

The villages Antioch and Maganxosini fall under the jurisdiction of Inkosikazi (Chieftainess)

Msingapantsi whose homestead is in Antioch. They form part of the Umzimkulu Local Municipality in the Alfred Nzo District Municipality in the Eastern Cape. Antioch-Maganxosini is about 180km from Pietermaritzburg, and roughly 35km from Umzimkulu, the closest town with large shops.

The villages are located in a remote mountainous area, which can be accessed only by means of a winding dirt road – often along steep slopes – which is for the most part in a poor condition. Most households do their major shopping in Umzimkulu – this is about an hour's drive if the road is dry, but in rainy conditions the road is slippery and dangerous.

Large parts of the villages are located on inclines, and a characteristic feature of the area is the homesteads built on terraces – typically a homestead comprises traditional rondavels built in a row on the same level. Homesteads generally include garden plots used to grow vegetables and mealies (maize) for own consumption. Many households also grow mealies in larger fields ploughed once a year after the first rains.

Antioch is the best served of the surrounding villages, as it has a primary school and small secondary school. A mobile clinic visits the area once a week. There are six shops in the village. The local electricity-vending station is also located in Antioch. Water is available from communal taps in Antioch (but not in Maganxosini). The water is gravity-fed from a local spring.

Research approach

Data collection has mostly been by means of household interviews in the two communities. In addition semi-structured interviews have been conducted with key informants (usually community leaders) as well as electricity vendors in both communities, and small businesses in Garagopola-Legabeng[13], which utilises electricity. Information has also been obtained during meetings and workshops with the two communities.

The research commenced in 1999. In 1999 a series of in-depth qualitative interviews were conducted with nineteen households in Garagopola, generally with more than one member of a household (Thom et al 2000b).

The second research phase was undertaken in 2001 (Thom 2002). In May 2001 a total of 55 households were interviewed in Garagopola, using questionnaires to collect mostly quantitative information. During the second period of fieldwork in August 2001 the emphasis was on collecting qualitative information, and 29 households were interviewed for this purpose. At the end of October 2001 a survey of 41 households was conducted in Antioch[14], collecting mostly quantitative information using questionnaires. No qualitative interviews have been conducted in Antioch as yet, but this will be done during 2002.

The household samples in Garagopola and Antioch are relatively small, particularly the Antioch sample. As the primary aim of the project is to collect qualitative information, the surveys were done merely to provide a broader context for the qualitative analysis. The samples were drawn from the load research sample in each area in such a way as to ensure that households in all consumption categories found in the load research sample are represented.

Electricity supply

Both areas were electrified in 1997:

- Garagopola, Legabeng and a neighbouring village, GaMathipa, were electrified in April 1997. Antioch and some neighbouring villages, including Maganxosini, were electrified in 1997 as part of a single-wire-earth-return (SWER) pilot project.
- Although all the households interviewed in the two communities are connected to the electricity grid, there is a difference in the electrification status of the two communities. Not all households in Antioch are connected, while everyone in Garagopola has electricity. One of the reasons for this is the provision of a free 8A-supply connection to all households in Garagopola who did not apply and pay for electricity connections.

The experience in Garagopola has shown that providing a low-capacity supply such as 8A with no connection fee is an effective way of targeting the poor. Those households who want to and can afford it, have upgraded to higher levels of supply (particularly 20A), but many households in Garagopola still have an 8A supply, years after they have been electrified. The 8A supply is seen in a positive light in Garagopola because it has provided access to electricity for the poor (Thom et al 2000b).

13 For simplicity, the name Garagopola is used to indicate both villages (Garagopola and Legabeng) in the rest of the chapter, unless stated otherwise.

14 For simplicity, the name Antioch is used to indicate both villages (Antioch and Maganxosini) in the rest of the chapter, unless stated otherwise.

No public lighting has been provided in either Garagopola or Antioch. Until the mid-1990s there were no municipalities in rural areas, but even now the municipalities which have been established are unlikely to have the resources required to pay for public lighting.

UNDERSTANDING ELECTRICITY USE IN THE TWO COMMUNITIES

Employment and income

There are a number of important differences between the household samples in Garagopola and Antioch, as far as employment and income are concerned (Thom 2002).

The percentage of household heads that are employed full-time, is higher in Garagopola than in Antioch, while the percentage of household heads that are resident elsewhere, is higher in Antioch. All the household heads in the Antioch sample, who are employed full-time, are resident outside of Antioch, while in the case of Garagopola about half of them are resident in the area. This reflects the greater availability of job opportunities in the area surrounding Garagopola.[15]

Nevertheless, the percentage of households (not household heads) who have formal sources of income, specifically wages and pensions, is much higher in Antioch than in Garagopola. The high percentage of households in Antioch with wage incomes (about 70%) is particularly interesting, as most wage earners are employed elsewhere, and the moneys received are therefore mainly in the form of remittances.

Garagopola and Antioch are both poor communities. The average income received[16] by sampled households in Garagopola is about South African Rand (R) 1 000 per month, while it is only about R700 in Antioch. One could therefore conclude that income poverty is greater among the Antioch households. However, the difference could partly be attributed to the fact that most of the formal income received in Antioch is in the form of remittances by people living elsewhere. Many of these people also contribute to their households by buying clothing, appliances, etc which is not reflected as a cash income.

The percentage of households with informal income sources – such as informal employment, informal selling activities, and assistance from family members – is higher in Garagopola (about 40%) than in Antioch (about 30%). Furthermore, while eleven households (20%) in the Garagopola sample are involved in some form of informal selling, either from home or in a nearby town, only one household in the Antioch sample sells things informally (from home).

The percentage of households with own businesses (other than informal selling activities) is similar in the two communities (about 10%). These include sewing, carpentry, shops, a cell phone service (in Garagopola) and a tractor-hiring service (in Antioch). The average income received from own businesses appears to be much higher in Garagopola than in Antioch, however.

Energy use and expenditure

The main differences between the sampled households in Garagopola and Antioch as far as the use of electricity is concerned, are the following (Thom 2002).

- The average electricity consumption of households in Garagopola, based on measured load at the time the interviews were conducted, was 110 kWh/month. The average electricity consumption of households in Antioch was about half of that.
- The percentage of households who report using candles for lighting every day is relatively high in both communities, but particularly in Antioch (about 30%). One of the main reasons for this is the fact that many homesteads still have rooms without electric lights.
- A large percentage (about 90%) of households in Garagopola who use wood for fuel, collect it on foot, while only a small percentage (about 10%) buy it. In Antioch the percentage of households that buy wood is very similar to the percentage that collects wood (about 60%), and a significant percentage of households both collect and buy wood (about 20%). This is a result of the scarcity of wood in the area surrounding Antioch.
- The average monthly expenditure on wood for fuel by households in Antioch who buy it, is considerable (about R80 per month) – as a result almost half of their total expenditure

15 It is interesting in this regard that a much higher percentage of household heads in Antioch (about 50%) have secondary school education than in Garagopola (about 20%), while a large percentage (about 30%) of household heads in Garagopola have no formal education at all.

16 A distinction has been made between the income earned and the income received by households, as many households, particularly in Antioch, did not know how much money was earned by people living elsewhere.

on energy goes towards wood. This is significant particularly because it affects such a large percentage of households in Antioch (more than half).

The percentage of households who use paraffin is very high in both communities, but tends to be higher in Antioch than in Garagopola. One of the factors that contributes to this is the scarcity of wood in the area surrounding Antioch.

The percentage of households who use paraffin every day is similar in the two communities (about 50%), as is the average quantity of paraffin used per month (about ten litres). Paraffin forms a significant proportion of total household energy expenditure in both communities (about 30%), particularly as such a high percentage of households use paraffin.

Wood is still the dominant fuel used for cooking in Garagopola – either alone or in combination with other fuels. This is followed by paraffin, which is also used either alone or in combination with other fuels. Electricity is therefore the third most important cooking fuel in Garagopola – again either alone or in combination with other fuels. By contrast, paraffin appears to be the dominant cooking fuel in Antioch. This is followed by firewood, while electricity is again the third most important cooking fuel.

A significant percentage of households in Antioch (about 40%) regularly use dry-cell batteries, mainly for powering radios. In Garagopola, radios powered by dry-cell batteries have been replaced almost completely by radios or hi-fis operated with grid electricity. Households who use dry-cell batteries spend a significant percentage of their total energy expenditure (about 20% in Antioch) on batteries.

Total household expenditure on energy, and energy expenditure as a percentage of income received, are both higher in Antioch. The main reason for this is the high expenditure on wood, particularly as more than half of the sampled households buy wood. The expenditure on dry-cell batteries also contributes to the high total energy expenditure in Antioch.

The percentage of total household energy expenditure that is spent on electricity is much higher in Garagopola (about 60%) than in Antioch (about 30%).

Use of electric lighting

<u>Inside lighting</u>

By far the majority of households in Garagopola used candles for lighting before electrification (Thom et al 2000b). All households included in the study now use electric lighting, and most of them only use candles during power failures, while some households continue to use candles in unelectrified rooms or when they are unable to afford electricity. Very poor households often have rooms without electric lighting. This limits the impact of electric lighting on these households. The main reason for this is the cost of extending electric wiring, particularly if a homestead comprises separate structures, and long extension cords are needed (see case study of household #34 below). These households tend to have other priorities for which they use the money that they have available.

As in Garagopola, all the households interviewed in Antioch use electric lighting. However, the incidence of unelectrified rooms is much more common – about 30% of households in Antioch have three or more rooms that are without electric lights, compared to about 10% of households in Garagopola. One household in Antioch has as many as nine rooms that are without electric lights (Thom 2002). This ties in with the finding that a higher percentage of households in Antioch use candles for lighting every day (Thom 2002).

An interesting phenomenon has been observed in Garagopola as well as Antioch. About 70% of households in both communities switch on all their inside lights in the evening even if the rooms are not being used – they keep it switched on for a few hours from dusk until they go to bed. During qualitative interviews in Garagopola people have explained that they do this because they like having a 'bright house' in which all the rooms are lit – it has become part of their culture (Thom 2002). In Antioch it is common that a number or all of the lights in the homestead are connected to the same switch, so that they can only be used together.

The qualitative research conducted in Garagopola suggests that most households have become dependent on electric lighting in the years that they have had access to electricity (Thom et al 2000b). They tend to buy new electricity tokens before the units expire to ensure that they have electric lighting at all times. Even very poor households try to find money to buy electricity for lighting, although some of them regularly go without electricity.

It has become clear that electric lighting is greatly valued by households in Garagopola, and probably in Antioch as well (Thom 2002). The value attached to electric lighting by newly electrified communities has probably been underestimated in the past.

About 60% of households in Garagopola and 30% of households in Antioch also use inside lights in the morning (Thom 2002).

Outside lighting

One of the services only available to people with electricity is good quality lighting at night for security purposes. About 80% of households in Garagopola and 60% in Antioch have installed outside lights at their homesteads. Most households use outside lights in the evenings for a few hours until they go to bed (about 70% in Garagopola and 60% in Antioch).

The percentage of households who use outside lights throughout the night is much higher in Garagopola (about 40%) than in Antioch (about 10%) (Thom 2002). This service is highly valued in Garagopola, as people feel it has improved safety in the area (Thom et al 2000b).

Household #34 (Garagopola)

This household's electricity consumption, based on measured load, increased slightly from 14 kWh/month in the period May to August 1999, to 23 kWh/month in the period March to May 2001. Their reported expenditure on electricity has stayed the same, however – in both July 1999 and May 2001 they reported spending R10 per month on electricity. Their homestead comprises three structures, all built of clay. The largest structure serves as a bedroom and kitchen, which share the single electric light installed in the kitchen. Another structure serves as a bedroom, and is without an electric light. The third structure is used as a spaza shop, and has an electric light. There is also an outside light, which is not used regularly. When they were interviewed in July 1999 the household had only one inside light – the one in the kitchen/bedroom. By May 2001 they had two inside lights – they had installed one in the spaza shop as well. They are using both their lights from about 6pm to 9pm every night. When asked why they had not installed an electric light in the separate bedroom as well, the respondent Florinah, whose mother is the head of the household, said, 'Because the extension cord that we bought is too short; it doesn't reach that room. So we need to add to it.' They are planning to install an electric light in the room, however: 'We are still planning to put a light there, but will have to wait until we get money to buy another extension cord. We have no alternative but to live under these conditions.'

Florinah had the following to say when asked what lights they switch on in the evening: 'We switch on all the lights. It is safer and important to light the house in the evening because it is our culture. And it can be scary to go into a dark room. Another thing is that we always spend more time in the lighted rooms in the evening, rather than the one with no light.' When asked whether she thinks it uses the same electricity whether you use one light or many lights, she said, 'I don't know, but we are not used to lighting one room only.' She denied that it is important that their neighbours should see they are using electric lights in their house: 'It's not important, because I live my own life.'

There have been other small changes in the household's use of electricity since July 1999. They bought a radio (costing R200) on hire-purchase in December 2000, and paid it off within a few months. The radio is their first electrical appliance, and they use it throughout the day. They did not have any radio (not even a battery-operated radio) in July 1999.

Furthermore, they now have access to electricity all the time, as they buy another electricity card as soon as their units are finished, 'so that we don't have to stay in the dark, especially at the spaza shop'. It is rare that they have no electricity at home: 'Only when we bought the card too late.' And in such cases they get electricity within a day. In July 1999, the situation had been very different. They had reported that they did not have electricity all the time, as they often had to wait for a week before they could afford to buy another electricity card. The household is therefore slowly improving their situation and benefiting more from electricity. Generally, their circumstances have improved slightly since 1999, as they are now able to use paraffin more regularly, and have acquired more furniture (a bed).

The main reason for these changes seems to be that they have managed to increase their monthly income slightly, although it remains low and unreliable. In 1999, they reported an income of about R200 per month from informal selling activities, while they reported an income of R600 per month in May 2001. The latter comprised about R200 from their spaza shop, about R300 from selling vegetables and fruit in Burgersfort, and R110 from the government in the form of a child grant. Some of their reported income was used to cover expenditure on income-generating activities, such as the daily costs to travel to Burgersfort, which amounted to about R250 per month. Their real income was therefore about R350 per month in May 2001. Nine people were part of the household at the time, including four adults and five children (younger than eighteen years). This household is therefore extremely poor. In order to survive they grow spinach, bananas and sugar cane for their own use. They also have a few goats, which they sell occasionally.

Ownership and use of electrical appliances

Households in Garagopola tend to have more electrical appliances than in Antioch. The percentage of households owning particular appliances is also generally higher in Garagopola, except in the case of electric irons, which is owned by a larger percentage of households in Antioch than in Garagopola.

Nevertheless, the percentage of households in Antioch that report using television sets, irons and hotplates is higher than in Garagopola, mainly because of the higher incidence of broken appliances in Garagopola. Many households in both areas do not fully utilise their appliances, but use them to a limited extent only (Thom 2002).

Electronic media

Radios/hi-fis are the most common type of electrical appliances in Garagopola (about 80% of sampled households). Ownership of electric radios/hi-fis is much lower in Antioch, however (about 50% of sampled households). One of the reasons for this is that a significant percentage of households in Antioch are still using radios powered by dry-cell batteries, which cannot be operated with grid electricity. A few households in Garagopola are still using dry-cell batteries to operate radios, but generally the use of dry-cell and car batteries has been replaced by electricity (Thom 2002).

Ownership of televisions is higher in Garagopola than in Antioch. However, the percentage of households who report using televisions is similar (about 50%). The reason for this is that all households in the Antioch sample with televisions use them, while in Garagopola only about two thirds of those with televisions use them. This discrepancy between the ownership and use of televisions in Garagopola is mainly due to the high incidence of broken televisions.

Electrification seems to have improved people's access to information in Garagopola (Thom et al 2000b). Prior to electrification, some people used dry-cell batteries and/or car batteries to power radios and television sets. They are now able to use the appliances for longer periods, while many people only obtained these appliances since electrification. Many people in Garagopola listen to news programmes, as well as radio programmes which provide local news. television sets are valued (also by women) for the entertainment provided and for relieving boredom.

Appliances used for domestic work

Electric irons are the only appliances discussed here that are owned by a larger percentage of households in Antioch (about 80%) than in Garagopola (about 70%). This is the most common electrical appliance in Antioch, and is the second most common appliance in Garagopola (after radios/hi-fis). However, because of the higher incidence of broken irons in Garagopola, the percentage of households who report using irons is much higher in Antioch than in Garagopola (Thom 2002).

The percentage of households with electric kettles is higher in Garagopola (about 50%) than in Antioch (about 40%). However, the percentage of households in Garagopola who use kettles is considerably lower than those who own kettles. This is mainly due to the incidence of broken kettles in Garagopola.

Hotplates and stoves – treated as a single category – are as common in Garagopola as electric irons (owned by about 70% of households). Ownership of hotplates/stoves is also very high in Antioch (about 60%).

The high percentage of households who own electric hotplates/stoves in Garagopola reflects the desire to cook with electricity expressed by the people interviewed. The high ownership of electric hotplates/stoves is partly due to the great influence of women on decisions to purchase appliances. This is the case not only in households headed by women or where women earn money, but also where the husband's earnings form the sole income of the household (Thom et al 2000b).

Ownership of hotplates (excluding stoves) is higher in Garagopola (about 60%) than in Antioch (about 50%), but the percentage of households who use hotplates is higher in Antioch (about 40%) than in Garagopola (about 30%). The enormous discrepancy between the ownership and use of hotplates in Garagopola is mainly due to the high incidence of broken hotplates, and problems experienced with the fixing of hotplates (Thom 2002). Another factor that prevents people from using their hotplates, is concern about the cost of using electricity for cooking, particularly when preparing foods that require a long cooking time (Thom et al 2000b).

Prior to electrification, firewood and paraffin were the main fuels used for cooking and water heating in Garagopola. In some households paraffin has been replaced almost entirely by electricity for cooking and water heating. All these households had used paraffin extensively for cooking and water heating purposes before electrification, while only a few of them had also used wood on a regular basis.

In many households some tasks previously performed on a wood fire are now being done with electricity (for example, ironing, quick cooking). However, wood is not replaced by electricity to a significant degree (Thom et al 2000b).

Impact of electrification on domestic work of women

Women in Garagopola generally feel that their work burden has stayed the same in spite of having electricity, even if the nature of the work has sometimes changed. Doing laundry by hand and collecting wood are the most difficult tasks, and electrification has had little impact on these. Many women don't complain about their work, however, but take pride in it (Thom et al 2000b).

Although electrification has not had a major impact on the overall domestic workload of women, the use of electric appliances like hotplates/stoves, kettles and irons has made an impact on domestic work. The most significant impact is that it makes domestic tasks easier and reduces the time required. Because of the greater convenience, cleanliness, and speed of electrical appliances (even compared to paraffin), access to electricity reduces the time that women spend on domestic activities such as cooking, water heating and ironing. This involves short 'bits' of time that are saved each time a task is done, rather than a large 'chunk' of time, such as the time required for wood collection, and is therefore hard to quantify. Nevertheless, the overall effect of small bits of time saved throughout the day can be significant.

Electric irons in particular have a widespread impact, as they are used more commonly than electric hotplates/stoves and kettles. Electric irons are also used by households which use very little electricity. For example, one household in Garagopola using about 20 kWh per month, reported using an iron. The use of electric irons is greatly appreciated for saving time and easing women's domestic work. Before electrification, ironing was done with steel presses heated on a wood fire or paraffin stove.

Refrigeration

The ownership of electric fridges/freezers is much higher in Garagopola (about 60%) than in Antioch (about 30%). The majority of households with fridges/freezers in both communities report using them all the time. However, a large group of households (particularly in Garagopola where the number of households with fridges/freezers is larger) use their fridge/freezer for part of the month only – for example, when they have bought some perishable food (Thom 2002). Electric fridges/freezers are highly valued for storing food, as well as foodstuff and drinks for selling from home.

In Garagopola, access to refrigeration has expanded as a result of electrification (Thom et al 2000b). Few households had paraffin or gas refrigerators or freezers before electrification. No households in Garagopola currently use other fuels for refrigeration, while a few households in Antioch still use gas fridges (Thom 2002).

From the household interviews in Garagopola, it is evident that the use of electric fridges and freezers has increased opportunities for informal home-based selling (Thom et al 2000b). However, in most cases, the income generated in this manner is very small. In some cases, households say that electricity has made a difference to their selling businesses, even though it is not essential (for example, a household that uses an electric light in a spaza shop at night). In other cases, electricity is regarded as essential because electric freezers are used to store or make items (for example, ice-lollies) for sale (Thom 2002).

Households using very little electricity

In both Garagopola and Antioch there are households who use very little electricity. This is prevalent particularly in Antioch. These households tend to have one or two lights and few, if any, appliances (see case studies of household #34 in section 3.3.1 and household #32 in section 4). In Garagopola, the worst-off case is a household which has one inside light, one outside light, and no appliances. In Antioch the worst-off cases are two households which each have one inside light only, with no outside light, and no appliances (Thom 2002).

Some households who use very little electricity, regularly run out of electricity without being able to buy more. They therefore have to live without electricity until they can next afford it. In some cases they run out of electricity almost every month, and have to make do without electricity for a few days or a week until the end of the month. In other cases, particularly when the household income is irregular, they buy electricity irregularly when they have money, with periods in between when they have no electricity. Approximately 20% of the households interviewed in Antioch indicated that they have insufficient money to ensure access to electricity all the time.

The number of households who report that they run out of electricity on a regular basis is surprisingly low considering how little electricity some households in Antioch are using. Six households interviewed in Antioch had used less than 10 kWh per month on average over a period of ten months (estimated from measured load). Some of them don't report being without electricity on a regular basis (except when thunderstorms cause power failures, which occur regularly in summer). These households seem to manage 'stretching' a few electricity units over a whole month.

For example, one household in Antioch used an estimated 7 kWh per month. The household has only one light inside the homestead, no outside lights and no electrical appliances. They report that they don't go without electricity except during power failures. They use one light only and use it sparingly to ensure that their electricity lasts throughout the month. A consumption of 7 kWh per month would enable them to use a 60W light bulb every night of the month for about four hours each night, or a 100W light bulb for about two and a half hours each night.

In Garagopola most households using 50 kWh per month or less use electricity mainly for lighting and radios/hi-fis. A few of these households use television sets, electric irons, kettles or hotplates to a limited degree. In order to illustrate this, an example is given here of a household who used between 40 and 50 kWh per month at the time they were interviewed. They indicated that they use electricity for the following purposes:

- Four lights for three hours each night.
- Four lights for one hour each morning.
- television for two to four hours per day.
- An electric iron three days per week.
- A hotplate a few days per month.
- An electric kettle about five times per month.

The only electrical appliances used to a significant degree by this household are therefore a television and an iron.

Households using less than 25 kWh per month, typically only use electricity for lighting and radios. An example is given here of a household in Garagopola who used between 20 and 30 kWh per month at the time they were interviewed. They indicated that they use electricity for the following purposes:

- Two lights for three hours each night.
- One light for one and a half hours each morning.
- A radio for sixteen hours per day.

Keeping a light on throughout the night, every night, can consume between 20 and 40 kWh per month, depending on the brightness of the light bulb and the period for which it is switched on. In Garagopola no households using less than 20 kWh per month reported leaving lights on at night. This service is therefore not available to the poorest.

In Garagopola, most of the households using less than 50 kWh per month are headed by women, while male-headed households are the majority in the rest of the sample. The female-headed households using little electricity tend to be the poorest households in the sample. No such trend was found in Antioch.

Reasons for the differences in electricity use between the two communities

A combination of factors would have given rise to the differences in electricity use between Garagopola and Antioch (Thom 2002). One of the most important of these is the much higher total expenditure on energy in Antioch. Because of the shortage of wood in the area, many people buy wood, while paraffin has replaced wood as the main cooking fuel. As a result, households in Antioch spend a lot more on energy per month than in Garagopola, where wood is still the main cooking fuel because it can be collected in the area. Added to this, households in Antioch have less money to spend on household necessities like food and fuels on a monthly basis, as the average income received by households is lower than in Garagopola. As a result the average percentage of income received that is spent on energy is higher in Antioch. It therefore appears that household budgets in Antioch are placed under severe strain by the need to buy wood or paraffin, so that households are not in a position to increase their use of electricity.

This situation is probably compounded by the following factors:[17]

The social context in which the electrification of these communities took place seems to have been different from the onset. When Garagopola was electrified, many other neighbouring communities had already been

[17] Please note that some of these differences still need to be confirmed by further (qualitative) research in Antioch.

electrified, and people in Garagopola would have looked forward to it, and felt that they wanted to be as 'advanced' as other communities around them. In Antioch the opposite seems to have been the case. Antioch, Maganxosini and a few other villages were the first communities in their immediate area to be electrified.

This social 'environment' was further entrenched by the degree to which the two communities were electrified. All the households in Garagopola were electrified because of the 8A option that was offered. This, in combination with the first factor, would have made access to electricity part of the dominant way of life in the area in and around Garagopola. In Antioch, on the other hand, there are many households who are still without electricity – this probably includes households who cannot afford the connection fee, as well as households who do/did not want electricity. Access to electricity is therefore not yet part of the dominant way of life in and around Antioch.

The physical environment is an additional factor. Garagopola is situated on a major regional road, while Antioch is physically isolated and served by a dirt road in very poor condition. Access to services such as water supply and telecommunications has been improving in Garagopola in the last few years, and the quality of services is higher compared to Antioch, where water reticulation is available only in the main village, for example.

People in Garagopola benefit from the fact that they live in a rural village, while at the same time having access to commercial goods and services, local job opportunities, and public services. They appreciate the rural aspects of life in Garagopola, such as free access to wood, large plot sizes at very little cost, the possibility of growing their own food, and keeping certain traditions. At the same time, most households in Garagopola aspire to a modern lifestyle with all its conveniences, including the use of electricity. People's social aspirations and expectations therefore encourage the use of electricity to some extent. It is possible that Antioch differs from Garagopola in this regard.

Because Antioch is more isolated than Garagopola, many people in Antioch may have less access to information. This could have an effect on the use of electricity, as people may have less knowledge of electricity, and fear of electricity may be more common. There may be less technical know-how that might enable the wiring of homes for lighting. There may also be even less knowledge about the cost-effective and safe use of electrical appliances, and the cost of using different appliances than in Garagopola. For example, the fact that such a high percentage of households in Antioch still use battery-operated radios, may result from a lack of knowledge about the savings possible by converting to electric radios.

The electricity service problems faced by people in Antioch – frequent power failures, and restrictions on the electricity units for sale from the local vendor – also probably have an effect on the use of electricity. Weather conditions – frequent rain in summer, and occasional snow in winter – often render the access roads dangerous. These conditions could make it impossible for many households to even imagine that they could use electricity for all their energy needs.

TRENDS IN ELECTRICITY USE BY HOUSEHOLDS OVER TIME

Seventeen households in Garagopola were interviewed in-depth in 1999 as well as in 2001. Among these households different trends in the use of electricity can be observed (based on measured load) (Thom 2002).

Most (thirteen) of these households bought more appliances between 1999 and 2001 (even if only a radio), as they want to use electricity for more purposes. However, due to circumstances, this is not always possible, so it does not always mean that they use more electricity.

Seven households were using much more electricity in 2001 compared to 1999, because they had bought new appliances (particularly fridges/freezers) (see case study of household #9 below) and/or because they were using other appliances more often. However, some of them may not be able to sustain this due to changed circumstances, which will affect their disposable income in the future.

Five households were using much less electricity in 2001 compared to 1999. Reasons for this include the following: changes in circumstances that affect disposable income, broken appliances, and other expenditure priorities (for example, on telephone services which have become available since 1999, furniture and/or education) (see case study of household #10 below).

Three households interviewed in 1999 and 2001 have consistently used less than 30 kWh per month. These households tend to use electricity for lights and radios only. The circumstances of these three households are very different. Two of them are female-headed. One of these seems the poorest of the three, but they have managed to improve their situation slightly (see case study of household #34), while another household is becoming progressively poorer as the income they depend on is eroded by inflation (see household #31). The household headed by a man is slightly better off than the other two, but seems to have other expenditure priorities, and appears to be satisfied with using electricity for lights and a radio (see case study of household #32 below).

Two households have consistently used more than 200 kWh/month, but were both using slightly less electricity in 2001 compared to 1999. Both of them have expressed the desire to get a 60A electricity supply in the future, and both are highly appreciative of the convenience offered by electricity. Nevertheless, one of these households is consciously attempting to reduce their electricity expenditure by increasing their use of paraffin for water-heating purposes, as they feel that electricity is more expensive to use than paraffin. They have a much lower income than the other household, and have been using more electricity over the last few years. The second household feels that the cost of electricity and paraffin is very similar. They seem to be using less electricity because of fewer needs in 2001, rather than a conscious attempt at reducing their expenditure. Their electricity consumption will probably increase significantly once the new house they are building has been completed.

An interesting phenomenon, which has been observed among households in each of these groups (except those who have consistently used very little electricity) is that of back-switching to the use of paraffin, particularly for water heating, but also for cooking. Households do this in order to reduce their electricity consumption, and/or because their hotplate has broken. The need to reduce their electricity consumption on cooking and water heating may arise because they feel their electricity consumption is getting too high, either because the price of electricity has increased, or because they are using new appliances, particularly fridges/freezers. This is greatly influenced by the perception that electricity is more expensive than paraffin for purposes such as water heating and cooking (see case studies of households #9 and #10 below).

Household #10 (Garagopola)

This household's electricity consumption, based on measured load, decreased from 130 kWh/month in the period May to August 1999, to 75 kWh/month in the period March to May 2001. Their reported expenditure on electricity was more or less the same, however – it was R50 to R60 in July 1999 and R50 to R70 in May 2001.

The respondents, Rebone and Maggie (daughter and mother respectively), said that they bought more electricity every month even if they had not finished the units in the meter. They thought that they were probably using fewer electricity units in 2001 because three of their electrical appliances were broken (a black-and-white television, kettle and hotplate). The first two had been broken in July 1999 as well, but their hotplate broke in 2000. In July 1999 Maggie had reported using the hotplate every day for preparing supper, and for all their water heating. She said that they were not using paraffin at all. However, in 2001 they were using paraffin for all cooking and water-heating purposes – in May 2001 Maggie said that they were using 25 litres of paraffin per month (costing R50 per month).

This household has therefore back-switched to using paraffin because of their broken hotplate and kettle. They seem content to use paraffin for cooking and water heating for the time being. One reason for this seems to be the lower cost of a paraffin stove compared to a hotplate: 'A hotplate is expensive, because it costs R125 and a primus stove costs only R20.'

But when asked what fuel they would prefer to use for cooking in the future, Maggie said that she would prefer to use electricity in the future: 'My children will be working and will be able to buy me an electric stove'. She had also said in July 1999 that she would like to buy a four-plate electric stove in the future. She likes cooking with electricity, 'because it saves time and it is cleaner than paraffin'.

The household could probably have bought an electric stove already if it was important enough to them, but they seem to have other expenditure priorities. The main income source of the household has been the wage earned by Maggie's husband who works at a nearby mine. In July 2001 they were also receiving R300 per month from a son who lived in Nelspruit, but in May 2001 their only income was from the wage earned by Maggie's husband. They reported a much lower income in May 2001 than in July 1999 – in May 2001 Maggie indicated that her husband contributed between R1 000 and R1 400 to the household per month, compared to the income of R2 400 they reported in 1999. However, the monthly expenditure they reported in August 2001 suggests that their income was closer to R2 000 than R1 000 per month. Their monthly expenditure amounted to about R1 825, excluding their telephone bill, which they could not estimate. The R1825 included R600 to R700 on groceries, food, fuels, electricity, transport and other small items; R625 on hire-purchase installments (on sofas and a colour television); R300 to a stokvel; and R250 to support someone living elsewhere. In addition, they were paying R750 on school fees every quarter. In August 2001 they said they were paying hire-purchase of R625 per month.

In July 1999 they had been spending even more on hire-purchase installments (R1 070 per month) on the sofas, a room divider (wall unit) and the colour television. The household therefore seems to be prioritising furniture, as well as education.

Household #9 (Garagopola)

This household's electricity consumption, based on measured load, increased from 144 kWh/month in the period May to August 1999, to 274 kWh/month in the period March to May 2001. Their reported expenditure on electricity also increased from R40 to R50 per month in July 1999 to R100 per month in May 2001.

The respondent, Cathrina, said that they were using more electricity, 'because we have bought a new deep freeze and a hi-fi'. They already had a combined fridge/freezer in July 1999, but had bought a deep freeze in March 2001. Cathrina said that they used both the fridge/freezer and the deep freeze: 'I need to use both fridges because I sell ice-lollies.' (The latter is flavoured ice in plastic covers, popular with children.) In July 1999 she had been selling fat-cakes at the local mines, using paraffin to prepare the fat-cakes. By May 2001 she had expanded her business, selling fat-cakes, chips, sweets and ice-lollies from home. Their electricity consumption therefore seems to have increased particularly because of the use of the additional freezer for business purposes.

An interesting effect of their increased electricity consumption is that they have back-switched to using paraffin for cooking and water heating. In July 1999 they had used only five litres of paraffin per month, and Cathrina had said that she mainly used it for making fat-cakes for selling. By May 2001 they were using twenty litres of paraffin per month, and were not using their electric hotplate at all. This in spite of the fact that she prefers to use an electric hotplate for cooking: 'The hotplate is the best, because it is cleaner and safer to use.' When asked what fuel she would prefer to use for cooking in the future, she said, 'Electricity, because paraffin smells and I am tired of using it'. She had also expressed this preference in July 1999.

Nevertheless, when asked about the reasons for using different fuels, she repeatedly said that she used paraffin 'because it is cheaper than electricity', and that she was not using her hotplate 'because it uses too much electricity'. She was not able to compare the costs of the two fuels directly, however. When asked how much paraffin she used to cook particular dishes, she responded, 'I have never thought about that'. She also did not know how many electricity units she used for cooking: 'I have never checked.'

The decision to switch back to paraffin seems to be based on what they (Cathrina and her husband, who makes most decisions on household expenditure) are prepared to spend on electricity per month. When asked what they would do if the price of electricity went up, she made the following revealing statement: 'I would be sad, but would continue to buy electricity. I would keep on buying electricity for the same amount of money, and would use fewer units – I would switch off one fridge/freezer, and the other one would stay on. Because I know that R100 per month is enough for me.' They therefore realise that the fridge and freezer use a lot of electricity and feel that they would spend too much on electricity if they used the hotplate as well. However, they seem content to spend R100 per month on electricity. When asked whether they were trying to reduce how much electricity they used per month, she said that they were not trying to reduce it, 'because I don't use too much at the moment. Maybe if I were spending R200 or more, I would try to reduce it.'

There have been no major changes in the circumstances of the household between 1999 and 2001, except a possible increase in household income. In 1999 they reported a monthly income of about R1 300 per month, but in May 2001 their total income was between R2 400 and R3 000 per month. Their income may have improved significantly between 1999 and 2001, but it is possible that they had under reported it in 1999. The main source of income has always been the wage earned by Cathrina's husband who works at a local mine. In May 2001 Cathrina reported her husband's earnings as between R2 200 and R2 600 per month, and also reported making between R200 and R400 per month from her home-based selling activities.

Household #32 (Legabeng)

This household's electricity consumption, based on measured load, decreased slightly from 20 kWh/month in the period May to August 1999, to 9 kWh/month in the period March to May 2001. Their reported expenditure on electricity increased, however, from R5 per month in July 1999 to R10 to R20 per month in May 2001.

Their reported use of electricity in July 1999 and May 2001 suggests that they are consuming slightly more electricity in 2001 than in 1999; it is not clear why the measured electricity consumption is lower.

They had only one inside light and one outside light in July 1999, which they used from 6pm to 9pm every night. In May 2001 they reported having two inside lights, both of which they used from 6pm to 8/8:30pm every night. They also used the outside light from 6pm to 9pm every night. They have had an electric radio since 1998, and listen to it throughout the day.

The circumstances of the household have changed somewhat between July 1999 and May 2001, although their main income is still the disability pension received by the male household head (R540 per month in May 2001). They no longer receive any supplementary income from selling vegetables at the communal garden project, or occasional contributions from their son who lives in Tembisa. But more significant is the additional expenditure they have in 2001 compared to 1999. The household obtained a fixed-line telephone service in mid-2001, and was paying up to R100 per month (but not always that much) on this service in August 2001.

They also made substantial changes to their homestead between July 1999 and August 2001. A brick structure, comprising two bedrooms, has been built where the fireplace was in 1999. This is the only brick part of their homestead; the rest are all clay structures. By August 2001 they had installed another electric light inside the new brick structure. In August 2001 they reported spending about R365 per month on building materials and labour (probably only for a few months).

Their low electricity consumption could therefore be attributed to other household priorities, including improvements to their homestead, and a telephone service. They seem to value electricity particularly for the lighting. The respondent Enica, daughter of the household head, said that they never stay without electricity (in spite of their low consumption), but make sure that they buy it every month on pension pay-out day. She said that they would continue using electricity even if the price increases: 'It is going up all the time, but we have not stopped using it because we are used to the lights.'

ELECTRICITY-RELATED PROBLEMS PEOPLE EXPERIENCE

Broken appliances

The incidence of broken appliances seems to be higher in Garagopola than in Antioch. High incidences of damage to the following appliances have been found in Garagopola (Thom 2002):

- **Television sets**: 22% of all households in the sample have broken television sets (a third of the households who own television sets); only one of them has a working television in addition to the broken one.
- **Hotplates**: 18% of all households in the sample have broken hotplates (almost a third of the households who own hotplates); only one of them has a working hotplate in addition to the broken ones.
- **Irons**: 15% of all households in the sample have broken irons (just more than a fifth of the households who own irons); three households have working irons in addition to the broken ones.
- **Kettles**: 11% of all households in the sample have broken kettles (a fifth of the households who own kettles); none of them have a working kettle in addition to the broken one.

It is interesting that no households in the sample have broken electric stoves or fridges/freezers. People complain about the poor quality of hotplates in particular. They tend to discard broken hotplates and other small appliances, as they don't know anyone who can fix them, or because they break again after fixing. Although there are a few people in the area who fix small appliances, they can provide a limited service only because of a lack of equipment and/or training. Their services are also not widely known. Some households who can afford to, buy new hotplates to replace the broken ones. Others are worried that the same thing will happen again (see case study of household #31 below). Some seem to be waiting until they are able to afford an electric stove (see case study of household #10).

Household #31 (Garagopola)

This household's electricity consumption, based on measured load, was similar in the period May to August 1999 (24 kWh/month) and the period March to May 2001 (28 kWh/month). Their reported expenditure on electricity was exactly the same – in both July 1999 and May 2001 they reported spending R10 per month on electricity.

They installed an extra light between July 1999 and May 2001, and therefore had four inside lights in May 2001. They differ from households #32 and #34, who have similar levels of electricity consumption, in that their homestead comprises a single building, and that they have electric lights in all their rooms. They also differ from the other households in that they own a few appliances, namely a radio, television and a one-plate hotplate. These appliances were all broken in August 2001, however. The radio was working in May 2001, but the television and hotplate had been broken at the time of the first interview in July 1999. The radio and television are both quite old, but the hotplate was bought in January 1999, and broke within a few months. The respondent Anna, who is head of the household, was very unhappy about the hotplate she had bought. When asked whether she felt a hotplate was more expensive than a paraffin stove, she responded, 'I feel a hotplate is too expensive, because I bought one and it blew within a month when I plugged it in to cook. I was so disappointed and I never bought another one because I thought it was going to do the same thing.' When asked which fuel she would like to use for cooking in the future, she said that she would prefer electricity, 'but only if I can have a guarantee that the hotplate I am going to buy won't do the same as the one I had previously.' She has not been able to fix any of the appliances – she asked someone to fix the hotplate in 1999, and her son tried to fix it as well. She has also not been able to replace the television or hotplate because the household is very poor. In May 2001 they were using the radio throughout the day (it was working at the time), and were using their five lights (four inside and one outside) from 6:30pm to 9:30pm every night. (They also have a cell phone, which was bought by a boyfriend for a daughter of the household head.)

The reasons for their low electricity consumption seem to be a combination of poverty and broken appliances. The only income of the household is a pension received by Anna, the household head, whose deceased husband worked at a mine – this was R400 in 1999 as well as in 2001. The household's real income has therefore been shrinking over time because of inflation.

Electricity services

Antioch is experiencing some serious problems with electricity services. Two complaints often made by households are the frequency and duration of power failures, particularly during the rainy season (summer), and the unavailability of electricity tokens from the local electricity vendor (Thom 2002).

Many households complain about the poor service provided by the electricity vendor, who generally rations the electricity sold to households at one time, and often runs out of electricity units to sell. As a result many households tend to buy electricity in the town Umzimkulu. This is a problem, particularly as Antioch is located in a remote mountainous area, which can be accessed only by means of a winding dirt road – often along steep slopes – which is for the most part in a poor condition. Umzimkulu is about an hour's drive from Antioch if the road is dry, but in rainy conditions the road is slippery and dangerous.

In Garagopola the regular occurrence of power failures in summer also encourages people to purchase paraffin stoves to provide a back-up system. Reducing the frequency and duration of power failures would probably result in a greater reliance on electricity among households who can afford to use electricity for all purposes (Thom et al 2000b).

Lack of information

A wealth of data is available from the qualitative interviews in Garagopola, which points to a great need for information among electrified households in rural areas (Thom 2002). The lack of information and misunderstandings that result from it leads to negative perceptions about the costs of electricity, which affect the use of electricity by households.

- Information is required about the meaning of electricity 'units' (kWh). People need to understand that the price of electricity is expressed per unit and to learn how to estimate the costs of using a particular appliance by counting the units consumed by that appliance.
- Information is needed on the typical electricity consumption of appliances (in terms of units and costs), as well as the consumption of electric lights, seeing that households tend to use all their lights for a few hours in the evening.
- Information is also needed on the total number of units that would be needed to provide a particular service – for example, keeping a light on throughout the night.
- Information is needed on electricity price increases – for example, how many units customers will receive for a standard amount (say R10) before and after the price increase.

Many people in Garagopola are unhappy because they are getting fewer electricity units when buying R10 of electricity now, compared to a few years ago. They often don't understand that this is because the price of electricity increases.

- Information is needed about the relative costs of using electricity and paraffin for purposes such as cooking and water heating.

Views about this vary considerably in Garagopola, with some people feeling that electricity is more expensive than paraffin, and others feeling that paraffin is more expensive. Nevertheless, the view that electricity is the most expensive energy source if used to prepare foods that require long cooking time, seems to be pervasive.

People often know how much paraffin they use for cooking or water heating, and therefore what the cost is, but they don't know how much electricity is used for these purposes, and therefore cannot compare the costs.

Information is needed that reflects the real conditions in rural homes, rather than ideal 'laboratory' conditions. For example, the quality and conditions of the stoves used in rural homes probably differ substantially from newly-bought stoves.

- Information is needed on the most cost-effective way to use electrical appliances – that is, how to minimise electricity consumption without reducing effectiveness and slowing down tasks unnecessarily.

For example, while it appears that many households in Garagopola know that it is more expensive to use hotplates on the highest setting, some people still do so because they believe the food cooks faster that way.

- Information is needed on the relative costs of using electricity to operate radios compared to dry-cell batteries. People need to know how much they could save per month by buying a radio that can operate on the mains rather than on dry-cell batteries.

- Information is needed on the safe use of electricity, as well as the safe installation of wiring in homesteads.

Generally people need to be provided with information on the appropriate behaviour that would enable them to get most benefit from their electricity supply.

RECOMMENDATIONS

Some recommendations on ways to facilitate greater use of electricity by rural households are provided here. The aim is to enable households to use electricity and to make informed choices. Clearly poverty is an underlying problem, which constrains the use of electricity, but this could not be addressed by Eskom alone.

- Creative ways to package the required information and to disseminate this to rural people must be developed – for example, approaches used in the Soul City project, which included well-targeted and attractive information booklets, as well as radio programmes.
- The information provided to electricity users must be of a practical nature, and rural people must be able to relate to it. The information collected in this research project could be used to develop 'case studies' to be used in booklets or radio programmes.
- The current approach of using mass meetings to educate people about electricity use is not very effective (see Chapter 5). This needs to be addressed – either by training staff in the appropriate skills, or by involving people with the necessary skills from outside the utility.
- Community information workshops that make use of interactive and participatory teaching approaches can play an important role in user education in addition to mass media such as the radio.
- Households who live in homesteads comprising more than one building, need to be assisted in some way with the extension of electric wiring to the various buildings. Ways to do this need to be investigated.
- Problems with the quality of appliances (particularly hotplates) need to be addressed by setting and enforcing quality standards.
- Entrepreneurs in rural areas need to be trained and equipped to fix broken appliances such as hotplates, irons and kettles.
- Problems with vending services such as those experienced in Antioch need to be addressed; for example, vendors need to be trained in business practices if they are not experienced business people.

REFERENCES

Dekenah, M 2000. Load Research Studies (2000). Eskom report RES/RR/00/13248. Rosherville: Eskom Resources and Strategy Division.

Thom, C 2000. Use of grid electricity by rural households in South Africa. *Energy for sustainable development* IV(4): 36-43.

Thom, C, Mohlakoana, N, Dekenah, M & Heunis, S 2000a. Case studies on the impact of electrification in rural areas. Eskom report RES/RR/00/11953. Rosherville: Eskom Resources and Strategy Division.

Thom, C, Mohlakoana, N, Dekenah, M & Heunis, S 2000b. Case studies on the impact of electrification in rural areas. Eskom report RES/RR/00/11953. (Version March 2001: Qualitative research only). Rosherville: Eskom Resources and Strategy Division.

Thom, C & Mohlakoana, N 2001. Use and impact of electricity in a rural village in the Northern Province. Proceedings of the 57th Convention of the Association of Municipal Electricity Undertakings (Southern Africa), 22-24 October 2001, Pretoria.

Thom, C 2002. Case studies on the impact of electrification in rural areas. Eskom report RES/RR/01/16289. Rosherville: Eskom Resources and Strategy Division.

Chapter 7

Residential Energy Efficiency: Improving Access and Supporting Development

Randall Spalding-Fecher[1], Alix Clark[2], Mark Davis[2], Gillian Simmonds[2], Albert Africa[3]

[1] University of Cape Town [2] Formerly University of Cape Town [3] Eskom

Residential energy efficiency can provide substantial economic and environmental benefits for South Africa. By effectively reducing the cost of electricity services, energy efficiency increases the affordability of these services for the poor.

INTRODUCTION: WHY RESIDENTIAL ENERGY EFFICIENCY FOR THE POOR?

South Africa's Reconstruction and Development Programme (RDP) set goals for providing basic services to all, including the mass housing and electrification programmes (ANC 1994). The White Paper on Energy Policy identified increasing access to affordable energy services as one of the top priorities for the sector (DME 1998). Meeting the goals for improving access requires careful analysis of the options for meeting them. The international energy policy literature has numerous examples of how investment in the demand side to increase end-use energy efficiency is often the least-cost way to provide energy services, while at the same time reducing the environmental impacts of energy use (Lovins & Lovins 1991; Energy Innovations 1997; IWG 2000; Renner 2000; Sant & Dixit 2000). In countries like South Africa where the gap between access to affordable energy and the demand for energy is very large, energy efficiency has the potential to accomplish multiple social and economic objectives. Earlier South African studies have shown that significant potential for energy efficiency exists across a range of sectors, although the costs were less well understood (Thorne 1995). The impacts of energy efficiency on the low-income residential sector are particularly important, because of the social priorities for upliftment and empowerment of the poor.

This chapter examines the economic and environmental impacts of residential energy efficiency on the urban poor – including how energy efficiency puts money in people's pockets that allows them to access greater energy services. We also examine how programmes can be implemented that support the goals of increasing access to affordable energy service. This chapter builds on several years of Eskom-funded research on residential energy use in low-income urban areas to present an overview of the case for residential energy efficiency and strategies for making it happen (see full list of reports at end of chapter). The chapter begins by outlining five residential energy-efficiency interventions, and the economic and environmental benefits that they create for the country and for poor households. This is followed by a discussion of the barriers to residential energy efficiency in South Africa, with a focus on the urban poor. Finally, we make policy recommendations on how to ensure that socially beneficial residential energy-efficiency investments can be promoted.

The context for residential energy efficiency in urban townships includes both ongoing initiatives as well as the patterns of energy use and decision making within those communities. Energy-efficiency programmes are a sub-set of a broader set of demand-side management (DSM) programmes, launched by Eskom in 1995. Activity in the field of DSM within Eskom has to date centred around tariff-induced load shifting and studies to quantify the potential benefits of DSM programmes. Following Eskom's decision to include DSM as an alternative to supply-side resource provision, a number of DSM targets have been set. As the magnitude of the undertaking is comparable to the building of a new power station, a comprehensive strategy and plan to achieve the targets is required. The DSM planning framework provides a high level outline of the principles, policies and processes to be followed in the development of the various DSM plans. It is the foundation upon which Eskom's DSM development and implementation plans are based across the residential, commercial and industrial sectors.

End-use energy efficiency involves the effective conversion and utilisation of energy in meeting customers' energy service needs in a manner which results in reduced life-cycle costs for both Eskom and its customers. A study of 32 potential energy-efficiency programmes reveals that a significant reduction in peak load is achievable by 2015 at a life-cycle cost that is considerably lower than that of an equivalent power station. Participating customers in the programme would realise a great benefit through reduced electricity costs.

Some of the residential energy efficiency projects that Eskom has undertaken in the last seven years include the following:

- residential pool pumps;
- residential water conservation;
- residential cooking awareness;
- 'de-marketing' to gas;
- energy-efficient residential lighting;
- residential energy-efficient refrigerators;
- low flow shower heads;
- energy-efficient cool storage;
- thermal efficiency/space heating;
- hot water conservation;
- hot water system efficiency (geyser blankets);
- appliance labelling; and
- social development.

Eskom's residential demand-side management (RDSM) programme is one of the most important ongoing initiatives. The goals of the RDSM programme are to reduce peak demand, to sustain the decrease in the real price of electricity in the long term, to increase electricity's competitiveness in the small customer energy market, and to contribute toward environmental conservation and awareness. This programme works along side Eskom's commitment to extend access to electricity for the low-income sector in South Africa. The interventions considered in this chapter are a sub-set of the residential programmes that Eskom has initiated – a sub-set where the University of Cape Town (Energy and Development Research Center (EDRC)) was able to undertake more detailed analysis of the potential impacts of the programmes.

At the government level, the South African White Paper on Energy Policy recognises the critical importance of energy efficiency for providing affordable energy services (DME 1998). The White Paper also includes a commitment by government to use integrated resource planning (IRP) for all electricity planning, and the National Electricity Regulator (NER) recently released the first draft national IRP. IRP is an approach to energy planning comparing different demand- and supply-side options for providing electricity services on an equivalent basis, considering the full economic, environmental and social impacts (Swisher et al. 1997). Implementing this policy will require sustained regulatory commitment to promote demand-side management and energy efficiency through both Department of Minerals and Energy (DME) and NER policies. At the household level, implementing energy efficiency in South Africa is also quite different than in many of the industrialised countries in which these programmes and technologies were developed. Multiple fuel- use patterns – even after electrification, irregular sources of income, and social and cultural influences on purchasing behaviour, all form the context in which decisions about energy efficiency are made.

RESIDENTIAL ENERGY EFFICIENCY PROGRAMMES TARGETING THE POOR

We investigate five residential energy-efficiency interventions for low-income households. These are part of a larger suite of initiatives that Eskom is developing. The five interventions presented here are those for which EDRC conducted detailed policy and economic studies to evaluate their potential benefits. The programmes are:

- the dissemination of compact fluorescent lamps (CFLs) to displace incandescent bulbs in low-income urban households;
- the installation of ceilings in low-cost housing and other no-cost thermal improvements (e.g. proper orientation on the site);
- the installation of more efficient refrigerators;
- the switch from electricity to liquefied petroleum gas (LPG) for cooking; and
- the switch from paraffin to gas for cooking.

It should be noted that while the first three are energy-efficiency interventions, the last two are fuel- switching strategies. While fuel switching away from electricity certainly saves electricity, it may not necessarily save energy. The two fuel switches presented here, however, do both save primary energy, the first because of the high losses in electricity generation.

Energy-efficient lighting

One of the most significant investments in energy efficiency in South Africa currently is the Bonesa company set up to implement the national Efficient Lighting Initiative. This joint venture company has received funding from Eskom over a period of three years, for 2000 to 2002 and from the International Finance Corporation over a period of two years, as part of a GEF grant. The programme for low-income households here is a sub-set of the larger programme covering all households that aims to install around 18 million CFLs (Bredenkamp 2000). Besides the environmental benefit, the programme stands to achieve a peak load reduction of 825MW over a period of 20 years.

CFLs use significantly less power than conventional incandescent bulbs. Many low-income households' use of electricity is less than 100 kWh/month, which implies that a large percentage of electricity use is for lighting. This is generally the case where households do not have hot water geysers and do not cook extensively with electricity. As a result, energy-efficient bulbs can have a significant impact on electricity bills and affordability of access to electricity. From the utility's perspective, lighting demand has a high degree of coincidence with peak demand, especially in the winter when the peak occurs in the evening and when daylight fades earlier. Consequently, energy- efficient bulbs can have a significant impact on peak demand. The programme analysed here involves displacing 75W incandescent bulbs (a weighted average of 60W and 100W bulbs in use) with 19W CFLs.

Thermally-efficient housing – installing ceilings to reduce space heating costs

The installation of a ceiling is one of the most cost-effective measures to improve the thermal performance of a dwelling. While this will improve comfort levels in both the summer and the winter, the impact on energy use will only occur in the winter as most low-income households do not use air-conditioning or fans. Other low- or no-cost measures such as north-facing orientation of the house also improve thermal efficiency of the building, thereby reducing energy consumption. Many households do not rely on electricity for space heating, but rather use coal (either in coal stoves or braziers), wood or paraffin. Consequently, while households may reap substantial benefits from reduced heating costs, the utility may only experience a small reduction in electricity demand. Nevertheless, heating loads peak in the evenings during winter – a time of peak electricity demand for the utility.

Energy-efficient appliances: refrigerators

The acquisition of a refrigerator by a low-income newly electrified household is a significant purchase. It is an expensive appliance requiring a large capital outlay, so the purchaser will be especially sensitive to capital cost as opposed to ongoing operating costs. A refrigerator usually introduces a new energy service into the household with significant benefits, including the health and financial benefits of being able to store perishable foodstuffs. In some cases refrigerators also contribute to household income – if the household runs a small retail enterprise (selling chilled drinks) or in cases where the household rents space in the refrigerator to neighbours.

In addition, modelling the impacts of more efficient refrigerators is an interesting case study in appliance efficiency because there have been significant advances in refrigeration technology. The same methodology can be applied easily for any other capital-intensive appliance with a long lifetime. The analysis also looks at two cases – where the refrigerator is a first-time purchase and where it is a displacement of an existing inefficient refrigerator.

Switching from electricity to gas for cooking

There has been significant discussion in South Africa about whether utilities should de-market electricity to gas – in other words promote gas use instead of electricity – for cooking and space heating. The argument is that using gas in the home may be more energy efficient, and also reduce the impact of very 'peaky' loads from newly electrified customers on the national load curve. While the end use efficiency of LPG stoves may be less than electric hot plates, when we consider the losses in electricity generation, the LPG fuel cycle is generally more energy efficient. The question is whether this strategy makes sense in urban areas, which have not been largely electrified and where LPG networks continue to be weak (although stronger than in rural areas).

When switching from electricity to LPG for cooking, there will be changes in costs and revenues, particularly for the utility. From an economic perspective the question is whether cooking with LPG incurs more or less resource costs than cooking with electricity. The perspectives of the utility and consumer are driven by the net impacts on their revenue. As with refrigerators, there are two cases to examine here – where households currently cook on electricity and must purchase a new gas appliance, and where households face a choice between gas and electricity for cooking. In the former case, the full cost of the gas cooker must be accounted for, whereas in the latter case the consumer avoids the purchase of an electric hot plate by choosing gas.

Switching from paraffin to gas for cooking

Paraffin is widely know to be one of the most dangerous fuels for household use, because of the high risks of fires and burns, as well as poisoning of children who accidentally ingest paraffin kept in cooldrink bottles (Spalding-Fecher et al. 2000; Biggs & Greyling 2001). Moving from paraffin to LPG therefore has major potential social benefits in addition to any energy savings. While switching from paraffin to gas will have no implications for the power utility, the same questions concerning the economic impact and effects on the consumer apply. As such, it presents an appropriate example of a non-electricity energy-efficiency intervention. This analysis does not investigate a specific sized programme, but examines the questions based on a single household switching fuels. As before, two cases are relevant: where the household must discard an existing paraffin stove, and where the choice is between purchasing either a new paraffin or a new gas stove.

METHODOLOGY: MEASURING THE ECONOMIC VALUE OF ENERGY EFFICIENCY

The analysis that EDRC conducted of residential energy-efficiency options follows a standard set of questions, originally developed by the public utility commission in California to evaluate demand- side management programmes. While this is similar to some of Eskom's internal analysis within the integrated strategic electricity planning (ISEP) process, these examples are not meant to be a substitute for that process or to represent its results (CEC 1987). In this section we describe the generic questions that the analysis addresses.

The objective of performing an economic analysis of energy efficiency is to answer a set of questions concerning the economic and financial viability of a proposed energy-efficiency programme. In general, the appraisal of capital investment projects is undertaken using discounted cash flow analysis, and this approach is adopted in the methodologies described below. In this sense, evaluating an investment in an energy-efficiency project is no different from evaluating any other type of capital project.

The questions being posed are as follows:

- **Is the project in the interests of the country?**

  This question addresses the economic viability of the project, i.e. does the project result in net economic benefits for the country as a whole? The principal tool used here is the total resource cost test, which involves calculating the total costs of providing energy services with and without the project.

- **Is the project in the utility's interests?**

  There are two ways of approaching this question. The first approach determines whether the energy-efficiency project is a lower cost approach for the utility to supply the energy service in question. The tool used here is the utility resource cost test, which examines only the costs which the utility incurs with and without the project, and ignores any of the revenue implications. The second approach concerns the financial viability of the project, i.e. does the project result in net benefits for the implementing agent, in this case the utility? The principal tool involved here is the utility revenue test, which involves calculating the net impact on the utility's income. As with all capital investment appraisal techniques, the projected income stream is discounted.

- **Is the project in the interests of participating consumers?**

  This question examines the attractiveness of the project to the poor consumer participating in the DSM programme. The simplest technique to use is the consumer revenue test. This is similar to the utility revenue test, except that we take the perspective of the consumer in estimating costs and revenues. In other words, this test will tell us if the consumer ends up with more money in their pocket because of the intervention.

- **Is the project in the interests of non-participating consumers?**

  This test builds on the earlier test in that it examines the impact on consumers who do not participate in the programme. The appropriate measure is the ratepayer impact test, which analyses the impact on electricity tariffs as a consequence of the programme. Where tariffs increase as a result of the programme, non-participants will see increased electricity bills, even if programme participants have their overall energy expenses reduced.

Details on implementing each of these methods, are based on the California Energy Commission Standard Practice Manual (CEC 1987).

RESIDENTIAL ENERGY EFFICIENCY CAN GENERATE SUBSTANTIAL ECONOMIC BENEFITS

The test used to determine economic viability is the total resource cost test. The result calculated is the net benefit of the project, calculated as the present value of costs without the project (i.e. the avoided costs), less the present value of costs with the project. If the result is positive, then the project generates net benefits for the economy. It is possible to calculate the net benefit for a single installation (e.g. one CFL bulb), as well as the net benefit for the entire programme. The latter is naturally sensitive to the scale of the programme. The key results are presented in Table 3.

Table 3: Economic benefits (costs) for each programme (2000 Rand)

		Without take-back effect		*With take-back effect*	
	Programme	*Single*	*Programme*	*Single*	*Programme*
		(R)	*(Rm/year)*	*(R)*	*(R/year)*
Energy efficiency	CFLs	71	6.2	56	4.8
	Ceilings	503	44.3	300	25.9
	Refrigerators[a]	(59)	(2.9)	(59)	(2.9)
Fuel switching for cooking	Elec to LPG[a]	(2 135)	(174)	(3 088)	(250)
	Para to LPG[a]	2 661	N/A	1 817	N/A

Notes: a. New purchase – only the additional cost of the efficient appliance is incurred.

Three of the five programmes generate substantial economic benefits, even when we consider the impact of the take-back effect. The CFL, ceiling and paraffin to LPG programmes have economic benefits. The negative impact for the refrigerator programme is still quite small – South African Rand (R) 60 on a purchase of R2500 – so that relatively small price reductions (or higher energy prices) would make this programme also positive. Only the switch from electricity to gas does not appear to have economic benefits, which merits further discussion. The result for electricity to gas is surprising given the recent emphasis from Eskom and other energy sector actors to move towards ‘energisation’ packages for low-income households that include electric connections for lighting and entertainment, coupled with a gas canister for cooking. Three points are important to note, however. First, energisation is mainly promoted in rural areas where grid electricity would be considerably more expensive and there is no infrastructure already in place for distribution. Second, given the lack of data on the ‘economic’ cost of producing LPG, prices have been used in the total resource cost calculations instead of long-run economic cost. Because of the high margins on LPG and limited distribution, current prices may significantly overstate the long-run marginal cost of LPG. On the other hand, investing in a parallel distribution network to electricity could be expensive, and is also not adequately captured by these calculations. Third, the peak coincidence for cooking in newly electrified urban areas, based on Eskom’s load profile data, is not as high as assumed in earlier analysis.

For the installation of a refrigerator and a new stove, two options are possible: where the new appliance displaces an existing one; and where the new appliance had to be purchased anyway. In the first case, the initial cost should be taken as the full cost of that appliance. In the second case, the initial cost should be taken as the additional expenditure which the efficient appliance requires, i.e. the net cost of the appliance. This difference can have a significant effect where appliance costs are large, as shown in Table 4. These results show that the refrigeration programme is not economically attractive if the programme displaces existing refrigerators. This contrasts with the result for a programme that targets new fridge purchasers. On the other hand, the results of the fuel-switching programmes are not influenced significantly, because the costs of the appliances are small compared to the operating costs. In the programmes described here, consumers would generally be choosing a new appliance, not displacing an existing one – this is part of the reason for rolling out the programmes over time.

Table 4: Economic benefits of choosing different new appliance versus displacement of an existing one, including take-back effect (2000 Rand)

		For single installation (R)
Refrigerator	New	(59)
	Displacement	(2 303)
Electricity to gas stove	New	(3 088)
	Displacement	(3 201)
Paraffin to gas stove	New	1 817
	Displacement	1 761

RESIDENTIAL ENERGY EFFICIENCY IS LESS EXPENSIVE THAN NEW SUPPLY FOR ESKOM, BUT HAS SIGNIFICANT REVENUE IMPACTS

There are two measures used to examine the impact on the utility:

The utility resource cost test: i.e. does the programme reduce the utility's costs while still providing the same service?
The utility revenue test: i.e. does the programme increase the utility's net income?

The results are naturally sensitive to the amount of subsidy towards the cost of the installation that the utility provides. A sensitivity analysis is conducted on this variable, but the basic results are calculated for no subsidy for individual installations, and where the generation and transmission (G&T) utility pays for the initial and annual overhead costs of each programme. In general these are small in comparison with the cost of the appliances. The results are also affected by whether the take-back effect is included or excluded.

The utility resource cost test

The concept of the utility resource cost test is to determine whether the utility incurs lower costs while providing the same service. For fuel switching, the utility no longer provides the service and so the test is inappropriate. Table 5 shows the impacts on utility costs for a single installation and the entire programme respectively. Two cases are examined : for a G&T utility only, and a generation, transmission and distribution (G,T&D) utility in terms of the programme for CFL's, ceilings and refrigerators.

Table 5: Impact on utility resource costs, including take-back effect (2000 Rand)[a]

Programme	*For one installation (R)*		*For entire programme (Rm/year)*	
	G&T	*G,T&D*	*G&T*	*G,T&D*
CFL	(65)	(84)	(6.7)	(8.0)
Ceiling	(45)	(57)	(3.9)	(5.0)
Refrigerator	(247)	(329)	(23.7)	(29.1)

Notes: a. Assuming no utility subsidy is provided; negative number indicates that utility costs have decreased.

The three programmes tested all result in lower costs for the utility even more or when including distribution. That is, the utility incurs lower costs while providing the same service to customers. It is interesting to test the level at which the utility would be able to implement the programme, and still not incur increased costs. This result is reported as the 'break even' cost in Table 6.

Table 6: Sensitivity of utility costs to the programme implementation (2000 million Rand/year)[a]

Subsidy	*CFL*	*Ceiling*	*Refrigerator*
0%	(6.7)	(3.9)	(23.7)
25%	(6.1)	11.4	(19.4)
50%	(5.4)	26.8	(15.1)
75%	(4.8)	42.1	(10.8)
100%	(4.1)	57.5	(6.5)
Break even subsidy	100%	7%	100%[b]

Notes: a. Results are for a G&T utility implementing the programme. Negative number indicates that utility costs have decreased. b. Percentage of the additional cost of an efficient refrigerator over a standard model.

These results show that the utility, at current rates of return, can afford to investigate even more expensive options for implementaiton than current considerations.

The utility revenue impact

The total resource cost does not take into acount the utility perspective in terms of revenue impact. The utility revenue approach takes both the revenue and cost changes into account and calculates the net effect on the utility's bottom line. In many cases, the financial impact of efficiency and fuel-switching projects will be negative, simply because of lost revenue and margin. Where tariffs are greater than the cost of supply, energy efficiency will always result in a net income loss. The exception to this only occurs when avoided costs become very large for reasons such as very peaky demand, or avoided capital investment in distribution and transmission.

Table 7 presents the results for the entire programme, including the take-back effect. In all cases, the programmes result in negative income impacts for the utilities involved, even without the utility providing a capital subsidy for the programme. The impacts are noticeably greater for distribution utilities since these agencies retail electricity and their avoidable costs resulting from energy conservation are small. These results are not surprising, given the current tariff structures in South Africa, which we discuss in more detail in the policy options section.

Table 7: Impact on utility net income, including take-back effect (2000 million Rand/year)[a]

Programme	*G&T*	*Distribution*
CFL	(1.8)	(19)
Ceiling	(3.2)	(15)
Refrigerator	(12)	(78)
Elec to LPG	(3.2)	(15)
Para to LPG	N/A	N/A

Notes: a. No utility subsidy or take-back effect.

PARTICIPATING CONSUMERS GENERALLY BENEFIT, BUT TARIFFS COULD RISE MARGINALLY

Participating consumers

There are two categories of consumers of interest here – participants and non-participants.

The revenue impact on participating consumers is naturally sensitive to the degree of subsidy provided, as well as whether take-back effects are considered or not. Table 8 shows the sensitivity of consumer income impacts to subsidy levels, including the take-back effect. While all of the programmes, with the exception of the electricity to gas switch, have a positive impact on consumer income, the subsidies increase the total consumer benefit substantially.

Table 8: Impact on consumer income: sensitivity to subsidy (2000 million Rand/year)[a]

Subsidy	*CFL*	*Ceiling*	*Refrigerator*	*Elec to LPG*	*Para to LPG[b]*
0%	0.30	26	0.9	(88)	827
25%	0.34	52	1.4	(86)	839
50%	0.39	77	2.0	(85)	850
75%	0.44	102	2.5	(84)	861
100%	0.48	128	3.0	(83)	872
Break even	0%	0%	0%	>100%	0%

Notes:

a. Including take-back effect.

b. Rand per household, not for the programme level.

Another way to express the impact on consumers is the change in disposal income per household – in other words, decreased energy costs excluding the capital costs associated with the intervention (see Table 9). Particularly if the initial costs of these interventions are covered by a subsidy from the utility, government or international funders, increased disposal incomes will raise consumers' standard of living and buying power. This can in turn contribute to economic growth and employment creation. Although changes in disposable income per participating household may be relatively small, the aggregate impact of the programmes could be substantial. The gains to participating consumers would be marginally offset by higher tariffs for non-participants (see next section).

Table 9: Impact of programmes on participant disposable income[a]

Increase in annual disposable income	*CFL*	*Ceiling*	*Refrigerator*	*Elec to LPG*	*Para to LPG*
Per household (R)	16	35	74	N/A	262
For total programme (Rm, 20 yr average)	18	27	77	N/A	N/A

Notes: a. Including take-back effect.

Non-participating consumers

Non-participating consumers are sensitive to the potential impact on utility rates that the programmes may have. In all cases examined here, the programmes result in small tariff increases.

Thus, while it is expected participants' bills will be reduced, non-participants will face increases in monthly energy bills. Nonetheless, these increases are generally small – less than 2% of current average residential tariffs.

Table 10: Tariff (c/kWh) and energy bill changes (Rand/month)[a]

	CFL	*Ceiling*	*Refrigerator*	*Elec to LPG*	*Para to LPG*
Tariff change	0.04	0.03	0.18	0.42	N/A
Participant bill change	(1.27)	(2.06)	(5.84)	25.9[b]	N/A
Non-participant bill change	0.28	0.21	1.21	2.86	N/A

Notes a. Including the take-back effect, with no utility subsidy.
b. Change in energy bill including gas, not just electricity bill.

RESIDENTIAL ENERGY EFFICIENCY REDUCES THE ENVIRONMENTAL IMPACTS OF ENERGY

Local impacts

A range of environmental and social impacts occur in the extraction, production, transmission and use of the different fuels consumed in low-income households. Reductions in these impacts, for example, in burns as a result of paraffin use, in health impacts from domestic fuels and in emissions from electricity generation can be realised.

For more detail on these impacts see (Spalding-Fecher et al. 1999).

Global impacts – greenhouse gas emissions reductions

South Africa ratified the UN Framework Convention on Climate Change (UNFCCC) in 1997, and the Kyoto Protocol in 2002. South Africa does not currently face any limits on emissions under the Convention and the accompanying Kyoto Protocol, but South Africa is eligible to participate in the Clean Development Mechanism (CDM). Under the CDM, investors from industrialised countries could contribute capital and technology to projects in South Africa that reduce emissions, in return for 'credits' for those emissions reductions. Table 10 illustrates the GHG impacts of the residential energy- efficiency and fuel-switching programme analysed. As expected, CFLs, efficient refrigerators and ceilings are low-cost. These could potentially present opportunities for South Africa as CDM projects.

Switching from electricity to gas for cooking appears to be quite expensive for the same reasons outlined earlier – lower costs for electricity in urban vs remote rural areas, uncertainty about the true economic cost of LPG, and low apparent peak coincidence of cooking. Switching from paraffin to LPG, on the other hand, produce emissions reductions – both because of the lower emissions factor for LPG and the higher efficiency of a gas stove. Note that emissions reductions for the last switch are shown per household because no programme was modeled.

Table 11: Greenhouse gas emissions impacts for each programme

		Cost of avoided emissions	
Programme	*Emissions reductions (kt CO_2/year*	*(2000 R/ton CO_2)*	*(US\$/ton CO_2)[b]*
CFLs	59	(91)	(13)
Ceilings	103	(270)	(39)
Refrigerators[c]	257	21	3
Elec to LPG[c]	584	3 362	485
Para to LPG[c]	226[a]	(2 120)	(306)

Notes: a. Kilograms per household. b. At 2000 exchange rate of R6.94 to the US dollar. c. Assumes appliance is a new purchase.

RESIDENTIAL ENERGY EFFICIENCY AND EMPLOYMENT

One of the top priorities of South Africa's Growth, Employment and Redistribution (GEAR) strategy is job creation (DTI 1996). While this study was not able to evaluate the direct impact on employment from residential energy efficiency, two major studies in North America and Europe suggest that DSM programmes create significantly more jobs than building new energy supply (Biewald et al. 1995; Energy Innovations 1997; Renner 2000). A survey of a number of research studies in Biewald et al. (1995) for example, showed that DSM programmes create 1.5 to 4 times as many jobs as building a new power plant. Most of the additional employment comes not from direct employment through implementing DSM programmes, but from consumers re-spending their energy bill savings: spending this additional disposable income stimulates the economy and therefore creates jobs. A South African research programme to evaluate the macroeconomic benefits of energy efficiency could provide valuable support to more aggressive energy-efficiency policy to meet government objectives for job creation.

WHY HASN'T IT HAPPENED ALREADY? BARRIERS TO ENERGY EFFICIENCY FOR THE POOR

Research in South Africa (James 1997; Mehlwana 1999; Mehlwana & Qase 1999) has demonstrated the significance of attitudes and perceptions in the prioritisation of appliance purchases and fuel use amongst poor households, as well as the more 'traditional' barriers to residential energy efficiency. The major lesson from this research is that one cannot generalise about the fuel and appliance use patterns of the poor – while income is a constraint, some households, motivated by the social status attached to, or the perceived modernity of, electric appliances, find means to access these appliances. This section outlines the barriers to residential energy efficiency in low-income households in South Africa, drawing on case studies presented in Mehlwana (1999).

Affordability and financing

Investment in energy-efficiency improvements is often constrained by the limited and irregular cash flow in poor households and the difficulties in accessing additional finance. Because of the affordability barrier, poor households sometimes end up investing in fuels and appliances which, ironically, are both energy and economically inefficient. Mehlwana (1999) notes that decisions to purchase and use the cheapest appliances are influenced by what consumers can afford at a moment in time. The pressures on household incomes force them to make short-term decisions and, therefore, overlook long-term factors such as the life-cycle costs, efficiency and safety of an appliance.

Mehlwana (1999) demonstrates how lack of access to financing, as an integral part of affordability, constrains people's choices. Low-income households are known to use a range of means to purchase appliances, including hire-purchase (HP) and stokvels or savings clubs. HP is, however, only available to consumers with regular, stable and relatively high incomes, as well as a fixed home address. This means that many households in informal, unplanned areas are excluded from HP agreements, irrespective of their incomes. Other households whose income is very low are not considered creditworthy. A prerequisite for belonging to a stokvel is also a stable and regular income. Many low-income households are, therefore, unable to save money in this manner. These households, who are unable to access either conventional or alternative forms of financing, often have to resort to paying cash for appliances – in this case only cheap and basic appliances are purchased. This accounts, in part, for the high use of paraffin wick stoves which have a low access cost.

For fuel purchases as well, households are often constrained in their choices by income flows. The decision on purchase has to take cognisance of the availability of money at a particular point in time. When there is little money, paraffin and coal stoves are used, because one can buy paraffin or coal in small amounts. Householders know that buying fuels this way is expensive, but have no choice because not enough money is available to buy in bulk.

Information

When addressing the information requirements for energy efficiency at a community or societal level, it is important to recognise that information or awareness programmes alone will not result in widespread energy efficiency. Often, low-income households have an understanding of energy efficiency and even practise energy efficiency – such as monitoring the electricity use of different appliances and back-switching to less energy consumptive appliances for certain uses. There are other motivations embedded in the poverty of their situations, such as lack of access to finance, and the cost of operating appliances which require bulk energy purchases, that compel them to continue using energy inefficiently. Furthermore, developers and manufacturers may be aware of the concept of energy efficiency, but are motivated by uncertainty, risk or profits and, therefore, do not incorporate energy efficiency in their products. Information and awareness programmes need to be implemented, therefore, in conjunction with other regulatory or incentive programmes.

Furthermore, information and awareness programmes need to take into account the wide range of stakeholders involved in the delivery of energy-efficiency services. Apart from participating consumers, there are a range of different stakeholders involved in the planning and implementation of energy-efficiency programmes and the successful adoption of energy-efficiency measures – local government, utilities, manufacturers, developers, builders, NGOs and so on – all of whom have different informational requirements to guarantee their effective participation in promoting and adopting energy-efficiency strategies and measures.

Finally, it is important to identify what the specific informational requirements are. Often, awareness programmes tend to provide broad information on the concept of energy efficiency and related savings, when the target audience requires more sophisticated information. Where people are already aware of broad notions of energy efficiency, the types of information required may be how to practically implement energy-efficient strategies: for example how to build an energy-efficient house or put in a ceiling; where to access financing to purchase energy-efficient appliances or to build an energy-efficient house; how to mobilise capital to finance energy efficiency for the poor; how to facilitate community participation, empowering people to choose energy efficiency and so on.

Physical access to or availability of fuels

Low-income households are, in certain circumstances, unable to secure the best mix of fuels because certain fuels are not readily available to them. For example, while paraffin networks are generally good, with both fuels and appliances being readily available, many South Africans do not have electricity connections and are thus excluded from the use of electricity. Coal networks are well established in areas close to the coal mines, but the high transport costs of coal result in fairly weak distribution networks in the rest of the country. The coverage of gas distribution networks is also relatively weak and is inhibited by poor transport infrastructure and a lack of access to transport.

Those living in planned settlements generally have better access to the range of different fuel options than those living in informal unplanned settlements (Mehlwana 1999). Planned settlements provide road infrastructure and spatial standards, as well as a sense of permanence, which facilitates the distribution of energy services such as electricity and gas. Furthermore, those living in their own homes, with their own electricity connections, have more secure access to electricity than those living in rented accommodation or backyard shacks. In backyard shacks, access to and use of electricity is at the landlords' discretion. Relationships between tenants and landlords are often unstable and conflicts arise about electricity use. In order avoid this conflict, many backyards would rather not access their landlord's electricity (Mehlwana 1999).

Split incentives – construction, ownership and use

In the delivery of housing, those making the initial capital investment in the construction of the house are most often separate from those who will live in and pay the operating costs of the house. Under these circumstances, it is not common to find developers investing in energy efficiency, and so the low-efficiency housing stock has high operating costs. Apart from a few self-built developments, most subsidised low-cost housing in South Africa is built by local municipalities or private developers. Whether local municipalities or private developers, the motivation is to cut corners, minimise initial costs and increase profit margins. As a result, there are few developers who invest in energy efficiency, so poor households are forced to bear the burden of the high operating costs of houses over time.

Lack of tenure and urban/rural commitment

In many settlement types, factors that determine appliance ownership will be constrained by space and tenure problems. Because of space problems, in informal electrified settlements and backyard shacks, more households own two-plate electric stoves than stoves with ovens (White et al. 1998:71; Mehlwana & Qase 1999). More importantly, the tenure problems in informal unplanned settlements and backyards also play a direct role in the purchasing of electrical appliances or other expensive investments in efficiency.

Migrant workers continue to play a large role in the urban workforce and urban communities. The migrants have deep commitment to their rural households and view life in urban townships as a temporary sojourn (see also White et al. 1998: 69). Generally, they tend to invest little in their urban households and either save or remit money for the maintenance of the rural households. This socio-economic system has important ramifications and influences fuel and appliance use patterns. Irrespective of the type of settlement and access to different energy sources, investing in rural homes is the most important aspect for some households. Expenses on appliances are kept to a minimum. Although electricity would be available, paraffin appliances are likely to be used because they are perceived to be cheaper. The households would also be even less likely to pay a higher cost for efficient appliances, given that they are saving money to send to their rural homes.

Multiple fuel use and household needs

Multiple fuel use means that households use more than one fuel for the same end-use. In some contexts, households use one appliance for more than one end-use. In the case of the latter, a paraffin or coal stove is used for cooking, while offering space heating. In the former case, for instance, it is common for households to use gas, paraffin, coal and/or electric stoves for cooking. Gas would be used for specific tasks (such as cooking special quick foods) and paraffin appliances used for foods that take a longer time to cook. Therefore even though gas may be a more energy-efficient cooking fuel than paraffin or electricity (and its use can prevent the high health costs of paraffin), we cannot assume that households will completely stop using paraffin once they buy a gas stove.

The symbolic value of appliances

Not surprisingly, consumers do not simply look at the economics of appliance choices to make their decisions. Research in South Africa has demonstrated that the symbolic value of appliances can be as important as their functional value when consumers make decisions (White et al. 1998; Mehlwana & Qase 1999). For example, a majority of formal households tend to replace their non-electrical appliances with modern and sophisticated appliances immediately after electrification. This is not simply because electricity is a cleaner and more convenient fuel. There is a general perception that non-electrical appliances are not appropriate for formal households. Having many electrical appliances brings both respect and envy from the neighbourhood. They are symbols of modernity and comfortable existence, and many people will go to extremes in order to acquire these appliances. The bigger the electrical appliance the better: a bigger electrical appliance is important more for its decorative function than for its end-use. Consumers might not be attracted to smaller, more efficient appliances, therefore, unless it had other features that enhanced the sense of 'modernity'.

STRATEGIES: CREATING AN ENABLING ENVIRONMENT FOR INVESTMENT IN RESIDENTIAL ENERGY EFFICIENCY

A detailed list of strategies for different role players aimed at improving the energy services of poor urban households can be found in Simmonds and Clark (1998), an earlier report written for the Eskom-funded energy-efficiency project. Our focus here is to emphasise strategies that link most directly to 'public benefit' residential energy-efficiency programmes that target the poor.

South Africa, like many developing and industrialised countries, is in the midst of restructuring its electricity sector, starting with the restructuring of the distribution industry. This restructuring will consolidate the more than 400 existing distributors into a much smaller number of financially viable regional electricity distributors. (Van Horen & Thompson 1998; Mkhwanazi 2001; NER 2001). Electricity sector restructuring, on top of existing barriers, can create risks for energy-efficiency programmes (Praetorius et al. 1998; Clark 2000).

International experience has shown that regulators have utilised various tools at their disposal to implement energy efficiency. For example, regulatory tariff structures often link energy sales (kWh) with utility revenues and profits, discouraging the utility from any energy-efficiency measures reducing sales. To overcome this disincentive demands a tariff structure that de-links utility income from sales volume, and links it to some other measures of service. This is common in the United States, where many state regulatory boards chose in the 1980s to base utility profits on a return on capital invested, including demand-side capital, rather than a margin on each unit sold (Swisher et al. 1997; Eto et al. 1998). In addition, so-called net-loss revenue adjustments allow the utility to recover the lost margin due to reduced sales from energy-efficiency programmes (Baxter 1995).

To sustain investment in socially beneficial energy-efficiency programmes some regulators introduce a charge on all electricity sales. This non-bypassable charge, sometimes called a 'wires charge', can be dedicated to funding public benefits such as energy efficiency, low-income access programmes, research and development, and renewable energy (Clark & Mavhungu 2000). This can provide funds to implement programmes that would not be in the interest of individual utilities, and distributes this cost equally across the industry.

CONCLUSION

This chapter has demonstrated the substantial economic and environmental benefits from residential energy-efficiency interventions for the urban poor. The most important finding is that, while almost all of these programmes have benefits for the country and can reduce the utility's cost base, they all negatively impact on utility income. This, along with the other barriers for consumers described here, mean that South Africa is not making the optimal use of residential energy-efficiency programmes to support increased access to affordable, modern energy services.

Given the current regulatory system in South Africa, utilities – particularly distribution utilities such as the new regional electricity distributors – will lose money if they sell less energy, a situation that exists in most other developing countries as well. Electricity Regulators can however provide the incentives for all utilities to invest in socially beneficial residential energy efficiency. New regulatory interventions, such as a non-bypassable wires charge and performance-based tariffs, can be used to ensure that energy efficiency will be a key tool in increasing access to modern energy services.

One final note is that this chapter has all been based on our assumptions about what impacts residential energy efficiency will have. In this sense, the methodology is a screening tool for possible investments that support access and affordability. To know the actual impacts of the projects, however, we need a framework for monitoring and verifying the results of projects after they are implemented. Only then will we be able to refine future policy analysis or proposals for new programmes based on experience in the real world. The next chapter will therefore look at the monitoring and verification of energy-efficiency programmes, and how this is evolving in South Africa.

REFERENCES

ANC (African National Congress) 1994. The Reconstruction and Development Programme: A policy framework. Johannesburg, Umanyano.

Banks, D 1999. The consumer discount rate applicable for low-income households in South Africa. Energy & Development Research Centre, University of Cape Town.

Baxter, L 1995. Understanding net lost revenue adjustment mechanisms and their effects on utility finances. Utilities Policy 5 (3/4): 175-184.

Biewald, B, Bernow, S, Dougherty, W, Duckworth, M, Peters, I, Rudkevish, A, Shapiro, K & Woolf, T 1995. Societal benefits of energy efficiency in New England. Boston, Tellus Institute.

Biggs, R & Greyling, A 2001. Project energy: Report for the Paraffin Safety Association of Southern Africa. Markinor.

Borchers, M, Qase, N, Gaunt, T, Mavhungu, J, Winkler, H, Afrane-Okese, Y & Thom, C 2001. National Electrification Programme evaluation: Summary report. Evaluation commissioned by the Department of Minerals & Energy and the Development Bank of Southern Africa. Energy & Development Research Centre, University of Cape Town.

Bredenkamp, B 2000. Lower costs for efficient lighting technologies expected. Energy Management News 6 (4): 50-51.

CEC (California Energy Commission) 1987. Standard practice manual: Economic analysis of demand-side management programs. Sacramento, California. CEC.

Clark, A 2000. Demand-side management in South Africa: barriers and possible solutions for new power sector contexts. Energy for Sustainable Development 4 (4): 27-35.

Clark, A & Mavhungu, J 2000. Promoting public benefit energy-efficiency investment in new power contexts in South Africa. Energy & Development Research Centre, University of Cape Town.

Davis, M 1995. A financial and economic analysis tool for electrification projects. Version E6.1. Energy & Development Research Centre, University of Cape Town. Accessed

Davis, M & Horvei, T 1995. Handbook for economic analysis of energy projects. Johannesburg, Development Bank of Southern Africa.

DME (Department of Minerals and Energy) 1998. White Paper on Energy Policy for South Africa. Pretoria, DME.

DME (Department of Minerals and Energy) 2001. South African National Energy Database. Energy prices. Pretoria, DME. November.

DTI (Department of Trade and Industry) 1996. Growth, employment and redistribution: A macro-economic strategy. Pretoria.

Ellman, M J 1999. Integrated resource planning (IRP) as a regulatory tool in the electricity supply industry (ESI). Electricity Regulatory Journal 6-7.

Energy Innovations 1997. Energy innovations: a prosperous path to a clean environment. Washington, D.C., Alliance to Save Energy, American Council for an Energy Efficient Economy, Natural Resources Defence Council, Tellus Institute, Union of Concerned Scientists.

Eskom 1997. Integrated Electricity Planning 6 (IEP6). Sandton, Eskom.

Eskom 1999a. Business plan for the Efficient Lighting Initiative. Sandton, Eskom.

Eskom 1999b. Residential load profiles. Microsoft excel spreadsheet. Sandton, Eskom Marketing.

Eskom 2000. Annual report 2000. Sandton, Eskom. www.eskom.co.za.

Eskom 2001. Tariffs and charges. Sandton, Eskom.

Eto, J, Stoft, S & Kito, S 1998. DSM shareholder incentives: recent designs and economic theory. Utilities Policy 7: 47-62.

Greening, L A, Greene, D L & Difiglio, C 2000. Energy efficiency and consumption – the rebound effect – a survey. Energy Policy 28 (6-7): 389-401.

Holm, D 2000. Performance assessment of baseline energy-efficiency interventions and improved designs. D. K. Irurah (ed.) Environmentally sound energy-efficient low-cost housing for healthier, brighter and wealthier households, municipalities and nation. Final report. Pretoria, Environmentally Sound Low-cost Housing Task Team and USAID: A-1-1 to A-2-27.

IWG (Interlaboratory Working Group on Energy-Efficient and Clean-Energy Technologies) 2000. Scenarios for a clean energy future. Oak Ridge, TN and Berkeley, CA. Oak Ridge National Laboratory and Lawrence Berkeley National Laboratory.

James, B 1997. Current limited supplies of electricity in the context of South African rural areas, Energy & Development Research Centre, University of Cape Town.

Lovins, A & Lovins, L H 1991. Least cost climatic stabilization. Annual review of energy and environment 16: 433-531.

Marbeck Resource Consultants 1997. Appliance energy performance labelling programme and awareness campaign. DME Report No. ED9504. Pretoria, Department of Minerals and Energy.

Mehlwana, A M 1999. The economics of energy for the poor: fuel and appliance purchase in low-income urban households. Energy & Development Research Centre, University of Cape Town.

Mehlwana, M A & Qase, N 1999. The contours of domesticity, energy consumption and poverty: The social determinants of energy use in low-income urban households in Cape Town's townships (1995-1997). Energy & Development Research Centre, University of Cape Town.

Mkhwanazi, X 2001. The changing regulatory environment during electricity supply industry restructuring. Speech to the South African Institute of Electrical Engineers by CEO of National Electricity Regulator, 8 February.

NER 2001. EDI restructuring update. Electricity Regulatory Journal August 2001 1-3.

Praetorius, B, Eberhard, A & Van Horen, C 1998. Energy efficiency and electricity sector restructuring in South Africa. Journal of Energy in Southern Africa 9 (2): 50-57.

Praetorius, B & Spalding-Fecher, R 1998. Greenhouse gas impacts of DSM: Emission reduction through energy efficiency interventions in low-income urban households. Energy & Development Research Centre, University of Cape Town.

Renner, M 2000. Working for the environment: A growing source of jobs. Washington, Worldwatch Institute. September 2000.

Roy, J 2000. The rebound effect: Some empirical evidence from India. Energy Policy 28 (6-7): 433-438.

Sant, G & Dixit, S 2000. Least cost power planning: Case study of Maharashtra state. Energy for Sustainable Development 4 (1): 13-28.

SARB (South African Reserve Bank) 2001. Quarterly bulletin. Pretoria. SARB. September.

SARB (South African Reserve Bank) 2002. Quarterly bulletin March 2002. Pretoria.

Schipper, L & Grubb, M 2000. On the rebound? Feedback between energy intensities and energy uses in IEA countries. Energy Policy 28 (6-7): 367-388.

Simmonds, G & Clark, A 1998. Energy strategies for the urban poor. Energy & Development Research Centre, University of Cape Town.

Simmonds, G & Mammon, N 1996. Energy services in low-income urban South Africa: A quantitative assessment. Energy & Development Research Centre, University of Cape Town.

Spalding-Fecher, R, Clark, A, Davis, M & Simmonds, G 1999. Energy efficiency for the urban poor: Economics, environmental impacts and policy implications. Energy & Development Research Centre, University of Cape Town.

Spalding-Fecher, R, Williams, A & Van Horen, C 2000. Energy and environment in South Africa: charting a course to sustainability. Energy for Sustainable Development 4 (4): 8-17.

Swisher, J, Jannuzzi, G & Redlinger, R 1997. Tools and methods for integrated resource planning. Riso, Denmark, UNEP Collaborating Centre on Energy & Environment.

Thorne, S 1996. Financial costs of household energy services in four South African cities. Energy & Development Research Centre, University of Cape Town.

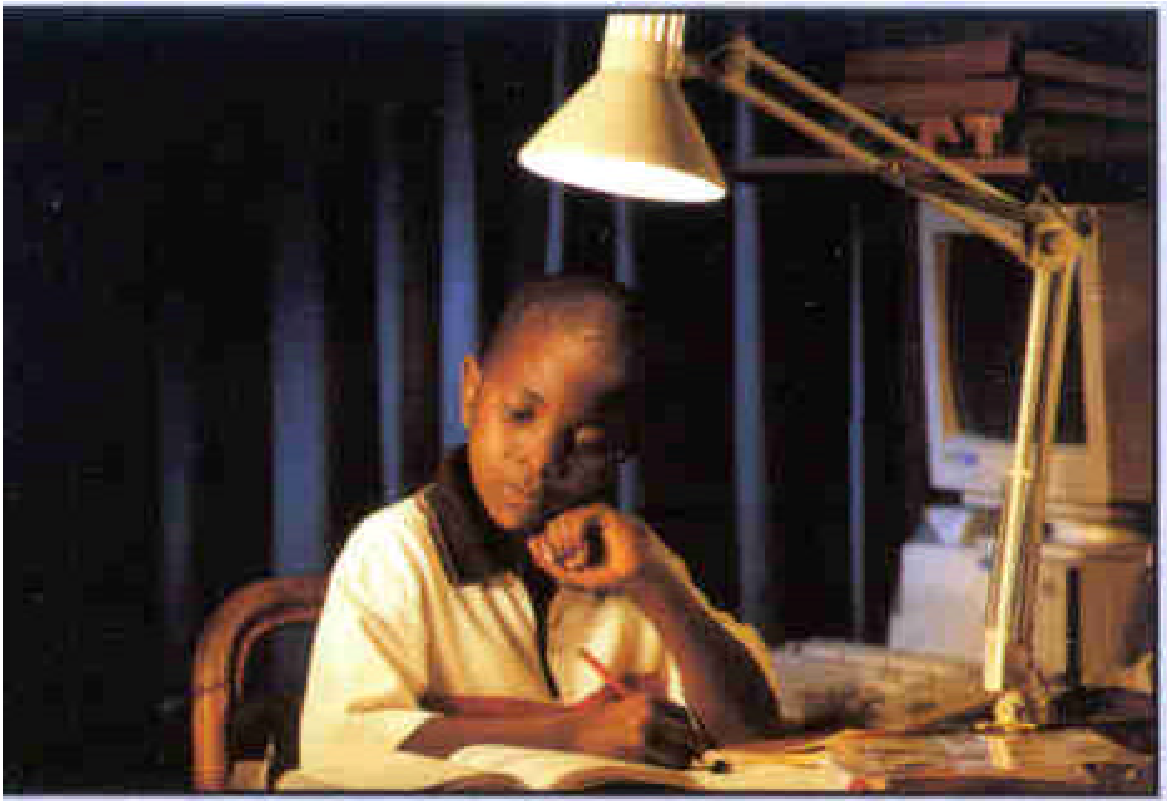
Tol, R S J 1999. The marginal costs of greenhouse gas emissions. Energy Journal 20 (1): 61-81.

Van Horen, C & Thompson, B 1998. Sustainable financing of electrification in South Africa. Energy & Development Research Centre, University of Cape Town.

White, C, Crankshaw, O, Mafokoane, T & Meintjies, H 1998. Social determinants of energy use in low-income metropolitan households in Soweto. Report No. EO9423. Pretoria, Department of Minerals and Energy.

Winkler, H, Spalding-Fecher, R, Tyani, L & Matibe, K 2000. Cost-benefit analysis of energy-efficiency in low-cost housing. Energy & Development Research Centre, University of Cape Town.

Winkler, H, Spalding-Fecher, R, Tyani, L & Matibe, K forthcoming Dec 2002. Cost-benefit analysis of energy-efficiency in urban low-cost housing. Development Southern Africa 19 (5).



Chapter 8

Monitoring and Verification: Savings, Access and links to policy

Jabavu Clifford Nkomo[1] and Albert Africa[2]

[1] University of Cape Town [2] Eskom

By building a culture of energy efficient communities and providing an understanding of the basic concepts of electricity, the effects of electricity on the environment and the technologies available, energy efficient communities can be developed. This lays the basis for the determination of both energy savings and reductions in greenhouse gas emissions.

INTRODUCTION

Recent technological innovations in the global market for efficient lighting have created opportunities to improve energy efficiency in domestic, commercial and industrial sectors. The experiences of industrialised countries show that such changes have led to manufacturing capacity, rapid technological innovation and reduced product prices. Given the potential growth in South Africa's demand for lighting products and the electricity to power them, demand-side management (DSM) offers numerous benefits. These benefits include the potential of improving many consumer- and environment-related benefits, of enhancing services and lowering operational costs, and providing the opportunity to limit financial costs associated with the generation of electricity.

This chapter takes an in-depth look at monitoring activities on several Bonesa projects. From the number of programmes that Bonesa is running, we focus on the public education program, and the free light-fitting being implemented through the Efficient Lighting Initiative (ELI) in South Africa. The ELI endeavours to transform the lighting market, by substituting incandescent bulbs with compact fluorescent lamps (CFLs). Table 1 shows the environmental implication of substitution. At an aggregate level, the ELI approach will result in a reduction in electricity consumption, and thus a reduction in resource utilization, with the potential to contribute to a substantial reduction in household electricity bills. Bonesa's task is to build a culture of energy-efficient communities by providing an understanding of the basic concepts of electricity, the effects of electricity on the environment, and the technologies available to facilitate energy-efficient communities.

Table 1: Environmental savings over the lifespan of a CFL

Resource	*Units*	*Production of one kWh of electricity*	*Use of 75W incandescent (in 10 000 hour lifespan)*	*Use of 15 W CFL (In 10 000 hour lifespan)*	*Implied savings*
Water usage	Litres	1.21	907.5	181.5	726
Coal usage	Kilograms	0.49	367.5	73.5	294
Ash produced	Grams	1.30	975	195	780
SO_2	Grams	7.95	5962.5	1192.5	4770
N_2O	Grams	0.011	8.25	1.65	6.6
NOx	Grams	3.56	2670	534	2136
CO_2	Kilograms	0.85	637.5	127.5	510

Notes: a. Calculations based on Eskom Environmental Report 2000.

Our task is to provide an overview of the project activities in relation to the baseline situation, to track the progress Bonesa has made in relation to its stipulated objectives and expected outcomes, and to link these with the socio-economic benefit of the initiative. This lays the basis for the determination of both energy savings and reductions in greenhouse gas emissions.

The plan of the chapter is as follows. We begin by providing an overview of monitoring goals and setting out the framework of analysis. Much of the Matatiela study that follows is based on the analysis of questionnaires that were administered before Bonesa introduced efficient lighting into this community. We attempt to establish what impact Bonesa's public education and free light-fitting programmes have, and to link the lighting programme with development policy goals.

OVERVIEW OF MONITORING GOALS

DSM programmes are subject to several forms of evaluation throughout their lifetimes, from the initial concept to post-implementation monitoring and evaluation (M&E). Impact evaluation is actually a continuous process throughout a DSM product's lifetime, just like maintenance and plant-efficiency monitoring are part of running a power station. This is illustrated in Figure 1 below.

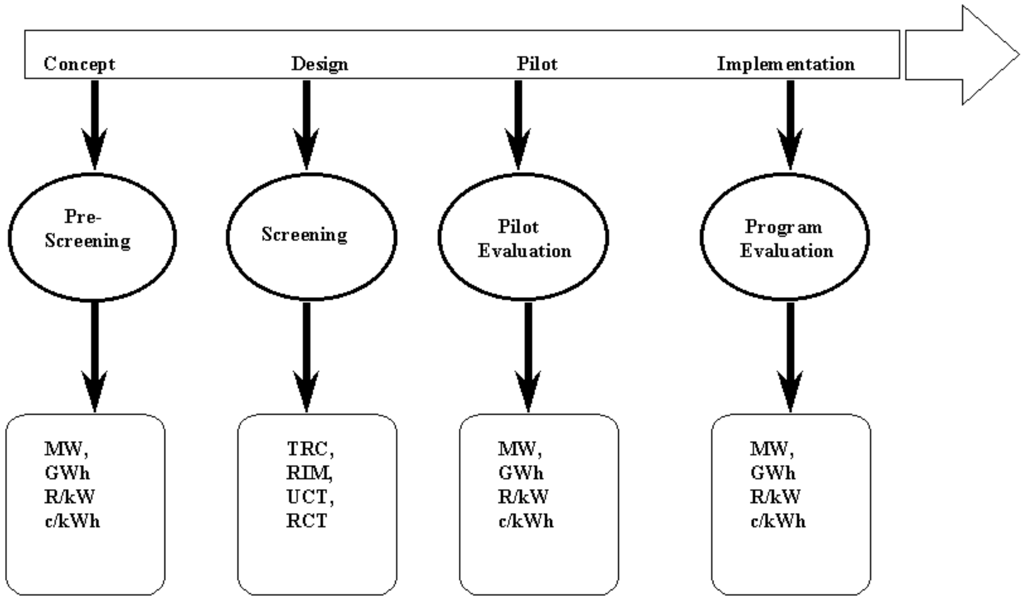


Figure 1: DSM evaluation and monitoring process components

In addition to the impact evaluations illustrated, several aspects concerning the DSM process, implementation process, and customer acceptance and satisfaction must be evaluated during and after the implementation phase. These are not isolated tests, but a continuation of the evaluation from the first stages of the programme. This means that post-implementation impact evaluation must be linked back to pilot evaluations as well as screening and pre-screening results. It must be clearly noted that this evaluation is not a single test, once implementation has been done, but a continual annual re-evaluation of each programme against penetration and impact goals. This becomes less important once market saturation has been achieved and incentives are removed. DSM evaluation serves a variety of purposes. These include:

- assessing attainment of programme goals and market projections;
- increasing programme effectiveness and efficiency;
- determining programme impacts and effects;
- calculating programme cost-effectiveness;
- identifying unmet utility or customer needs;
- meeting the needs of customers;
- meeting the strategic objectives of Eskom; and

ensuring the products are properly developed.

Similarly, there are several aspects of DSM programmes that need to be evaluated, including:

- demand (kW) impact;
- energy (kWh) impact;
- number of participants;
- proportion of free riders;
- customer usage pattern;
- cost of programme;
- cost-effectiveness (benefit) of programme;
- participant satisfaction with programme concept;
- participant satisfaction with programme procedures;
- customer satisfaction with utility service;
- reasons for participation and non-participation;
- ways to improve appeal of programme to customers;
- efficiency of utility programme operations;
- effectiveness of utility programme operations;
- ways to improve programme operations;
- ability of utility to expand the programme.

FRAMEWORK OF ANALYSIS

Objectives

The purpose of monitoring is to provide Eskom with key planning information that can be used for decision-making on planning, policies, strategies, project management and projects. This way, monitoring allows for accountability for resource use based on transparent procedures, enables comprehensive assessment of the project or programmes effectiveness, ensures the development of monitoring skills, and takes into account feedback, and results and lessons learned. This study paves the way for the ultimate objectives presented in Table 2, which are intended to transform South Africa's lighting market through promotion and follow-up activities.

Table 2: Overall objectives

Objective	*Output*
To estimate savings and greenhouse gas emission reductions in the electricity sector.	Accurate quantification of DSM programme results (demand and energy savings).
To reduce peak demand for electricity.	Accurate quantification.
Building and promoting demand for energy-efficient lighting in South Africa.	Planning information such as customer willingness, customer acceptance, technical comparability, customer satisfaction, sustainability of DSM initiative, customer support and DSM programme delivery.
Building relationship between stakeholders within the lighting industries.	Continuous feedback on performance and progress of programmes.

It is useful to look at the objectives in terms of what each focus area undertakes to do, and to verify whether this was done as originally envisaged. This makes targeted awareness, satisfaction levels, behaviours, and services crucial, with explanations that can be given with baseline data obtained. Policy implications can be derived from the lessons learned. The baseline data lays the basis for first, the quantification of outcomes cost-effectiveness and the resultant direct and indirect outcomes of energy consumption; and second, determination of whether or not there is a significant and sustainable shift in market demand and penetration of the product as a result of intervention. Objectives per focus area are shown in Table 3, Table 4, and Table 5.

Table 3: Free light-fitting

Objective	*Output*
Selection of samples for undertaking Monitoring and verification (M&V) of fitted CFLs.	Selected households with appropriate fittings for ELI.
Develop strategy and tools for undertaking M&V in selected households.	Developed M&V techniques and tools based on internationally accepted M&V techniques and tools.
Determine and train implementers for data collection.	Trained personnel to implement M&V tools.
Collect and analyse data for M&V on households fitted with CFLs.	Collected and analysed data on the free lighting system.

Table 4: Schools and tertiary sector

Objective	*Output*
Select samples for M&V of units with DSM programmes.	Selected schools and tertiary institutions for M&V units.
Develop techniques and tools to undertake M&V for ELI system in schools and tertiary sector.	Developed M&V techniques and tools based on internationally accepted M&V techniques and tools.
Train suitable personnel to undertake M&V in schools and tertiary sector.	Trained personnel to administer M&V tools and techniques in schools and tertiary sector.
Collect and analyse appropriate data on selected schools and tertiary institutions.	Analysed data for M&V of ELI in the school and tertiary sector.

Table 5: Public awareness

Objective	*Output*
Raise public awareness about the importance of DSM on production and energy use.	Awareness-raising materials on energy saving.
Inform energy users of the benefits of using CFLs.	Tools and documentation for popularising the use of CFLs.
Train appropriate personnel to follow up public awareness campaign.	Trained personnel in public awareness.

Free light-fitting applies to Reconstruction and Development Programme (RDP) housing and new electrification. Bonesa's mandate is to make CFLs available to newly electrified consumers, and new RDP homeowners. In schools, the objective is to inform pupils of the benefits and importance of using efficient lighting. In the tertiary sector, Bonesa seeks to increase student and faculty awareness of the subject of efficient lighting, through the provision of technical information on lighting, and teaching and study-aid materials to lecturers and students at participating institutions. The primary objective of public education is to increase awareness about efficient lighting. The programme includes a broad range of marketing and public-relations activities, and feeds directly into programmes in different income segments as well as commercial, industrial and institutional programme activities. As a guiding principle, the framework follows established standards, ensuring the credibility, impartiality, transparency and usefulness of the project.

Monitoring criteria

The monitoring criteria we adopt, as spelled out by the Global Environmental Facility, are intended to provide policy-makers with essential information about the present and future decisions on projects and programmes. Specific criteria are:

Effectiveness: Effectiveness measures the extent to which the objectives are achieved.
Efficiency: Of importance here is the assessment of outputs in relation to inputs, and economic and financial results.
Relevance: Our main concern here is the extent to which the project or programme is justified at any time, taking into account national/local environmental and developmental priorities.
Sustainability: Here emphasis is placed on the continuity of benefits from a particular project or programme.

CASE STUDY - BONESA

The roles of ELI and Bonesa are central to promotion and sustainability. The ELI programme and Bonesa seek to: build demand for energy-efficient lighting in South Africa, establish relationships with strategic lighting and related stakeholders, improve customer service through reduced electricity bills, ensure capacity building and skills transfer, conserve the environment and promote job creation and poverty alleviation.

The principles guiding the ELI's public education campaign (as contained in ELI South Africa Strategy Document (2000)) are designed to give educational value to customers, as well as teach customers and policy makers about energy-efficient lighting. This involves strategies such as building partnerships and developing linkages with schools, curriculum bodies, marketing and design groups, manufacturers and distributors, and gathering planning information such as customer willingness, acceptance and satisfaction, technical comparability, sustainability of the DSM initiative, customer support and DSM programme delivery. One of the ELI's focus areas is working with disadvantaged communities and supporting small business and community-development initiatives.

These efforts should lead to economic, social, and environmental benefits. In order to benefit the economy, the project should be geared towards improvement in human welfare through increases in the production of goods and services. Benefits can be expressed in the form of financial savings, enriched human relationships, the achievement of individual and group aspirations, and the environment. The focus should be on long-term benefits, and the avoidance of measures that might lead to vulnerabilities over time.

The case of Matatiela: basis for monitoring and verification activities

Background on Matatiela

Matatiela consists of three villages (Dengwane, Khoapa and Zwelitsha), and is geographically located in the Eastern Cape. With about 2 550 households, it receives its electricity from Eskom's Eastern Region in Kwa-Zulu Natal. Each household has an average of four indoor and two outdoor fixtures. The incandescent lamps completely dominate electric household lighting.

There is a large dependence on migrant labour, with men working in mines around Johannesburg and some women working as far away as Durban and Pietermaritzburg (about 450 kilometres away). These workers remit their income to support families. There is however a high incidence of poverty. Unemployment is quoted at 65%, and there are no programmes to promote income-generating projects.

The communities have limited access to running water, regulated by a card system. This access is only at a central point in Khoapa, and some residents, particularly women and children, travel three to four kilometres to collect tap water. For this reason, a large section of the community relies on water from the river for drinking, cooking and other domestic purposes.

Energy consumption

Most houses in Matatiela are electrified as a result of the government's drive for rural electrification, and residents use pre-paid card meters. Electricity, however, does not satisfy all energy needs, and multiple fuel use is common, with households selecting fuels for different end-uses, as well as using more than a single fuel for the same end-use (see also Eberhard and van Horen (1995) and Davis (1998)). Rational decision making is related to a number of variables such as household income levels, availability and affordability of energy resources. Electricity consumption levels are low, and poorer residents use electricity almost exclusively for lighting. Electricity is also used for entertainment and, to a lesser extent, and depending on the affordability of appliances, for cooking. Paraffin is used for cooking and, to some degree, lighting, but it is not a fuel of preference, and its use by households is largely attributable to accessibility and affordability. The use of liquid petroleum gas (LPG) (mainly for cooking) is low. This is attributable to the cost of securing and refilling LPG cylinders. Candles are used for lighting. Wood is traditionally used for cooking, heating, and providing light, but due to the depletion of wood resources, wood for fuel is scarce and women and children must travel long distances to collect it. The positive correlation between paraffin and candle use should be explained with caution. The Matatiela households' mix these fuels to make floor polish, which is regarded as cost-effective and is said to give a better shine than commercial polishes.

Although we can expect fuel switching in favour of electricity for cooking, lighting and other household purposes to increase, as income levels rise and distribution improves, evidence elsewhere suggests that complete displacement occurs in a minority of homes (Davis (1998)). Electricity is typically considered an additional fuel in low-income households. Undoubtedly, electric lighting is more efficient and of a better quality than that provided by the other fuels, but poverty limits the use of cleaner energy, and results in continued reliance on other fuels.

Developmental activities

The ELI should benefit the Matatiela low-income and disadvantaged communities in several ways. Although the overall impact of electricity is not known, its increased use and accessibility to households plays a role in improving their economic, social, and environmental well-being. A lighting programme should therefore be seen as an important contribution to the reconstruction and development of impoverished areas. The developmental goal towards which the project contributes, is in harmony with the country's macro-economic objectives, and addresses the allocation of resources by focusing on a sustainable developmental path in the following ways:

Economic objective: To keep the cost of electricity low. ELI is a central component to the demand-side management for promoting energy-efficient lighting. Efficient lighting should release resources, previously tied to the expensive use of incandescents, to meet economic needs and to improve access to basic services. Even though the initial cost of the CFL is higher than that of the incandescent, the savings to the average household are expected to be significant in the long run.
Social objective: Job creation. This objective supports the African Renaissance through job creation and poverty alleviation. With the stimulation of the lighting market, ELI has the potential to contribute to national development priorities, such as the creation of new employment opportunities and opportunities for black empowerment, and to encourage small business development (Clarke (1999).

Environmental objective: ELI is also concerned with the reduction of emissions and resource use associated with the use of electricity (see Table 1). Similarly, a reduction in dependence on traditional sources of energy has the potential of reducing the risk of fires and burns that are commonly associated with paraffin and candle use, of reducing paraffin poisoning and of improving indoor air quality.

Immediate objectives

The immediate task of ELI is to accelerate the penetration of energy-efficient lighting technologies into the market. Obstacles to be encountered include: lack of knowledge about options to reduce energy expenditure though efficiency investments, lack of knowledge about available energy-efficiency options, ignorance and uncertainty, and lack of confidence. By positively influencing individual behaviour and changing consumer purchase preferences to favour energy-efficient lighting choices, success in transforming the residential lighting market can be expected. This implies substitution of standard incandescent lamps by CFLs. This can be accomplished by activities that have as their objective, the maximization of market penetration. A number of interventions are needed in order to increase awareness for energy-efficient lighting. Public education, in this regard, plays a vital role in increasing awareness around efficient lighting, thereby stimulating consumer demand.

There are a number of reasons for the low levels of awareness in the Matatiela community. Information about energy efficiency is not easily accessible, and low levels of education and training prohibit consumers from using the information they have access to. There are additional barriers that inhibit residents from investing in energy-efficient lighting, such as:

Affordability: The absence of local manufactures of CFLs means that energy lamps are imported and are therefore subject to import taxes and fluctuations in currency. This results in a purchase price that is prohibitive to low-income or disadvantaged households, even if they have information about expected energy savings and reductions in energy bills.
Access: The lack of CFL manufactures in South Africa gives incandescent lamps a competitive advantage. After all, CFLs are a new concept, and households prefer using a technology to which they are accustomed.
Risk: Aversion to risk is likely to lead to low levels of penetration of CFLs, especially if households perceive themselves to be the only purchasers of the product.

These market barriers have important implications for the feasibility of the project, especially given the economic status of the Matatiela households. A mix of strategies such as public education, quality control (to enhance consumer confidence and to reduce the element of risk), subsidisation, a penetration pricing strategy to entice consumers, and local manufacture, should promote market penetration of CFLs. The resulting economies of scale should reduce costs in the long run. Additional measures, like incentives on bulk purchases by retail chains, hypermarkets and supermarkets can also increase accessibility.

Assessment of project/policy performance

The Bonesa programme in Matatiela focuses on modular type CFLs. Unlike a screw-base or bionet, that allows a CFL lamp to fit into the same type of socket that a standard incandescent lamp uses, thus allowing for the ease for substitution. The modular lamp plugs into a special socket wired to the ballast, that receives its power from a standard wall outlet. Screw-based lamps or bionet have both the ballast and the lamp integrated in one piece that can be fitted into the socket. Bonesa will, instead, make available modular CFLs. The main advantages of the modular CFL are that it offers a more sustainable solution in terms of less electronic waste, offers lower costs, and has a reduced risk of being replaced by, or having the customer reverting back (‘snapback’) to, the incandescent lamps. The separate ballast reduces the price of the lamp when the bulb is replaced. Given that the ballast is not discarded with the change of a lamp, less solid waste is generated.

As part of its promotions strategy, Bonesa launched a public awareness campaign in the three villages of Matatiela and gave each household two modular based lamps with CFL bulbs for free. This should demonstrate to the residents that CFLs are an excellent investment on the grounds that they are energy saving, have a low maintenance cost, and provide an excellent light distribution.

Sustainability of the project

Together with the implementation strategies discussed above, the ELI programme allows markets for efficient technology to sustain themselves through measures such as educating the households about how to adapt efficient-lighting technologies; providing support to the technical, financial and professional infrastructure to accelerate market growth for efficient lighting; and promoting efficient-lighting technology. But although meeting its social and environmental objectives, the ELI programme cannot achieve financial and economic sustainability on the basis of low-income programme activities alone.

THE BONESA NATIONAL PROGRAMMES

We will now try to establish whether Bonesa has accomplished some of the goals that it set out to achieve, and we will consider the impact of public education and free light-fitting programmes. We examine each objective and implementation strategy, point out the progress/successes achieved, explain problems, weaknesses and barriers encountered, and account for lessons learned.

RDP housing and new electrification

The objective with RDP housing and new electrification is to introduce new Eskom or municipal customers to efficient-lighting technology, and to provide new electricity customers with an affordable option to purchase energy-efficient lighting at the time of hook-up. The lighting technology is a modular CFL that uses an electro-magnetic ballast and a removable PL lamp, with a three to five meter lead between plug and the luminaire for ease of movement. This allows for the luminaire to be either hung on the ceiling or to stand on a table.

The target market for this technology is a new electricity customer in the emerging market. These are households, whether in shacks or subsidised formal houses, which have recently been, or will soon be electrified. The ELI South Africa Strategy Document (2000) estimates the size of the market to be 250 000 households per year, and that Bonesa is to electrify about 70% of these, with municipal authorities accounting for the rest. The initial focus will be on the provinces prioritised for development: the Limpopo and the Eastern Cape Provinces. While not attempting to capture the entirety of this market, the expectation was for Bonesa to target 60% of the Eskom total in 2001, and 80% of the total, as well as a substantial number of municipally-serviced households, in 2002.

As its implementation strategy, Bonesa provides product information to the new electrification customers and pays Eskom and selected other distribution utilities to provide luminaires (without glassware) to customers, as part of the customers' new hook-up. Electrification contractors are used to deliver the efficient-lighting product and regional implementation co-ordinators (RICs) provide these contractors with information (including formal training). Customers are supplied with a coupon, redeemable at local retailers, to purchase the necessary glassware. Together with the RICs and with the assistance of the local distribution company representatives, Bonesa identifies local retailers at the inception of each electrification intervention. The retailers are furnished with information (brochures and posters) and with incentives to sell the lamps. The RICs, in turn, identify local community leaders and brief them on the forthcoming project as well as on ways to create jobs within the community via the project.

Even though progress has been slow, there have been some successes. Potential local retail partners have been identified, informed about the technology and provided with brochures and posters. Bonesa is still intending to conduct a pilot study in the Northern Province. The RICs are still identifying and briefing community leaders about the project and its potential benefits, and seem to be liasing well with their communities.

The monitoring exercise identified the following problems and barriers:

The initial strategy was based on a one-roomed RDP house requiring one fixture. The reality, however, is different, and this may increase the costs for a community that cannot afford the expense.
Problems were experienced with the distribution of CFL's.
Bonesa did not take adequate account of the need for storage. Eskom's storage is small and private storage is expensive.

There are several challenges to address when adopting policy. Firstly, effective education/awareness and an affordable price will reduce the likelihood of reverting back to incandescent bulbs (snap-back). The technology being promoted is imported, and there are no local manufactures. Secondly, Bonesa should have an electronic system in place for stock control so as to ease the burden on retailers or shop owners.

Schools

Bonesa's activities at schools are of a public-education nature. They are interrelated, and include creating awareness through informing pupils and students about the electrical energy market; promoting lighting technology; highlighting the link between electricity usage, wealth, environment, impact and associated benefits; and educating learners on the importance of using electricity cost-effectively. The target market comprises private and government schools that already have electricity.

Pilot projects are planned for the Limpopo, Eastern and Western Cape Provinces.

Bonesa's implementation strategy takes the form of training. This training, in the form of a workshop with teaching material provided, is intended to make the teachers play a leading role in their schools. The facilitating team in each case consists of a technical specialist, a regional co-ordinator and an education circuit officer. Schools are encouraged, via educational newsletters, to participate voluntarily, and participating schools are selected with the help of the regional project co-ordinator and location education officer. Bonesa envisages implementing this project in 150 schools.

The main problem that has been encountered, is the development of a training manual for schools, which has to be approved by the provincial education departments. Each province has been approached for feedback & input and further delays are expected to be in terms of standardising the manual for the satisfaction of all the provinces.

Tertiary sector

For the tertiary sector, the objectives are broadly three-fold: to increase the awareness among students and faculties of the technical requirements of efficient-lighting products, to assist designers in commercialising CFL-dedicated luminaires and other electricity-efficient technologies, and to support Bonesa's Luminaire Competition as an incentive to young designers to learn more and get involved in the lighting industry. Targeted institutions are technical colleges, technikons and universities. The programme is targeted at selected faculties, with Engineering as a primary focus, followed by Arts, in particular, Interior Design students. The first pilot phase is to roll out in 35 institutions in the Limpopo, Eastern Cape and Gauteng Provinces.

To facilitate implementation, Bonesa has planned on a number of strategies designed to do the following:

Provide participating institutions with information on lighting.
Provide teaching/study-aid material to lecturers and students for project use in class.
Establish competitions to increase awareness and interest in the lighting technology.
Help competition winners to commercialise their designs.
Invite institutions to participate in the programme via journals and newsletters.

Evidence shows that Technicon Pretoria, Pretoria University, University of Cape Town and some schools have been involved in luminaire design competitions. Assistance of designers is linked to luminaire competition, but the challenge is on how to market it. As with the schools, the main problem has been the development of appropriate material.

Public education

Bonesa has been holding promotional events in malls across the country. Activities at these promotions include an exhibition stand, children's entertainment, demonstrations of the CFL advantages, and subsidised sales of CFLs. Promotions are complemented by a newspaper publication, live radio broadcasts and a national competition. Television advertising, however, has been scant. The main barriers and lessons learned are the following:

Forward planning is essential, as are realistic lead times when organising promotional events.
Pre- and post research is necessary for continuous feedback to the programme.
It is important to keep the website current and dynamic, as well as offer a toll-free telephone service. After promotional events and advertising campaign rollout, Bonesa phones are inundated with calls.
Interaction with stakeholders is critical. Increased awareness has not been matched by increased lamp sales because of insufficient interaction with stakeholders.

In considering growth in lamp sales, Table 6 shows that CFLs are growing faster than other lighting products and that their market shares exhibit a positive trend (Table 7). Incandescents dominate the lighting market. It is unclear how many lamp sales the Bonesa programme, through its public education programme, is achieving. Bonesa aims to have eighteen million CFLs installed in homes by 2015 (Eskom 2001a), an equivalent of 1.2 million lamps per year. Such replacement would translate into a huge environmental and economic saving (Table 8). Considering the dominance of the incandescent bulb in the lighting market, its relatively affordable prices and ease of availability, Bonesa faces a real challenge in achieving its objectives.

Table 6: Average growth rates of lamps (1997-2001)
Source: Calculations based on annual lamp sales provided by Bonesa

Type	Incandescent	Tungsten	Dichroic	HID	Linear Fluorescent	CFL
Growth rates (%)	19	10	33	30	3	33

Table 7: Lamp sales: market shares (%)
Source: Calculations based on annual lamp sales provided by Bonesa

	Incandescent	*Tungsten*	*Dichroic*	*HID*	*Linear Fluorescent*	*CFL*
1997	*80.1*	*-*	*-*	*1.8*	*15.8*	*2.3*
1998	*75.7*	*2.0*	*1.4*	*2.5*	*16.6*	*1.8*
1999	*79.6*	*2.0*	*2.0*	*1.6*	*12.2*	*2.7*
2000	*79.1*	*2.0*	*1.9*	*1.6*	*12.4*	*3.0*
2001	*73.8*	*2.2*	*2.7*	*3.1*	*13.3*	*4.9*

Table 8: Savings associated with replacing 1.2million 75 W incandescents with 15W CFLs

Resource	*Units*	*Year 1*	*Year 10*
Electricity/cost	R billion	0.002	1.19
Energy use	Gigawatt/hours	72.00	3960
Water usage	Gigalitres	0.09	4.79
Coal usage	Kilotons	0.04	1.94
Ash produced	Kilotons	0.09	5.48
SO_2 emissions	Kilotons	0.57	31.48
N_2O	Tons	0.79	43.56
NOx emissions	Kilotons	0.26	14.10
CO_2 emissions	Megatons	0.06	3.34

Note: a. The figures assume lamps are used 10 000 hours per year. b. Savings are resources used by incandescent lamps, less resources used by CFLs.

POLICY IMPLICATIONS: SUSTAINABLE DEVELOPMENT LINKS

Various lessons and recommendations can be drawn from the efficient-lighting promotion. Of importance are the following:

Public education raises the level of awareness about efficient lighting.
Uncertain product performance erodes consumer confidence in efficient lighting.
Poverty and inequality does not make television advertising cost-effective, although this medium appeals to higher income groups with access to television.
Public school educational programmes, meetings with community leaders and the community, and the use of print media, lead to success in awareness building.
Continued promotion of CFL-dedicated luminaires is necessary to avoid snap-back.

At some point it will be useful to account for the welfare effects of efficient lighting. It is important to determine if efficient-lighting programmes result in: improved income and income generation, an improved standard of living, changes in consumption behaviour of energy leading, changes in the energy bill, efficient lighting and the creation of new businesses. Similarly, contributions of the programme can be tested on changes in the following variables: poverty alleviation, health, empowerment, housing, education, security and public participation. Such an approach goes further than the current policy desire to reduce the residential peak load, since it touches on various national policy goals and has the improvement of quality of life as a central objective.

Notes:
1. In order to meet the desired objectives, Eskom, International Finance Corporation, and the Global Environmental Facility jointly proposed to address the issue of a cost-effective, robust market for energy-efficient lighting. This resulted in the formation of Bonesa, a joint-venture company between Eskom Enterprises, Africon Engineering and Umongi-Karebo, to implement the ELI programme.

REFERENCES

Clark, A (1998) Energy-Efficient Lighting in Low-Income Households: Barriers and Opportunities. Proceedings: Domestic Use of Electrical Energy Conference. Cape Technikon., Cape South Africa.

Clark, A (1999) The Efficient Lighting Initiative: Bringing About a Lighting Revolution in South Africa. Proceedings: Domestic Use of Electrical Energy Conference. Cape Technikon, Cape South Africa.

Clark, A (2001) Bonesa: January 2000 to July 2001. Unpublished Paper.

Davis, M (1998) Rural Household Energy Consumption: The Effects of Access to Electricity Evidence from South Africa. Energy Policy. Vol. 26 No 3.

Eberhard, A and van Horen, C (1985) Poverty and Power. Pluto Press.

ELI/GEF Efficient Lighting Initiative (ELI) Tranche 1: Argentine, Peru and South Africa. Project Document March 1999. http://www.efficientlighting.net/document/general/eli-tranche-1.pdf

ELI South Africa Strategy Document (2000), November. Document Prepared by Bonesa (Pty) Ltd for UFISA and Eskom.

Eskom (2001a) Efficient Lighting Initiative. Elektrowise.

Eskom (2001b) Environmental Policy.

Grobler L J and Heijer W (2002) Measurement & Verification Workplan for 2002. February. Unpublished Paper.

Haarman, C (2001) Social Assistance Programmes: Options and Impact on Poverty and Economic Development in South Africa. AFReC Research Monograph Series. No 22 April. University of Cape Town.

Hirschowitz, R (1997) Earning and Spending in South Africa. Selected Findings of the 1995 Income and Expenditure Survey. Central Statistics.

Indicators of Sustainable Development: Framework and Methodologies. Background Paper Number. Department of Economic and Social Affairs//Department for Sustainable Development. April 2001. http://www.un.org/esa/sustdev/csd9/csd9_indi_bp3.pdf

Jepma, C J and Munasinghe, M (1998) Climate Change Policy: Facts, Issues and Analyses. Cambridge University Press.

Michaelowa A (2002) Baseline Rules and Monitoring Protocols for the CDM. HELIO Monitoring Course. Cape Town, March. Unpublished Paper.

Munasinghe M (1993) Environmental Economics and Sustainable Development. Washington, D. C. World Bank.

Munashinge, M. Sunkel, O. de Miguel, C., and Gunasekera K. (2001) Growth and Sustainability: An Overview. In Munasinghe, M Sunkel, O and de Miguel C (ed.) The Sustainability of Long-term Growth: Socioeconomic and Ecological Perspectives. Edward Edgar.

Why M&E? IFC/GEF Efficient Lighting Initiative (ELI) Monitoring and Evaluation Overview. http://www.efficientlighting.net/m-and-e/why_me.html

Chapter 9

Major Lessons Learnt and Future Direction

Ogunlade Davidson[1] and Wendy Poulton[2]

[1] University of Cape Town [2] Eskom

Targeted research and investigation programmes can play an important role in ensuring that electrification programmes are optimised, customers' expectations are met, and costs are reduced. Thus programmes need to be continually adapted and modified in order to include lessons learnt.

SUMMARY OF ACHIEVEMENTS

The studies undertaken as part of this collaborative effort demonstrate the importance of electrification in the process of economic development and social progress to improve the overall quality of life of its citizens, while also benefiting the environment. A summary of the detailed Chapters is provided below.

Chapter 1 begins by describing the state of electrification in Africa with respect to other developing regions and also shows the significant variation in access to electricity among countries in the continent.

Chapter 2 discusses issues related to the planning of an electrification programme of this scale. It was identified that the prediction of medium- and long-term impacts on the demand for electricity in the residential sector was required. By using modelling techniques, the impact of increased demand at peak times were assessed, including the assessment of both demand- and supply-side options in order to meet or reduce that demand, as well as related cost implications.

The technical parameters governing any electrification programme are crucial, because the technologies used should be reliable and cost-effective. A group of studies exploring these issues, conducted over a number of years, are summarised in **Chapter 3**. These studies focused on designing technologies related to electrification, including line and network systems, pre-payment metering, required voltages and appliance utilisation. It was shown that changes in line design (such as the distance between poles in the network, as well as the voltage of lines) can be optimised at reduced cost. Identifying mechanisms to lower additional cost requires further work.

In addition, Eskom developed an approach which resulted in reducing connection costs. As a result, 1.5 million connections were made in five years, with a 50% reduction in the cost per connection. The technical innovations in this approach included the development of readily available structures and conductor cable types that facilitated easy construction at lower cost. Defining the parameters of network design and matching them to load demand by users were also found useful in reducing the cost of electrification.

Chapter 4 shows that financing rural electrification is a complex problem, influenced by many factors, including the economic status of the community and the cost of connections. Studies around this problem assessed two selected areas, identifying the conditions under which electrification can be economic. The importance of prepayment was established; and limiting the load to suit affordability was also tested. Results showed significant gains were achieved in the cost of connection, well above what was predicted.

Once electricity has been supplied to a community, studies are needed to determine the resulting benefits. **Chapter 5** details work undertaken in collaboration with the Department of Minerals and Energy and the Norwegian Overseas Development Agency. Although studies tend to generalise conditions in rural areas, these ones show large variations in electricity usage, largely defined by income level and the purposes for which electricity is used. While most people own radios and use electricity for lighting and cooking in the areas tested, only about half of the people own heavy-consumption appliances like refrigerators, electric kettles and hotplates. The study demonstrated that ownership does not always imply usage: for example, 16% of households in the study areas own electric heaters, but only 3% use them frequently.

However, in studying the benefits of electrification it was concluded that electrification leads to improved health by reducing burns and acute respiratory infection, and generally raising the standard of living – through, for example, better adult education opportunities. The work also showed that, in introducing electrification in rural areas, customers should be given options relating to payment, and that there should be facilities for upgrading.

Chapter 6 details longer-term research which was subsequently undertaken in order to better understand the impacts of electrification on energy-use patterns, benefits such as economic opportunities, and factors that influence electricity consumption. The studies showed that factors such as local situation, shortage of alternatives and previous knowledge of electrification affect communities' attitude to electrification. As soon as people are exposed to electricity they desire more; but increased levels of information on various aspects of electricity are required in order to achieve maximum benefits and help people make informed choices.

Chapter 7 describes studies that were initiated to assess the introduction of different energy efficiency measures in low-income households: energy-efficient lighting and appliances, improved thermal performance (e.g. from ceilings and insulation), and fuel switching. The results show that energy efficiency in low-income households can lead to economic and environmental benefits. There are, however, barriers to implementation and uptake, including initial cost, information and awareness about potential benefits, lack of access, and multiple fuel-use patterns. Where programmes have been successfully implemented, benefits at both household and national levels can be realised.

Monitoring and verifying energy efficiency programmes were identified as crucial for determining the extent to which potential benefits could be realised. **Chapter 8** outlines studies that were undertaken to outline a framework for doing this, including an evaluation of energy savings, reducing peak load, testing customer behaviour, and exploring ways of building consensus among users. Comprehensive strategies that include overcoming barriers related to public awareness and uncertainties in product performance need to be implemented in order to positively influence individual behaviour in favour of efficient lighting systems. Information from monitoring and verification is essential to optimise programmes and benefits and to make better-informed decisions.

Chapter 9 concludes with some key findings, lessons learnt and identifies possible future work.

The electrification programme in South Africa that started in 1994 made profound changes to the country, economically and socially. There are also specific lessons that could be useful in replicating such programmes. These are summarised as follows:

- Electrification programmes require strong government intervention at early stages of development, especially when the overall energy economy is far from saturated and the government wants to improve the socio-economic development of the country.
- Electrification should not be evaluated only in terms of financial cost-effectiveness but also by considering access to electricity, socio-economic development and progress towards improved quality of life.
- Attempts should be made to use optimal technological and operational options in any electrification programme as this will help to reduce costs.
- Cost recovery of electrification programmes should be strongly linked with affordability to the users.
- Realising the full benefits of electrification may be slow, and there is a need to look for ways to maximise benefits over both the shorter and longer terms.
- Modelling is a useful tool to develop options to manage load distribution and ensuring optimal conditions for electrification.
- Demand-side management can assist with the realisation of benefits. It should, however, be linked to affordability, as the cost of implementation can be a barrier, as can physical access to the suggested measure. For such benefits to be realised and maximised, these programmes should be closely monitored and verified.

EMERGING LESSONS FOR OTHER DEVELOPING COUNTRIES

This document gives some useful information which might assist other African countries in implementing electrification schemes. In addition to the lessons learnt detailed in the summary of Chapter 9 above, the following are highlighted:

- Political will, commitment and determination are essential ingredients in undertaking a comprehensive electrification programme.
- Economic justification for such programmes is important, but social, environmental and other benefits are equally so.
- Cost-recovery mechanisms are more effective after a reliable and efficient service has been delivered.
- Careful planning and use of planning tools are important in conceptualising and implementing the programme.
- Energy efficiency and cost savings can be realised, but such programmes should be monitored and verified in order to realise benefits.
- Targeted research and investigation programmes can play an important role in ensuring that electrification programmes are optimised, customers' expectations are met, and costs are reduced. Thus programmes need to be continually adapted and modified in order to include lessons learnt.

SUGGESTIONS FOR FUTURE WORK

The work undertaken to date is comprehensive and covers a wide spectrum of activities. It shows that the electrification programme has had profound impacts on many people's lives. It has, however, also highlighted that the full benefits of electrification are not always immediately realised. It is, therefore, critical to continue to address some of the issues highlighted in this report, such as the monitoring of the benefits and impacts of electrification and factors influencing the continued uptake of electricity. Issues of affordability are also central, so research must continue addressing the issue of affordability and thus ultimately increased access.

The recent initiative by African leaders to embark on a new development path, as expressed in the "New Partnership for Africa's Development" (NEPAD), is based on a common vision and a firm and shared conviction of a pressing duty to eradicate poverty and to place their countries, both individually and collectively, on a path of sustainable growth and development and, at the same time, to participate actively in the world economy and body politic.

Experience has shown that developing focused partnerships between major stakeholders is a key mechanism for achieving effective development programmes. In Africa these typically include government, the local and international private sector and state- owned enterprises. Development projects could benefit from the experience Eskom has gained in combining development priorities with good business sense.

Eskom's success in the field of national electrification and regional power grid development provide an excellent basis for implementing similar projects in the continent.

In order to advance these successes further, focused development frameworks such as NEPAD are required as a core vehicle for the developing long-term commercial and developmental projects across Africa – combining local business and equity partners with international public and private sector partners.

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Chapter 7

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Chapter 8

Bonesa.