Rural Electrification in Swaziland
Phase 3 - Policy Formulation

Draft Final Report

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Modelling of this scheme indicates that, on average, a total subsidy of E800 000 will be required to cover the full costs of the loan repayments.

It is further estimated that there will be operating losses of E3.3 million, on average, for this programme. This is mainly a consequence of the existing cross-subsidies in the domestic tariff, and if this is addressed through a "rebalancing" of tariffs, this loss should fall away.

Institutional issues

The resolution of the most appropriate institutional framework requires Government, together with other stakeholders, to decide how much of the responsibilities should be assigned to SEB, and whether these responsibilities can be better managed by existing or proposed agencies. Some of the options available require a substantial restructuring of the electricity industry - an institutional route which, if preferred, clearly requires careful consideration.

The key recommendations made here are as follows:

- **Electrification planning:** a small sub-committee of SCORE be established to perpetuate planning functions.
- **Implementation:** it is recommended that SEB take the lead in implementing the projects funded through this programme. If it is necessary for SEB to contract in outside assistance in the form of consulting engineers and contractors, this route should be adopted.
- **Operation:** it is recommended that SEB operate the electrification projects funded through this programme.
- **Monitoring and evaluation:** it is recommended that monitoring and evaluation be shared between SEB, the MNRE, PEU and SCORE, in the manner discussed above. In the development of a new performance contract for SEB, attention should be paid to the inclusion of rural electrification targets and funding systems.

Whichever agency is made responsible for the tasks associated with rural electrification, Government must recognise the funding implications which accompany such a delegation of duties.

Electrification planning

Every effort should be made to ensure that electrification planning integrates rural electrification with other development initiatives. The following recommendations are made in support of this.

Planning and prioritisation process

The following recommendations are made:

- ***A planning sub-committee of SCORE be established,*** comprised of representatives from MNRE, SEB and MEPD. This sub-committee should be driven by MNRE and should be responsible for the following tasks:
- ***Information collection for line extension projects***: each year the following years' line extension projects should be visited and information collected as per the questionnaire at the end of this appendix.
- ***Monitor the line extension fund***: monitor the line extension fund and evaluate the impact which new projects will have on this fund. Use this information to inform Government budgets for rural electrification.
- ***Evaluate applications for grid extension***: if a community applies to be included in the line extension programme, the committee should collect information on the

settlement and evaluate whether it should be included in the medium term electrification programme

- *Monitor rural development initiatives:* The planning committee should monitor rural development initiatives, with attention paid to future irrigation projects and the development of the "economic corridors". Future developments may mean that the line extension programme should be updated to take account of new initiatives.

Rural development initiatives
The prioritisation of the line extension programme should take consideration of the following factors:

- *Rural services:* A number of unelectrified clinics have been identified. These should be considered for grid electrification. There are also a large number of unelectrified rural schools. A number of these can be electrified at low cost (i.e. they are close to existing distribution lines). The position of unelectrified high schools should be considered when planning future line extension projects.

- *Physical infrastructure:* Many Tinkhundla centres do not have access to electricity, and SPTC has 35 unelectrified telecommunication stations. Attempts should be made to include these in the grid extension programme, as well as consideratino given to any unelectrified government facilities such as police stations and army barracks. The RWSB is planning a number of macro projects over the next few years. A number of these require pumping - and electricity is the preferred fuel. In addition, there are a number of existing water schemes where electricity is required either to replace defunct diesel pumping systems or to introduce a pumped reticulation scheme.

- *Economic activities:* The MHUD has developed a system of classifying rural centres according to their future economic growth potential. It is further recommended by the NPDP that centres with a classification of six and above merit electrification. A total of 19 such unelectrified centres have been identified and should be considered in the electrification programme. A irrigation potential in the major river basins was documented and it is clear that there will be pumping requirements in the future - mainly in the Lubombo region. The electrification planning committee should monitor irrigation developments.

Optimisation of rural electrification projects
It is widely accepted that electricity is a necessary but insufficient condition for development. The following strategies may assist in optimising rural electrification projects.

- *Appliance sales:* The promotion of electrical appliances will assist in broadening the benefits of electrification. It is recommended that SEB and the MNRE collaborate in introducing appliance distributors to newly electrified areas, with the intention of holding demonstrations and the promotion of appliance sales through local stores.

- *Battery charging centres:* It is recommended that a system of battery charging centres be piloted for the rural electrification programme.

- *Promotion of productive applications:* It is recommended that in newly electrified areas a demonstration be held by the MNRE, together with small business development agencies, on the potential business opportunities made possible by electrification.

- *Load management:* A number of load management strategies should be considered if rural load factors lead to unacceptably high cost increases.

Off-grid options

It is evident that not all households, community facilities or commercial enterprises will be able to obtain a grid connection. The following recommendations are made for off-grid options:

Households

Support should be given to the current solar home dissemination programme. This support should include information transfers regarding future line extension projects as well as advice on standards and specification.

Where households are relatively close to a grid line, but too far to be able to afford a grid connection, it is recommended that battery charging centres be established. This would involve the sale of suitable equipment to households, who can then transport their batteries to local recharging points. As far as possible, this should be a private sector initiative, although Government and utility assistance may be required to initiate the first pilot projects. It is recommended that Kubuta be considered for a pilot project (since a grid line is here, a battery charging centre could easily be established).

Clinics

There are a number of clinics which are too far from the grid to warrant electrification. These are Mpuluzi, Sigcineni, Musi and possibly Makhava. Other non-Government clinics which cannot be easily reached by the grid include Sincaweni and Manyeveni (among others).

It is recommend that where diesel generators exist, these should be upgraded to genset plus battery systems in order to improve the quality and reliability of supply. This will allow the installation of security equipment, including motion detector lights and alarms. The approximate cost of a large upgrade is in the region of E45 000 per site. It is recommended that this system be provided at Mpuluzi, Sigcineni, Musi, Makhava and Manyeveni.

Where solar systems exist (at Sigcineni and Musi), it is recommended that these be connected to the battery bank.

At Sincaweni, where no diesel generator exists, it is recommended that the existing solar system be upgraded to include lights in all nurses' accommodation as well as an upgraded system at the clinic (incorporating motion detector lights).

Schools

There are a large number of unelectrified schools in the country, many of which will remain beyond the reaches of the grid.

A set of off-grid supply options have been prepared (see Appendix A.3) for the Ministry of Education and these are under consideration by this ministry.

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Chapter One
Introduction

1.1 Introduction

This report forms part of a rural electrification planning project for Swaziland. The project has been divided into three phases and has been implemented during 1996.

The first phase, "Technical and financial aspects" collected and analysed much of the information required for the planning project. A "Land Information System" detailing networks, population densities and public services has been established and populated. This was used to provide a first prioritisation of future electrification projects based on connection costs and estimated future consumption.

The second phase, "Cost-Benefit Analysis" analysed the socio-economic consequences of electrification in Swaziland. The impacts of electrification were quantified using cost-benefit methodology and attention was paid to various options for capital cost recovery. This phase provided economic information on which to adjust the original prioritisation provided by phase 1.

The third phase is "Policy Formulation" and this document reports on the work and recommendations of this phase.

1.2 Objectives

The overall objective has been to provide a policy framework within which rural electrification can occur. More specific objectives have been to:

- examine the role of off-grid options in rural electrification;
- propose an institutional framework for the planning, implementation and operation of rural electrification projects;
- examine funding options and to propose tariff and connection policies for rural electrification;
- propose mechanisms whereby rural electrification can be integrated with overall rural development activities; and
- integrate the three phases of the entire study in order to prepare a rural electrification plan.

1.3 Study components of phase 3

Phase three was required to examine four different elements of rural electrification. These are:

- **Off-grid options**
  This involved the examination of non-grid electricity supply options. Following consultation with key actors in Swaziland, it was decided to focus on off-grid options for rural schools and clinics, photovoltaic water pumping systems, as well as guidelines and training for solar home system installation.
- **Institutional & financing aspects**
  This component defined the different tasks associated with rural electrification and looked at the various institutional options available. The merits and demerits of each were discussed at workshops held in Swaziland, and the key public policy decisions were identified.

  Similarly, the options for financing rural electrification were identified and discussed at workshops held in Swaziland. Recommendations on financing schemes were made, and these were modelled on the proposed rural electrification programme.

- **Integration of rural electrification with rural development initiatives**
  This component looked at the background to rural development in Swaziland, and documented the various inititatives in the country. Opportunities for electrification to contribute to these were identified, and this influenced the selection of grid extension sites.

- **Preparation of a rural electrification plan.**
  Finally, the information from phases 1, 2 and 3 were integrated to produce a rural electrification programme. This comprises of (1) identified grid extension sites, (2) prioritisation of reticulation schemes, (3) proposed insitutional arrangements, (4) proposed financing methods - tested against the proposals.

The structure of this document follows the above study plan, with each study component being documented in a separate chapter. The main body of the report is precise, with more detailed supporting information found in the appendices. Each chapter has a set of appendices which contain the supporting information. Lastly, Appendix E contains summaries of the implications of the programme for a selection of Government ministries.

Chapter Two
Off-grid Options

Four separate topics were identified for investigation. These are as follows:

- A review of clinic and school off-grid electrification to date was conducted;
- Proposals for an school and clinic off-grid electrification programme were made;
- Policy issues for the solar home electrification project were identified;
- An overview of photovoltaic pumping options was conducted.

Unfortunately the IT Power report on the role of renewables in Swaziland was not available. Consequently it was difficult to follow up any recommendations, and suggestions made here may repeat or even contradict its findings.

2.1 Review of clinic and school off-grid electrification to date

Appendix A.1 documents this review. The main findings are given below.

The existing off-grid school and clinic electrification programme in Swaziland is very much a pilot programme. It is a modest programme which was launched in 1991 to provide minimal levels of electricity using solar photovoltaic (PV) systems for lighting (teachers' homes, clinics and nurses' homes) and vaccine refrigeration (in two clinics). The PV systems were installed at six schools and ten clinics. In addition sixteen street lights were installed.

The main benefit of this pilot programme has been the provision of very basic levels of electricity for lighting. In this regard it has been a moderate success. The benefits of vaccine refrigeration have not been realised.

The secondary benefits have been the experience gained with the installation, operation, reliability and maintenance of small PV systems in the context of infrastructural service provision a developing country.

Problems have included:

- unclear lines of responsibility, resulting from the irresolution of ownership rights;
- poor quality of installation;
- poor reliability of DC lights;
- poor technical backup through a lack of planning, administration and maintenance capacity.

Based on this review, the following recommendations are made:

1. All the systems in the programme need to be assessed in terms of their condition and their appropriateness to the future needs at the site.
2. The decision regarding the upgrading or removal of the systems should be made in the context of the above survey and the proposed rural electrification plan for Swaziland.
3. In the event of off-grid systems being appropriate, a more structured programme is recommended which includes appropriate planning, system upgrading, improved technical specification, project management and the establishment of institutional capacity for administration, monitoring, maintenance, training of the programme.

2.2 Proposals for an off-grid programme for schools and clinics

Based on the findings of the review, an off-grid programme focussing on schools and clinics was prepared. This took three stages:

- Firstly, the off-grid supply options were considered and a suitable generic design selected in consultation with health and education officials.
- Secondly, unelectrified schools and clinics were identified and it was noted if grid extension was a feasible options.
- Thirdly, for those buildings earmarked for off-grid electrification were visited and an implementation programme prepared and costed.

Supply options for schools and clinics

Appendices A.2 and A.3 presents the off-grid supply options for schools and clinics. These are summarised in Table 1.

Table 1: Summary of off-grid options for schools and clinics

	Clinics	Schools
Option 1	***PV vaccine refrigeration*** If gas refrigeration is deemed unreliable, then it is possible to install a PV system. This would cost ±E20,000 per system.	***Diesel and gas*** Diesel generator for lighting and electricial needs at school and teachers' homes; Gas for cooking and heating at 3 teachers' homes. The capital cost is ±E108,000.
Option 2	***Diesel genset + small battery bank*** Existing diesel gensets can be supplemented by a battery bank to supply 24hr and security lighting at the clinics. The cost is ±E20,000.	***DC solar and gas*** Solar for lighting and television in teachers' homes only; Gas for heating and cooking. The capital cost is ±E85,000.
Option 3	***Diesel genset + large battery bank*** Option 2 can be strengthened by a larger battery bank & automation. This would provide 24hr electricity to nurses' homes as well as the clinic. The cost is ±E45,000.	***AC solar*** For extensive lighting and audiovisual equipment at school only. The capital cost is ±E77,000
Option 4	***DC PV system for clinic & nurses' homes*** A DC PV system can provide power for lights & communications at the clinic & nurses' homes. The cost is ±E27,000.	***DC solar*** For very basic lighting at school only. The capital cost is ±E6,000 per school.

Discussions were held with officials at the Ministries of Health and Education to identify a suitable supply source. At clinics one of the main energy needs is improved security. It was decided that, in general, where diesel generator existed, these should be upgraded to include batteries, a battery charger and an inverter. This allows the installation of security and motion detector lights as well as a panic buttor audible alarm. It also allows easier use of the clinic after-hours and prepares the way for the installation of radio-telephones where no other telephones are available. Further, the battery system allows nurses the use of lights and television for longer period during the evening without adding to the cost of running the diesel generator.

Where there is no diesel generator at a clinic (for example at some non-Government clinics), DC solar systems would be used, sized to provide lights but not vaccine refrigeration. In all cases it was decided to retain gas vaccine refrigeration.

The Ministry of Education has yet to decide whether off-grid systems will be installed in rural schools.

Number of rural schools and clinics without electricity

There are currently nine government clinics without access to grid electricity. Further, there are an unknown number of mission clinics without a grid supply. Of these unelectrified mission clinics, there are 6 which currently have solar systems installed as part of the off-grid electrification programme described above.

Table 2 lists the unelectrified government clinics, together with the approximate distance to the grid. The number of nearby schools and clinics is also listed, and the approximate cost of line extension, expressed as a figure per government institution present in the area, is given. Those sites where the costs of grid extension were significantly less than E100 000 per government intsitution were selected for grid electrification, and the others were selected for off-grid supply.

Table 2: Unelectrified government clinics

Clinic name	Approx. distance to grid	Nearby Telecom stations	Nearby high schools	Nearby primary schools	Cost per institution for grid supply	Recommended supply choice
Mpuluzi (Manzini)	10 km	0	0	0	E300 000	Option 3
Singcineni (Manzini)	10 km	0	0	0	E300 000	Option 3 with existing solar
Musi (Manzini)	10 km	0	0	1	E150 000	Option 3 with existing solar
Makhava (Shiselweni)	6 km	1	0	1	E60 000	Option 3 or grid supply
Mashobeni (Shiselweni)	6 km	0	1	1	E60 000	Grid supply
Nkwene (Shiselweni)	8 km	1	1	1	E60 000	Grid supply
Jericho (Shiselweni)	5 km	1	0	1	E50 000	Grid supply
Nkonjwa (Lubombo)	5 km	0	1	1	E50 000	Grid supply
Ntshanini (Shiselweni)	12 km	4	2	3	E36 000	Grid supply

Note: in the case of Singcineni and Musi clinics, there are existing solar sysems and these can be easily connected to the battery bank, providing additional power.
Note: A cost of E30,000/km is used to calculate the approximate line extension costs.

Of the six mission clinics currently with solar systems, four are less than 2 km from the grid, and thus an upgrade does not seem appropriate. Instead, these clinics should be targeted for electrification as part of the grid extension programme. The three non-Government clinics (for which there is information) which cannot be supplied by the grid are Sincaweni, Malindza and Manyeveni. It is recommended that the solar systems at Sincaweni and Malindza be upgraded and the system at Manyeveni be converted to a genset plus battery system.

Table 3: Unelectrified non-Government clinics
(this list appears incomplete)

Clinic name	Approx. distance to grid	Nearby Telecom sites	Nearby high schools	Nearby primary schools	Cost per institution for grid supply	Recommended supply choice
Sincaweni (Manzini)	12 km	0	1	0	E180 000	Upgraded solar system
Manyeveni	5 km	0	0	0	E150 000	Genset plus batteries
Malindza (Manzini)	4 km	1	0	0	E60 000	Grid supply
Ngculwini (Manzini)	2 km	0	1	0	E30 000	Grid supply
Mafutsene (Manzini)	0.5 km	0	0	1	E7 500	Grid supply
Bethany (Shiselweni)	0.5 km	0	0	1	E7 500	Grid supply
Ikwezi Joy (Shiselweni)	0.5 km	0	1	1	E5 000	Grid supply

Note: All clinics except Manyeveni currently have a solar system

The number of unelectrified schools is far higher. There are a total of 66 secondary and high schools without electricity, which represents nearly 40% of such schools. The number of unelectrified primry schools is even higher at 358, and this is over 65% of such schools.

Table 4: Government schools in Swaziland

	Total number of schools	Without electricity		Without water		Without electricity and water	
Primary	538	358	*(65%)*	196	*(35%)*	171	*(30%)*
Secondary	63	45	*(70%)*	30	*(50%)*	26	(40%)
High	107	21	*(20%)*	16	*(15%)*	8	*(5%)*
Total	708	424	*(60%)*	242	*(35%)*	197	*(30%)*

Despite the large numbers of unelectrified secondary and high schools, it is apparent that many are close to the existing grid. At least 28 of the unelectrified high and secondary schools are less than 5 km from the grid.

Implementation programme for off-grid electrification of clinics

The recommended option for clinics where there is a diesel generator is to provide a large battery bank and inverter in order to supply uninterrupted power to both the clinic and nurses' homes. The costs will depend on the number of nurses' homes at the clinic and approximate costs of these are provided below for four homes. This system would be fully automated so that the diesel generator could be switched on and off automatically by the control system whenever the battery was low.

If a pump was included in the system, this would be powered directly from the generator and not through the battery bank. Manual switches would be required to run the pump.

Approximate costs for upgrade of diesel genset (excl. contingencies):

Battery	460Ahr @ 36V	E14 000
Inverter	800 W sine wave inverter	E5 000
Battery charger	3 kVA	E5 000
Automation	Auto start & stop	E3 000
Motion detector lights	4 @ R400	E1 600
Outside pole-mounted security light (at gatehouse)		E2 400
Installation		E10 000
Project management		E4 000
Total		**E45 000**

This upgrade is recommended for the following clinics: *Sigcineni, Musi, Mpuluzi* and *Manyeveni*. For clinics receiving this upgrade where solar systems have already been installed (i.e. Musi and Singcineni), it is recommended that the existing PV modules be connected to the battery bank. The diesel generator at Musi clinic requires refurbishment.

At *Sincaweni*, it is recommended that the existing solar system be upgraded to provide additional security lights at the clinics, and lights/plug point at additional nurses' homes.

The following overall costs should be budgeted for (figures qre in 1996 terms and may have to be increased to account for inflation):

• *Sigcineni*	Battery system installation	E45 000
	Wiring rehabilitation	E5 000
	Installation of PV supplement to batteries	E3 000
• *Musi*	Genset refurbishment	E20 000
	Battery system installation	E45 000
	PV supplement to batteries	E3 000
• *Jericho*	Battery system installation	E45 000
	Genset installation	E5 000
• *Mpuluzi*	Battery system installation	E45 000
• *Sigcaweni*	Upgrade to DC solar system (clinic & 2 nurses' homes)	E20 000
	Subtotal	E241 000
	Contingencies @ 10%	E24 000
TOTAL		**E265 000**

It is recommended that project management assistance be contracted at least for the first sytem upgrade. This will include more detailed specification of the installation, evaluation of tenders, a site-visit with the appointed contractor and commissioning of the installed system.

It is further recommended that a maintenance contract be implemented with the supplier to ensure periodic checks on the systems.

2.3 Solar home electrification

A two day training programme was held in Swaziland. Attendees included personnel from the Ministry of Health, SCOT, Swazitronix, MNRE, Voctim and the Ministry of Works. The first day of the workshop involved an introduction to off-grid systems and was held in Mbabane. Topics covered included theory of photovoltic energy systems, system design, sizing and configuration, installation practice, practical measurements and system documentation. The second day involved a visit to a solar lighting system installed at Sincaweni clinic. This system was improved through the installation of new wiring and a new battery. This involved an analysis of the existing systems, fault finding, replacement of battery, charge controller, array wiring, load wiring and re-routing of the wiring. User training was also undertaken.

A solar home dissemination and financing scheme is soon to be implemented in Swaziland. In support of this programme, a set of installation standards were prepared. These are presented in Appendix A.4. It is necessary to consider the role of the Swazi Government in household dissemination of solar home systems. The two issues of importance are access to adequate finance, and quality standards for systems, installation and maintenance.

Regarding finance, it is clear that in the past there has been only limited access to finance, often on expensive or restrictive terms. However, a recent initiative has been launched by the private sector to provide finance for solar home systems. It is recommended that this initiative be monitored and supported. Further interventions should only be considered when the success of this initiative has been evaluated.

It is possible to adopt detailed quality standards. However, given the limited size of the local PV industry, and the commitment of the main players to improving standards, it is considered that a formal system of legislation and licensing is unnecessary. Instead, it is recommended that the MNRE continue to build on its relations with the main players in order to improve standards. Possible interventions include additional training and development of the standards presented in Appendix A.4.

Photovoltaic system design software (Powacost) was provided to the MNRE.

2.4 Decentralised battery charging stations

It is further recommended that the option of establishing decentralised battery charging stations be piloted. Such a system would involve the installation of a battery charger at a local store, and the sale of solar home type systems (minus the solar module) to households. Owners of such systems would then have to transport their batteries to the store to be charged, and would pay a fee for this. It is recommended that the management of this sytem be handled primarily by the private sector.

The project facilitated presentations from companies able to operate a decentralised battery charging system. Presentations were made to Government, SEB and the private sector. In addition, local company contacts with manufacturers of battery charging products were faciliated.

2.5 Photovoltaic water pumping

A survey was conducted of photovoltaic water pumping products available in Swaziland and South Africa. A Photovoltaic Pump Handbook was updated and distributed to Rural Water Supply as well as the MNRE, Swazitronix and the Ministry of Health.

This handbook contains information on system configuration, design, selection and installation. It provides data to support system selection and design, as well as sizing charts and daa collection tables. Finally, it includes a comprehensive list of manufacturers and suppliers in the region, and includes documentation of the products they offer.

Chapter Three
Institutional and Financial Aspects of Rural Electrification

3.1 Institutional options

Rural electrification involves a number of distinct tasks. These include the following:

1) responsibility for raising and providing funding for rural electrification;
2) responsibility for planning electrification projects;
3) responsibility for implementing and operating the electrification programme;
4) responsibility for co-ordinating any off-grid electrification activities.
5) responsibility for monitoring the programme;

The following section presents the different options available.

Institutional implications of different funding of rural electrification

The funding options for rural electrification are discussed in more detail in Appendix B.2. This section examines the institutional implications of using the possible routes.

The costs of electrification must be recovered from some source. In essence there are three options available (although a combination of these options is also possible):

- **User charges:** through connection fees and tariffs;
- **Cross-subsidies:** from other electricity consumers;
- **Grants:** from Government or international donors.

User charges: If user charges are used, then it is likely that some form of bridging finance is required. For example, if customers are allowed to pay the cost of connection over a number of years, it is necessary for the utility to raise sufficient finance in order to cover the initial costs. This finance can either be arranged independently by the utility, or arranged by the Government.

Cross-subsidies: If cross-subsidies are used, two options are possible. One is to use "hidden" cross-subsidies, that is, the cross-subsidies are not made explicit to other customers, but surplus income is raised from these customers and used to cover losses on electrification projects. The second option is to place an explicit levy on electricity sales, and to earmark the revenues from this levy for electrification purposes. This second option may be implemented by keeping the funds within the utility and accounted for separately, or may be taken out of the utility and managed by Government (an off and on-budget difference).

Grants: If grants are to used to support electrification, then it is likely that support would be channelled through the MEPD, even if foreign sources were used. Thus it would be necessary for the Ministry to manage the disbursement of these funds.

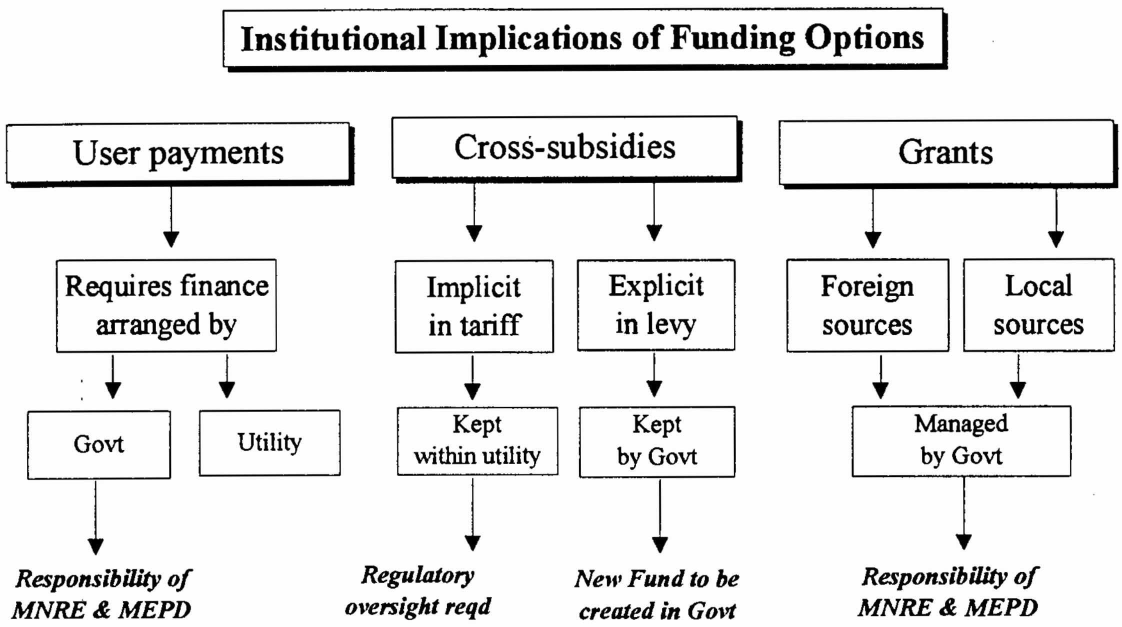

Figure 1: Institutional implications of funding options

Planning issues

The options available for planning are listed below:

- **SCORE acts the planning forum**
  SCORE is a forum where most of the interested parties are represented. One of its original functions was deemed to be a co-ordination and planning of rural electrification. However, the committee is probably too large to act as a suitable forum for detailed planning. In addition, it would be necessary for one agency or person to champion the planning work.

- **Establish a planning sub-committee of SCORE**
  It is possible to constitute a planning sub-committee of SCORE which would undertake the rural electrification planning work. One possible structure would be for the MNRE and the utility to be responsible for driving the planning work (as a SCORE sub-committee) and to be responsible for consulting other parties as required. The advantages of this are firstly that a smaller and more manageable forum is established (whilst maintaining accountability to a larger forum), secondly that one or two individuals are identified with the responsibility of driving the planning process, and thirdly that parties without a direct interest in planning issues are not required to attend meetings.

- **The utility undertakes planning**
  A third option is to leave the planning up to the implementing utility. The advantage of this is that planning is situated close to the implementing agent. However, utilities themselves have capacity constraints and this option reduces the opportunities for co-ordination of different interests. Further, if Government funds are being used for electrification, it is likely that more direct involvement of Government agencies would be required.

- **Planning functions are contracted to consultants**
  As with the current electrification planning project, it is possible that planning functions can be contracted out to consultants. This has the advantage of resolving capacity constraints in the utility and Government, but has cost implications. Further, it reduces the opportunity for more inclusive participation in planning by local agencies.

- **The MNRE undertakes planning functions**
  It is possible that the planning functions are allocated to the MNRE. There may be pressure to do this if Government funds are used for the programme, and if the utility remains at arm's length from detailed planning. Further, the original intention was that the electrification maps and financial models (essentially planning tools) would be handed over to the MNRE. However, the MNRE has capacity constraints, and this approach would probably require the creation of a new position at the Energy Section of the MNRE.

- **A MNRE member of staff is seconded to work at the utility on planning RE**
  A variation of the above option is to create a new post at the MNRE, specifically for rural electrification, and to have that person based at the utility. This would mean that the planning work would be closer to the utility, and would ensure that the person would not be distracted by the many other functions of the MNRE.

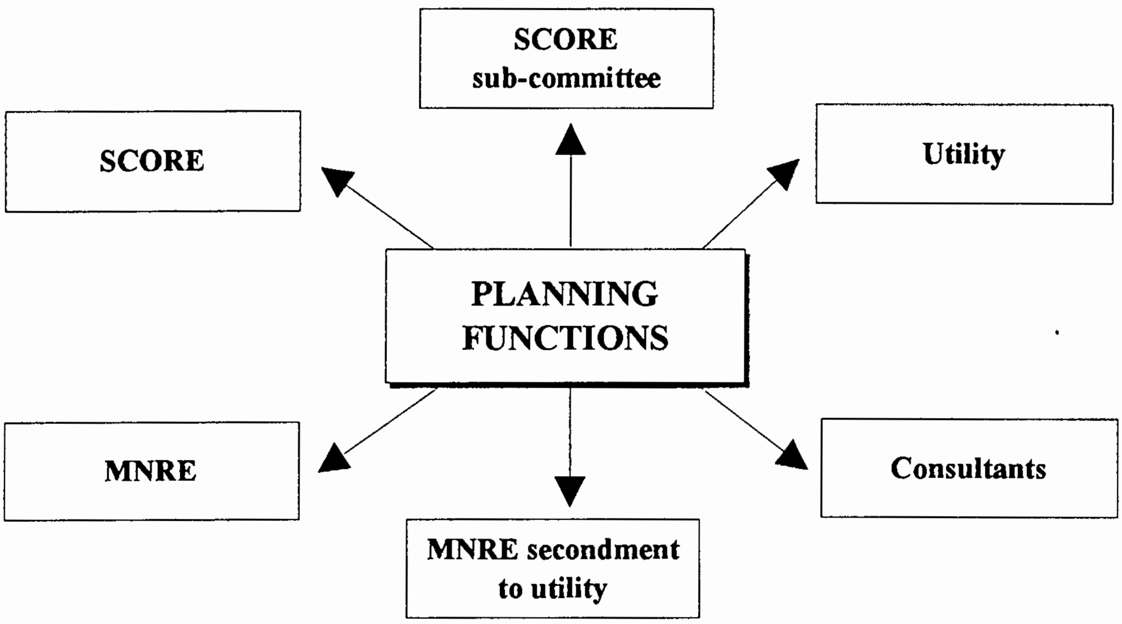

Figure 2: Institutional options for planning

Implementation of rural electrification
Implementation comprises of project management, construction and commissioning of grid extension lines, as well as reticulation schemes. The institutional options available are as follows:

- **SEB implements the programme, using its own resources**
  One option is to task SEB with the job of implementing the rural electrification programme. SEB has in-house line construction teams available, and may be in a position to project manage the programme as well as construct lines and do connections. However, capacity constrains may make this option infeasible.

- **SEB implements the programme, using contractors and consultants**
  A variation of the above programme is for SEB to project manage the programme, but to contract out much of the construction to the private sector. This may be necessary if the workload exceeds in-house capacity. Further, it may even be necessary to contract out the project management functions.

- **The MNRE commissions contractors and project managers**
  It is possible that, if Government funds are used for the full capital costs of supply, that the MNRE directly contracts consultants to manage the electrification

programme. The project managers than make use of private-sector contractors to do the construction.

- **A new rural electrification agency is established**
  If it is felt that it is inappropriate that SEB undertakes the rural electrification programme, then it may be possible to create a new utility, or a new rural distribution division within SEB. If this option is adopted, then it is likely that such a new institution would be tasked with the responsibility of implementing the programme, probably using private contractors. If the new institution is separate from SEB, than the initial costs of establishing such an agency are likely to be high. Further, there may be problems attracting suitably qualified staff and management to run the new organisation. These issues are discussed in more detail below.

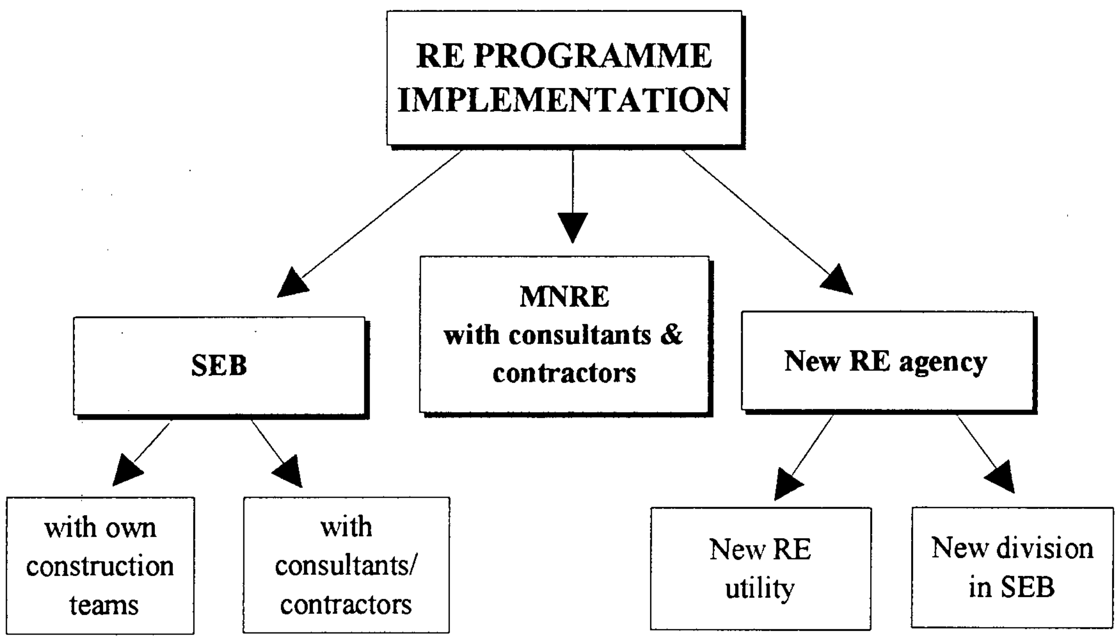

Figure 3: Institutional options for implementation

Operation of rural electrification

Operation of rural electrification involves the maintenance of equipment, meter reading and billing, revenue collection, marketing, financial management, and other functions commonly associated with the operation of a distribution utility. If the funding arrangements require that the utility undertakes some of the risk of rural electrification (e.g. if some of the capital costs are recovered through the tariff), then operation includes management of this risk and responsibility for loans.

The four institutional options available are as follows:

- **SEB**
  The most straight-forward option is for SEB to undertake the rural electrification programme as part of its normal distribution activities, utilising existing billing systems, staff etc.

- **A new rural distribution agency within SEB**
  A second option is for SEB to create a new division within itself specifically to undertake rural electrification projects. Although this may have the advantages of ring-fencing rural electrification and of providing a focus for staff, it may imply additional costs. Further, the establishment of such a division is a matter of

concern for utility managers, and may be beyond Government's jurisdiction. If rural electrification is assigned to SEB, then SEB management may prefer to take a decision based on their own assessment of the advantages and disadvantages of internal restructuring.

- **A new rural distribution utility, separate from SEB**
  A third option is to create a new rural distribution utility. This may be necessary if SEB is unable to take on the responsibilities of Government's proposed programme. However, if such an agency is to be financially viable, it will require the revenues of existing rural customers, in addition to new connections within the electrification programme. Not only will the start-up and transaction costs associated with this be large, and the availability of qualified staff questionable, but the idea amounts to a substantial restructuring of the electricity industry in Swaziland. Such a restructuring goes beyond the issues of rural electrification and would require careful consideration by Government.

- **A private management contract**
  A final option is the contracting of rural electrification operations to the private sector. This may take the form of a management contract to a group able to manage operations and maintenance. However, it is likely that the financial risk associated with the programme would have to remain with Government, unless substantial tariff increases are allowed. This option would probably increase costs, and there is concern that there may not be sufficient private sector capacity in Swaziland to undertake the task.

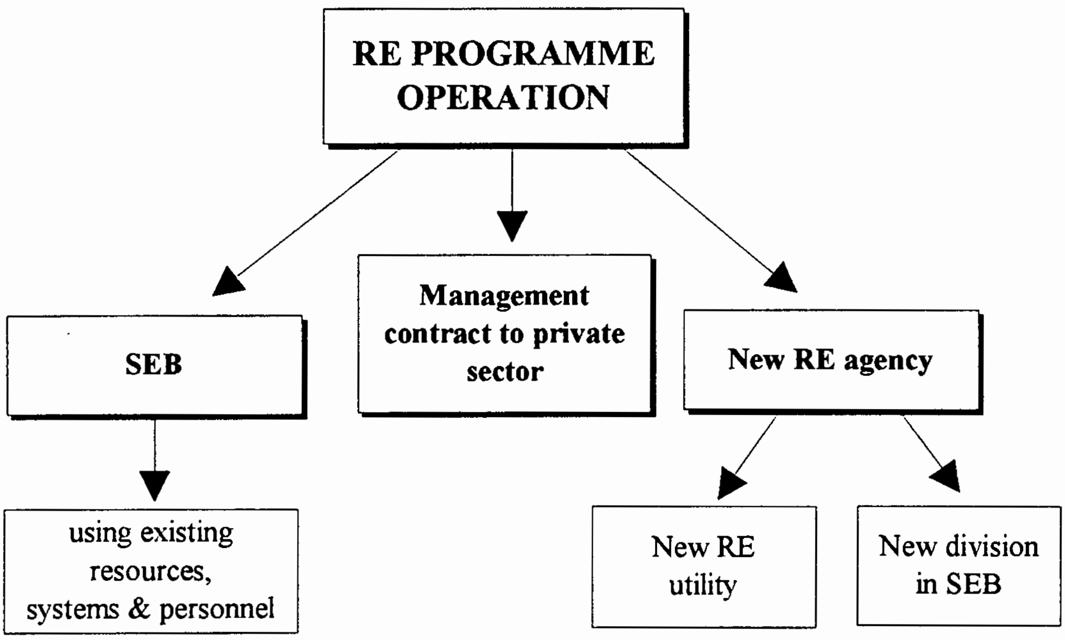

Figure 4: Institutional options for RE operation

Implementation and co-ordination of off-grid electrification

The rural electrification planning project has also considered the use of off-grid systems, mainly for schools and clinics. The following recommendations are made concerning institutional issues relating to this programme:

- A programme for the dissemination of solar home systems is being planned by the private sector. It is recommended that this be left to the private sector with minimal Government or utility involvement.

- The implementation of the clinic off-grid programme should include the use of project managers, and this should be budgeted into the total costs.

- Contracts awarded on tender should be inspected and commissioned by the project manager prior to acceptance.
- Maintenance is a key issue, and until adequate capacity is built up within the relevant ministries, it will be necessary to arrange maintenance contracts with private contractors. For clinics, it is likely that extending the diesel maintenance contract to include maintenance of batteries would be most cost-effective.
- There are benefits to be gained from co-ordination of maintenance contracts and sharing of experience. The Solar Energy Committee of the MNRE is recommended as the optimum forum for this. The planning group of SCORE should be able to present any changes in the grid extension programme to this committee, and this should assist in the development of off-grid electrification plans.

Monitoring and evaluation

A number of different monitoring and evaluation options are available, as described below.

- Firstly, SEB is required to prepare an annual report for the Minister of MNRE and this report should cover details of the rural electrification programme.
- Secondly, the PEU has the responsibility of overseeing SEB, and this oversight should include monitoring of the programme, and the financial impact which it will have on SEB.
- Thirdly, SEB and the planning group will be required to report progress to bi-annual or quarterly meetings of SCORE.
- Lastly, it is recommended that the MNRE commission an evaluation study in 1999 to assess the impacts of the rural electrification programme.

It is further recommended, should SEB undertake the programme, that the targets and committments of the rural electrification programme be incorporated into the new performance contract between SEB and Government. This would entail a set of proposed connection targets, principle electrification sites, and committments from Government for funding.

Conclusion and recommendations

The resolution of the most appropriate institutional framework requires Government, together with other stakeholders, to decide how much of the responsibilities should be assigned to SEB, and whether these responsibilities can be better managed by existing or proposed agencies. Some of the options available require a substantial restructuring of the electricity industry - an institutional route which, if preferred, clearly requires careful consideration.

The key recommendations made here are as follows:

- **Funding:** the following section examines this in more detail.
- **Electrification planning:** a small sub-committee of SCORE be established to perpetuate planning functions.
- **Implementation:** it is recommended that SEB take the lead in implementing the projects funded through this programme. If it is necessary for SEB to contract in outside assistance in the form of consulting engineers and contractors, this route should be adopted.
- **Operation:** it is recommended that SEB operate the electrification projects funded through this programme.

- **Monitoring and evaluation:** it is recommended that monotring and evaluation be shared between SEB, the MNRE, PEU and SCORE, in the manner discussed above. In the development of a new performance contract for SEB, attention should be paid to the inclusion of rural elecrification targets and funding systems.

Whichever agency is made responsible for the tasks associated with rural electrification, Government must recognise the funding implications which accompany such a delegation of duties. The following section examines the financing options available.

3.2 Financing options

A distinction is made here between income and financing options. The former refers to funds which can recover the costs of electrification projects. The latter refers to loans or equity investments which can be used to provide capital for projects, but must ultimately be recovered from funding sources.

Income options for rural electrification

There are three possible sources of income: user payments, cross-subsidies from other consumers, and direct grants, either from the Swaziland Government or donors.

- **Grants**
  Government or foreign donors may be willing to provide grants for electrification. However, other priorities together with growing constraints on Government budgets, may mean that such contributions are likely to be limited.

- **Cross-subsidies**
  Cross-subsidies from urban and other large users may be used to cross-subsidise electrification projects.

- **User payments**
  These include connection fees, monthly line extension charges as well as surcharges on the energy tariff.

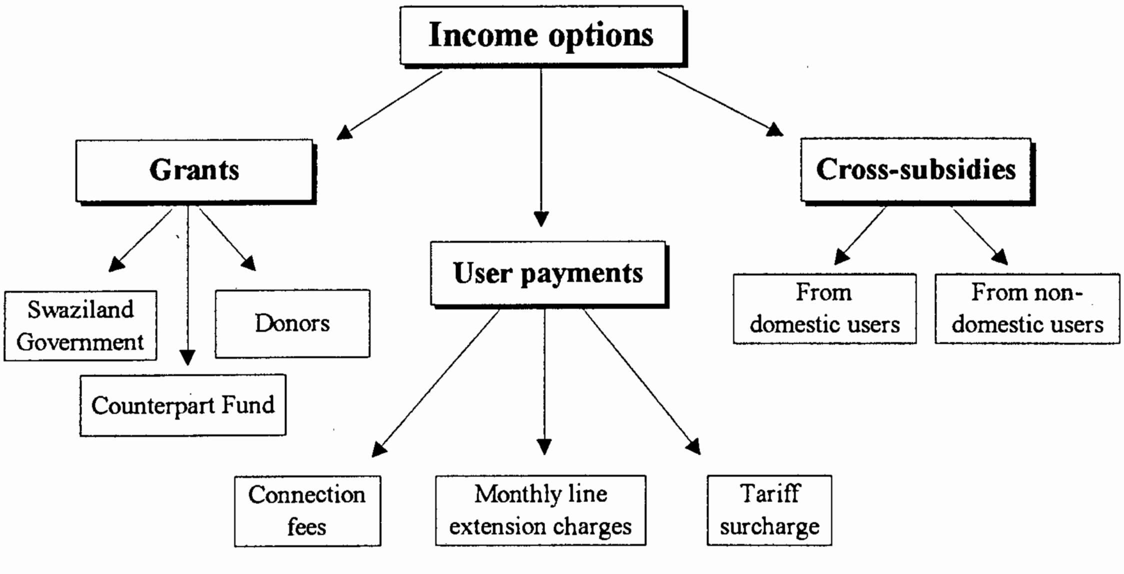

Figure 5: Income options for rural electrification

Financing options for rural electrification

Where connection fees and grants do not cover the full costs of the project, "bridging" finance will be required. Possible sources include Swaziland Government loans, concessionary loans from foreign sources (including the DBSA), utility equity finance (i.e. self-finance), and commercial credit.

- **Government loans**
  Government may be in a position to lend funds to the utility for the purpose of electrification. Concessionary rates on such loans may reduce the finance charges on electrification.

- **Concessionary finance**
  Much of SEB's loan portfolio is on concessionary terms, and there exists the possibility of raising additional capital on easy terms. However, lenders are likely to be sceptical of rural electrification projects and many traditional sources of concessionary finance (e.g. DBSA) are now charging much higher rates. Concessionary loans, if in foreign currency, carry a foreign exchange risk.

- **Commercial credit**
  Commercial finance may be available on the strength of a utility's overall accounts. However, such finance typically means fairly high finance charges. A public enterprise loan guarantee scheme exists whereby the Swaziland Central Bank guarantees 65% of the loan, provided the interest rate is 1% above prime (currently 18.75% in Swaziland[1]). However, to date the loan guarantee scheme has been under-utilised.

- **Utility equity finance**
  A utility may be able to utilise surpluses and depreciation provisions to invest in electrification. Depending on rate-of-return requirements, such investments may prove more or less expensive than other forms of finance. They do however, carry no foreign exchange risk which foreign loans, even if on concessionary terms, would.

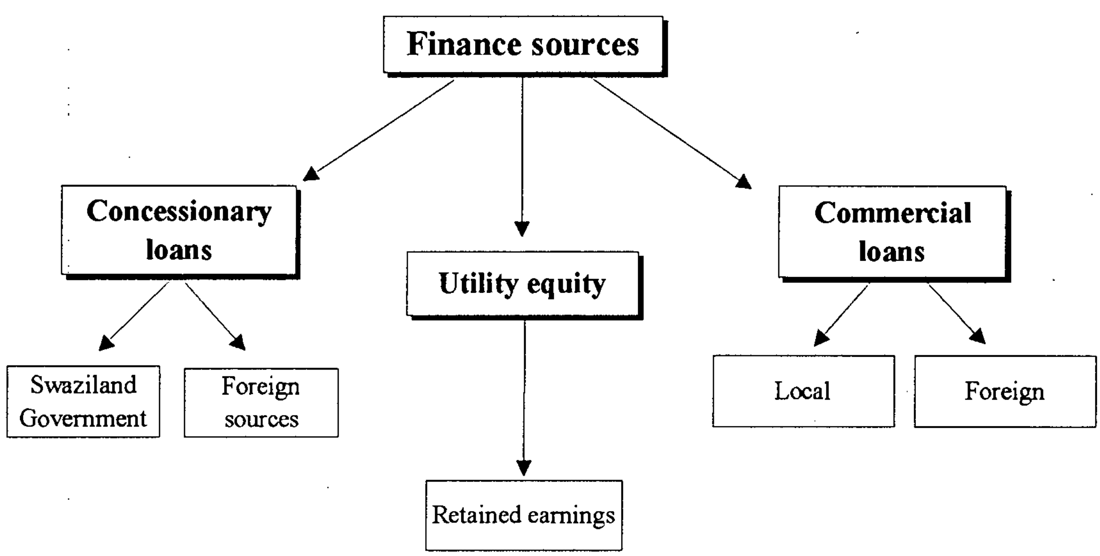

Figure 6: Financing options

[1] As at October 1996. There have been a number of interest rate fluctuations this year.

Options for line extension projects
The following section examines some options for financing line extension costs (excluding household reticulation). Four options are examined: (1) connection fees, (2) monthly line extension charges, (3) a combination of these two, and (4) subsidies and cross-subsidies.

- **Option 1: Line extension costs recovered through connection fees**
  Under this scenario, all line extension costs must be paid in cash by non-domestic consumers. If small power users (SPUs) are required to pay for 30% of the costs, and large power users and government institutions (LPUs/Govt.) are required to pay for the remaining 70%, then the connection fees (based on data from the pilot projects) would be around E5 000 for SPUs and E20 000 for LPUs/Govt. It would be possible to refine this system by using more categories of users.

  A weakness of this arrangement is that if not all of the projected users take electricity, then the utility (or Government) is faced with a deficit. Although it is possible that finance can be arranged in the hope that future connections will be made, this option is risky.A second problem is that if all the line extension costs are recovered through connection fees (and initial fees cover all the investment costs), future users will not be required to pay a contribution towards the line. This has the potential to give rise to disputes.

- **Option 2: Line extension costs recovered through monthly line extension charge**
  Under this scenario, users pay a nominal connection fee, and the remainder of the line extension cost is recovered through the levying of a monthly line extension charge.

  An advantage of this system is that as new customers join the scheme, the monthly fee can be reduced. This would provide an incentive for existing customers to encourage new customers to join the scheme, even though it would necessarily require a fairly sophisticated billing system which links the monthly fee to the remaining unpaid cost of the scheme and the current number of non-domestic connections.

  Obviously, this system requires that financing be arranged - either through the utility or the Government. If concessionary rates can be obtained, then the monthly costs would be reduced. For example, if the interest rate was 10% instead of 16%, then the average fee would reduce from E165/month to E120/month. If fewer than expected users connect, then the line extension charge is that much larger.

- **Option 3: Combination of connection fees and monthly line extension charges**
  It is possible to combine a system of connection fees with line extension charges. The system would require a set of standard connection fees for users, together with a monthly line extension fee to repay the remainder.

- **Option 4: Subsidies for line extension projects**
  If any of the above options are combined with subsidies, then the costs to users will decrease accordingly. For example, if line extension costs are subsidised by 50% (approximately E110 000 per project), then the connection fees and/or monthly line extension costs would be reduced by a corresponding 50%.

Options for reticulation projects
The following section examines three options for financing reticulation projects. These projects take place where the distribution line has already been, or is being, installed. As with distribution line extensions, the options are to balance connection fees, subsidies and other user payments against one another. Given that the majority of

customers would be domestic users, it is likely that high connection fees would result in very low take-up rates. Further, low take-up rates increase the unit costs of reticulation, as well as increasing the unit overhead costs of operating the project.

- **Option 1: High connection fees**
  If all of the reticulation costs are to be recovered through the connection fees, then these fees will be particularly high - in the order of E2500 per customer or more. This would effectively exclude the majority of rural homesteads.

  The advantage of this system is that connection fees can be tailored for each group, and so the utility does not face any risk or have to carry any financing.

- **Option 2: Lower connection fees and monthly repayments**
  If connection fees are set at a lower level, then the remainder of the costs must be recovered through the tariff. This can be structured as a monthly repayment (much like the line extension fee), where users are on a billed metering system.

- **Option 2: Lower connection fees and a tariff surcharge**
  Instead of a monthly fee, it is possible to implement a tariff surcharge so that, on average, the same revenues are received. The difference is that (1) this charge can be implemented with a prepayment meter; and (2) the charge affects higher income users to a greater degree.

Options for operating losses
It is likely that household electrification in rural areas will result in operating losses for the implementing utility, *at current SEB domestic tariff levels.* Depending on consumption, this loss may be as much as E10 to E20 per customer per month. Although losses in rural areas are likely to be higher than elsewhere due to lower consumption levels, the current SEB tariff system means that, on average, losses are made on the domestic customer base. That is, cross-subsidies from other customers are incorporated into the current tariff levels.

The options to cover operating losses are as follows:

- **Option 1: Increase domestic tariffs**
  A "rebalancing" of tariffs to remove cross-subsidies between customer groups would require domestic tariffs to increase fairly substantially, and other tariffs to decrease slightly. However, this rebalancing would mean that, on average, revenue from domestic customers met the costs of supplying them. Since rural consumption is generally lower than elsewhere, it would still mean that there would be cross-subsidies from urban households to rural ones. As the rural customer base increased, so there would be upward pressure on prices.

  The option of introducing a higher rural domestic tariff is possible, but probably infeasible, both for political reasons and pragmatic reasons.

- **Option 2: Provide Government subsidies to cover losses**
  Government subsidies, calculated to cover the additional losses incurred by rural customers is possible. However, such a subsidy can be difficult to calculate and monitor, as well as committing Government to long-term subsidisation of utility operations. It is widely accepted that subsidies, if used at all, should be used to meet capital costs rather than operating losses.

- **Option 3: Utilise cross-subsidies from other consumers**
  The current system includes cross-subsidies from other consumers to households. It is possible that this system be continued. If the domestic tariff is increased, then cross-subsidies would be retained within the domestic customer base. Alternatively, if the domestic tariff remains below average costs, then cross-

subsidies from other customers could be continued. Selecting rural electrification areas where there is the maximum amount of non-domestic consumption would reduce the additional burden on existing customers.

Recommendations

Four different types of users are defined here: Government and public enterprises (clinics, schools, Telecoms, water projects, etc.), large power users (LPUs) who would be on tariff K5, small power users (SPUs) who would be on tariff S2 or tariff S3, and households, who would be on a domestic tariff.

The following recommendations are made.

Financing of distribution line extension

A rural electrification grid extension fund should be established and operated by the rural electrification agency (SEB, or some other institution). Government should make payments to this fund, through the MNRE, in order to cover the costs of line extension projects.

User charges should be levied in order to recover much of the costs, and so make additional funding available for future projects. These charges should be accounted for and placed in the grid extension fund.

Distribution line connection fees from non-domestic users should be set as follows, and should include the cost of service connections:

- Government & public enterprises: .... E25 000 per connection
- Large power users: .... E25 000 per connection
- Small power users: .... E7 500 per connection

If revenue from the initial fees collected is more than the estimated costs, then the fees will be reduced accordingly. If future consumers connect, they will be charged the same connection fees and this revenue will go towards the funding of other grid extension projects.

The financial effects of this proposal for the proposed rural electrification programme are presented in Chapter Five of this report.

Financing of reticulation schemes

It is proposed that SPUs and households be offered the choice of two tariffs as follows:

1. Where connection fees must be paid to cover the full costs of supply, and standard SEB tariffs are applied.
2. Where the initial cost is reduced by E2000[2], but users pay a 30% surcharge on the energy tariff.

For every customer who chooses the second option, financing of E2000 must be arranged. It is proposed that Government arranges a loan for the required amount (e.g. if 2000 connections are made, then Government loans E4 million to the utility), and that repayments should be linked to consumption by these customers. The repayment scheme should be modelled so that the risk is borne primarily by the Government. The key elements are as follows:

- Government raises adequate finance for the reticulation costs, and loans this to the utility;

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2 This discount should increase with inflation over the years.

- The utility monitors revenue received from the tariff surcharge and from this revenue a small management fee to arrive at a net revenue from the tariff surcharge;
- The utility pays the Government the greater of the following two amounts:
  1: the net revenue from the tariff surcharge; and
  2: 50% of the loan repayment commitment for that year.
- The Government pays the loan repayment commitment for that year.

This arrangement means that risk is shared between the utility and the Government, with the Government taking the greatest share of the risk. An analysis of likely scenarios shows that this arrangement would require subsidies in the medium term, that total subsidies would be in the region of E7.6 million over 10 years, and that 98% of this would be paid by Government.

The financial effects of this scheme on the proposed rural electrification programme are presented in Chapter Five of this report.

Chapter Four
Integration with other development activities

It is often said that rural electrification is a ***necessary but insufficient*** condition for development, and that any electrification programme should be closely co-ordinated with other development initiatives and strategies. This chapter will review the efforts made to ensure that the proposed programme is as closely co-ordinated with other development initiatives as possible.

The approach taken here has been to firstly conduct an overview of rural development initiatives in Swaziland. Secondly, it is recognised that the integration between rural electrification and other development initiatives lies primarily at the planning level - the selection of potential rural electrification sites and the co-ordination with other agencies. Consequently, the discussion focuses on the planning process. Thirdly, the chapter examines the links between rural electrification and current development initiatives, identifying the areas where electricity supply has the potential to make the most impact. Lastly, there are some comments on specific strategies which can be employed to optimise rural electrification projects, and hence maximise the benefits from the investments.

Appendix C examines the subject matter of this chapter in more detail.

4.1 Overview of rural development

The bulk of the rural population lives in Swazi Nation Land (SNL) in some 88 000 scattered homesteads. Although agricultural activities currently account for less than half of average homesteads' income, the opportunities for employment creation in the formal job sector (in both the agricultural and industrial sectors) are limited. It is estimated that by the year 200 there will be some 560 000 workers seeking employment of some form. Employment opportunities outside of SNL are likely to be limited, and hence the pressure on SNL to support the increasing population will intensify. Consequently, it is important that rural electrification seek to facilitate opportunities for income generation and employment formation.

Although attempts to improve productivity on SNL have met with only limited success, there remain opportunities through the wider use of irrigation on SNL. Since irrigation is closely linked to the use of electricity for water pumping, it is important that the rural electrification programme attempt to link and support, as far as possible, with irrigation projects.

4.2 The planning and prioritisation process

Appendix B.1 contains a discussion of institutional arrangements for rural electrification. One of the functions identified has been that of planning, and updating plans, of rural electrification. It is proposed that a sub-committee of SCORE be established to manage these functions. It is proposed that this sub-committee be comprised of representatives from SEB, the MNRE and the MEPD.

Although this planning project will propose a set of future line extension projects, as well as recommendations on the scheduling of reticulation schemes, it is important that this plan be flexible and able to change to changing circumstances.

The responsibilities of this group will be as follows:

1. to obtain more detailed information on the following year's line extension projects;
2. to monitor the line extension fund and estimate future revenues and Government subvention requirements;

3. to evaluate applications for a reprioritisation of the line extension plan, and to effect changes if necessary;

4. to monitor rural developments (particularly proposed irrigation schemes), and to ensure that the rural electrification plan takes adequate cognisance of these.

The following section details planning and prioritisation procedures which it is recommended this committee should follow.

Obtain more detailed information on line extension projects for each year

Each year, the planning committee should obtain detailed information for the following year's line extension projects. This is necessary to update the information collected in phase 1, and to more accurately estimate the revenue from line extension charges. Further, if the information gathered suggests that a centre does not warrant electrification, then changes to the plan should be made.

This document (in Appendix D.1) sets out the proposed future line extension projects. On an annual basis, each of the following year's projects should be visited and the questionnaire presented at the end of this appendix (*"Information on rural electrification area"*) should be filled in.

Monitor the line extension fund

The line extension fund established by Government with SEB is used to finance the initial costs of distributor line extension projects. Revenue from connection fees is paid back into the fund and used to finance future projects. Although SEB will report on the status of the fund on an annual basis, the planning committee should investigate the likely effect of new projects on the fund.

Using detailed information collected on each site, it is possible to calculate the annual capital costs and expected revenues as follows:

- *For each project,*
  calculate the total capital cost expected
  calculate the connection fees per user category
  calculate the expected revenue from connection fees
  calculate the potential deficit (costs - revenues)
- *For the entire year's projects,*
  calculate the total capital cost expected
  calculate the total expected revenue from connection fees
  calculate the total potential deficit (costs - revenues)

This information should then be used to prepare Government budgets in support of the grid extension programme. Two factors should be considered: (1) whether there is sufficient capital in the fund to cover expected capital costs, and (2) whether new projects will result in a deficit which should be covered by Government allocations.

Evaluate applications for grid extension

It is likely that residents of certain places not on the medium term electrification list will apply for electrification. If circumstances merit it, then the prioritisation list should be adjusted to take account of these applications.

The evaluation process should start with the completion of the information form presented at the end of this appendix. This information should be used to determine the following:

1. whether the project will result in a net deficit after connection fees are accounted for; and

2. what group classification the centre is (according the MHUD criteria)

If the project does not result in a deficit, then approval for it should be given, and the project should be scheduled to fit with the capital expenditure programme.

If the project does result in a deficit, then establish what classification the centre is according to MHUD criteria. If the classification is group 4, 5 or 6, then the centre should be scheduled for distributor line extension within the next three years.

If the project results in a deficit, but residents are willing to pay for all costs, and make a substantial deposit towards the costs (for example, a deposit equal to the full deficit), then again the project should be scheduled for the medium term.

Lastly, if residents are unwilling to pay for the deficit, then the project should not be undertaken.

Monitor rural development initiatives and the implications for rural electrification
The planning committee should monitor rural development initiatives and assess their implication for rural electrification. This may require a reprioritisation of electrification projects if new opportunities are identified.

Particular attention should be given to productive agricultural applications on Swazi Nation Land. Opportunities for irrigation projects, as well as agro-processing applications should be considered.

4.3 Rural development initiatives and project prioritisation

This section will look at a range of rural development initiatives and present information which should be used when planning the grid extension programme. Areas which will be considered include the links between rural electrification and services, services, physical infrastructure and productive activities.

Rural electrification and services
There are a number of unelectrified facilities which provide social services. These are clinics, schools and other Government services.

There are nine unelectrified Government clinics and at least even unelectrified non-Government clinics. At least ten of these facilities can be reached by the grid at investment costs less than the alternative of an upgraded off-grid system. Appendix C lists these facilities.

The prioritisation of grid extension should, as far as possible, take these clinics into consideration. Electricity supply to rural health facilities is important for a number of reasons. Firstly, grid electricity improves the standard of health services provided. Importantly vaccine refrigeration can be run on electricity reliably, and 24-hour lighting improves security, facilitates response to emergencies (especially where there is a maternity wing), and allows a range of electrical equipment to be operated. In this way, the benefits of electrification are spread to all those who use the clinic, and hence are spread across the entire community, reaching even the poorest families. Secondly, electricity improves the quality of life of nurses who work in these often isolated and remote facilities. This is important in terms of improving staff morale and encouraging staff to work in rural area.

There are a large number of unelectrified schools in Swaziland, as shown in Appendix C. Access to electricity at secondary and high schools is important for a number of reasons. Firstly, electricity is required for the equipment which such schools would like to use. This includes teaching aids (such as overhead projectors), and equipment in science laboratories. It is inevitable that computers will be introduced to secondary and high schools, and this will require an electricity supply. Secondly, secondary and high schools may wish to run night classes, particularly as examinations approach, allowing students extra-tuition or self-study classes. Thirdly, electricity at teachers' houses improves their quality of life, provides good quality lighting when preparing lessons at night, and encourages teachers to remain working in rural areas. Lastly, it is not uncommon for schools to be used as community facilities (requiring lighting at night), and there are examples of schools using televisions and videos to raise money for the school and other community needs.

Electricity supply at primary schools is perhaps less important than at high schools, given the less sophisticated equipment at primary schools and the unlikelihood of evening classes. However, electricity for primary school teachers' houses is considered important by the Ministry of Education.

A number of unelectrified high/secondary schools are relatively close to existing electricity distribution lines. For these facilities, connection costs are likely to be fairly low. These schools are listed in Appendix C.

Electricity and physical infrastructure

Electricity can play an important role in supporting physical infrastructure such as telecommunications stations and water pumping sites. Attempts were made to identify such potential users in Swaziland.

The rural telephone network in Swaziland operates on a system of microwave repeater and terminal stations. These have to be powered by electricity, either from the grid or a stand-alone supply. Where grid was not available (or too expensive), solar PV systems were installed (to 35 stations). However, these have proved unsatisfactory due to the high occurrence of theft. SPTC would prefer grid supply to these stations, which are listed in Appendix C.

A second phase to the rural telephone network has been proposed. However, it is uncertain when this will be implemented. If adopted, it is important that the rural electrification planning committee examine the implications and funding opportunities for rural electrification.

Rural Water Supply has planned a number of macro schemes for the next three years (listed in Appendix C). In addition, there are also a number of unoperational diesel pumps, and a number of sites where it is recommended that hand pumps be upgraded to electrical pumps (see Appendix C). It is not clear when these upgrades will be conducted, but the planning committee should maintain contact with RWSB to determine the extent to which the rural electrification programme overlaps with pumping projects.

Rural electrification and economic activities

It is important that rural electrification be aimed at those places where productive uses of electricity can be expected. This is important not only from a financial point of view - greater consumption and revenues can be expected - but also from an economic perspective - greater economic benefits can be expected to accrue from the investment in electricity supply.

The MHUD has developed a methodology for the ranking of projects according to economic activities. They further recommend that settlements with a ranking of six or above should have access to electricity. In these centres, it is estimated that electricity can contribute positively to the economic development in that centre, and that likely future consumption will warrant the installation of electricity.

The need to expand productive and income generating agricultural activities has been highlighted. One of the ways of doing this is to adopt irrigation farming practices where soil conditions are appropriate and water supply available.

However, it is potentially wasteful to provide electricity in the hope that irrigation projects will subsequently develop. It is preferable to encourage a demand-driven process whereby proposed irrigation projects approach SEB or SCORE for electricity supply. However, it is important that the planning committee monitor developments in irrigation projects, particularly in the nine identified river basins.

4.4 Optimisation of rural electrification projects

There are a number of issues related to rural electrification, which if addressed appropriately, can lead to greater benefits - both in a financial (greater utility revenues) and economic (greater benefits) sense. These are addressed below.

Appliance sales

Electricity is not desirable in itself, but only as a means to power end-uses. Electrical appliances are thus required to realise the benefits of electricity supply. For households, the purchase of appliances can frequently present a hurdle to the greater use of electricity. Partly this is due to availability in rural areas (only a limited range of appliances may be stocked by local stores), but also the initial cost of such appliances.

Although utility involvement in appliance dissemination may appear attractive, Eskom's experience suggests that there are complications. If appliance sales are to be continued over a longer period, it is necessary that local agencies be involved in selling appliances. If the utility offers low cost appliances to users on connection, this effectively undercuts local stores and discourages them from stocking appliances.

It is recommended that two strategies be pursued:

- When an area is first connected, appliance manufacturers/distributors should be encouraged to present a display and demonstration of electrical appliances. It is possible the SEB may be able to co-ordinate this, although the responsibility may well fit as well with the MNRE.
- Information sheets be prepared outlining the different appliances available, their typical initial costs and the likely costs of using them. The MNRE has made some progress here by compiling a database of appliances. Information from this can be presented in a suitable format and distributed to electrification areas through local stores.

Battery charging centres

The settlement pattern on most of SNL is very dispersed, meaning that reticulation projects are often prohibitively expensive without extensive resettlement. Even with a E2 000 discount on the initial cost of connection, it is likely that a large percentage of the population in areas close to an 11kV line will be unable to afford to connect. Further, the minimum fee which SEB charges may well be beyond the means of many rural households (even if this fee is affordable on average, many poor households prefer not to have minimum monthly financial commitments due to the irregular nature of income).

For these households which would still like access to some electricity (even if for only a few applications), one alternative option is to use a battery system with DC lights and a plug point for radio or television. A solar home system provides a stand-alone supply of electricity but has two disadvantages: firstly the cost of the solar module adds significantly to the overall cost; and secondly there is a risk of the solar module being stolen. An alternative is to use a battery charging system whereby a local agent with a grid supply (such as a local store) acts as a battery charging centre and also sells the kits required (battery, lights etc.).

It is recommended that a battery charging centre be established in one of the pilot projects (possibly Kubuta) through co-operation with the private sector. Agents capable of supplying suitable systems have been introduced to Swaziland, and contacts with battery charging manufacturers have been provided.

Promotion of productive applications
The success or failure of rural electrification projects probably depends on the extent to which they can encourage productive uses of electricity. There are a large number of types of enterprises which can potentially be established when electricity is introduced into an area. Experience indicates that generally, enterprise formation in newly electrified areas tends to be mostly in the commercial and trading sectors - small shops, bar and entertainment centres. However, there are also examples of productive applications such as welders, millers, weavers and sewers, and so on.

It is recommended that when a line extension project is completed, a presentation be held in the area to inform residents of the potential business opportunities which electricity makes available, and to provide information on equipment suppliers, business training opportunities and sources of credit. It is recommended that this task be co-ordinated with the Swazi small business development group.

Load management
Rural electrification projects tend to have low load factors, leading to higher costs - both in terms of the variable costs of supply (peak demand charges, per unit of electricity consumed, are higher), and in terms of the initial costs of capital required to supply the peak (fewer users per transformer etc.). It is thus important that some attention be paid to load management strategies. A number of possible strategies are described in Appendix C.

4.5 Key recommendations

Planning and prioritisation process
The following recommendations are made:

- *A planning sub-committee of SCORE be established,* comprised of representatives from MNRE, SEB and MEPD. This sub-committee should be responsible for the following tasks:
- *Information collection for line extension projects*: each year the following years' line extension projects should be visited and information collected as per the questionnaire at the end of this appendix.
- *Monitor the line extension fund*: monitor the line extension fund and evaluate the impact which new projects will have on this fund. Use this information to inform Government budgets for rural electrification.
- *Evaluate applications for grid extension*: if a community applies to be included in the line extension programme, the committee should collect information on the settlement and evaluate whether it should be included in the medium term electrification programme
- *Monitor rural development initiatives:* The planning committee should monitor rural development initiatives, with attention paid to future irrigation projects and the development of the "economic corridors". Future developments may mean that the line extension programme should be updated to take account of new initiatives.

Rural development initiatives

The prioritisation of the line extension programme should take consideration of the following factors:

- ***Rural services:*** A number of unelectrified clinics have been identified. These should be considered for grid electrification. There are also a large number of unelectrified rural schools. A number of these can be electrified at low cost (i.e. they are close to existing distribution lines). The position of unelectrified high schools should be considered when planning future line extension projects.
- ***Physical infrastructure:*** SPTC has 35 unelectrified telecommunication stations. Attempts should be made to include these in the grid extension programme. the RWSB is planning a number of macro projects over the next few years. A number of these require pumping - and electricity is the preferred fuel. In addition, there are a number of existing water schemes where electricity is required either to replace defunct diesel pumping systems or to introduce a pumped reticulation scheme.
- ***Economic activities:*** The MHUD has developed a system of classifying rural centres according to their future economic growth potential. It is further recommended by the NPDP that centres with a classification of six and above merit electrification. A total of 19 such unelectrified centres have been identified and should be considered in the electrification programme. A irrigation potential in the major river basins was documented and it is clear that there will be pumping requirements in the future - mainly in the Lubombo region. The electrification planning committee should monitor irrigation developments.

Optimisation of rural electrification projects

It is widely accepted that electricity is a necessary but insufficient condition for development. The following strategies may assist in optimising rural electrification projects.

- ***Appliance sales:*** The promotion of electrical appliances will assist in broadening the benefits of electrification. It is recommended that SEB and the MNRE collaborate in introducing appliance distributors to newly electrified areas, with the intention of holding demonstrations and the promotion of appliance sales through local stores.
- ***Battery charging centres:*** It is recommended that a system of battery charging centres be piloted for the rural electrification programme.
- ***Promotion of productive applications:*** It is recommended that in newly electrified areas a demonstration be held by the MNRE, together with small business development agencies, on the potential business opportunities made possible by electrification.
- ***Load management:*** A number of load management strategies should be considered if rural load factors lead to unacceptably high cost increases.

Chapter Five
The rural electrification programme

5.1 Introduction

This chapter outlines the grid based rural electrification programme. It draws together the work conducted in phases 1 and 2 of the project, and incorporates new analyses and information collected in phase 3.

The capital expenditure of rural electrification can be seen as comprising a distribution ***line extension programme***, which entails the extension of 11kV lines to new areas, and a ***reticulation programme***, where low voltage networks are established in areas which have a grid line.

Section 5.2 outlines the distributor line extension programme, summarising the scheduling and costs of the programme. Section 5.3 presents similar information for the reticulation programme. Section 5.4 examines the financial effects of the funding and tariff options.

5.2 The distributor line extension programme

Many of the proposed reticulation projects already have electricity present in the area, and so no, or at least only limited, distributor line extensions are required. However, a number of proposed projects are some distance from the grid, and so require investment in 11kV lines. Further, certain electrification sites, identified as priorities by Government Ministries such as Health and Education, require line extension. Attempts have been made to incorporate these priorities into the prioritisation exercise conducted by phases 1 and 2. Every effort has been made to identify places where there are common interests among the different parties interested in rural electrification. However, it should be noted that the proposed programme does not mean that other line extensions should not be undertaken, if funding is available from those wishing to use electricity. Examples of this are likely to be for water pumping under the rural water supply board, where many of the proposed pumping sites could not be accommodated under the proposed programme.

Appendix D.1 presents the distributor line extension programme.

This schedule of costs leads to an annual capital expenditure budget, as shown in Table 5. If the connection fees policy recommended is adopted, the funding requirements for the proposed distributor line extension fund are shown.

Table 5: Costs of distributor line extension programme

Year	Distance of extensions	Capital costs	Revenue from connection fees	Annual subsidy required
1997	29.0	E870 000*	E725 000	E145 000
1998	31.0	E930 000*	E675 000	E255 000
1999	22.0	E660 000	E400 000	E260 000
2000	23.5	E705 000	E560 000	E145 000
2001	19.5	E585 000	E497 500	E87 500
2002	14.5	E435 000	E300 000	E135 000
2003	11.5	E345 000	E160 000	E185 000
2004	16.5	E495 000	E207 500	E287 500
2005	26.5	E795 000	E282 500	E512 500
2006	24.0	E720 000	E390 000	E330 000
Total	218	E6 540 000	E4 197 500	E2 342 500

* both 1997 and 1998 involve line extension to a water pumping project where capital of E100 000 has been budgeted for by RWSB.

5.3 The reticulation programme

A rural electrification programme is proposed which connects some 2 000 users per annum. Although the majority of these are domestic users, attempts have been made to identify areas where there is greater potential for productive and commercial uses of electricity.

Two prioritisation exercises were conducted. Phase 1 looked at ranking potential projects on the basis of the reticulation capital cost per unit of electricity supplied (combining electricity consumption of new and existing users). This is an approximation to the ranking which a financial NPV would provide. Phase 2 calculated a financial and economic NPV for new users in each of the potential projects, and used the economic results to rank projects. This second approach is a development of the first and is preferable for two reasons: (1) it looks at economic rather than just financial factors, and (2) it looks at only new users, and so ranks projects on the basis of marginal net benefits.

Appendix D.2 shows the prioritisations from the first approach (i.e. phase 1), and the report of phase 2 shows the priotisations using the economic NPV methodology.

Table 6 shows the reticulation programme scheduled using the ranking obtained from phase 1. It shows, for each year, the project sites where reticulation is initiated, and the number of potential new users which can be reached, as well as the average reticulation costs.

Table 6: Reticulation schedule
(numbers of households etc show potential total number of users, including existing users)

Year	Project codes*	House-holds	Schools & clinics	Shops
1997	SW02,S20,S15,SE06,SE07,W10,W12,W06,W19,W07,W11,C25, C10,C15,C09,C07,C12,C04,E02,E03,E11,NW10,NW06,N18,N22	4 100	104	267
1998	SW15,SW04,C08,E01,N13	1 300	23	34
1999	SW03,SW07,S25,S02,S11,S13,S21,W13,W14,C22,C11,C17,C2 3,C05,C14,C13,E08,NW07,N01,N09,N28	5 400	74	176
2000	SW16,SW11,S09,S10,SE05,W20,C03,N23, N04,N07,N06,NE02	3 000	30	87
2001	SW01,S28,S27,C01,C24,E09, NW02,NW03,N03	1 400	18	39
2002	SW17,SW10,SW06,SW05,SW12,SW09,S42,S07,SE3,W15,C16, C06,C26,C20,C18,E06,N02,N19,N15,N05	3 700	33	69
2003	SW14,S26,S14,S23,SE04,W04,W01,W03,C02,E10, E14,NW09,N17,N14,N20,NE09	3 100	26	56
2004	S06,S18,S22,S01,S04,S17,W21,W09,E07,NW08,N10,N12,N26, N16,N21,N27,NE08	2 500	11	38
2005	SW08,S12,S19,S05,S08,S03,SE08,W02,W17,W18, W08,W16,C21,NW05,NW04,N25,N24,N11,N08,N29	2 150	9	30
2006	S16,SE01,C27,N30	640	1	4

* The codes refer to those mapped by phase 1.

If the proposed reticulation programme is adopted, then Table 7 shows the annual capital costs and number of connections which it is estimated will be made. It should be noted that the number of connections made differs from the potential given in Table 6 due to the fact that not all households are expected to connect, and the rate of connection is spread over a number of years.

Table 7: Annual reticulation costs and connections

Year	New domestic users	Reticulation cost per connection	Total reticulation cost
1997	1030	E2 700	E2 781 000
1998	1270	E2 600	E3 302 000
1999	1400	E2 750	E3 502 000
2000	1830	E2 600	E4 758 000
2001	1930	E2 700	E5 211 000
2002	1700	E2 800	E4 760 000
2003	2220	E2 800	E6 216 000
2004	1680	E2 800	E4 704 000
2005	2300	E2 900	E6 670 000
2006	1840	E3 000	E5 520 000

5.4 The financial effects of the reticulation programme

The financial effects of the programme depend not only on the cost, but also on the tariff and connection fee policies in place. Three different policy options have been examined here:

- **"Business-as-usual":** Existing SEB connection and tariff policies are used. All new connections are expected to pay up-front for the reticulation costs, and users go onto existing SEB tariffs. Under this scenario, it is anticipated that the number of domestic connections achieved is 750 per annum, i.e. a penetration rate of 30% (similar to that achieved in existing electrified rural areas) is achieved after 10 years.
- **The "low connection fee" option:** This is the policy proposed in phase 1 of the project, where users are expected to pay only a nominal connection fee (E50), regardless of the capital costs of supply. Under this scenario, a connection rate of 60% of all potential household connections in the rural electrification areas is achieved after some 10 years, leading to an average connection rate of 2000 households per annum.
- **The "tariff surcharge" option:** Under this scenario, users are offered a choice: either the full reticulation cost must be paid by the users and standard SEB tariffs apply; or E2000 of the reticulation cost is covered by a Government loan, and users pay a 30% surcharge on the energy rate. This option corresponds to the financing recommendation made in Chapter Three. It is assumed that 1500 domestic connections are made per annum.

The "business-as-usual" scenario

Under this scenario, the implementing utility faces no risk on the capital costs - i.e. users only receive a connection if they are prepared to pay the full reticulation costs. However, one of the consequences of this is that only a limited proportion of households can afford to pay for the connection.

Domestic tariffs, at present, are inadequate to fully cover the costs of supply, particularly in rural areas. Consequently, the rural electrification programme results in operating losses for domestic users. The table below summarises the results of the business as usual scenario.

The principle reason for the operating losses is the fact that existing tariffs in SEB include cross-subsidies to domestic users. A "rebalancing" of tariffs would mean that these operating losses would be substantial reduced. A once-off tariff increase of 8c/kWh for domestic users would mean that the domestic operating loss would turn to a surplus.

Table 8: The "business-as-usual" scenario

	Domestic	Non-domestic	Total
Number of connections over 15 years	11 250	1 500	12 750
Ave. no of connections per year	750	100	850
Operating surpluses or (losses)			
NPV of surplus/(loss) per customer	(E685)	E17 000	E1 000
Annual operating surplus or (loss)	(E1.4 mill)	E3.6 mill	E2.2 mill

The low connection fee option

The option of charging a low connection fee would mean that more households would be able to connect. However, if tariffs remain as they are, the programme would not only sustain operating losses (as in the "business-as-usual" scenario), but would make substantial losses on capital expenditure. These losses would have to be subsidised either by the Government or other electricity users.

If the domestic operating losses are to be covered by income from domestic users, then a once-off tariff increase of approximately 10c/kWh would be required.

If the full capital costs were to be covered by income from domestic users, then a once-off tariff increase of 45c/kWh would be required.

Table 9: The "low connection fee" scenario

	Domestic	Non-domestic	Total
Number of connections over 15 years	30 200	1 500	31 700
Ave. no of connections per year	2 000	100	2 100
Operating surpluses or (losses)			
NPV of surplus or (loss) per customer	(E750)	E17 000	E140
Annual operating surplus or (loss)	(E4 mill)	E3.6 mill	(E0.4 mill)
Unrecovered capital expenditure			
NPV of surplus or (loss) per customer	(E2 750)	n/a	(E2 750)
Ave. annual surplus or (loss)	(E5.5 mill)	n/a	(E5.5 mill)
Total surplus or (loss)			
Per customer	(E3 500)	E17 000	(E2 610)
Ave. annual surplus or (loss)	(E9.5 mill)	E3.6 mill	(E5.9 mill)

The tariff surcharge option

This scenario presents the consequences of adopting the financing recommendation outlined in Chapter 3. The scenario assumes that Government and commercial users pay for their reticulation costs up-front, but domestic users choose the low connection fee with higher tariff. This means that there are potential losses or surpluses made on capital expenditure (if revenue from the tariff surcharge exceeds or is less than the annual repayments on the loan raised for household reticulation). These losses must be met by subsidies from Government or other electricity users.

Table 8 shows that, as in the previous scenario, there are operating losses for new domestic users in rural areas. The total loss is slightly higher than the above scenario, as the tariff surcharge is assumed to depress consumption by some 10%. The loss is calculated to be approximately E3.3 million per annum, which is equivalent to a loss of E800 per domestic customer over 15 years. If this loss is to be eliminated through a tariff increase, the domestic tariff would have to rise by approximately 11c per kWh.

Non-domestic customers generate a surplus (if they are on tariff S3), and this surplus is identical to that found in the previous scenario. Overall, the surpluses from non-domestic customers are just sufficient to cover losses on the domestic account.

In this scenario, domestic users receive a E2 000 discount on paying for the cost of reticulation, in return for paying a 30% surcharge on the energy tariff (an 8.4c/kWh increase). The revenue from this surcharge is then used to repay a loan of E2 000 per customer. However, it is likely that, given the low consumption levels in rural households (which are depressed further by the higher tariff), the additional revenue from this surcharge is insufficient to cover the required repayments. The financial modelling shows that a subsidy of approximately E190 per connection is required to make this option financially viable, and that this corresponds to an average total subsidy of E780 000 per annum.

Table 10: The "tariff-surcharge" scenario

	Domestic	Non-domestic	Total
Number of connections over 15 years	22 500	1 500	24 000
Ave. no of connections per year	1 500	100	1 600
Operating surpluses or (losses)			
NPV of surplus/(loss) per customer	(E800)	E17 000	E140
Annual operating surplus or (loss)	(E3.3 mill)	E3.6 mill	E0.3 mill
Unrecovered capital expenditure			
NPV of surplus or (loss) per customer	(E190)	n/a	(E190)
Ave. annual surplus or (loss)	(E0.8 mill)	n/a	(E0.8 mill)
Total surplus or (loss)			
Per customer	(E990)	E17 000	(E50)
Ave. annual surplus or (loss)	(E4.8 mill)	E3.6 mill	(E0.5 mill)

It is evident that this model requires the Government to provide loans for reticulation, as well as subsidising the payment of these loans. Figure 7 shows the annual net revenue from the tariff surcharge, as well as the subsidy required to repay the reticulation loans. It can be seen that the annual subsidy starts relatively small and climbs to a maximum of E800 000 (in 1996 terms). It should be noted that if consumption is lower, or higher, or if the number and cost of reticulation projects varies, then the required subsidy will vary.

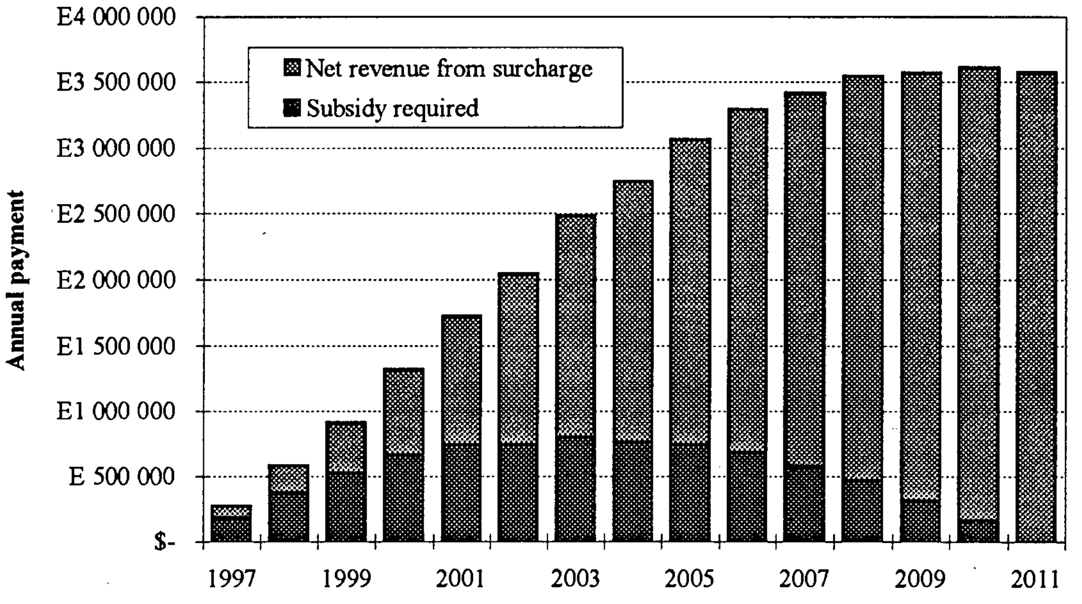

Figure 7: Subsidies and repayments on domestic reticulation loans
(figures in constant prices)

Figure 8 shows the size of new loans which the Swaziland Government must raise for rural electrification reticulation projects on an annual basis, as well as the size of outstanding loans over time. It can be seen that, on an annual basis, the Swazi Government must raise financing of between E2 million and E4.4 million in order to finance the reticulation projects. If these loans are financed over 15 years, then the debt will peak at E22 million around ten years from now. Again, it should be noted that these results are sensitive to the number of connections financed every year, the terms of the loans, and the extent of financing that is offered (E2 000 per connection in this example).

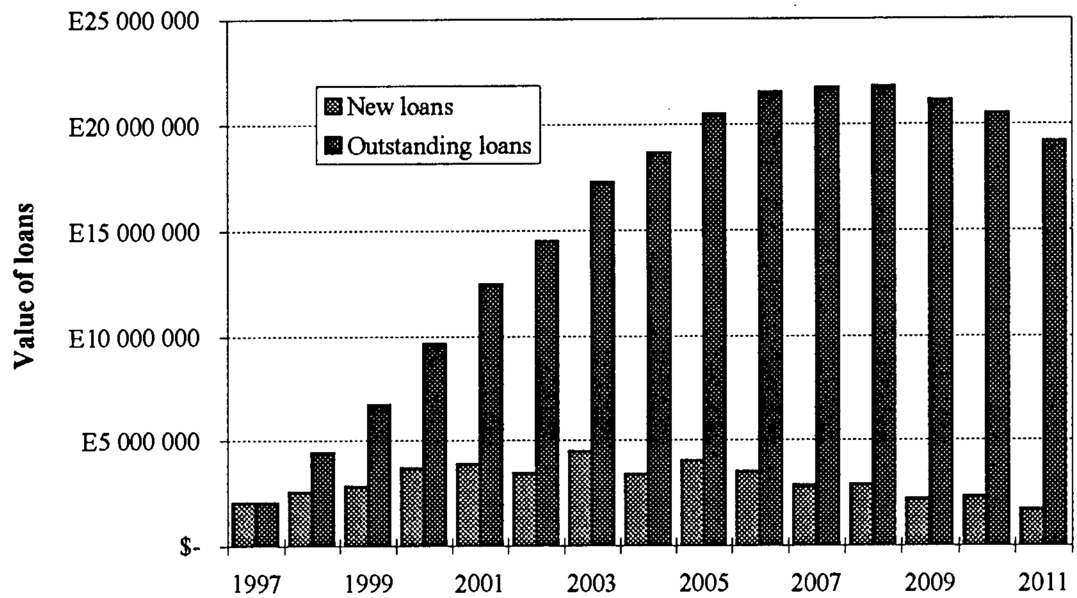

Figure 8: Value of new and outstanding loans for reticulation projects
(figures in constant prices)

5.5 Summary

Distribution line costs

The costs of the distribution line extension programme, over ten years, amount to E6.5 million, which is equivalent to a sum of E650 000 per annum.

Reticulation costs

Average reticulation costs are in the region of E2 750 per connection, and the total capital cost depends directly on the number of connection made. The three scenarios examined had capital expenditures of between E2 million and E5.5 million per annum.

Given the current tariffs, it is evident that operating losses will be sustained on the domestic customer base in rural areas. It has been estimated that this loss amounts to between E700 and E800 per customer (depending on consumption) if discounted over 15 years. The monthly loss is in the region of E15 per month and would require an increase in the domestic tariff of around 10c/kWh if cross-subsidies were not to be used.

The recovery of capital costs for reticulation projects depends on the policy adopted:

- *In the "business-as-usual" scenario* each customer pays in full for the reticulation, and so no losses will be sustained. However, this scenario is likely to result in low take-up rates amongst domestic users.
- *In the "low connection fee" scenario* only a nominal connection fee is charged. Although this is likely to result in high take-up rates, given current tariffs, revenue from sales will be insufficient to recover any of the reticulation costs.
- *In the "tariff-surcharge" scenario* the surcharge suggested is sufficient to recover 90% of the capital cost loan offered (E2000 per connection). This means that subsidies of less than E1 million per annum will be required. If larger subsidies are available, it is possible to either increase the loan (and directly increase the subsidy required), or to finance a larger number of connections.

Table 11: Summary of reticulation scenarios

	Business as usual	**Low connection fee**	**Tariff surcharge**
Ave no. of connections per annum	750	2000	1500
Average annual capital cost	E2 mill	E5.5 mill	E4.1 mill
Operating loss per domestic user	E685	E750	E800
Total domestic operating loss per annum	E1.4 mill	E4 mill	E3.3 mill
Unrecovered capital expenditure per user	E0	E2 750	E190
Total loss per domestic user	E685	E3 500	E990

Appendix A.1
Review of Existing Off-Grid School and Clinic Electrification Programme

A.1.1 Summary

The existing off-grid school and clinic electrification programme in Swaziland is very much a pilot programme. It is a modest programme which was launched in 1991 to provide minimal levels of electricity using solar photovoltaic (PV) systems for lighting (teachers' homes, clinics and nurses' homes) and vaccine refrigeration (in two clinics). The PV systems were installed at six schools and ten clinics. In addition sixteen street lights were installed.

The main benefit of this pilot programme has been the provision of very basic levels of electricity for lighting. In this regard it has been a moderate success. The benefits of vaccine refrigeration have been a failure.

The secondary benefits have been the experience gained with the installation, operation, reliability and maintenance of small PV systems in the context of infrastructural service provision a developing country.

Problems have included:

- unclear lines of responsibility in terms of ownership
- poor quality of installation
- poor reliability of DC lights
- poor technical backup through a lack of planning, administration and maintenance capacity

Based on this brief review, the following recommendations are suggested:

1. All the systems in the programme need to be assessed in terms of their condition and their appropriateness to the future needs at the site.
2. The decision regarding the upgrading or removal of the systems should be made in the context of the above survey and the proposed rural electrification plan for Swaziland.
3. In the event of off-grid systems being appropriate, a more structured programme is recommended which includes:
    - planning
    - interim upgrading
    - technical planning
    - project management
    - establishment of institutional capacity for administration, monitoring, maintenance, training

A.1.2 Introduction

A.1.2.1 Background

The MNRE has sponsored the supply and installation of a number of solar photovoltaic (PV) systems in schools and clinics in Swaziland. These have included basic lighting systems at staff accommodation, as well as lighting systems in clinics. In some cases PV-powered refrigerators have been installed in clinics.

A.1.2.2 Scope and objectives

The purpose of this report is to present a review of this programme with emphasis on the technical aspects, such as system configuration, specifications and quality of supply and installation, as well as the institutional arrangements.

The scope has been defined to include solar water heating systems, as these are important complementary systems to solar electricity systems, which cannot supply hot water cost-effectively.

A.1.2.3 Method of investigation

The review relied on data collection through personal interviews, internal reports (Nxumalo:1995 and Malone:1996) and records of the MNRE, a site inspection of a school (Maphalaleni Primary School) and two clinics (Nkwene Clinic and Sigcaweni Clinic). The locations of these sites are shown on the map in Figure 1. Interviews were held with Mr Peterson Dlamini (MNRE), Mr Bhekie Ntshangase (Biomedical Engineer, Ministry of Health), Ms Zodwa Mabuse (Ministry of Education) and Mr Ian Salt (Swazitronics). The site inspections were conducted on 31 July 1996 with Messrs. John Malone and Mr Mandla of the MNRE.

Two solar water heating systems have been installed at Nkwene clinic. These were not inspected in detail but two SWH systems installed in an experimental configuration at the Swaziland College of Technology (SCOT) were inspected on 01/08/96 with John Malone, lecturer Mr Elliot Lushaba and other SCOT technicians.

Photographs and electrical measurements were recorded for analysis prior to synthesis and reporting here. No lighting levels or fridge temperatures were measured.

- In addition to the site visits to schools and clinics in Swaziland, the project team arranged site visits for a delegation from Swaziland to two clinics in the Embuhleni Health Ward, Mpumalanga Province, South Africa to allow the Swazi delegation to learn from the experience in South Africa.

A.1.3 Findings

A.1.3.1 Scope of the programme

The off-grid school and clinic electrification programme is a pilot programme launched collaboratively in 1991 by the MNRE and the local PV supply and installation contractor, Swazitronics. The purpose of the programme was to develop some experience with solar electrification for key community services such as schools and clinics. The programme was planned on the basis of providing minimal electricity services to a number of facilities thereby spreading these low levels of service to as many facilities as possible within the fixed programme budget. No provision was made for pilot project overheads such as planning, administration, training, monitoring or publicity for the programme. Furthermore, no provision was made for recurrent costs such as maintenance and replacement or upgrading of systems.

Lists of the schools and clinics in the programme are presented in Table A.1.1 and Table A.1.2 below.

Table A.1.1: List of schools in the off-grid programme

No.	Name	System description	Comments
1	Makhonza Primary	four large DC lighting systems	in four teacher's homes?
2	Hosea Primary	five large DC lighting systems	in five teacher's homes?
3	Magojela Primary	five large DC lighting systems	in five teacher's homes?
4	Maphalaleni Primary	four medium DC lighting systems	in four teacher's homes - confirmed
5	New Hebron Primary	one large DC lighting system four small DC lighting systems	in five teacher's homes?
6	Sigceni Primary	two large DC lighting systems one small DC lighting system	in three teacher's homes

Notes:

- a *large* DC lighting system typically comprises a 50 - 60 W_p module, a 96 Ah battery, and supplies between 4 - 6 20 W fluorescent lights
- a *medium* DC lighting system typically comprises a 30 - 45 W_p module, a 50 Ah battery, and supplies between 3 - 4 20 W fluorescent lights
- a *small* DC lighting system typically comprises a 20 - 30 W_p module, a 40 Ah battery, and supplies between 2 - 3 20 W fluorescent lights

It was not clear, whether all or any of these schools had streetlight systems. In total, between 19 - 25 solar-powered streetlights have been installed at clinics, schools, water pumping installations and in public spaces.

Table A.1.2: List of clinics in the off-grid programme

No.	Name	System description	Comments
1	Nkwene Clinic	three large DC lighting systems one small DC lighting system one DC vaccine refrigerator system standalone streetlight	in clinic and nurse's homes
2	Sigcineni Clinic	two large DC lighting systems one DC vaccine refrigerator system	in clinic and nurse's home?
3	Ikwezi Joy Clinic	one large DC lighting system two medium DC lighting systems	in clinic and nurse's home?
4	Musi Clinic	three large DC lighting systems one medium DC lighting system	in clinic and nurse's home?
5	Jericoe Clinic	four large DC lighting systems	in clinic and nurse's home?
6	Bethany Clinic	two large DC lighting systems	in clinic and nurse's home?
7	Mafutseni Clinic	one large DC lighting system two medium DC lighting system standalone streetlight	installed in 1991 in clinic and two nurse's homes
8	Ngculwini Clinic	two large DC lighting systems	in clinic and nurse's home
9	Sigcaweni Clinic	one large DC lighting system one medium DC lighting system standalone streetlight	in clinic and nurse's home
10	Malindza Clinic	two large DC lighting systems	in clinic and nurse's home

A.1.3.2 Description of PV systems

All the PV systems at the schools and clinics are small low-voltage DC systems.

The DC lighting systems are typically "Home-lite" solar home lighting kits as configured and supplied at the time by a South African company called Optitron. Each system included a PV module, battery, charge controller, battery box, roof mounting frame, DC lights, cabling and three-pin audio connectors for easy installation.

Table A.1.3: Specifications for lighting systems

Component description	Specification	Comments
PV module	Arco Solar, Siemens, Solarex or Helios Power crystalline modules 30 - 55 W_p	a Siemens T20 amorphous module was supplied on one system at Nkwene Clinic
Battery	71 Ah "OMEGA" modified SLI lead calcium MF battery	replaced with 96 Ah Raylite / Exide RR2 Leisure Pak lead antimony
Charge controller	PDI PWM electro-mechanical series type or Omnilite unit	
DC lights	Omnilite 15 W units and unidentified others	
Battery box	fibreglass	
Wiring	0.75 mm^2 or 1.5 mm^2 two core rip-cord	

Note: SLI - starting, lighting and ignition
PWM - pulse width modulation

The specifications of the two vaccine refrigerator systems are set out in Table A.1.4 and those of the streetlight systems are presented in Table A.1.5.

Table A.1.4: Specifications for vaccine refrigerator systems

Component description	Specification	Comments
PV module	Arco Solar or Siemens 55 W_p crystalline modules	originally one module per system was supplied
Battery	105 Ah Delco 2000 modified SLI lead calcium MF battery	originally a single battery was supplied, now replaced with two 96 Ah Raylite / Exide RR2 Leisure Pak lead antimony batteries
Charge controller	PDI PWM electro-mechanical series type or Siemens SR-11	
Vaccine refrigerator	Siemens BF56 chest type with 12 V Danfoss compressor and Ranco thermostat	
Battery box	none	
Wiring	0.75 mm^2 or 1.5 mm^2 two core flex cable	

Table A.1.5: Specifications for stand-alone street light systems

Component description	Specification
PV module	Arco Solar or Siemens 55 W_p crystalline
Battery	105 Ah Delco 2000 modified SLI lead calcium MF battery
Charge controller	Technipower linear shunt regulator
DC light	Osram DULUX
Battery box	BP Telelite type HDPE pole-mounted
Pole	6 m galvanised with 2 m overhang

A.1.3.3 General issues noted during the survey

Based on the interviews and site visits there appears to have been no structured programme planning for the pilot programme. No documentation was available for reference to confirm the programme objectives.

Furthermore, there appeared to be no structured project management, monitoring or reporting. In most cases, any management was in response to requests for repairs and replacement of components after failure.

A.1.3.4 Technical aspects

No needs analysis

It appears that no assessment of energy needs was undertaken prior to the programme to determine the nature of the energy needs of the staff and end-users at schools and clinics and the relative priority of these needs. Here the Ministries of Health and Education would need to have been involved.

No optimisation of system configurations

The systems appear to have been supplied and installed as standard "home lighting systems", stand-alone vaccine refrigeration systems or streetlight systems without consideration of the optimal system configuration or optimal sizing.

An example is Nkwene Clinic where six independent 12 V DC systems (four DC lighting systems, one DC refrigeration system and one streetlight system) have been installed on one site. In this case, a more optimal system configuration may have been a single AC system. The poor choice of system configuration at Nkwene is compounded further when considering that the clinic and staff accommodation are wired for 220 V AC and supplied by a well-maintained diesel genset on the site. This genset is operated on a daily basis for 3 hours a day in the evenings.

No specification for components and systems

There appears not to have been any documented specifications for the supply of the components or systems. This makes it difficult to monitor the scope and quality of supply and installation. Furthermore, the systems were supplied with inadequate specifications.

For example, the lighting systems were installed with inadequate conductor sizes and no short circuit protection on the battery. In addition, the original lead calcium modified SLI batteries which were supplied are not suited to deep discharge cycling or protracted partial states of charge and consequently are likely to have had a reduced effective operating life. These have now been, or are being, replaced with lead antimony batteries. This may be a problem in terms of voltage regulator settings which are battery-specific.

The vaccine refrigerator systems were supplied and installed according to the specifications recommended by the supplier, Siemens or Optitron via Swazitronics, without any reference to the existing WHO standard specifications for vaccine refrigeration systems (WHO: 1990). The two vaccine systems are grossly undersized (55 W_p and 105 Ah installed versus 200 W_p and 300 Ah W recommended to meet WHO/UNICEF specifications) and consequently have not worked adequately since installation.

Poor quality of installation

Perhaps the most glaring technical inadequacies in the programme are aspects of the quality of installation. These include aspects such as safety, efficiency and reliability. The systems were installed without any reference to a code of installation such as that prepared by the Botswana Technology Centre or more recently the EDRC.

Safety problems include: no battery short circuit protection (i.e. battery fuse); unsafe wiring methods and inadequate insulation.

Efficiency problems include: poor system sizing (especially the vaccine refrigerator systems); poor system configuration; inadequate conductor sizing; poor wiring configuration; shading of PV modules; poor matching of regulator set-points and replacement battery type and inadequate maintenance i.e. cleaning of modules and luminaires.

Reliability problems include: very poor electrical connections (on battery terminals and in load wiring - use of connector blocks to splice lengths of cable); inadequate protection of cable insulation against chafing and damage; failure of lights and general lack of maintenance.

Poor reliability of DC lights

A common problem at all sites appears to have been that DC lights have failed (both tubes and electronic ballasts). This is a general problem in small PV systems and is currently being addressed in South Africa at EDRC and Eskom TRI. The problem can be minimised by careful selection of lights and the light manufacturer.

Shading of PV modules

At two of the systems visited, the PV modules were completely shaded at midday. This is completely unsatisfactory as even partial shading of a crystalline module will dramatically reduce the output.

These modules should be moved or the cause of the shading should be removed. The removal of trees should be avoided if possible and only undertaken after full consultation with all interested and affected parties.

Poor location of regulator for staff to monitor battery condition

A key requirement for effective utilisation of PV systems is for the users to be able to monitor the state of charge of the battery and adapt their electricity use accordingly to avoid load shedding. The charge controllers are equipped with LED's to indicate the approximate state of charge of the battery.

In all cases, the location of battery box and regulator against a wall in the corner of the room (or under a table) prevented the users from seeing the state of charge LED's.

These should be relocated to a more prominent and visible position in the rooms.

Undersizing of conductors
In general the conductors are undersized. It appears that 0.75 mm^2 or 1.5 mm^2 two-core rip-cord or three core flex has been used.

A voltage drop of 1.1 V (9% drop) was measured on one light at Nkwene Clinic at a current of 1.09 A. This is above the recommended voltage drop of 5% in load wiring, i.e. 600 mV. High voltage drops affect the charging of the storage batteries (in the case of array/regulator wiring) and operation of appliances, such as lights, which require a supply voltage greater than say 10.5 V. Low voltage at the loads can lead to intermittent performance or poor starting due to inrush currents.

In general, it is recommended that 4 mm^2 conductors are used for array to battery wiring and 2.5 mm^2 conductors for load circuits.

No spares on site (or in the relevant Ministries)
None of the sites which were visited had spares. Nor did the staff know whom to contact or where to obtain spares. In one case (at Maphalaleni School) the regulator fuse had blown. Nxumalo notes that replacement fluorescent tubes are only available from Swazitronics, which is awkward and impractical for the staff.

No system O&M manuals or user manuals
No user manuals or operation and maintenance (O&M) manuals were found at the shool or clinics. The report by Nxumalo notes the absence of user manuals in 1995. Swazitronics maintain that user manuals were originally supplied. It is highly likely that even if manuals were originally supplied, they have since been lost. This is a problem as the staff are not able to learn how to operate the system or how to respond to any problems which they may experience.

Unsafe installation and maintenance practices
Nxumalo (1995) reported a case of damage by burning of wires and the battery due to user mistakes in trying to connect a radio. This should be preventable by means of a battery fuse and clear user instructions (in a user manual).

No system logbook to document maintenance and system history
None of the systems had any form of documentation, apart from labels on individual components, to enable a traceable history of operation and maintenance to be maintained.

It is highly recommended that system documentation be implemented, including: technical specifications, operation and maintenance manuals, maintenance log book and user manuals.

The establishment of a temperature log sheet, in the case of vaccine refrigeration systems, would complement the technical documentation of the PV systems.

A.1.3.5 Maintenance

The need for maintenance is clearly indicated by Nxumalo. The site visits confirmed this need as it seems that there has been no systematic or planned maintenance. The systems have been maintained on an ad-hoc basis.

It is highly recommended that a maintenance programme be implemented, with the involvement of the Ministry of Works, which is responsible for all maintenance on Government buildings.

A.1.3.6 Solar water heating systems

The solar water heating systems were not investigated in any detail. Brief discussions with staff at Nkwene Clinic indicate that the two SolarHart systems at this clinic are operating well, although one appears to be operating better than the other. It is not clear why.

Solar performance tests may be conducted to investigate these further.

A.1.3.7 User perceptions

In view of the limited time available for the site visits, the survey did not assess user perceptions in detail. However, the conversations with some of the users confirmed the observations by Nxumalo. For example, there appears to have been no of involvement by the users in the programme - this perception may be due to staff turnover at the schools and clinics. However, there also seems to have been a deliberate policy of limiting user involvement in the operation and maintenance of the systems. For example, users were instructed not to touch anything except the light switches. This would definitely have exacerbated any feelings of alienation towards the systems.

User involvement in a programme is critical to encourage a sense of ownership and user training is recommended to ensure effective utilisation of the systems within the capacity of the systems.

A.1.3.8 Theft and damage

It was not possible to assess the situation at all the facilities, but based on the three sites visited, there appears to have been no incidences of theft of modules. However, Nxumalo reported that the modules at Jericho Clinic and New Hebron Primary School had been stolen.

In the cases of the school systems, it is likely that the direct benefits of lighting in the teachers' houses have increased the security of these systems against vandalism or theft. Similarly, the perception of direct benefits to the community due to the lighting systems at the clinics is likely to reduce the risks of damage or theft to these systems. Finally, the constant presence of the resident beneficiaries is a good insurance against theft and damage.

A.1.3.9 Financial arrangements

The financial arrangements of the programme appear to be pragmatic and ad-hoc with no structured open procurement or tender process (for transparency and cost-effective programme costs), and no budgeting for recurrent costs.

Furthermore, there has been no coordinated or documented financial accounting/reporting for the programme.

It is difficult to assess the benefits of the programme if these cannot be balanced against costs.

A.1.3.10 Institutional issues

At present the PV systems appear to be owned by the MNRE. None of the end-users at the sites visited knew who owned the systems. Consequently, there is no clear sense of responsibility for technical, administrative and financial management of the programme.

Furthermore, there are at present no clear lines of communication / reporting for maintenance.

It is recommended that the Ministries of Health and Education take an active role in ownership (and maintenance perhaps in the case of clinics) to provide clear criteria for the levels of supply and lines of accountability for operation and maintenance.

A.1.3.11 Human resources capacity

At present there appears to be very limited capacity in Swaziland for setting up and managing an off-grid school and clinic electrification programme. This includes programme conceptualisation and planning, financial planning, programme management, technical and quality management, user training, monitoring and maintenance.

These are all necessary for success and sustainability of a programme.

A.1.3.12 Benefits of the programme

Although the brief survey did not attempt to quantify the benefits of the programme, there have been clear qualitative benefits. These include lighting, entertainment (with radios and perhaps TV's), learning - by users and visitors at schools and clinics - that PV systems can work, and finally the practical experience and understanding of the unique problems and requirements of an off-grid programme.

A.1.4 Conclusions

The programme was a pilot programme with basic objectives of providing lighting at schools and clinics - and vaccine refrigeration at two clinics - using solar electricity systems and gaining experience in the installation and operation of these systems. Except for the failure of the vaccine refrigeration systems to operate at all, the programme has succeeded moderately well.

The programme was initiated at a time when there was little experience in southern Africa with off-grid school and clinic electrification programmes. Certainly, aside from WHO publications regarding specifications and testing of PV-powered vaccine refrigeration systems, there was very little published material on the technical or programme considerations for such a pilot.

However, the programme was planned and implemented in a relatively adhoc manner. The technical and institutional problems are a direct consequence of this.

A.1.5 Recommendations

Based on this brief review, the following recommendations are suggested:

- All the systems in the programme need to be assessed in terms of their condition and their appropriateness to the future needs at the site.
- The decision regarding the upgrading or removal of the systems should be made in the context of the above survey and the proposed rural electrification plan for Swaziland.
- In the event of off-grid systems being appropriate, a more structured programme is recommended which includes:
    - planning
    - interim upgrading
    - technical planning
    - project management
    - establishment of institutional capacity for administration, monitoring, maintenance, training

A.1.6 References and sources

Nxumalo NR (undated), *A report on the evaluation of the solar energy project*, MNRE, undated report.

Malone J (1996), *Report on solar electricity systems at schools and clinics*, MNRE.

Loineau JP, et al (1994), *Rural lighting: A guide for development workers*, IT Publications, London.

WHO (1989), *Installation Handbook for Photovoltaic Refrigerators*, Expanded Programme on Immunization, World Health Organisation, Geneva.

WHO/UNICEF (1990), *WHO/UNICEF Standard Specification for Solar (Photovoltaic) Refrigerators and Icepack Freezers*, Expanded Programme on Immunization, World Health Organisation, Geneva.

Measurements Recorded During Site Visits

Maphalaleni Primary School

Overall description

The school has four teacher's homes on site. These are in two pairs of semi-detached homes with five rooms (sitting room, kitchen, bathroom and two bedrooms) each in two buildings. Each home is equipped with a four light DC lighting system.

Description: Swazitronics "Homelite" system for 4 DC lights and DC TV

System 1
Time: 10:40
"solar" battery removed for charging in town and replaced with borrowed automotive battery which was not connected
Solarex 30 W_p module
V_{OC}= 19.17 V
I_{SC}= 1.97 A

System 2
Time : 10:55
lights not working; fuse blown: module shaded
Helios Power 55 - 60 Wp module
PDI regulator : PDI 120510LF-5.0LM
SN 250610
VOP= 14.06 V
IOP= 0.56 A

System 3
Time : 11:05
lights working; very poor connections to battery; battery apparently fully charged
Helios Power 55 - 60 Wp module
VOP= 14.09 V; 14.23 V
IOP= 2.34 A; 2.35 A

System 4
Time : 11:10
battery away to be charged; battery connections lying in water/sludge at bottom of battery box; module shaded
Helios Power 55 - 60 Wp module
VOC= 18.14 V
IOP= 0.5 A

Nkwene Clinic

Overall description

The clinic is in a large building on the clinic site. The building has three nurse's homes in addition to the clinic. Each accommodation unit is equipped with a DC lighting system. In addition, the clinic is equipped with a DC lighting system and a solar-powered DC refrigerator.

Description: Swazitronics "Homelite" system for 4 DC lights and DC TV

Refrigeration system: Optitron / Siemens BF56 fridge system which has been recently upgraded with extra module (M55) and battery (EXIDE / Raylite RR2)

V_{OC}= 19.0 V

I_{SC}= 4.0 A

***System 1** : Nurses' accommodation*

6 light system with a star configuration for wiring.
lights look like Omnilite / National Luna lights
PDI 120510LF-3.5LM regulator
SN 229626

***System 2** : Clinic lighting*
Four (or five) light system with robust looking 15 / 20 W fluorescent tubes
PDI 120510LFA-3.5LM regulator
SN 207622
V_{OP}= 13.7 V
I_{OP}= 1.62 A
Voltage drop measured between one of the lights and the regulator
I_{light}= 1.09 A
V_{reg} = 13.4 V
V_{light}= 12.30 V
Voltage drop = 1.1 V

Genset specifications
LISTER R11HR2/39 aircooled diesel engine
16.9 kW @ 1500 rpm
Powergen alternator
15 kVA / 12 kW
Engine hours: 2115.4 hours

A.2.1 Number of clinics and their current energy supplies

There are nine such Government clinics, listed below. Of these, up to five can possibly be incorporated into the grid extension plan. This leaves between five and seven which must be served through other options.

Table A.2.1: Unelectrified Government Clinics

Area name	Grid extension distance	Number of nurses' homes	Diesel Generator	Comment	Grid supply
Sincineni	9	4 houses	10 kVA		Not feasible
Musi	11	3 houses	n/a	Genset not working	Not feasible
Mpuluzi	10	4 houses	Large	New clinic & not operational	Not feasible
Makhava	6	3 houses	20 kVA		???
Jericho	10	3 houses	None	Clinic is not operational	Possible
Ntjanini	12	4 houses	20 kVA		Possible
Nkonjwa	5	2 houses	n/a		Feasible
Mashobeni	6		n/a		Feasible
Nkwene	8 (12 to Tinkh)		n/a		Feasible

There are at least seven unelectrified non-Government clinics, although the list presented below is likely to be incomplete. Of this seven, four can be easily reached with the grid, and the others are further from the grid, making electrification fairly expensive.

Table A.2.2: Unelectrified non-Government clinics
(this list is incomplete)

Area name	Grid extension distance	Number of nuses' homes	Diesel Generator	Comment	Grid supply
Sincaweni	12	2 houses	None	A small clinic with solar	Not feasible
Manyeveni	5	n/a	Has genset		Not feasible
Malindza	4	n/a	n/a	Has solar	Possible
Mafutsene	0.5	n/a	n/a	Has solar	Feasible
Ngculwini	2	n/a	n/a	Has solar	Feasible
Bethany	0.5	n/a	n/a	Has solar	Feasible
Ikwezi Joy	0.5	n/a	n/a	Has solar, clinic at school	Feasible

The description below covers existing energy services at Government clinics.

Vaccine refrigeration: This is managed through the use of gas refrigerators. These systems appeared to be good quality and in most cases the temperature records indicated that temperatures were consistently within the band required (0°C to 8°C).

Clinic electricity supplies: All clinics were wired for AC power, and in most cases visited the wiring appeared in good condition (with the exception of Sincineni where some rehabilitation may be required). Lights were installed in all rooms, as well as outside lights. Plug points were installed in most rooms. Diesel generators were provided, either 13kVA or 25kVA. In most cases the diesel generators appeared in good condition and were reported to be in working order. The exception to this was Musi clinic. In general, the diesel generators were run for three hours a day (from 6pm to 9pm). In two cases (Musi and Sincineni) solar powered system powered DC lights, although these did not appear to operate satisfactorily.

Nurses' homes electricity supplies: As with the clinics, most nurses' homes were wired for AC power and powered through the diesel generators. In two cases solar systems were provided for lights and television in the nurses' homes.

Cooking and heating in nurses' homes: In some cases nurses' were expected to provide their own fuels and appliances, and in others they were provided with fuel. Fuel/stove combinations included gas, coal and wood.

Water heating: In most cases no dedicated water heating appliances were provided, with the exception of Sincineni clinic where old solar water heating geysers were provided. Not all of these worked.

Water pumping: At Makhava Clinic the diesel generator also powered an AC pump which provided water from a brothel. However, the three hour restriction on the generator meant that insufficient water was pumped.

A.2.2 Supply options for clinics with diesel generators

A.2.2.1 Supply option 1: Clinic refrigeration with PV

If it is felt that gas vaccine refrigeration is inadequate, this can be upgraded to PV systems. The size and costs of the system are as follows:

Approximate costs (excl. contingencies):

Refrigerator	Minus 40 vaccine fridge for DC power (WHO)	E4 000
Batteries	300Ahr deep cycle tubular cell batteries	E2 500
PV array	200 Wp array	E8 000
Regulator	PDI	E500
Wiring & installation		E3 000
Project management		E2 000
Total		**E20 000**

The total costs for five systems would thus be E100 000.

A.2.2.2 Supply option 2: Uninterrupted electricity supply to clinic using genset & batteries

At present electricity is only available to the clinic when the diesel generator is operating. This means that security lights can not be installed to operate all night, and during emergencies the generator must be started, at some inconvenience and delay.

An improvement to this system would be to add a battery bank to the generator. The batteries would be charged when the generator operated, and would supply power to clinic when the generator was switched off. This would allow security lights and motion detector lights to be installed, as well as allowing convenient access to lights in the clinic at any time of the night.

Should a radio-phone be installed, this could also be operated off the battery set.

It the clinic includes an operating maternity wing, then it may be necessary to double the size of the battery bank in order to provide sufficient power for the loads in the maternity wing.

The inclusion of batteries reduces maintenance requirements, extents the lifetime of the diesel generator and improves operating efficiency, thereby reducing the operating costs. The reduced costs are likely to be in the order of E1 000 per annum per site, and so do not equal the costs of the upgrade, even over a ten year period.

Approximate costs (excl. contingencies):

Battery	100Ahr @ 24V deep cycle tubular cell	E5 000
Inverter	400W sine wave inverter	E2 500
Battery charger	1.5kVA charger & regulator	E2 500
Wiring & security lights (incl. motion detector lights)		E3 500
Installation		E5 000
Project management		E1 500
Total		**E20 000**

The total cost for a system with a larger battery bank for a clinic with a maternity wing would be in the order of E25 000.

Costs for five systems would be in the order of E100 000.

Maintenance of the battery system could be managed by the diesel maintenance crew. Avoiding the introduction of PV means that no new maintenance systems need to be established.

It should be noted that there is no diesel generator at Jericho clinic and the generator at Musi is not working. It is possible that old gensets for grid electrified clinics could be relocated here, or new generators purchased and installed.

A.2.2.3 Supply option 3: Uninterrupted electricity supply to clinic and nurses' homes using genset and batteries

A third supply option is to provide a larger battery and inverter in order to supply uninterrupted power to both the clinic and nurses' homes. The costs will depend on the number of nurses' homes at the clinic and approximate costs of these are provided below for four homes.

This system would be fully automated so that the diesel generator could be switched on and off automatically by the control system whenever the battery was low.

If a pump was included in the system, this would be powered directly from the generator and not through the battery bank. Manual operation would be required to run the pump.

Maintenance and fuel savings are likely to be in the order of E5 000 per annum.

Approximate costs (excl. contingencies):

Battery	460Ahr @ 36V	E14 000
Inverter	800W sine wave inverter	E5 000
Battery charger	3kVA	E5 000
Automation	Auto start & stop	E3 000
Wiring & security lights (incl. motion lights)		E4 000
Installation		E10 000
Project management		E4 000
Total		**E45 000**

Total costs for five systems would thus be in the order of E220 000.

A.2.2.4 Supply option 4: PV refrigeration and a diesel generator with batteries

It is possible to combine the installation of a PV powered refrigerator with the addition of batteries to the diesel system. This would combine the costs of Option 1 with either Option 2 or Option 3.

One of the advantages of this system is that excess power from the PV array could be diverted to the diesel battery bank, thereby reducing the need to operate the diesel generator.

A.2.3 Supply options for clinics with solar systems and diesel generators

The two Government clinics with solar systems are Musi and Sincineni. Both these sites have diesel generators (although the set at Musi needs to be replaced or repaired).

A.2.3.1 Option 1: Where a small battery bank is installed with the genset

If the diesel generator system is upgraded to supply uninterrupted power at the clinic only (and not nurses' homes), then it is recommended that the solar systems be reconfigured to supply lights at the nurses' homes. This will provide more hours of light than the three hours from the diesel generator. Upgrades should be undertaken to strengthen the existing solar systems and to move the modules currently supplying the clinic from the clinic to the nurses' homes.

Approximate costs are as follows:

Musi clinic:	Three independent systems	
	3 new batteries	E900
	3 regulators	E900
	Light replacements	E500
	Balance of system	E1 500
	Installation	E1 000
	Total	**E4 800**
Sincineni clinic	Four independent systems: 2 upgrades, 2 new	
	1 50Wp module	E2 000
	4 new batteries	E1 200
	2 regulators	E600
	Light replacements	E1 000
	Balance of system	E2 000
	Installation	E1 000
	Total	**E7 800**

The total cost of these two upgrades will be E12 600.

A.2.3.2 Option 2: Where a large battery bank is installed with the genset

If the diesel generator system is upgraded to supply uninterrupted power to the clinic and nurses' homes, then it is recommended that the solar systems be reconfigured to simply charge the battery bank, using existing modules at the site. This would charge batteries as a supplement to the diesel generator, and would reduce the operating costs at the site as well as increasing reliability.

The approximate costs for each site are as follows:

Array structure	for four modules	E500
Charge controller		E500
Wiring & switchgear		E500
Installation		E1 500
Total		**E3 000**

The approximate costs for both sites will be E6 000.

A.2.4 Supply options for non-Government clinics

A.2.4.1 Option 1: Install a genset plus battery system

The first option is to install a system similar to that at Government clinics, i.e. a genset with batteries. The approximate costs of this is as follows:

Diesel generator	3kVA	E15 000
Battery charger	1.5 kVA	E2 500
Batteries	100Ahr @ 24V	E5 000
Inverter	400W	E2 500
AC wiring in clinic & lights & installation		E20 000
Project management		E5 000
Total		**E50 000**

Where a diesel generator and wiring already exists at the clinic, the costs will be lower - in the order of E18 000.

A.2.4.2 Option 2: Install/upgrade a DC PV system

The second option is to install a DC PV system. Assuming that there are four nurses' homes to supply, the approximate costs are as follows:

PV array	300 Wp	E12 000
Battery	400 Ahr (deep cycle tubular cell)	E3 000
Regulator		E500
Wiring & switchgear		E3 000
Lights (incl. security & motion detector lights)		E3 500
Installation		E3 000
Project management		E2 000
Total		**E27 000**

Where a solar system already exists, the upgrading costs will be reduced by the cost of existing and reusable equipment - typically by E5 000 to E10 000.

A.2.5 Overall budgets

A.2.5.1 Option 1: Where a small battery bank is installed with the genset

The total costs for all Government clinics (which cannot be electrified) and Sigcaweni (the mission clinic with a solar system which cannot be electrified) are as follows:

Sincineni	Battery system installation	E20 000
	Wiring rehabilitation	E5 000
	PV upgrade to nurses' homes	E7 800
Makhava	Battery system installation	E20 000
Musi	Genset refurbishment	E20 000
	Battery system installation	E20 000
	PV upgrade to nurses' homes	E4 800
Jericho	Battery system installation	E20 000
	Genset installation	E5 000
Mpuluzi	Battery system installation	E20 000
Sigcaweni	Upgrade to DC solar system (clinic & 2 nurses' homes)	E20 000
Subtotal		E177 600
Contingencies @ 10%		E16 000
TOTAL		**E193 600**

A.2.5.2 Option 2: Where a large battery bank is installed with the genset

The total costs for all Government clinics (which cannot be electrified) and Sigcaweni (the mission clinic with a solar system which cannot be electrified) are as follows:

Sincineni	Battery system installation	E45 000
	Wiring rehabilitation	E5 000
	PV supplement to batteries	E3 000
Makhava	Battery system installation	E45 000
Musi	Genset refurbishment	E20 000
	Battery system installation	E45 000
	PV supplement to batteries	E3 000
Jericho	Battery system installation	E45 000
	Genset installation	E5 000
Mpuluzi	Battery system installation	E45 000
Sigcaweni	Upgrade to DC solar system (clinic & 2 nurses' homes)	E20 000
Subtotal		E296 000
Contingencies @ 10%		E29 000
TOTAL		**E315 000**

Appendix A.3
Off-Grid Electrification of Rural Schools

The project "Rural Electrification in Swaziland" is concerned with the planning of electricity supply to rural parts of the country. This comprises two elements:

- Planning SEB's grid extension, and
- Examining off-grid options where grid supply is unlikely to arrive for the next five to ten years.

A network planning firm is currently examining the possible options for grid extension. In prioritising the network expansion, consideration is being given to the location of schools, clinics, households, commercial enterprises and industrial and agricultural enterprises. A scheduling of projects will be proposed which will attempt to provide electricity to the most economically viable areas first, and the pace of the programme will be affected by available financing.

It is likely that a number of areas will be excluded from the grid extension programme, at least for the medium term, and the project aims to examine the options of providing important services, such as education, health and water supply, with off-grid energy supplies.

This short document will set out the non-grid energy supply options which are possible for schools , and will indicate the likely costs of each. It is hoped that this will assist the Ministry of Education in deciding whether off-grid supplies are worth providing, and if so, which supply options best meet the needs within the given budget constraints.

There is no doubt that grid electricity will always be the preferred option, where it is available. However, other supply options may present a viable and reliable alternative.

A.3.1 Status of electrification of schools in Swaziland

The Ministry of Education & Training (MET) operates a network of primary, secondary and high schools throughout the country and Table A.3.1 shows that there remain a total of 424 (58%) without electricity. If only secondary and high schools are considered, then there are 66 (38%) without electricity, of which 34 have neither electricity nor adequate water. A further 32 non-primary schools have access to electricity but have inadequate water supplies.

The MET has capital budgets available for, among other projects, water supply to schools, rehabilitation of schools and construction of additional teachers' houses, school classrooms and science laboratories. No funds are directly allocated within the MET to the electrification of schools or teachers' houses, although the Ministry of Works and Construction has funds available for wiring of Government buildings, and some of this money is used for electrification of schools.

Table A.3.1: Government Schools in Swaziland

	Primary	Secondary	High	Total
Number of schools	538	63	107	708
without electricity	358	45	21	424
without water	196	30	16	242
without electricity or water	171	26	8	197
Average number of teachers	10.9	8.8	22.3	12.4
Average number of pupils	133	177	366	173

A.3.2 Energy needs at schools

Before considering the possible energy supply options, it is necessary to identify the nature of energy needs at schools and to recognise the different priorities which the Ministry may wish to attach to these needs.

If grid electricity is provided, then electricity can easily be used to meet all these needs without much more cost than that incurred in bringing the grid in. That is, if grid electricity is available then almost all energy needs should be met through electricity (although specific alternatives such as solar water heating may still be considered). However, if grid is not available and if off-grid options are considered, then more attention should be paid to energy needs since the cost of supply is dependent on which needs are met.

A.3.2.1 Energy needs at teachers' homes

In many cases teachers' accommodation is provided near to the school. The energy needs at these houses comprise the full range of domestic requirements. The main requirements are:

- Lights
- Plugs (for TV, radio)
- Refrigeration
- Hot water
- Cooking
- Water pumping, if piped water is not available.
- Other energy needs might include ironing, heating the home, electric fans and so on.

From the Ministry's point of view, energy supply to teachers' homes may be important both in order to improve the standard of living for teachers (and so hopefully to attract teachers to work in rural areas), as well as providing teachers with more time and better quality lighting in order to undertake preparation and marking tasks in the evening.

A.3.2.2 Energy needs in the school

The energy needs at schools are related to the range of activities undertaken at the school. Thus, primary schools may have different energy needs from secondary and high schools; schools which offer domestic science and have science laboratories will have additional energy needs; schools which offer night classes or evening self-study will have a greater need for good-quality lighting; schools with hostels or vocational training are likely to require the greatest range of energy services. Some of these energy needs are listed below.

- **Classroom lighting:** if extensive use of the school property is made at night, then full or at least extensive lighting will be required. However, if only limited evening activities occur, then it is possible that lighting for only a small number of classrooms and office will be required.
- **Security lighting:** outside lights may be important to improve security at schools.
- **Audio-visual teaching aids:** This includes overhead projectors, video and television for educational programmes. Access to computers may also be considered important, particularly in the medium term. Ownership of these appliances may impose security problems for school principals who may be reluctant, in some circumstances to leave this equipment in the school overnight, weekends or holidays.
- **Water pumping:** where piped water is not available, it may be possible for a borehole to be drilled, in which case a pump will be required. Although handpumps do not require fuels (other than human effort), their use may be restricted is the water levels are deep, if water consumption is high, or if the borehole is far from the school. Under these circumstances power-driven pumping equipment may be required.
- **Other energy needs:** Where science laboratories are provided, adequate energy supplies will be needs. This includes electricity for electrical equipment and gas for Bunsen burners. Where domestic science is taught, energy may be required for refrigeration, cooking and sewing machines. Where hostels are present, energy will be required for extensive lighting, cooking and refrigeration.

A.3.2.3 Priorities in energy needs at schools

The Ministry of Education should give consideration to the relative priorities of energy needs at schools. If energy supplies at teachers' houses is top priority, then this will affect decisions on supply options. If security lighting is considered especially important, it is possible to provide just for this without meeting other needs. If minimal lighting at schools is adequate, this will reduce costs over a full lighting system.

Priorities may also be different for different school levels, with high and secondary schools possibly taking greater priority over primary schools.

A.3.3 Off-grid energy supply options

There is one basic choice to be made: whether to opt for a diesel generator or whether to opt for photovoltaic (solar) power. This section will describe the configuration and costs for four types of systems:

- A diesel & gas system for full energy supplies at a school & teachers' housing;
- A solar photovoltaic (DC) and gas system for teachers' housing;
- A solar photovoltaic (AC) system for a school; and
- A small solar photovoltaic (DC) system for a school.

A.3.3.1 Diesel genset plus other supplies

A small diesel generator will be able to supply all light electrical needs including all lighting, audio-visual equipment as well as any water pumping requirements. However, a diesel generator would probably not be run during the day and so refrigeration is best powered by gas (LPG). Also, a small diesel generator could not supply thermal loads and so gas heaters and gas stoves would be required, and water heating could be either solar or gas.

Table A.3.2: Energy supply options with a diesel generator & gas

Energy need	Energy source
Lighting & plugs in classrooms	3kVA Diesel genset
Security lighting	As above
Lighting & plugs in teachers' homes	As above
Water pumping	As above
Cooking	Gas cookers
Refrigeration	Gas refrigerators
Heating	Gas heaters
Water heating	Solar water heaters or gas water heaters

Advantages of this option are that the school and teachers' housing would be wired for AC power (which may already exist) and could be easily converted to grid electricity if and when it arrives. Further, the system is flexible in that generator could be run for different lengths of time, depending on the requirements.

Disadvantages primarily relate to the need to maintain a reliable supply of diesel and bottled gas, and the need to implement a maintenance regime for the diesel generator. This consideration is of utmost importance and may seriously limit the suitability of this energy supply configuration. The costs of supplying diesel and maintaining the system should be taken into consideration.

In addition, the generator must be started if power is required. This may be an inconvenience if a teacher wishes to use an overhead projector, say, and must arrange for the generator to be switch on for this purpose. A solution to this problem is to link batteries to the system so that for occasional loads there is always power available without having to start the generator. Diesel generators are also noisy, often dirty and have been known to be stolen.

Table A.3.3: Advantages and disadvantages of diesel option

Advantages	Disadvantages
Wired for AC (easy upgrade)	Requires reliable fuel supply
Flexible	Requires regular maintenance
Low capital cost	May require batteries & inverter
Meets low power needs easily	High operating costs
	Noisy and dirty

The capital costs of this system include the capital costs of a small diesel generator, wiring, lights, audio-visual equipment, a genset building and possible an electrical pump and wiring. In addition, there are the costs of solar water heaters, refrigerators and gas heaters.

Operating costs include diesel supply and maintenance, and gas supplies. It is estimated that the total operating and maintenance costs for a system of this nature are in the order of E23 000 per annum. All these costs are shown in Table A.3.4.

Table A.3.4: Approximate costs of diesel option for school and four teacher's houses

Quantity	Description	Cost, each	Total cost
1	3 kVA genset	E 15 000	E 15 000
1	Genset room	E 15 000	E 15 000
1	AC wiring *(possibly already existing)*	E 20 000	E 20 000
60	Compact fluorescent lights	E 100	E 6 000
1	Audio-visual equipment	E 8 000	E 8 000
4	Gas heaters	E 250	E 1 000
4	Gas refrigerators	E 2 500	E 10 000
4	Gas stoves	E 3 000	E 12 000
4	100 l solar water heaters	E 4 000	E 16 000
1	AC pump & wiring	E 5 000	E 5 000
	Sub-total per teacher's house*	E 10 500	
	Sub-total for school building**	E 41 000	
	Sub-total for pumping	E 5 000	
	Sub-total for wiring	E 20 000	
	Total capital cost for 1 school, 4 homes and a pump		E 108 000
	Annual operating and maintenance costs		E 23 000

* Excluding wiring and diesel generator

** Excluding wiring but including diesel generator

A.3.3.2 Solar and gas system for teachers' homes

This system just considers the energy needs of teacher's homes. Lighting and electrical loads are provided by solar photovoltaic systems; heating, cooking and refrigeration are provided by bottled gas; water heating is met by solar hot water heaters (or gas); and water pumping (if required) is met with a solar photovoltaic pump.

Table A.3.5: Energy supply options at teachers' homes with solar PV & gas

Energy need	Energy source
Lighting & plugs in teachers' homes	Solar photovoltaic system
Cooking	Gas cooker
Refrigeration	Gas refrigerators
Heating	Gas heaters
Water heating	Solar water heaters or gas water heaters
Water pumping	Solar photovoltaic pump

Advantages of this option are that maintenance costs would be relatively low (no diesel genset maintenance is required) and operating costs would be restricted to gas supplies. However, it is important to note that solar systems (lights as well as pumps) do require occasional maintenance and this should be factored into the costs. Batteries must be replaced, light bulbs must be changed if they break, and small pumps require an annual service.

Disadvantages are that solar panels are easily stolen. Although installation can reduce the risk of theft, it cannot be removed altogether. Further, solar systems are restricted in the amount of power that they can provide, and these systems cannot meet more than lighting and media (TV, radio) needs. If houses are wired for a small solar lighting system, it would usually be DC wiring. This means that any existing AC wiring cannot be used, or if grid does arrive, new AC wiring must be installed.

Table A.3.5: Advantages and disadvantages of solar PV & gas option

Advantages	Disadvantages
Low maintenance	Does require some maintenance
Low operating costs	AC wiring cannot be used
Quiet and clean	Electricity only for lights & media
Requires minimal user operation	Risk of theft

Approximate costs are shown in Table A.3.6. For comparison with the diesel option, costs are shown for four teachers' houses.

Table A.3.6: Approximate costs of solar & gas option for four teacher's houses

Quantity	Description	Cost, each	Total cost
4	Solar home system (DC)	E 5 000	E 20 000
20	Compact fluorescent lights	E 100	E 2 000
4	DC wiring	E 1 000	E 4 000
4	Gas heaters	E 250	E 1 000
4	Gas refrigerators	E 2 500	E 10 000
4	Gas stoves	E 3 000	E 12 000
4	100 l solar water heaters	E 4 000	E 16 000
1	Solar PV pump	E 20 000	E 20 000
	Sub-total per teacher's house	E 16 250	
	Sub-total for pumping	E 20 000	
	Total capital cost for 4 homes and a pump		E 85 000
	Annual operating and maintenance costs		E 18 000

A.3.3.3 Solar PV electricity at a school

It is possible to provide basic electricity at a school using a solar PV system. The system described and costed here provides for lighting in classrooms, plugs for audio-visual equipment and security lighting. The system is designed to operate on AC, which means that existing wiring, if it exists, can be used. alternatively, if grid arrives at the school, it is easy and cheap to convert to grid power.

If water pumping is required for the school, a small solar PV pump can be used.

Table A.3.8: Basic electricity at a school using solar (PV) power

Energy need	Energy source
Lighting in class rooms and office	Solar photovoltaic system (AC)
Security lighting	As above
Audio-visual equipment	As above
Water pumping	Solar photovoltaic pump

Advantages of this option are that maintenance costs would be relatively low (no diesel genset maintenance is required) and operating costs would be restricted to battery and lamp replacements. As with the option described above, it is important to note that solar systems (lights as well as pumps) do require occasional maintenance and this should be factored into the costs. Since this is an AC system, it is possible to use existing wiring (if available) and to switch to grid if it arrives.

Again there are the disadvantages that solar panels are easily stolen and that solar electricity can only be used for low power applications.

Table A.3.7: Advantages and disadvantages of solar PV electricity at a school

Advantages	Disadvantages
Low maintenance	Does require some maintenance
Low operating costs	Electricity only for lights & media
Quiet and clean	Risk of theft
Requires minimal user operation	

The total capital costs of a school system of this nature are in the region of E50 000, although operating and maintenance are low. Table A.3.8 shows the likely costs.

Table A.3.8: Approximate costs of solar option for school

Quantity	Description	Cost, each	Total cost
1	School solar system (AC)	E 50 000	E 50 000
50	Compact fluorescent lights	E 100	E 5 000
1	Audio-visual equipment	E 7 000	E 7 000
1	AC wiring for site *(possibly exists)*	E 15 000	E 15 000
1	Solar PV pump	E 20 000	E 20 000
	Sub-total for school	E 77 000	
	Sub-total for pumping	E 20 000	
	Total capital cost school and pump		E 97 000
	Annual operating and maintenance costs		E 2 000

A.3.3.4 Basic DC lighting system for one classroom and office

It is possible to provide a very basic lighting and plug system for a school which would only power a small number of lights. This would be a DC system and would cost in the region of E6 000 per installation.

A.3.4 Summary

In summary, when considering the energy supply to schools and teachers' houses there are a number of off-grid options available. These are summarised below:

- **Combined school and teachers' housing: Diesel & gas**
  A diesel and gas system which provides for the majority of needs at a school and teachers' housing. Solar hot water heaters may also be used. The diesel generator can be used for all non-thermal energy applications (i.e. excluding cooking, heating and water heating) as well as pumping.

- **Teachers' houses: DC solar and gas system**
  A DC solar and gas system for teachers' houses which provides electricity for lighting and media (radio/TV), and gas appliances for heating applications. Solar hot water heaters may be used and a solar photovoltaic pump if water pumping is required.

- **School: AC solar system**
  An AC solar system for a school which provides extensive lighting and plug for audio-visual needs.
- **School: small DC solar system**
  A very small solar system providing only very limited electricity supply to a school.

Table A.3.9 summarises the costs. Although the diesel and gas system is cheaper in both capital and lifecycle cost terms than the combination of solar & gas (for homes and pumping) and AC solar for a school, consideration should be given to the need to establish an extensive operating and maintenance service.

Table A.3.9: Summary of costs

	Diesel & gas School & homes	**Solar & gas** Homes only	**AC solar** School only	**DC solar** School only
School	E 64 000	n/a	E 77 000	E 6 000
1 teachers' house	E 10 500	E 16 250	n/a	n/a
Pump	E 5 000	E20 000	n/a	n/a
Total	E 108 000[1]	E 85 000[2]	E 77 000[3]	E 6 000[3]
Annual O&M	E 23 000	E 18 000	E 2 000	E 1 000
Life cycle cost[4]	E 285 000	E 225 000	E 92 000	E 14 000

1 School, four teachers' homes and pump
2 Four teacher's homes and pump
3 School only
4 Over ten years at 5% real discount rate.

Appendix A.4
Guidelines for a Solar Home Electrification Programme

In general the principal obstacles to effective SHS programmes have been the mechanisms for dissemination and financial management. In the case of the Swaziland SHS programme these obstacles are not as significant because the programme is designed to use and augment the existing dissemination methods and financing mechanisms which have been developed by Swazitronics.

The main problem in SHS programmes is *quality control* in

- documentation
- system design and specifications
- installation
- maintenance

A.4.1 Documentation

It is highly recommended that good documentation be developed to enhance the access to information about the programme and the systems themselves. This documentation should include the following:

- marketing information (pamphlets which clearly indicate what is offered and how the programme is organised)
- a clear user manual (or booklet) and a poster to hang in a prominent position near the regulator indicator lights
- ongoing newsletters or information sheets to provide feedback to owners and elicit response from users
- monthly billing statements - this could be combined with the newsletters
- user workshops or meetings to enable users to meet one another and the programme managers to learn from one anothers' experience
- a project evaluation report

A.4.2 Technical design and specifications

The technical design and specifications will affect the functionality of the systems. This has largely been defined already. However, if possible the following aspects should be incorporated:

- a good user interface to enable load management - either on the regulator or by a remote "power gauge" as in the case of the Namibian system
- use of appropriate wiring - 2.5mm^2 for load wiring and 4mm^2 for array cabling
- use of RR2 or Willard 774 modified "deep-cycle" SLI type batteries similar to those which are likely to be replaced with
- proper matching between battery type and charge controller to maximise battery life
- use of wall mounted rocker-type light switches (rather than pull switches) to reduce the problems of damage through pulling and to enable clear ON/OFF indications

A.4.3 Installation

Even well designed and specified PV systems are useless if they are not properly installed. It is therefore essential that great care is taken in planning and doing the installation. The following suggestions are relevant:

- read the Code of Practice developed by EDRC
- read the installation and wiring section of the RAPS Design Manual
- read Chapter 10 in Mark Hankins book
- equip the installation teams with all the required tools and instrumentation - multimeters and a mini-clamp meter

In general, installation teams should not leave the workshop if they have not got at least 100% extra of all components required to do the planned installations.

It is essential that the first few systems be inspected in detail, prior to proceeding on a large scale, to identify any problems and potential bad habits which would be difficult to rectify at a later date.

A.4.4 Maintenance

It is recommended that, at least for the initial systems installed, routine maintenance visits be undertaken to provide a mechanism for keeping the systems operating and to provide feedback on the performance.

These trips should be scheduled as follows:

1st visit	- after the first six weeks
2nd visit	- after the next three months
3rd visit	- after the next six months
thereafter	- annually

This may seem like an onerous overhead, but in a new programme with future viability at stake it is highly recommended. It also provides a very useful mechanism for training administrators, maintenance technicians and end users.

A.4.5 Networking

It is also highly recommended that the programme managers in Swaziland liaise (preferably visit) the Namibian managers. These are:

- Hansjorg Muller: GTZ,
  tel: 09 264 61 284 8294 fax: 09 264 61 284 8201
- Conrad Roerdern: Solar Age Namibia,
  tel: 09 264 61 215 809 fax: 09 264 61 215 793

References

EDRC (1996), *Code of Practice for installing low voltage PV power systems*, Energy for Development Research Centre

EDRC (1992), *RAPS Design Manual*, Energy for Development Research Centre.

Hankins M (1995), *Solar electric systems for Africa*, Commonwealth Science Council.

Appendix B.1
Institutional Framework for Rural Electrification in Swaziland

Consideration must be given to the institutional framework within which rural electrification is placed. Attention should be paid to the range of different players, their capacities, and the interactions between them. The focus should be on identifying the separate tasks of planning, financing, implementing, operating and monitoring rural electrification projects. Responsibilities should be clearly defined and appropriately assigned to each insititution.

Recognition should be given to the fact that the institutional framework for Swaziland will likely be different from other countries. Existing organisations, the relationships between them, and their individual capacities vary from country to country, and it is important that initiatives be aimed at best utilising existing resources. For Swaziland, this means taking stock of the number and form of existing organisations and examining their strengths and weaknesses in the light of the requirements of the rural electrification programme.

B.1.1 Existing institutional framework

It is worthwhile sketching the range of organisations involved in rural electrification in Swaziland. These include the power utility (SEB), various Government ministries, inter-ministerial committees, any organised user groups as well as private-sector firms. Each of these will be discussed briefly below.

B.1.1.1 Swaziland Electricity Board (SEB)

SEB is the public enterprise responsible for the generation and supply of commercial electricity. In addition, there are some 15 private establishments which generate electricity for their own consumption. Approximately 30% of electricity consumption in the country is self-generated.

SEB has a generation capacity of 50 MW, of which 40,5 MW is hydro and the remainder diesel. A further 96 MW is available through three feeder links with Eskom's system in South Africa. A fourth feeder designed to operate at 275 kV (but initially operated at 132 kV) should be completed in 1997/8. Although in recent years hydro generation has been affected by water availability, in 1995 some 15% of SEB's electricity generation and purchases (a total of 706 GWh) were generated by the utility. This is somewhat below the figures of 27-30% recorded in the early 1990s. Table B.1.1 summarises some of the key characteristics of SEB's system.

Other proposed developments include the construction of a transmission line to Mozambique (a further 50 MW), the construction of a 15 MW hydropower station at the Maguga Dam (although restrictions on water availability will mean that this will not contribute greatly towards electricity requirements), and the possible construction of a 100 MW (expandable to 200 MW) privately owned coal plant. The construction of a 4th feeder from Eskom will also increase import capacity as well as providing greater reliability on the system.

There were a total of 26 600 connections in Swaziland in 1995, and this represents an increase of 2 106 connections over 1994. The bulk of these new connections (85%) were made in rural areas (SEB 1995). Pilot rural electrification projects, largely funded by the Swaziland Government, are being undertaken and these should lead to a number of new connections in rural areas. Residential customers account for some 80% of all connections, although only 20% of total consumption is for domestic purposes.

Table B.1.1: Key characteristics of SEB's generation, transmission and distribution infrastructure (in 1995)
Source: SEB 1995

	Capacity [MW]		Production/ purchases [GWh]		Transmission & distribution lines	
Hydro	40,5	(28%)	109	(15%)	132 kV	206 km
Diesel	9,5	(6%)	0.8	(0%)	66 kV	912 km
Imports	96	(66%)	597	(85%)	33 kV	91 km
Total	**146**	**(100%)**	**706**	**(100%)**	11 kV	2669 km

SEB employs a total of 631 staff, split between the four functions of administration, distribution & survey, transport & services and generation & system control. Over 40% of staff are employed in the distribution & survey department. There are a total of 10 area offices and a headquarters located in Mbabane.

As a public utility, SEB reports to Government and Ministerial approval is required for tariff increases above inflation as well as any major infrastructure developments. In addition to SEB's own board of directors, the institutions responsible for the governance of SEB are the Public Enterprise Unit, and the Ministry of Natural Resources and Energy (MNRE). Each of these are discussed below.

SEB is also linked to Government through its loan stock. SEB (at 31 March 1996) had a debt of E117 million (now reduced), of which E73 million was in foreign currency. A total of E54 million of foreign currency debt are loans to the Swaziland Government, which are then on-lent to SEB. In addition, a further E18.5 million in local currency loans are from the Swaziland Government. Thus over 75% of SEB's debt is routed through the Swaziland Government. The financial restructuring of SEB, although apparently not yet finalised, has led to some of SEB's debt being written off, or at least SEB is not required to service this debt. A total of E19.3 million of Government loans and a Government contribution of E25 million towards the repayment of IBRD[1] loans (SEB 1995) has been affected in this way. The transfer of a further E50 million is envisaged as the Government contribution towards the construction of the fourth Eskom feeder - one third of the total costs (Development Plan 1996).

B.1.1.2 Ministry of Natural Resources and Energy (MNRE)

The Energy Section of the MNRE was established in 1992 and is responsible for co-ordinating, planning and policy formulation of all energy related activities. The overall national energy policy goal is to "increase the share of energy supplied from local sources as long as it is justifiable economically, ecologically and strategically" (EPO 1996: 268).

The Energy Section of the Ministry consists of four non-administrative staff, plus two expatriate secondees from GTZ and Skillshare Africa. The Principal Secretary of the Ministry sits as an observer on SEB's Board. The Energy Section has contracted consultants for a number of energy-related tasks, including the assessment of renewable energy options as well as the rural electrification planning project.

The planned medium-term activities of the Energy Section is to focus on energy conservation, energy policy and planning, energy policy formulation and reformulation of the SEB performance contract and the 1963 electricity act. Capital expenditure projects undertaken by the Ministry include a community pilot woodlot project and a selection of solar pilot projects including installations at schools, clinics and water pumps. Planning and analysis projects include a study on renewable energy potential in Swaziland, preparations for the introduction of unleaded petrol, a feasibility study on the establishment of a 60 day strategic fuel storage facility and a planning

[1] International Bank of Reconstruction and Development (World Bank).

project on rural electrification in Swaziland (of which this report forms a part). Policy initiatives include the formulation of a comprehensive energy policy for Swaziland, and a focus on household and renewable energy initiatives. Initiatives in the private sector, in which the Energy Section has an interest, include the establishment of a solar home dissemination project, briquetting of wood wastes for fuel and examination of the construction of a privately owned coal fired power plant in Swaziland.

Table B.1.2 shows Government's capital expenditure programme for energy related projects, including those undertaken by MNRE as well as other Ministries. It can be seen that by far the largest expenditure is a contribution to the cost of the 4th Eskom-SEB feeder. The MNRE had a non-capital budget of E350 000 for the 1995/6 financial year.

Table B.1.2: Capital expenditure (E '000) on energy related projects

Ministry	Project	1995/6	1996/7	1997/8	1998/9
MNRE	Community woodlot	0	170	0	0
	Rural electrification	110	514	600	679
	Household energy	180	0	0	0
	Solar pilot project	200	0	0	0
Central Transfers	4th Eskom feeder	23 000	29 000	0	0
Health	Clinic rehabilitation	2 000	2 200	0	0
Works & Constr.	Wiring of Govt buildings	2 000	1 120	1 110	0

B.1.1.3 Ministry of Economic Planning and Ministry of Finance

There are three "core ministries" - Economic Planning & Development (MEPD), Finance (MoF) and Public Service & Information. The Economic Planning Office within the MEPD has the overall responsibility for co-ordinating the preparation of national development plans and the annual capital budgets. The planning system comprises four components: (1) a set of development reviews, (2) a long-term statement of national development objectives; (3) a series of three year rolling plans, which among other things set out capital expenditure programmes; and (4) periodic progress reports on capital expenditure programmes.

The preparation of the National Development Strategy is currently being undertaken and should contain both an assessment of past performance as well as a long-term statement of objectives, strategies and policies. In addition, the strategy should "establish firm guidelines for resource allocations between and within each sector" (EPO, 1996: 211).

The three year rolling plans contain Government's capital expenditure programme. Although line-function ministries are responsible for preparing project proposals, the three core ministries jointly allocate fiscal resources. The MEPD is responsible for performing an appraisal of all proposals, although capacity constraints mean that this appraisal is not always rigorous. In many cases, projects are either postponed until future years, or returned to individual ministries for more detailed planning. For the next few years, Government's capital budgets are dominated by three large projects: the development of the Komati River Basin, the upgrade of the Mbabane/Manzini road, and the urban development programme. These three programmes account for one third of planned capital expenditure and mean that there is limited potential for large new projects to be introduced into the capital expenditure programme within the next few years.

Table B.1.3: Major capital expenditure projects (E millions)

	1996/7	1997/8	1998/9	Total*
Komati River Basin	32	92	70	**202**
Mbabane/Manzini road	80	40	0	**210**
Urban development	38	85	58	**212**
Total	**150**	**217**	**128**	**624**
Total as % of all expenditure	28%	38%	30%	**31%**

* Including expenditure in 1995/6 and after 1998/9

The Public Enterprise Unit (PEU) is part of the MoF. The PEU has as its responsibilities monitoring of public enterprises, provision of technical and advisory assistance where required, advising Cabinet on relevant issues and ensuring efficient operation of public enterprises. It was established in 1989 following an act of parliament.

There are a total of 20 public enterprises operating in the agricultural, transport, financial sectors as well as the three traditional public utilities: electricity, posts & telecommunications and water & sewerage. Although the overall operating surplus for all public enterprises has consistently been positive, a number of public enterprises experience operating deficits.

The PEU, in its early years, has focused on the collection and analysis of data on public enterprises. Its task of technical assistance has been largely performed through the contracting of consultants, which absorbed 25% of PEU's recurrent budget in 1995/6. The PEU has also been instrumental in establishing performance contracts for certain public enterprises, financial restructuring of public enterprises, negotiating management contracts with private sector firms as well as the establishment of a public enterprise loan guarantee fund.

An interim performance contract was signed with SEB in 1992. This contract specified targets for a wide range of technical and financial parameters for SEB. The interim performance contract lapsed in 1993 and although plans exist to sign a longer term one, this has not yet happened. Other performance contracts have been signed with Swaziland Posts & Telecommunications and the Water Service Corporation.

Financial restructuring, involving Government write-off of public enterprise debt or accumulated deficit has occurred. Such a capital restructuring was proposed for SEB in 1993. Two options were presented as being possible:

Restructuring option 1: Government converts SEB's foreign loans of E74 million to Government loans, which SEB must repay over 20 years at an interest rate of prime less 6%. The interest rate subsidy is to be used by SEB to finance ongoing capital works. Government raises additional debt to pay SEB's foreign loans. SEB is responsible for raising finance for the Eskom 4th feeder line.

Restructuring option 2: SEB discharges its foreign loans itself, by raising local loans backed by a Government guarantee. Government then gives SEB a direct grant of E50 million for the Eskom fourth feeder.

It is apparent that neither option has been fully implemented. SEB still has a foreign exchange debt of E68 million (although repayments have continued, exchange rate changes have acted to increase the debt), but Government has made provision for a grant of E50 million towards the cost of the Eskom 4th feeder.

In addition, the restructuring scheme proposed that existing Government loans to SEB be converted to an equity investment. This includes both E25 million which was given to SEB by Government to repay a IBRD loan, and E19.3 million in other loans. At present this conversion is noted in SEB's annual report, but the loans continue to be listed under the loan portfolio. Of the Swaziland Government loans, only numbers 5 and 7 continue to be repaid (close to E1 million was repaid on these loans in 1995).

B.1.1.4 Ministries of Health, Education, Works & Construction

The Ministries of Health and Education are important since they run the rural schools and clinics which will benefit from a rural electrification programme. The Ministry of Works & Construction is usually contracted by other ministries to undertake much of the maintenance and construction of rural facilities and consequently has an interest in electricity supply to rural areas.

There are over 300 health facilities throughout Swaziland. This includes 7 hospitals of which 5 are Government and 2 are mission facilities, and 12 health centres (mini-hospitals), of which 5 are Government, 2 are mission and 5 are industry facilities. Hospitals and health centres administer the clinics and outreach points, which together constitute the backbone of the primary health care system. Clinics offer full-time services to outpatients, although some clinics have a maternity wing with over-night facilities. Outreach points offer similar services to clinics, but are part-time and do not have health staff housed at the site. Substantially more than 70% of the population live within 8 km of a health facility, and immunisation levels are between 93% and 99%.

Table B.1.4: Rural Clinics
Source: Ntshangase 1996

		Number	Without grid electricity	Without piped water
Clinics	Government	48	10	14
	Non-Government	???	???	???
	Total	142	11	14

Basic energy services required at clinics include vaccine refrigeration, lighting, security lighting, water heating and cooking. At present, only a minority of clinics have radio-communication services where telephones are unavailable. Government clinics include nurses' accommodation and energy is required for lights, media, refrigeration, water heating, cooking as well as other domestic purposes.

Maintenance, rehabilitation and, in some cases, construction of rural clinics is being undertaken. This includes structural rehabilitation where premises have lacked adequate maintenance in the past, replacement of maternity units in rural clinics where necessary and the construction of new clinics at Lamgabhi, Bhahweni and Gucuka (all medium sized clinics with staff housing but without a maternity wing). In addition, budgets have been prepared to improve security at rural clinics and the purchase of equipment for health facilities. All budgets for these projects are contained within the Ministry of Health's capital allocation and do not form part of Works & Construction's budget.

The Ministry of Health contracts out construction work to the private sector, but has a small maintenance team within the Ministry capable of undertaking routine maintenance. The Biomedical Engineering Department operates from Mbabane Hospital and is responsible for the procurement and maintenance of medical and non-medical equipment at health facilities.

The Ministry of Education & Training (MET) operates a network of primary, secondary and high schools throughout the country and Table B.1.5 shows that there remain a total of 424 (58%) without electricity. If only secondary and high schools are considered, then there are 66 (38%) without electricity, of which 34 have neither electricity nor water. A further 32 non-primary schools have access to electricity but have inadequate water supplies.

The MET has capital budgets available for, among other projects, water supply to schools, rehabilitation of schools and construction of additional teachers' houses, school classrooms and science laboratories. No funds are directly allocated within the MET to the electrification of schools or teachers' houses.

All construction, rehabilitation and maintenance work is contracted out to the Ministry of Works and Construction, and the MET does not retain any capacity itself to undertake these tasks.

Table B.1.5: Government educational facilities in Swaziland

	Primary	Secondary	High	Total
Number	538	63	107	708
Without electricity	358	45	21	424
Without water	196	30	16	242
Without electricity or water	171	26	8	197
Average number of teachers	10.8	8.8	22	12.4
Average number of desks	158	208	413	203

The Buildings Section of the Ministry of Works and Construction (MOWC) is responsible for the construction, supply and maintenance of all Government buildings, except where individual ministries take responsibility for this. Although the Section has in-house professionals and construction teams, it also contracts out work, especially where large or specialised construction is required.

The MOWC operates budgets for, amongst other projects, the rehabilitation of Government facilities and the wiring of Government buildings. Between E2 million and E3 million per annum has been set aside for wiring projects, and although this focuses on internal wiring, it is also used for grid extension.

B.1.1.5 Rural water supply

The Rural Water Supply Board (RWSB) is a section of the MNRE, although prior to 1995 it was constituted as a project within the ministry. The Board is responsible for supplying potable water to rural households in Swaziland, and together with the Ministry of Health, is responsible for the provision of adequate sanitation.

The RWSB has four regional offices, plus a headquarters in Mbabane. In addition to technical and administrative staff, the RWSB employs in-house construction teams and community development officers. The latter are responsible for assessing the community commitment to any proposed water supply or sanitation project. The staff work closely with the rural health inspectors, particularly on sanitation provision.

Projects are divided into macro and micro schemes. The former generally supply water to 400 households or more and involve the construction of extensive pipelines and water treatment facilities. Micro schemes typically serve around 200 households and are primarily based on borehole pumps and spring protection projects. Pumping equipment at boreholes is generally handpumps, although there are limitations on the use of this technology where the water table is low and the number of households to be served is high. Where grid electricity is available, it is the preferred pumping technology, although there have been problems with arranging community payment for electricity bills. Together with the Energy Section, there have been a few photovoltaic pumps installed as pilot projects.

The next phase of water supply projects involves the construction of two macro schemes and at least 75 borehole projects. This project includes the provision of electricity lines where substantial pumping requirements warrant it. A rehabilitation project is also underway to restore water to 87 presently inoperable projects. Both a technical rehabilitation and a community training and motivation programme are planned.

Budgets for rural water supply projects cover capital costs. Communities are expected to manage and pay for the operation and maintenance of projects. This has two effects. Firstly, the RWSB's budgets can supply more people if low capital cost projects are adopted. Secondly, there are concerns about a community's ability to maintain and operate the supply system. Although the community development officers attempt to address this latter issue, it still poses problems.

Table B.1.6: Planned capital expenditure on rural water supply projects (E'000)

Code	Project	1995/6	1996/7	1997/8	1998/9
RWS V	6 macro & 80 micro schemes	1 659	175	0	0
RWS VI	4 macro and 34 micro schemes	0	24 000	30	0
RWS VII	Rehabilitation of old schemes	0	900	518	285
	TOTAL	1 659	25 075	548	285

Tinkhundla administration

The Tinkhundla Administration system, under the Deputy Prime Minister's office, provides for local level administration, local representation and should facilitate the "smooth evolution of Swazi socio-political and economic development". In addition, the Tinkhundla should assist in the co-ordination of Government and non-Government activities at the local level. However, the Tinkhundla system was only created in 1992/3 and most Government activities remain the function of line-departments.

The total number of Tinkhundla centres in the country is 55, each headed by an Indvuna and assisted by Bucupho/councillors. At present only 22 of the 55 Tinkhundla centres have physical structures and an investigation is being undertaken to assess the construction and rehabilitation needs of Tinkhundla. Budgetary estimates at present are to spend E4.4 million on the development of Tinkhundla centres over the next two financial years.

B.1.1.6 The private sector

Capacity exists in the private sector to undertake civil, mechanical and electrical engineering and construction work. Although many Government ministries and public enterprises retain in-house design and construction capacity, contracting out is common, particularly where projects are large, complex or if other work absorbs in-house capacity.

Most photovoltaic installations have been undertaken by a Swaziland company, Swazitronix, occasionally in collaboration with South African equipment suppliers (for example, the photovoltaic pumping installations). A recent initiative has been the establishment of a private-sector financing company to provide credit for the sale of solar home systems in Swaziland.

B.1.1.7 Select Committee on Rural Electrification (SCORE)

SCORE is a committee responsible for the planning and co-ordination of rural electrification projects. It is open to any private and public institution interested in supporting rural electrification and has had a wide ranging representation. Its terms of reference state that the scope of its work includes:

- rural electrification policy formulation,
- co-ordination of financing for rural electrification,
- definition of specific regional strategies,
- oversight of the implementation of rural electrification, and
- evaluation of the programme.

The structure of SCORE includes a Main Committee, elected annually, and an Executive Board comprising the Principal Secretaries of MNRE, Economic Planning & Development, Tinkhundla and Works & Construction. Representation on the Main Committee includes the following: Ministries of Natural Resources, Environment & Energy, Health, Education, Works & Construction, Economic Planning & Development, Tinkhundla, Agriculture & Co-operatives, Police, Defence. In addition, SEB is represented, and other invited members have included the

Assembly of Non-Government Organisations, UNDP and EEC Micro Projects Programme, Posts & Telecommunications and engineering consultants.

SCORE is envisaged to manage a set of sub-committees and suggestions for these have included focus groups on Technology, Finance, Surveys and Regional Strategies. In practice, SCORE has tended to operate only as a Main Committee with extensive representation.

Five pilot projects were identified and government funding obtained for the bulk supply. The total investment in all five projects (excluding any reticulation costs) is E1 137 350, as shown in Table B.1.7. The intention is that as each consumer connects, a connection fee will be charged and that if all potential consumers (including an estimated future growth in the number of potential users) connect, the revenue will be sufficient to recover costs. In addition, costs incurred during reticulation would have to be recovered in some, as yet unspecified, manner.

Table B.1.7: SCORE pilot rural electrification projects

	Kubuta	Sigombeni	Kashoba	Emvembili	Zandondo
Cost (excl retic)	E430 000	E245 100	E118 250	E129 000	E215 000
Potential number of connections at start					
Domestic	300	600	265	156	314
Commercial	30	7	6	6	10
Institutions*	8	8	5	5	5
Farms	30	0	0	0	0
Industry	5	0	0	2	2
Total	**373**	**615**	**276**	**169**	**331**
Suggested connection fee					
Domestic	E200	E200	E200	E350	E300
Commercial	E1 000	E1 000	E1 000	E1 000	E1 000
Institutions	E18 500	E12 000	E8 000	E10 000	E15 000
Farms	E3 000	n/a	n/a	n/a	n/a
Industry	E10 000	n/a	n/a	E3 500	E6 000

* Institutions means Government facilities (e.g. schools, clinics etc.)

B.1.1.8 Summary

The figure below illustrates the number of organisations with an interest in rural electrification.

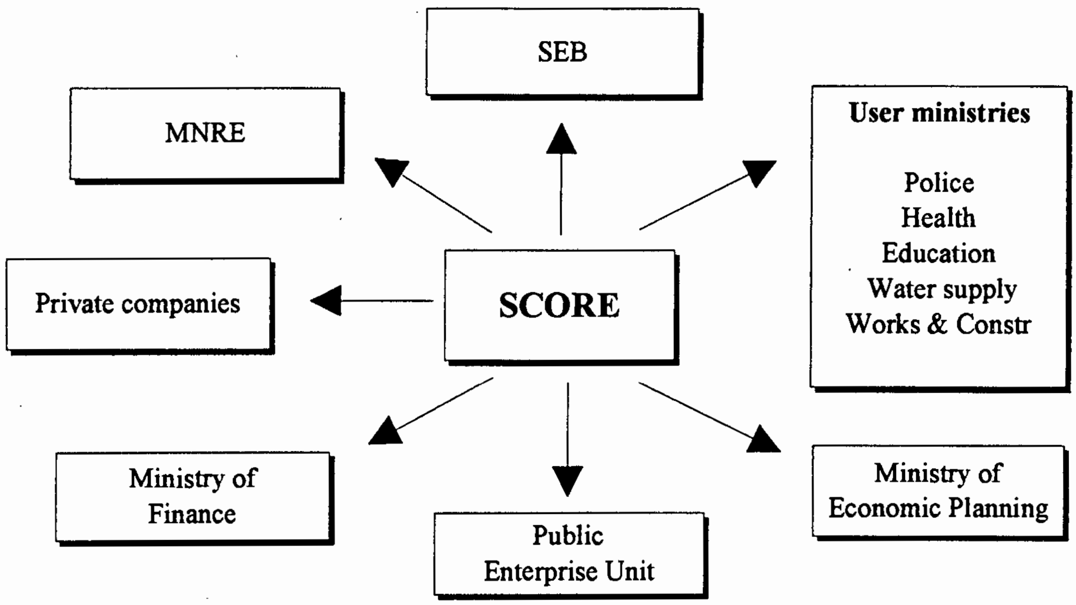

Figure B.1.1: Institutions with an interest in rural electrification

B.1.2 Identification of tasks

Rural electrification involves a number of distinct tasks. These include the following:

1) responsibility for raising and providing funding for rural electrification;
2) responsibility for planning electrification projects;
3) responsibility for implementing and operating the electrification programme;
4) responsibility for co-ordinating any off-grid electrification activities.
5) responsibility for monitoring the programme;

B.1.2.1 Funding of rural electrification

The funding options for rural electrification are discussed in more detail in Appendix B.2. This section examines the institutional implications of using the possible routes.

The costs of electrification must be recovered from some source. In essence there are three options available (although a combination of these options is also possible):

- **User charges:** through connection fees and tariffs;
- **Cross-subsidies:** from other electricity consumers;
- **Grants:** from Government or international donors.

User charges: If user charges are used, then it is likely that some form of bridging finance is required. For example, if customers are allowed to pay the cost of connection over a number of years, it is necessary for the utility to raise sufficient finance in order to cover the initial costs. This finance can either be arranged independently by the utility, or arranged by the Government.

Cross-subsidies: If cross-subsidies are used, two options are possible. One is to use "hidden" cross-subsidies, that is, the cross-subsidies are not made explicit to other customers, but surplus income is raised from these customers and used to cover losses on electrification projects. The second option is to place an explicit levy on electricity sales, and to earmark the revenues from this levy for electrification purposes. This second option may be implemented by keeping the funds within the utility and accounted for separately, or may be taken out of the utility and managed by Government (an off and on-budget difference).

Grants: If grants are to used to support electrification, then it is likely that support would be channelled through the MEPD, even if foreign sources were used. Thus it would be necessary for the Ministry to manage the disbursement of these funds.

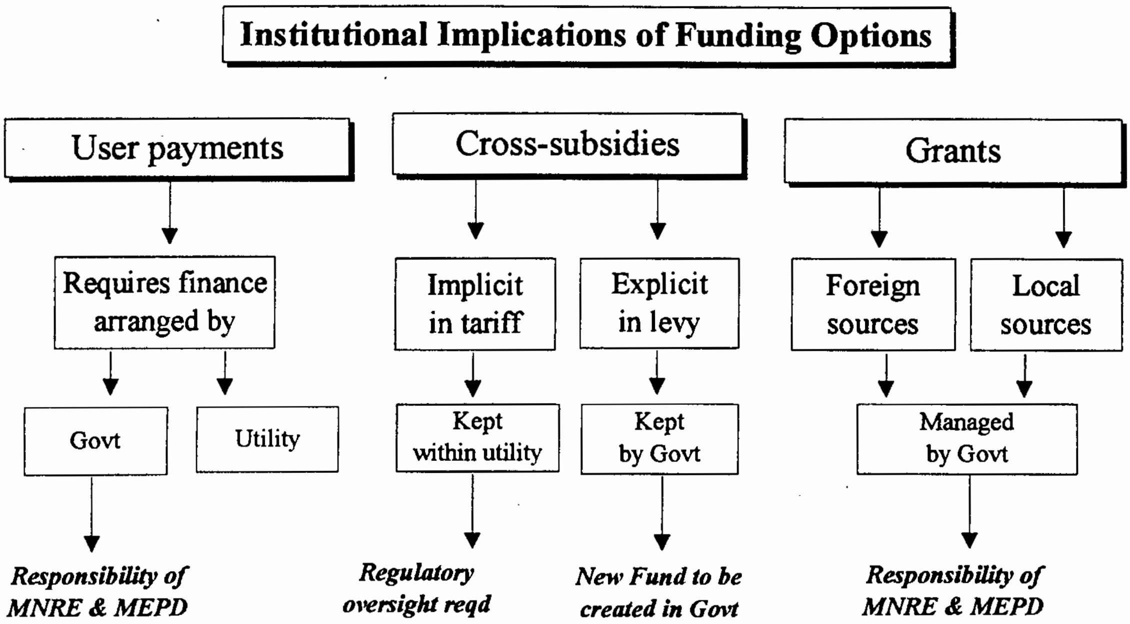

Figure B.1.2: Institutional implications of funding options

B.1.2.2 Planning issues

Although design, construction and operation are naturally largely the responsibility of the utility (with some portions of work being contracted out to the private sector), it is planning and financing where larger numbers of organisations are involved.

Firstly, the needs of potential users need to be taken into consideration when network expansion is planned. At one level this can take the form of the utility preparing quotes for line construction in response to individual requests. However, this system may fail to effectively co-ordinate different interests so that costs can be more easily shared.

Secondly, certain areas may be targeted for grid extension for "strategic" reasons, and it may be preferable to undertake active planning rather than passive responses to requests. For example, Government may wish to target areas where considerable growth potential exists, and where future projects are likely to emerge.

In order for electrification planning to adequately take into consideration different users' needs, it is important that institutional arrangements structure the involvement of these users. Within Government, the ministriess with an interest include health, education, rural water supply, Tinkhundla as well as other ministriess such as the police, nature conservation, and so on. Works and Construction, being responsible for Government buildings, has a direct interest as this ministry often assumes other ministry's responsibilities for electricity supply.

One of the possible financing options is for bulk extension to be at least partially, if not completely, paid for by user payments. Thus, in order to embark on projects where there can be a reasonable expectation that costs will be recovered, it is necessary to match electrification planning closely to the needs of those likely to pay for it. Further, there must be public awareness of the planning arrangements so that potential users, including the private sector, are aware of the opportunities and costs of participating in the grid extension programme.

The orientation of rural electrification to meet "strategic" goals has slightly different implications. Firstly, such projects require the identification of potential sites, which requires a good overall analysis of development opportunities and initiatives in Swaziland. Although this planning project hopes to achieve this as at the end of 1996, there will always be the need to update and change plans in response to a changing environment. It is necessary to identify the organisations to lead and participate in this process.

Secondly, these future electrification projects may not, at present, have a high density of load or possible users. As such, it may not be possible to rely on existing users to pay for much or most of the line extension. Either substantial subsidies or bridging financing may be required. Related to this is the higher risk that such projects may entail, both in economic and financial terms. If demand fails to grow as originally estimated, subsidies will have been wasted, and the project may result in financial losses to the utility (if the utility undertook some of the financial risk). Consequently, special consideration must be given to the financing of such projects.

The establishment of SCORE was intended to provide an institutional vehicle which would drive rural electrification. Two factors appear to have inhibited the successful operation of SCORE. One has been the lack of information on which to base planning decisions. This inadequacy should be addressed by phase 1 of the rural electrification planning project. A second concern has been the size of SCORE, which has made it unwieldy for detailed planning work. It is clear that some intervention is required to improve the functioning of SCORE.

The options available are listed below:

- **SCORE acts the planning forum**
  SCORE is a forum where most of the interested parties are represented. One of its original functions was deemed to be a co-ordination and planning of rural electrification. However, the committee is probably too large to act as a suitable forum for detailed planning. In addition, it would be necessary for one agency or person to champion the planning work.

- **Establish a planning sub-committee of SCORE**
  It is possible to constitute a planning sub-committee of SCORE which would undertake the rural electrification planning work. One possible structure would be for the MNRE and the utility to be responsible for driving the planning work (as a SCORE sub-committee) and to be responsible for consulting other parties as required. The advantages of this are firstly that a smaller and more manageable forum is established (whilst maintaining accountability to a larger forum), secondly that one or two individuals are identified with the responsibility of driving the planning process, and thirdly that parties without a direct interest in planning issues are not required to attend meetings.

- **The utility undertakes planning**
  A third option is to leave the planning up to the implementing utility. The advantage of this is that planning is situated close to the implementing agent. However, utilities themselves have capacity constraints and this option reduces the opportunities for co-ordination of different interests. Further, if Government funds are being used for electrification, it is likely that more direct involvement of Government agencies would be required.

- **Planning functions are contracted to consultants**
  As with the current electrification planning project, it is possible that planning functions can be contracted out to consultants. This has the advantage of resolving capacity constraints in the utility and Government, but has cost implications. Further, it reduces the opportunity for more inclusive participation in planning by local agencies.

- **The MNRE undertakes planning functions**
  It is possible that the planning functions are allocated to the MNRE. There may be pressure to do this if Government funds are used for the programme, and if the utility remains at arm's length from detailed planning. Further, the original intention was that the electrification maps and financial models (essentially planning tools) would be handed over to the MNRE. However, the MNRE has capacity constraints, and this approach would probably require the creation of a new position at the Energy Section.

- **A MNRE member of staff is seconded to work at the utility on planning RE**
  A variation of the above option is to create a new post at the MNRE, specifically for rural electrification, and to have that person based at the utility. This would mean that the planning work would be closer to the utility, and would ensure that the person would not be distracted by the many other functions of the MNRE.

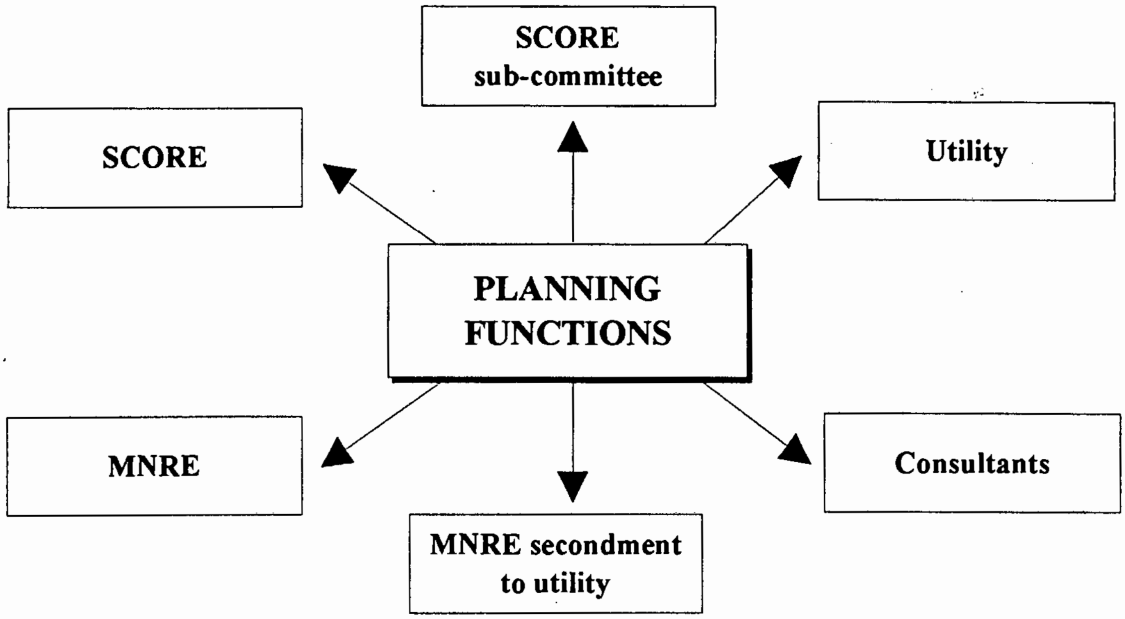

Figure B.1.3: Institutional options for planning

B.1.2.3 Implementation of rural electrification

Implementation comprises of project management, construction and commissioning of grid extension lines, as well as reticulation schemes. The institutional options available are as follows:

- **SEB implements the programme, using its own resources**
  One option is to task SEB with the job of implementing the rural electrification programme. SEB has in-house line construction teams available, and may be in a position to project manage the programme as well as construct lines and do connections.

- **SEB implements the programme, using contractors and consultants**
  A variation of the above programme is for SEB to project manage the programme, but to contract out much of the construction to the private sector. This may be necessary if the workload exceeds in-house capacity. Further, it may even be necessary to contract out the project management functions.

- **The MNRE commissions contractors and project managers**
  It is possible that, if Government funds are used for the full capital costs of supply, that the MNRE directly contracts consultants to manage the electrification programme. The project managers than make use of private-sector contractors to do the construction.

- **A new rural electrification agency is established**
  If it is felt that it is inappropriate that SEB undertakes the rural electrification programme, then it may be possible to create a new utility, or a new rural distribution division within SEB. If this option is adopted, then it is likely that such a new institution would be tasked with the responsibility of implementing the programme, probably using private contractors. If the new institution is separate from SEB, than the initial costs of establishing such an agency are likely to be high. Further, there may be problems attracting suitably qualified staff and management to run the new organisation. These issues are discussed in more detail below.

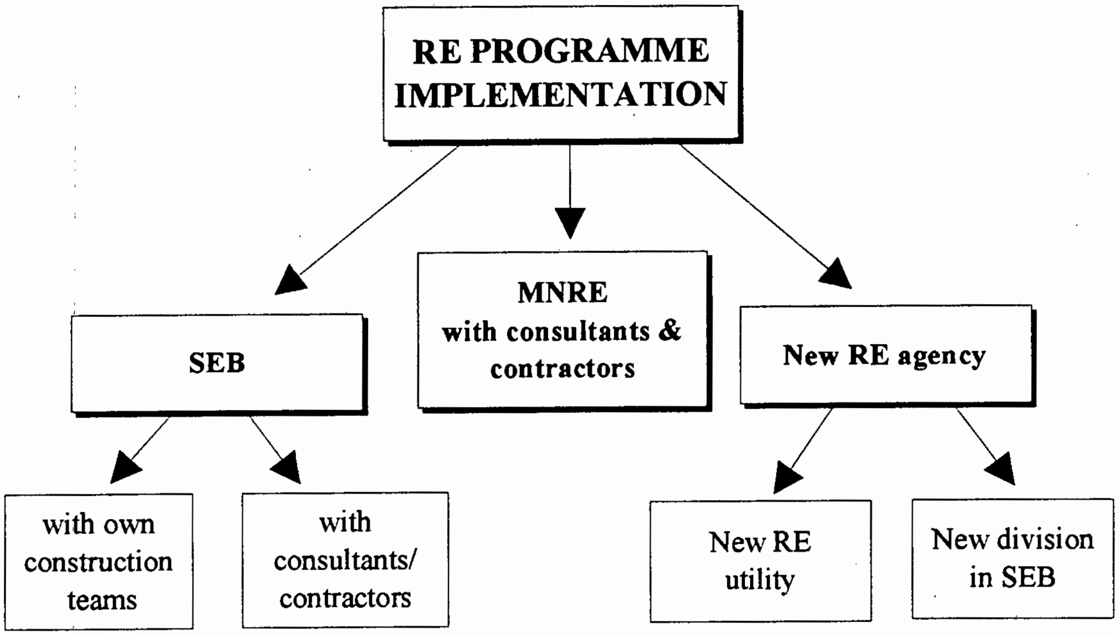

Figure B.1.4: Institutional options for implementation

B.1.2.4 Operation of rural electrification

Operation of rural electrification involves the maintenance of equipment, meter reading and billing, revenue collection, marketing, financial management, and other functions commonly associated with the operation of a distribution utility. If the funding arrangements require that the utility undertakes some of the risk of rural electrification (e.g. if some of the capital costs are recovered through the tariff), then operation includes management of this risk and responsibility for loans.

The four institutional options available are as follows:

- **SEB**
  The most straight-forward option is for SEB to undertake the rural electrification programme as part of its normal distribution activities, utilising existing billing systems, staff etc.
- **A new rural distribution agency within SEB**
  A second option is for SEB to create a new division within itself specifically to undertake rural electrification projects. Although this may have the advantages of ring-fencing rural electrification and of providing a focus for staff, it may imply additional costs. Further, the establishment of such a division is a matter of concern for utility managers, and is strictly beyond Government's jurisdiction. If rural electrification is assigned to SEB, then SEB management may prefer to take a decision based on their own assessment of the advantages and disadvantages of internal restructuring.
- **A new rural distribution utility, separate from SEB**
  A third option is to create a new rural distribution utility. This may be necessary if SEB is unable to take on the responsibilities of Government's proposed programme. However, if such an agency is to be financially viable, it will require the revenues of existing rural customers, in addition to new connections within the electrification programme. Not only will the start-up and transaction costs associated with this be large, and the availability of qualified staff questionable, but the idea amounts to a substantial restructuring of the electricity industry in Swaziland. Such a restructuring goes beyond the issues of rural electrification and would require careful consideration by Government.

- **A private management contract**
  A final option is the contracting of rural electrification operations to the private sector. This may take the form of a management contract to a group able to manage operations and maintenance. However, it is likely that the financial risk associated with the programme would have to remain with Government, unless substantial tariff increases are allowed. This option would probably increase costs, and there is concern that there may not be sufficient private sector capacity in Swaziland to undertake the task.

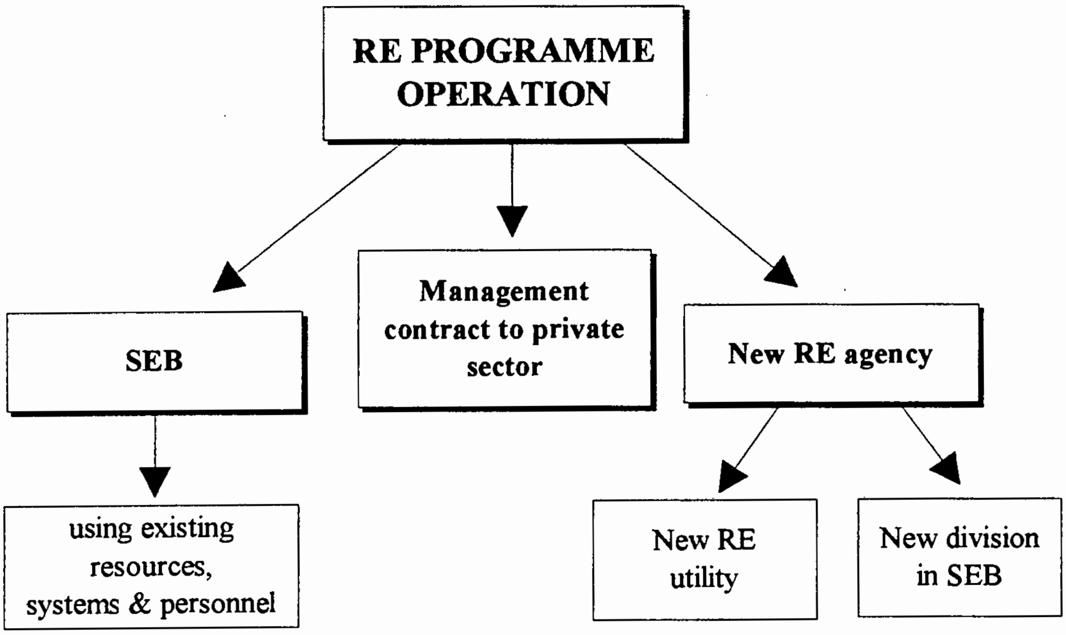

Figure B.1.5: Institutional options for RE operation

B.1.2.5 Implementation and co-ordination of off-grid electrification

The rural electrification planning project has also considered the use of off-grid systems, mainly for schools and clinics. The following recommendations are made concerning institutional issues relating to this programme:

- A programme for the dissemination of solar home systems is being planned by the private sector. It is recommended that this be left to the private sector with minimal Government or utility involvement.
- The implementation of the clinic off-grid programme should include the use of project managers, and this should be budgeted into the total costs.
- Contracts awarded on tender should be inspected and commissioned by the project manager prior to acceptance.
- Maintenance is a key issue, and until adequate capacity is built up within the relevant ministries, it will be necessary to arrange maintenance contracts with private contractors. For clinics, it is likely that extending the diesel maintenance contract to include maintenance of batteries would be most cost-effective.
- There are benefits to be gained from co-ordination of maintenance contracts and sharing of experience. The Solar Energy Committee of the MNRE is recommended as the optimum forum for this. The planning group of SCORE should be able to present any changes in the grid extension programme to this committee, and this should assist in the development of off-grid electrification plans.

B.1.2.6 Monitoring and evaluation

A number of different monitoring and evaluation options are available, as described below.

- Firstly, SEB is required to prepare an annual report for the Minister of MNRE and this report should cover details of the rural electrification programme.
- Secondly, the PEU has the responsibility of overseeing SEB, and this oversight should include monitoring of the programme, and the financial impact which it will have on SEB.
- Thirdly, SEB and the planning group will be required to report progress to bi-annual or quarterly meetings of SCORE.
- Lastly, it is recommended that the MNRE commission an evaluation study in 1999 to assess the impacts of the rural electrification programme.

It is further recommended, should SEB undertake the programme, that the targets and committments of the rural electrification programme be incorporated into the new performance contract between SEB and Government. This would entail a set of proposed connection targets, principle electrification sites, and committments from Government for funding.

B.1.3 Conclusions

The paper has summarised the relevant institutional arrangements in Swaziland, and has identified the different tasks involved in the rural electrification programme. For each task, the different options available have been spelt out. In each case, a decision must be made concerning the extent to which Government assumes responsibilities, and the extent to which it delegates the responsibilities to a different agency. At the bottom of many of the options is the question as to whether SEB should be responsible for the rural electrification programme, or whether a new agency, or existing Government institutions should be made responsible. Ultimately, Government must make decisions on which option it wishes to implement, and meet the consequent financial obligations.

Appendix B.2
Rural Electrification Funding Options

The success of any rural electrification initiative will be determined by the nature and availability of finance. The issues to consider are (1) the source and terms of financing; (2) the structure and level of revenue; and (3) availability and structure of subsidies.

In this context, financing refers to both investment capital for project construction and working capital to cover any operating losses sustained on new projects. Revenue refers to user payments from connection fees, energy sales and any special line extension charges. Lastly, subsidisation refers to both grants and cross-subsidies from other consumers.

B.2.1 Financing needs

Financing is required for three activities:

- Capital for distribution line (11 kV) extensions,
- Capital for reticulation projects, and
- Funding of any operating losses.

B.2.1.1 Distribution line extensions

Although there are a number of areas where reticulation projects can be undertaken without distribution (11 kV) line extensions, many projects will require such extensions. All five rural electrification pilot projects have required 11 kV extensions and costs have varied from E430 000 (26 km extension in Kubuta) to E118 250 (7 km extension in Kashoba). On average the line extension costs were E227 000, which is equivalent to E680 per ***potential*** customer.

Although reticulation costs may well constitute the bulk of the total costs for an electrification project, the pilot studies indicate that roughly 20% of capital costs will be due to line extension. More importantly, whereas reticulation costs may be incurred over an extended period as customers gradually connect to the grid, line extension costs will be incurred at the start of the project and, in the early years will supply only a small customer base.

B.2.1.2 Reticulation costs

Reticulation costs refer to the step-down transformers, the low-voltage reticulation infrastructure and the household connections (including the meters). Typical costs estimated by Capricon are E2 500 to E3 000 per connection, depending on the density of settlement.

If all potential customers in the pilot projects connect to the grid, then the total reticulation costs will be approximately four times the distribution line extension costs, i.e. reticulation will account for 80% of all capital costs. In practice, connection take-up rates of significantly less than 100% will reduce the cost of reticulation and will stagger the reticulation expenses over a fairly long time period. Nevertheless, reticulation costs can be expected to be high.

B.2.1.3 Operating losses

Although careful selection of rural electrification sites can reduce operating losses, it is likely that many projects will experience financial losses, particularly in the early years. If capital costs and interest on capital are recovered through special charges (or subsidised), then it is possible that projects will eventually earn a surplus from electricity sales. However, consumption in rural areas is likely to grow only slowly, meaning that SEB will be likely to sustain losses, at least in the early years.

The actual losses will be sensitive to estimates of consumption growth. Figure 1 shows the monthly operating surplus/loss per customer as a function of consumption[1]. The break-even point is around 300 kWh/month and it is likely that, in rural areas, consumption will be below this. Naturally, if non-domestic consumers are in the area and if their consumption is high, then their revenues will help reduce losses. But this is in effect a cross-subsidy from non-domestic to domestic consumers.

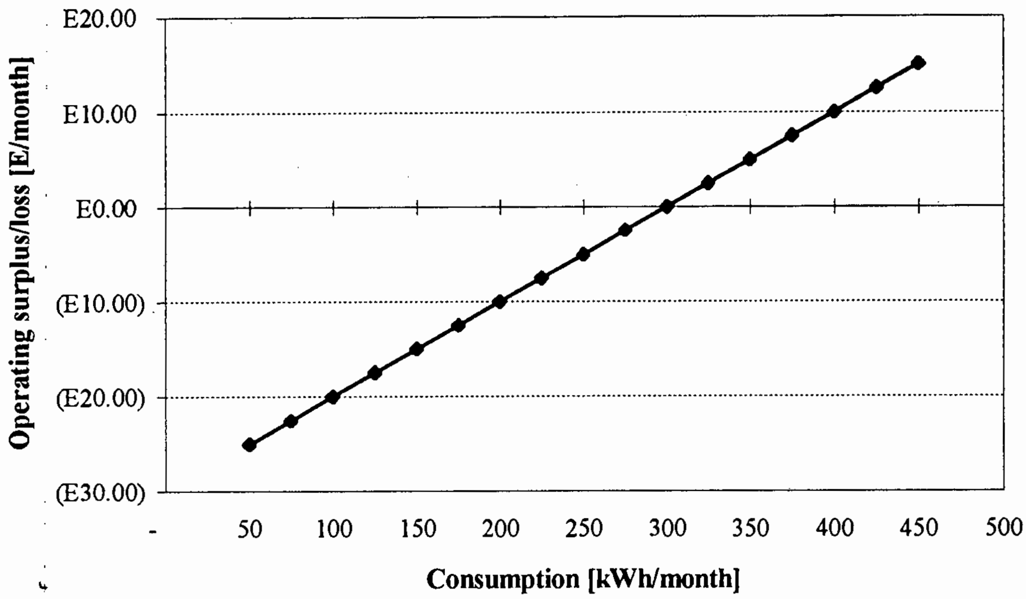

Figure B.2.1: Operating loss/surplus as a function of consumption

The pilot rural electrification projects have had an average of 300 domestic customers and, if early losses are in the region of E20/customer per month, this implies an average annual loss of E72 000 per project. This annual loss is in the order of 30% of line extension costs and so is not insignificant. If interest were charged on capital and if depreciation were included in the calculation, losses would be even greater.

Table B.2.1: Financing needs

Financing need	Characteristics	Typical costs
Line extension	Investment required at the start of project	E100 000 to E400 000 per project
Reticulation	Can be staggered over a number of years	E2000 to E3000 per customer
Operating losses	Should decrease over time as consumption increases	E10 to E12 per domestic customer per month

In summary, the financial position of rural electrification for domestic consumers looks poor. Although some projects may be financially viable as a result of targeting larger users, household electrification will suffer operating financial losses.

1 This assumes supply costs of 15c/kWh supplied plus E35/month per customer, and revenues of 25c/kWh. Note that depreciation and any interest on capital are ***excluded*** from this and if these costs were to be included, monthly losses would be substantially higher.

B.2.2 Metering options

Before considering capital redemption options, it is necessary to consider possible metering and billing systems, as these affect the way in which charges can be levied. Three basic forms of metering and billing are described below: credit metering, prepayment, and flat rate.

B.2.2.1 Credit metering

A conventional credit meter allows a flexible tariff to be charged. It is possible to charge any combination of a monthly service fee, an energy charge (fixed or block rates) and a monthly line extension fee. A tariff can be structured to recover a utility's fixed overhead costs (through the service fee), the variable costs (through the energy costs), and depreciation and finance charges on line extension (through the line extension fee).

SEB already runs a credit metering and billing system and this can be used to implement all three charges. The disadvantage of this system is that individual meters must be read and bills delivered. In addition, the utility must arrange appropriate revenue collection sites. All three tasks (meter reading, billing and revenue collection) are more costly in dispersed and remote rural localities. In addition, rural consumers may pose a higher risk of building up arrears, particularly where incomes are irregular.

A variation of the traditional credit metering system is the point-of-sales billing-system. This is where meter readers issue bills as they read the meters. Payments must still be made at a central revenue collection point. This system is suitable for rural areas where many households do not have postal addresses, and where the postal system may be irregular.

B.2.2.2 Prepayment metering

A prepayment meter requires that users purchase electricity tokens (either cards or number sequences) from a dispensing/revenue collection point. The tariff usually associated with this type of metering is a fixed energy charge with no service fee or monthly line extension charge. However, surcharges on the energy tariff can be used to recover the overheads as well as the capital costs.

A wide range of prepayment meters are available on the market. The basic choice is between a card meter or a number-pad meter. Although number-pad meters are less prone to insect and dust penetration, the generation of number sequences in remote revenue-collection sites can present a problem. A card distribution system, where cards are issued centrally and distributed to sales points, may be easier logistically in rural areas.

Due to widespread tampering with prepayment meters in South Africa, a number of variations have been developed. In addition to various innovations to make tampering more difficult, split meters have been developed where much of the meter is located on a pole outside the home. In addition, meters with radio communications to a base station have been developed, although there is a cost premium attached to this, as well as difficulty in implementing a radio-linked system in rural areas.

Prepayment meters also differ in the interface with the user, with a range of interfaces and information display options available. Households tend to prefer a system which allows them to monitor small amounts of electricity consumption more closely.

B.2.2.3 Current-limited supplies & flat-rate tariffs

Current-limited supplies include a current-breaker which trips the supply when the load exceeds a certain limit. If the limit is set at 2.5A, this means that only very low power appliances can be used (lights, radio, television and possibly a small iron). This, in turn, means that the maximum monthly consumption is likely to be low and so the utility can charge a flat rate (a fixed monthly sum) with only a small risk of losing money on electricity consumption. As soon as the limit reaches 5A or more, thermal appliances can be used, and the potential for consumers to use large amounts of electricity increases and so metering and an energy-related tariff is required.

Although current limited supplies may meet many rural residents' electricity needs, their use poses a number of problems in practice. Firstly, customers tend to dislike them due to the current limits and their perception that the tariff is unfair, since it does not relate payment to consumption. This dissatisfaction is likely to result in poor levels of payment. Secondly, many rural households rely on irregular or non-monthly incomes, and so the payment of a regular sum can present a practical problem (such households tend to prefer a system where they can regulate their consumption and expenditure closely). Thirdly, the collection of a monthly sum can pose logistical problems in rural areas. Lastly, irregular payments mean disconnections must be made - itself an additional expense and an inconvenience for both the user and the utility. Although radio-controlled disconnection systems are available, they significantly increase the cost of the meter, and thereby negate one of the main reasons for opting for current-limited supplies.

B.2.2.4 Other meters

A number of other meters are available. One example is a meter which credits the user a fixed number of units per day. This removes the need to read a meter and allows a flat rate (fixed monthly fee) tariff to be charged, without the restrictions imposed by current limiters. However, the cost of such meters is approximately the same as prepayment meters, which are more flexible and more suited to users' needs.

Some current limiters have been designed which allow users to use (say) 2.5A most of the time, and (say) 10A for a limited period per day (e.g. for a total of 15 minutes spread over the day). This allows a flat rate (fixed monthly fee) tariff system to be implemented, but removes the restriction that users cannot use kettles or irons for short periods. However, such meters are not much cheaper than prepayment meters which again are more flexible.

Table B.2.2: Tariff options

Meter type	Tariff options	Characteristics
Conventional	Basic, energy & line extension	Requires meter reading & billing Cheap to install & is used by SEB Vulnerable to arrears build-up
Prepayment	Energy only	Requires card distribution system No need to read meters & bill customers More expensive No risk of arrears (although theft may occur) Revenue is completely dependent on consumption
Load-limited	Basic only	No meter reading required Revenue collection may still be a problem Cheap to install Restricted use - may result in dissatisfaction Only very low tariff can realistically be charged
Other	Mixed	Mostly not cheaper than prepayment

B.2.3 Sources of income

A distinction is made here between income and financing options. The former refers to funds which can recover the costs of electrification projects. The latter refers to loans or equity investments which can be used to provide capital for projects, but must ultimately be recovered from funding sources.

There are three possible sources of income: user payments, cross-subsidies from other consumers, and direct subsidies, either from the Swaziland Government or donors.

B.2.3.1 Government grants

Government may be willing to provide grants for electrification. However, other priorities together with growing constraints on Government budgets, may mean that such contributions are limited. In particular, the demands of the Komati River Basin scheme, the Mbabane/Manzini road, and the urban development projects mean that in the medium term there is limited scope for expensive new capital projects.

B.2.3.2 Foreign grants

Foreign donors may be willing to provide grants towards the cost of electrification projects. An example is the counterpart fund where an annual amount of approximately E2.8 million (in 1995/6) is provided for investment by SEB. Some of this may be used for rural electrification.

B.2.3.3 Cross-subsidies

Cross-subsidies from urban and other large users may be used to cross-subsidise electrification projects. A 1c/kWh levy on all consumption would raise approximately E6 million per annum. However, additional real tariff increases are likely to meet with substantial opposition from commercial and industrial users. They would also impose additional input costs on industry, adding to inflation and eroding their competitiveness.

B.2.3.4 User payments

These include connection fees, monthly line extension charges as well as surcharges on the energy tariff.

Connection fees: These fees recover costs quickly and represent the least risk and impose the lowest financing burden on the utility. If connection fees reflect the full, or at least a large portion of the true costs of providing a supply, they will be high and this will prevent the majority of potential users from obtaining a connection.

Where Government facilities such as schools, clinics, police stations etc., are connected in a project, the relevant Ministry may be willing to pay for a substantial portion of the total project capital cost up-front. This form of user payment represents an important source of funding.

Monthly line extension charges: These can be calculated so that the utility receives an adequate return on the capital investment, i.e. revenues will match depreciation and finance charges on capital invested. These charges imply low risks for the utility, i.e. revenues are not linked to consumption, but may be perceived to be excessive for users who only consume a small amount of electricity per month. There are significant risks of arrears building up if the monthly fee is too high for households, small farmers and small shops. Monthly extension charges can only be levied where there is a billing system (as opposed to a prepayment system).

The use of line extension charges requires the utility to raise finance to cover the costs of supply. However, if customers do not build up arrears, the utility can be expected to earn an adequate return on this investment.

Tariff surcharges: The surcharge on the tariff can be calculated so that the additional revenue generated is sufficient to meet the revenue requirements of depreciation and finance charges. However, tariff surcharges have two effects: (1) adequate revenue is only generated some years later when consumption has grown; and (2) there are high risks for the utility if consumption is lower than predicted. These risks are particularly high in Swaziland where there is only limited data on which to base consumption predictions, and where the South African experience of high levels of electricity theft may be repeated. Tariff surcharges can be levied with credit metering and with prepayment metering, but not with flat rate (fixed monthly) tariffs.

As with line extension charges, tariff surcharges require the utility to raise finance to cover the initial costs of providing the supply. This system, although risky for the utility, is progressive in that low electricity consumers (who are presumably poor) pay less towards the cost of providing the supply.

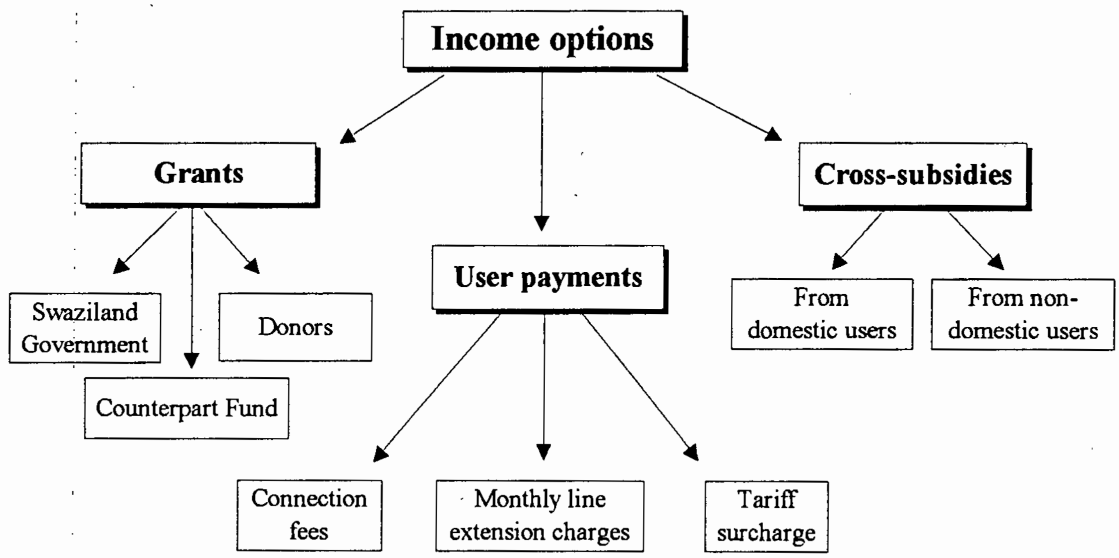

Figure B.2.2: Income options for rural electrification

B.2.4 Financing options

Where connection fees and grants do not cover the full costs of the project, "bridging" finance will be required. Possible sources include Swaziland Government loans, concessionary loans from foreign sources (including the DBSA), utility equity finance (i.e. self-finance), and commercial credit.

B.2.4.1 Government loans

Government may be in a position to lend funds to the utility for the purpose of electrification. Concessionary rates on such loans may reduce the finance charges on electrification.

B.2.4.2 Concessionary finance

Much of SEB's loan portfolio is on concessionary terms, and there exists the possibility of raising additional capital on easy terms. However, lenders are likely to be sceptical of rural electrification projects and many traditional sources of concessionary finance (e.g. DBSA) are now charging much higher rates.

B.2.4.3 Commercial credit

Commercial finance may be available on the strength of a utility's overall accounts. However, such finance typically means fairly high finance charges. A public enterprise loan guarantee scheme exists whereby the Swaziland Central Bank guarantees 65% of the loan, provided the interest rate is 1% above prime (currently 18.75% in Swaziland[2]). However, to date the loan guarantee scheme has been under-utilised as public enterprises appear to have been able to obtain loans at rates better than this.

B.2.4.4 Utility equity finance

A utility may be able to utilise surpluses and depreciation provisions to invest in electrification. Depending on rate-of-return requirements, such investments may prove more or less expensive than other forms of finance. They do however, carry no foreign exchange risk which foreign loans, even if on concessionary terms, would.

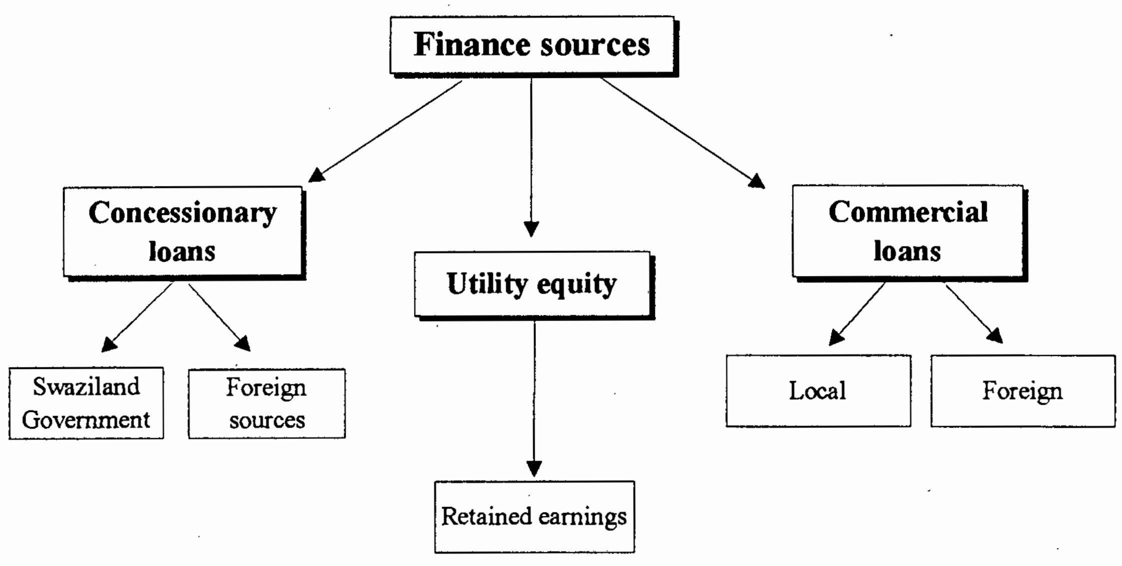

Figure B.2.3: Financing options

B.2.5 Funding mechanisms for distribution line extensions

Distribution line funding should be considered separately from reticulation projects for a number of reasons. Firstly, substantial costs are incurred up-front and revenues in early years may be less, especially if take-up rates are low. Reticulation costs, on the other hand, are incurred slowly over a number of years and are always directly linked to new connections. Secondly, it is not always easy to directly calculate a "fair" line extension charge to a user for two reasons: firstly many other users may connect later and so benefit from the original investment, and secondly, it is not always reasonable to allocate the costs of the line extension to one set of users when future additional line extensions may benefit new groups of consumers.

The section will describe a number of different, although often complementary, financing options for line extension.

2 As at October 1996. There have been a number of interest rate fluctuations this year.

B.2.5.1 Connection fees

Cash payments from users may contribute towards the costs of grid extension. However, if it is expected that the number of users will grow slowly over time, and if required revenues are spread over all likely connections, then financing will be required. The proposals for financing the pilot projects is based on this method. Government provided the original capital, and connection fees are meant to completely recover the costs. However, the connection fees proposed assume that all existing residents and other consumers take a connection, as well as anticipated new residents and businesses. These assumptions are highly optimistic and it is unlikely that all the capital loaned would be recovered in this way.

An alternative is to charge connection fees based on much less optimistic assessments of the number of future connections. Unless the assumptions are very conservative (i.e. the costs are based on only a small percentage of consumers connecting, which will easily be achieved in the first year), this will still imply the need to raise capital to finance the original investment. However, the more conservative the assessment, the higher the connection fees have to be. Given that additional fees may have to be charged to recover reticulation costs, the connection fee may present too high a barrier to connection.

The pilot rural electrification projects calculated a household connection fee (to cover line extension - reticulation would incur additional fees) of between E200 and E350 per domestic connection, and much higher fees for businesses and Government buildings. The differences were based on the principal that the cake of costs should be sliced into unequal sized portions for different categories of consumers. However, the determination of the size of the slice was rather arbitrary.

The household connection fees were based on 130% of all households connecting (i.e. a 100% take-up rate was assumed, together with a 30% household growth after 10 years). Table B.2.3 shows how much the connection fee would be if lower take-up rates were assumed. It can be seen that domestic connection fees have to increase dramatically if lower (and more realistic) take-up rates are assumed.

Table B.2.3: An example of the increase in domestic connection fees as take-up rates decline

Take-up rate	130%	100%	75%	50%	25%
Connection fee	E300	E390	E520	E780	E1 520
Increase over original assumption, i.e. 130% take-up	0%	30%	73%	160%	420%

The pilot projects heavily weighted the costs of line extension onto commercial, industrial & agricultural (where they exist) and Government users. For example, commercial users are to be charged E1 000 to connect, Government users are charged between E8 000 and E20 000 with similar fees for industrial users. Given that the costs of alternative (solar and diesel) systems for government buildings and larger shops are likely to be even higher than this, there is scope to extract high payments for grid connection from Government and larger enterprises (in addition, these users are likely to connect immediately - so reducing the need for long-term finance), and so reduce the costs for other users.

If connection fees cover all or a large portion of the costs, there is the problem of how much subsequent users should contribute. If these users are charged much lower amounts, this may cause users to refrain from connection until others have paid their fees. In addition, those who have paid may be reluctant to allow others to connect, perceiving that the line "belongs" to them. If subsequent connections also pay high connection fees, this may be perceived as "fair" but will mean that the utility has overcharged for the line extension. Another option is to charge high connection fees, but to rebate the original users. Although this would provide an incentive to promote new connections, the practicalities and precedent for making rebates may make this option impractical.

B.2.5.2 Monthly line extension charges and tariff surcharges

Connection fees may be used to recover only a portion of the capital costs of grid extension, with the remainder being recovered through charges over a longer period. The options of monthly line extension fees and tariff surcharges have been discussed above.

Given the uncertainty which exists around the future number of consumers, there are problems in actually setting the monthly fee. If assumptions are optimistic, then the utility under-recovers its costs; if the assumptions are pessimistic, then the utility overcharges. One option is to commence with pessimistic assumptions, and as more consumers connect, the monthly charge can be reduced. This solution would be perceived to be equitable, would reduce the risks for SEB and would provide incentives for new connections. However, it would impose an administrative burden as the billing amount for each project would have to be adjusted each time batches of new consumers connected.

Tariff surcharges are sensitive to both the number of future consumers as well as the level of actual consumption. Again, if optimistic or pessimistic assumptions are made, this will result in under-recovery or over recovery respectively. The option of starting with pessimistic assumptions and reducing the surcharge may prove complex to implement. However, one option may be to start with pessimistic assumptions, and retain the surcharge until sufficient capital has been recovered. If growth is low, then this may take the planned time of say 10 years, and if growth is high, the surcharge can be removed earlier.

Figure B.2.4 shows the tariff surcharge for different assumptions on consumption and take-up rates for the Kubuta pilot project. It can be seen that the surcharge increases with lower take-up rates and decreases with higher consumption. An affordable tariff surcharge is probably less than 10c/kWh, which would mean that take-up rates would probably have to be between 50% and 75% for expected consumption levels of around 150 kWh/month. It should be noted that this surcharge is for a line extension cost of E117 000 for 300 potential domestic consumers (E390 per potential connection) only and does not cover the much higher costs of reticulation.

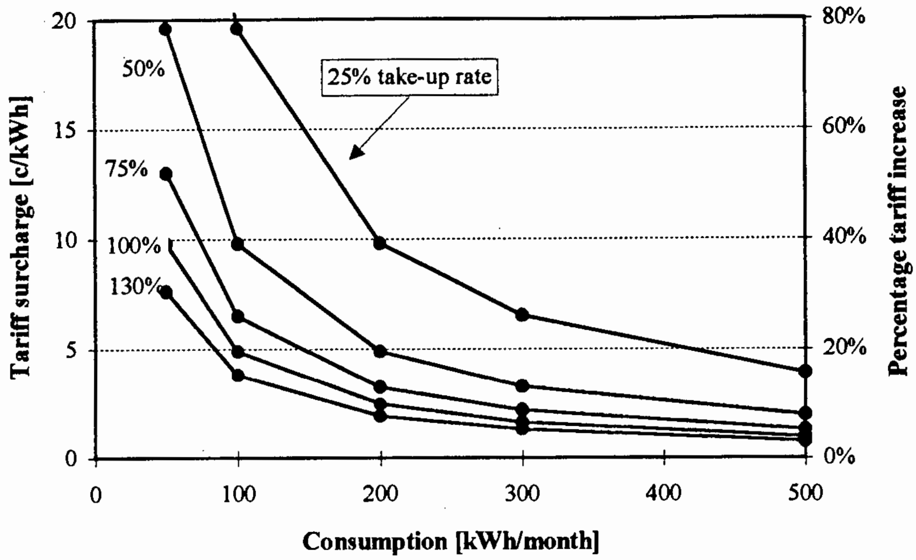

Figure B.2.4: Domestic tariff surcharges for line extension costs in Kubuta (assuming 8% real interest rates on finance)

B.2.5.3 The effect of subsidies

Subsidies from Government, other electricity consumers or donors (possibly in the form of concessionary loans) would bring down the level of user fees. The size of subsidies would determine the level at which user fees could be pitched. The reduction would be in direct proportion to the availability of subsidies. For example, if line extension was subsidised by 50%, user fees would halve.

The level of subsidisation may dictate the pace of the line extension programme. If user payments are set according to estimates of ability to pay, then the subsidy (if available) could be used to top up utility revenues. The extent of subsidisation would then directly set the pace of the programme.

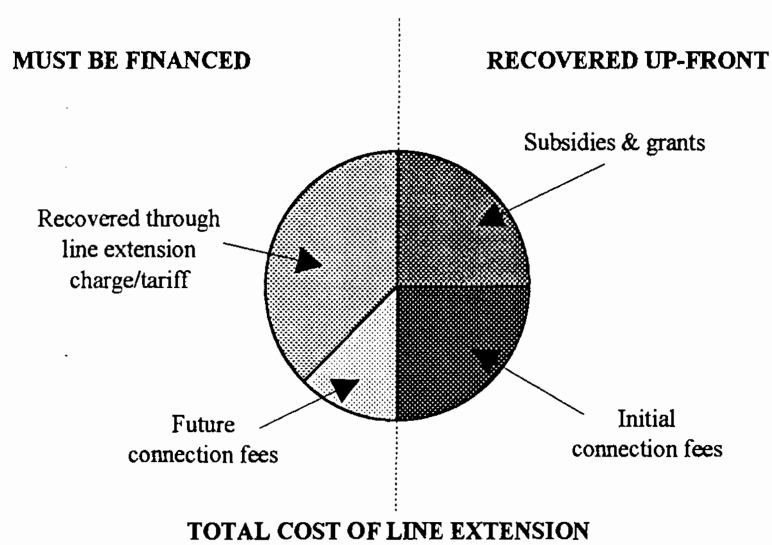

Figure B.2.5: Schematic representation of funding options

B.2.6 Funding mechanisms for reticulation projects

The financing and cost recovery options for reticulation projects are similar to those for line extension, with the exception that it is easier to calculate the cost per connection.

If SEB continues with its policy of encouraging "group schemes", then the costs for each group can be calculated with accuracy, and divided among the group.

Again, the options of connection fees, monthly charges and tariff surcharges are possible, or a combination of the above. As with line extension, there is the need to provide incentives for existing consumers to encourage new consumers to connect. This is best achieved by offering credit and reducing the repayments (either monthly fees or tariff surcharges) when new customers connect.

If the reticulation cost is E3 000 per connection, and if all of this is financed, then the repayments over a 10 year period, at 8% real interest rate, would be around E40 per month. Either this could be levied as a monthly fee (as with the line extension charge), or it could be added to the tariff. If domestic consumption is 200 kWh/month, then the surcharge would be in the order of 20c/kWh - an 80% increase in the tariff. The tariff surcharge or monthly fee could be decreased if connection fees reduced the amount that had to be financed, or if subsidies were available.

However, a credit scheme implies the need to raise finance. Given the high costs of reticulation (in the order of E3 000 per connection) this may mean that large levels of debt are built up. Supposing the rural electrification programme aims for a connection rate of 2 000 new rural customers per year, and each connection must be financed by an amount of E3 000, then this implies addition debt of E6 million per annum. If repayments are designed to recover this over ten years, then the peak debt in 10 years time (expressed in 1996 prices) would be in the order of E36 million. The availability of finance under this type of cost recovery scheme would determine the pace of the reticulation projects.

Table B.2.4 shows the level of user payments for different reticulation costs, expressed both as a monthly fee and a tariff surcharge.

Table B.2.4: Example of reticulation monthly fee and tariff surcharge

Reticulation cost	E1 000	E2 000	E3 000	E4 000	E5 000
Monthly fee	E12.50	E25.00	E37.50	E50.00	E62.50
Tariff surcharge for different consumption levels [c/kWh]					
100 kWh/month	12.4	24.0	36.0	48.0	60.0
200 kWh/month	6.0	12.0	18.0	24.0	30.0
500 kWh/month	2.5	5.0	7.5	10.0	12.5
1000 kWh/month	12.0	2.4	3.6	4.8	6.0

B.2.7 Summary and discussion

Financing is required for three types of requirements:

- Capital for distribution line extensions
- Capital for reticulation projects
- Funding of operating losses

Distribution line costs will vary from site to site, but costs are in the region of E16 000 per km (although experience in South Africa is that costs are in the region of R25 000 to R30 000 per kilometre), and extension distances in pilot projects have varied from 7 km to 26 km. Reticulation costs will also vary, but estimates by Capricon are that costs are in the region of E2 500 to E3 000 per connection. Operating losses will depend on the consumer mix, but if only domestic consumers are considered, the operating loss will be in the order of E10 to E20 per customer per month (excluding any depreciation or finance on capital charges).

Possible sources of revenue to cover capital costs include ***user payments*** through connection fees, monthly fees and possible surcharges on the tariff; ***subsidies*** from Government; and ***cross-subsidies*** from other consumers. The nature of user-payments will partly be dependent on the type of metering and billing system installed.

Where user connection fees and subsidies to not cover the full costs, finance will be required. Possible sources include Government loans, SEB equity, foreign concessionary loans (including the DBSA), and commercial credit.

Connection fee policy will determine the extent of financing and subsidy that will be required. The availability of both of these will determine the pace at which electrification can proceed.

B.2.7.1 Options for line extension

The following section examines some options for financing line extension costs (excluding household reticulation). Four options are examined: (1) connection fees, (2) monthly line extension charges, (3) a combination of these two, and (4) subsidies and cross-subsidies.

Option 1: Line extension costs recovered through connection fees

Under this scenario, all line extension costs must be paid in cash by non-domestic consumers. If small power users (SPUs) are required to pay for 30% of the costs, and large power users and government institutions (LPUs/Govt.) are required to pay for the remaining 70%, then the connection fees (based on data from the pilot projects) would be around E5 000 for SPUs and E20 000 for LPUs/Govt. It would be possible to refine this system by using more categories of users.

A weakness of this arrangement is that if not all of the projected users take electricity, then the utility (or Government) is faced with a deficit. Although it is possible that finance can be arranged in the hope that future connections will be made, this option is risky.

A second problem is that if all the line extension costs are recovered through connection fees (and initial fees cover all the investment costs), future users will not be required to pay a contribution towards the line. This has the potential to give rise to disputes.

Table B.2.5: Line extension costs recovered through connection fees
(with SPUs paying for 30% of costs and LPU/Govt paying for 70%)

Project	Line cost	Number of SPUs	Number of LPUs/Govt	SPU connect fee	LPU/Govt connect fee
Kubuta	E430 000	60	13	E2 150	E23 154
Sigombeni	E245 100	7	8	E10 504	E21 446
Kashoba	E118 250	6	5	E5 913	E16 555
Emvembili	E129 000	8	5	E4 838	E18 060
Zandondo	E215 000	12	5	E5 375	E30 100
Average	**E227 470**	**19**	**7**	**E5 756**	**E21 863**

Option 2: Line extension costs recovered through monthly line extension charge

Under this scenario, users pay a nominal connection fee, and the remainder of the line extension cost is recovered through the levying of a monthly line extension charge. Table B.2.6 shows the likely line extension charges for the pilot projects where an E100 connection fee is levied and the remaining costs are repaid at 16% over 15 years. The average charge is E165 per month, but this varies widely from project to project.

An advantage of this system is that as new customers join the scheme, the monthly fee can be reduced. This would provide an incentive for existing customers to encourage new customers to join the scheme, even though it would necessarily require a fairly sophisticated billing system which links the monthly fee to the remaining unpaid cost of the scheme and the current number of non-domestic connections.

Obviously, this system requires that financing be arranged - either through the utility or the Government. If concessionary rates can be obtained, then the monthly costs would be reduced. For example, if the interest rate was 10% instead of 16%, then the average fee would reduce from E165/month to E120/month. If fewer than expected users connect, then the line extension charge is that much larger.

Table B.2.6: Line extension costs recovered through monthly line charges

Project	Line cost	Number of SPUs	Number of LPUs/Govt	Connection fee	Monthly line charge
Kubuta	E430 000	60	13	E100	E87
Sigombeni	E245 100	7	8	E100	E243
Kashoba	E118 250	6	5	E100	E159
Emvembili	E129 000	8	5	E100	E147
Zandondo	E215 000	12	5	E100	E188
Average	**E227 470**	**19**	**7**	**E100**	**E165**

Option 3: Combination of connection fees and monthly line extension charges

It is possible to combine a system of connection fees with line extension charges. The system would require a set of standard connection fees for users, together with a monthly line extension fee to repay the remainder. Table B.2.7 shows a case where approximately 50% of the total line extension cost is paid for by connection fees and the remainder financed through line extension charges.

This system reduces the amount which must be financed by the utility. It also means that the monthly line extension charge is reduced more rapidly for every new connection (since the connection fees remain relatively high). On average, the monthly fee is reduced by E11 per month for every new SPU which connects.

Table B.2.7: Connection fees & line extension charges
(where 50% of the costs are paid by connection fees and 50% by line extension charges)

Project	Line cost	SPU connection fee	LPU/Govt connection fee	Amount to be financed	Monthly line charge
Kubuta	E430 000	E3 000	E10 000	E237 000	E25
Sigombeni	E245 100	E3 000	E10 000	E216 100	E144
Kashoba	E118 250	E3 000	E10 000	E95 250	E69
Emvembili	E129 000	E3 000	E10 000	E100 000	E63
Zandondo	E215 000	E3 000	E10 000	E174 000	E113
Average	**E227 470**	**E3 000**	**E10 000**	**E164 470**	**E83**

Option 4: Subsidies for line extension projects

If any of the above options are combined with subsidies, then the costs to users will decrease accordingly. For example, if line extension costs are subsidised by 50% (approximately E110 000 per project), then the connection fees and/or monthly line extension costs would be reduced by a corresponding 50%.

The overall scale of required subsidies would be determined by the scope of the programme. An indication is that a subsidy of E1 million per annum, used to pay for 50% of the line extension costs, would enable 10 schemes per year similar to the pilots projects. Alternatively, if cross-subsidies on other users were used, then a 0.17c/kWh levy would raise at least E1 million per annum.

B.2.7.2 Options for reticulation projects

The following section examines three options for financing reticulation projects. These projects take place where the distribution line has already been, or is being, installed. As with distribution line extensions, the options are to balance connection fees, subsidies and other user payments against one another. Given that the majority of customers would be domestic users, it is likely that high connection fees would result in very low take-up rates. Further, low take-up rates increase the unit costs of reticulation, as well as increasing the unit overhead costs of operating the project.

Reticulation costs have the potential to become much larger than the line extension costs. For example, if all domestic customers in the pilot projects receive a connection, and if typical reticulation costs are E2500/customer, then the reticulation costs are anything between 65% and 85% of the total capital costs. Thus, the scale of financing required suggests that subsidies are unlikely to be available, and that other cost recovery options must be investigated.

Option 1: High connection fees

If all of the reticulation costs are to be recovered through the connection fees, then these fees will be particularly high - in the order of E2500 per customer or more. This would effectively exclude the majority of rural homesteads.

The advantage of this system is that connection fees can be tailored for each group, and so the utility does not face any risk or have to carry any financing.

Option 2: Lower connection fees and monthly repayments

If connection fees are set at a lower level, then the remainder of the costs must be recovered through the tariff. This can be structured as a monthly repayment (much like the line extension fee), where users are on a billed metering system.

The costs of every reticulation scheme will be different, and it is preferable to design a cost recovery scheme which reflects this, as well as encouraging new customers to connect. However, there is a direct trade-off between flexibility and simplicity. For administrative reasons, it is preferable to have a standard monthly repayment fee which reflects ***average costs***, rather than actual project costs. It can be seen that the monthly fees would be between E9 and E45, with around E25 being representative of the most likely case. These charges assume that the monthly charges increase with inflation every year.

Table B.2.8: Monthly repayment for different average reticulation costs and connection fees
(costs are recovered over 15 years at 16% interest)

	Connection fee			
Reticulation cost	**E50.00**	**E300.00**	**E500.00**	**E1000.00**
E2000/connection	E18.00	E15.50	E14.00	E9.00
E3000/connection	E27.00	E24.50	E23.00	E18.00
E4000/connection	E36.00	E33.50	E32.00	E27.00
E5000/connection	E45.00	E42.50	E41.00	E36.00

Option 2: Lower connection fees and a tariff surcharge
Instead of a monthly fee, it is possible to implement a tariff surcharge so that, on average, the same revenues are received. The difference is that (1) this charge can be implemented with a prepayment meter; and (2) the charge affects higher income users to a greater degree.

The table shows the tariff surcharge which would have to be levied to recover the E2500 in reticulation costs, assuming a certain average consumption. It can be seen that the tariff surcharge would have to be between 5c/kWh and 23c/kWh.

Table B.2.9: Tariff surcharge to recover reticulation costs
to recover a E2500 cost over 15 years at 16%

Household	Connection fee			
consumption	E50.00	E300.00	E500.00	E1000.00
100 kWh/month	23 c/kWh	20 c/kWh	18 c/kWh	14 c/kWh
150 kWh/month	15 c/kWh	13 c/kWh	12 c/kWh	9 c/kWh
200 kWh/month	11 c/kWh	10 c/kWh	9 c/kWh	7 c/kWh
250 kWh/month	9 c/kWh	8 c/kWh	7 c/kWh	5.5 c/kWh

B.2.7.3 Options for operating losses

It is likely that household electrification in rural areas will result in operating losses for the implementing utility, *at current SEB domestic tariff levels.* Depending on consumption, this loss may be as much as E10 to E20 per customer per month. Although losses in rural areas are likely to be higher than elsewhere due to lower consumption levels, the current SEB tariff system means that, on average, losses are made on the domestic customer base. That is, cross-subsidies from other customers are incorporated into the current tariff levels.

The options to cover operating losses are as follows:

Option 1: Increase domestic tariffs
A "rebalancing" of tariffs to remove cross-subsidies between customer groups would require domestic tariffs to increase fairly substantially, and other tariffs to decrease slightly. However, this rebalancing would mean that, on average, revenue from domestic customers met the costs of supplying them. Since rural consumption is generally lower than elsewhere, it would still mean that there would be cross-subsidies from urban households to rural ones. As the rural customer base increased, so there would be upward pressure on prices.

The option of introducing a higher rural domestic tariff is possible, but probably infeasible, both for political reasons and pragmatic reasons.

Option 2: Provide Government subsidies to cover losses
Government subsidies, calculated to cover the additional losses incurred by rural customers is possible. However, such a subsidy can be difficult to calculate and monitor, as well as committing Government to long-term subsidisation of utility operations. It is widely accepted that subsidies, if used at all, should be used to meet capital costs rather than operating losses.

Option 3: Utilise cross-subsidies from other consumers
The current system includes cross-subsidies from other consumers to households. It is possible that this system be continued. If the domestic tariff is increased, then cross-subsidies would be retained within the domestic customer base. Alternatively, if the domestic tariff remains below average costs, then cross-subsidies from other

customers could be continued. Selecting rural electrification areas where there is the maximum amount of non-domestic consumption would reduce the additional burden on existing customers.

B.2.8 Recommendations

The following recommendations are made.

Four different types of users are defined here: Government and public enterprises (clinics, schools, Telecoms, water projects, etc.), large power users (LPUs) who would be on tariff K5, small power users (SPUs) who would be on tariff S2 or tariff S3, and households, who would be on a domestic tariff.

Financing of distribution line extension

A rural electrification grid extension fund should be established and operated by the rural electrification agency (SEB, or some other institution). Government should make payments to this fund, through the MNRE, in order to cover the costs of line extension projects.

User charges should be levied in order to recover much of the costs, and so make additional funding available for future projects. These charges should be accounted for and placed in the grid extension fund.

Distribution line connection fees from non-domestic users should be set as follows, and should include the cost of service connections:

- Government & public enterprises: .... E25 000 per connection
- Large power users: .... E25 000 per connection
- Small power users: .... E7 500 per connection

If revenue from the initial fees collected is more than the estimated costs, then the fees will be reduced accordingly. If future consumers connect, they will be charged the same connection fees and this revenue will go towards the funding of other grid extension projects.

Financing of reticulation

It is proposed that SPUs and households be offered the choice of two tariffs as follows:

1. Where connection fees must be paid to cover the full costs of supply, and standard SEB tariffs are applied.
2. Where the initial cost is reduced by E2000[3], but users pay a 30% surcharge on the energy tariff.

For every customer who chooses the second option, financing of E2000 must be arranged. It is proposed that Government arranges a loan for the required amount (e.g. if 2000 connections are made, then Government loans E4 million to the utility), and that repayments should be linked to consumption by these customers. The repayment scheme should be modelled so that the risk is borne primarily by the Government. The key elements are as follows:

- Government raises adequate finance for the reticulation costs, and loans this to the utility;
- The utility monitors revenue received from the tariff surcharge and from this revenue a small management fee to arrive at a net revenue from the tariff surcharge;

[3] This discount should increase with inflation over the years.

- The utility pays the Government the greater of the following two amounts:
  1: the net revenue from the tariff surcharge; and
  2: 50% of the loan repayment commitment for that year.
- The Government pays the loan repayment commitment for that year.

This arrangement means that risk is shared between the utility and the Government, with the Government taking the greatest share of the risk. An analysis of likely scenarios shows that this arrangement would require subsidies in the medium term, that total subsidies would be in the region of E7.6 million over 10 years, and that 98% of this would be paid by Government.

These results are sensitive to estimates of consumption growth. The table below shows the effects of this scheme for the proposed rural electrification programme, assuming that all households adopt the higher tariff. It can be seen that the utility bears very little risk (a potential loss of E176 000 over 10 years), but that Government is liable for subsidies of up to E1 million per annum.

In addition, it can be seen that Government must provide finance between E2 million and E4 million for the rural electrification programme. The total financing required over a ten year period is E36 million (in 1996 terms).

Table B.2.10: Reticulation loan scheme
(monetary figures are in 1996 E thousands)

Year	No. of connect-ions	Average consump-tion	Govt loan to utility	Net income from surcharge	Utility repayment to Govt	Govt repayment on loan	Utility subsidy	Govt subsidy
1	1 031	120	2 062	106	136	271	30	136
2	1 436	125	2 872	264	314	629	51	314
3	2 055	130	4 110	503	561	1 122	59	561
4	2 391	135	4 782	798	834	1 668	36	834
5	1 989	140	3 978	1 066	1 066	2 067	0	1 002
6	2 055	145	4 110	1 358	1 358	2 455	0	1 096
7	1 963	150	3 926	1 657	1 657	2 789	0	1 132
8	1 530	155	3 060	1 915	1 915	2 985	0	1 070
9	1 857	160	3 714	2 231	2 231	3 252	0	1 021
10	1 604	165	3 208	2 527	2 527	3 433	0	906
Total	17 911		35 822	12 424	12 599	20 670	175	8 072

Note: Loans are paid over 15 years at 10% interest. Consumption starts at 120 kWh/month and grows over 10 years to 165 kWh/month. The tariff is 25c/kWh plus a 30% surcharge.

Table B.2.11 illustrates the effect of different levels of consumption from rural households on the total subsidy required over ten years. Consumption levels up to 50% below and 50% above the base case were tested, and the effects on the ten year total subsidies can be seen.

Table B.2.11: Effect of consumption on Government and utility subsidies to rural electrification
(figures in 1996 terms)

	Base consumption less 50%	Base consumption less 25%	Base consumption	Base consumption plus 25%	Base consumption plus 50%
Utility subsidy	E3 800 000	E1 100 000	E162 000	E0	E0
Govt subsidy	E9 600 000	E9 400 000	E7 500 000	E4 700 000	E2 300 000
Total subsidy	E13 400 000	E10 500 000	E7 662 000	E4 700 000	E2 300 000

Financing of operating losses

It is recommended that the domestic tariff be increased through a tariff "rebalancing" exercise so that total domestic revenue matches average costs for this consumer group. Even after this exercise, it is likely that the rural programme, particularly in the early years, will still sustain losses. It is recommended that these losses be covered through cross-subsidies from other domestic customers. However, it is anticipated that after the tariff rebalancing exercise, these losses will be relatively small.

B.2.9 Conclusions

This paper has set out the financing options for rural electrification, together with the associated tariff and connection policies. A set of recommendations have been made, although it must be stressed that ultimately Government, together with SEB, must choose a preferred option and provide adequate resources to ensure that rural electrification occurs without substantial adverse financial consequences to the implementing agent.

It is clear that substantial subsidies are required to support rural electrification, even if a tariff surcharge is applied. Subsidies are required, for the following reasons:

- to cover unrecovered costs of line extension;
- to cover losses on the reticulation financing scheme.
- to cover operating losses on domestic users (since the existing domestic tariff is not cost reflective); and

It is reasonable to expect Government to bear the bulk of the losses associated with capital investment. However, operating losses on domestic users need to be addressed through the "rebalancing" of tariffs, which SEB is currently attempting to implement.

Appendix C
Integration with Other Development Initiatives for Rural Electrification in Swaziland

C.1 Overview of rural development policies and initiatives

Swaziland covers a total land area of 17 364 square kilometres. Table C.1 shows the population density in each of the four administrative regions in 1995.

Table C.1: Population Density by Administrative Region, 1995

Region	Population	%	Area (km^2)	%	Density (pop/km^2)
Hhohho	238 678	26	3 569	21	66.9
Manzini	256 581	28	4 068	23	63.1
Shiselweni	208 100	23	3 779	22	55.1
Lubombo	204 760	23	5 947	34	34.4
Total	908 119	100	17 363	100	52.2

Source: Ministry of Housing and Urban Development (MHUD), Government of Swaziland "National Physical Development Plan, 1996 - 2006", Volume 1: Background Study; Table 7.1

The largest of the regions, Lubombo, is the most sparsely populated with an average 34.4 people per square kilometre. Hhohho and Manzini regions have densities almost double that of Lubombo, at 66.9 and 63.1 people per square kilometre respectively, in part due to the pull effects of the two cities of Mbabane and Manzini.

C.1.1 Agricultural production

The agricultural sector plays a vital role in Swaziland's economy even though its relative importance in domestic output has declined over the last five years. Agriculture has contributed more than 14 percent of GDP for the past seven years and provides substantial inputs to the value-added manufacturing sector. 26 percent of the sector is accounted for by maize and cotton produced on Swazi Nation Land ; 67 percent by sugar, citrus and pineapple production on Title Deed Land; and the rest (seven percent) by livestock

It accounts for as much as 50 percent of the country's export earnings and is the principle source of livelihood for over 70 percent of the population. 23,3 percent of agricultural production is maize and cotton production on Swazi Nation Land; 58,4 percent is sugar, citrus and pineapple produced on Title Deed Land and the remainder is from livestock.

The agricultural sector is based on two production sub-sectors, namely that on Swazi Nation Land (SNL) and that on Title Deed Land (TDL). As a result of different production conditions there have been variations in output trends between the two sectors. According to the Swaziland Electricity Board's "Rural Electrification Policy", February 1996, "rural" is defined as being those areas within the Kingdom in which, among other criteria, "The settlements are on Swazi Nation Land, under the leadership of Chiefs". An understanding of the economic activities on SNL, the most dominant of which is agriculture, sets the context within which the RE Programme operates.

C.1.2 Swazi Nation Land

SNL is typified by communal tenure based, semi-subsistence production with generally low productivity with communal grazing. SNL accounts for about 60 percent of the land area of the country. Of this, about nine percent is cropped, 65 percent is classified as pastures and 14 percent as commercial forests. Table C.2 summarises the trend in land usage on SNL over the past three decades. Cropping land has steadily increased (by 40 percent since 1966) whilst grazing land has declined (by 19 percent).

Table C.2: Land Use Pattern for Grazing and Crops on SNL, 1966-1991 (000's ha)

	1966	1976	1988	1991
Grazing Land	1 268	1 206	1 149	1 032
Crops	132	165	180	219

Source: Ministry of Housing and Urban Development, Government of Swaziland "National Physical Development Plan, 1996 - 2006", Volume 1: Background Study; Table 7.5.

Altogether about 98,900 hectares of SNL are under maize and 17,000 hectares under cotton. Total annual maize output varies between 110,000 and 155,000 tonnes depending on rainfall conditions, but in general is insufficient to meet domestic food requirements. There is also some limited commercial production of tobacco. Over 95 percent of Swazi cattle owners and SNL residents account for just over 80 percent of the total herd.

C.1.3 The employment challenge for agriculture

The rural SNL population live on some 88 000 scattered homesteads under traditional chieftainship authorities. Average holdings are 3.5 ha with about half being cultivated at any one time. Agricultural production accounts for less than half of average homesteads' income (both cash and kind). There is a considerable dependency on wage earnings, with 60 percent of the working male and 30 percent of the working female homestead members occupied in paid employment in plantations, manufacturing, trading and service industries. Most of the agricultural labour for the SNL farms is provided by women, older men and children. Some 40 percent of the homesteads are headed by women.

It is estimated that the labour force of Swaziland has been increasing by over 70 percent from 1986 to 2000, reaching an estimated 650 000 by the year 2000. Part of this labour force will be absorbed by the formal sector - manufacturing and construction, commercial agriculture and mine employment in South Africa; and part will be absorbed by the informal sector including SNL. To obtain an estimate of the dimension of the employment problem facing agriculture in the near future, it is necessary to first estimate non-agricultural growth and related employment.

In 1993 there were 72 735 workers in the formal sector, including government, manufacturing, mining, services, distribution and transportation, finance and construction, but excluding commercial agriculture. Formal sector employment (excluding commercial agriculture) increased at 3.2 percent per annum over the period 1987 - 1993. Assuming a similar growth rate to the year 2000, it is projected that there will be some 90 678 workers in the formal sector (excluding commercial agriculture) by 2000.

Labour emigration from Swaziland to the mines and farms of South Africa will absorb a part of the labour force. However the numbers are being restricted by South Africa which itself faces high unemployment rates. It is expected that labour emigration will maintain its low level (of 15 300 in December 1995) or decrease.

Therefore by the year 2000, about 560 000 workers will be looking for jobs in the agricultural sector, either as paid labourers on commercial farms or as self-employed farmers on SNL. To date commercial agriculture has functioned as one of the country's main sources of exports and foreign exchange earnings, while providing rather low employment opportunities due to its capital intensity. For the foreseeable future this role is not likely to change significantly. From 1987 to 1993, employment in commercial agriculture was almost static (22 629 in 1987 to 22 670 in 1993), due in large part to the severe drought in 1992/3. The World Bank estimates that employment in the sector will grow at between three to four percent annually. At these rates of growth, the demand for agricultural labourers should increase from around 23,000 presently to 30 000 by the year 2000.

This implies that by the year 2000, about 530 000 persons, most of whom will be living in rural areas, will be looking for on-farm work on the SNL. Based on present labour-output ratios, it is estimated that total output, comprising both crops and livestock, on the SNL, would have to increase by over seven percent per year to employ this number of people. This is an enormous task. The development challenge facing Swaziland in the short-term is to come as close to this rate of growth as possible in order to raise the standard of living and keep unemployment to a minimum.

C.1.4 Government rural development initiatives

Government attempts so far to rationalise and improve productivity on SNL have met with limited success. In the early 1980s a Rural Development Areas Programme (RDAP), backed by the World Bank and several other donors, was set up with the aim of improving the management of livestock, and through the provision of inputs and access to facilities such as loans and irrigation, of boosting output and facilitating integration of the traditional with the commercial sector. By the end of the 1980s financial support for the RDAP was ended, largely due to the lack of tangible results from the huge amount of money being spent.

The National Development Plan 1996/97 - 1998/99 stresses that the Ministry of Agriculture and Cooperatives "will continue to promote the intensification of agricultural production amongst small scale farmers on Swazi Nation Land (SNL) ... whilst ensuring that such support will not negatively affect agricultural production on TDL" (p 103). Through the *"Land Use for Rational Utilisation of Land and Water Resources Project"* and successive projects, the Government is presently committed to developing strategies and procedures to increase rural productivity through rehabilitation of land, reorganisation of land use and rearrangement of settlements within selected areas and to define an integrated regional land use plan for implementation. Because of the scattered nature of Swazi homesteads the provision of amenities such as water, electricity, roads, schools, etc. is very expensive and uneconomical. The current Land Use Planning and Development Project will attempt to reorganise major land uses in a pilot implementation phase which will address some of these problems.

There is little doubt that traditional agriculture, if accompanied by other measures, could perform much better than at present under irrigation, as the output of those SNL farmers to irrigation has proved. Less than 10 percent of SNL farmers have access to irrigation at present and this is clearly an area in which government will place more emphasis in the future.

C.1.5 Irrigation

Agricultural irrigation is currently the largest consumer of water in Swaziland. Current and potential future requirements completely dwarf the requirements of other use sectors. Table C.3 presents the number of hectares currently irrigated from each of the rivers.

Table C.3: Irrigated areas, 1979

River	Area Irrigated (hectares)	Further Irrigation Potential (hectares)
Komati[1]/	12 657	12 657
Mbuluzi[2]/	10 914	5 000
Lower Great Usutu	10 840	
Upper Great Usutu	3 261	> 6 600
Ngwavuma	2 609	
Lomati	732	3 600-14 200
Ngwempisi	591	10 900
Mkondo	251	
Little Usutu	150	> 18 000
Total	**42 005**	

[1]/ Most of the area irrigated is within the Mbuluzi basin. 171 million cubic metres [mcm] represents total diversion rate. Consumptive use is actually 103 mcm.
[2]/ 1983 projection

Most of the current consumptive use of the Lomati river is for the Isis Ngonini estate, which lies within the Mbuluzi river basin. Most of the water use in the Mbuluzi river basin occurs on two sugar estates downstream from the confluence of the Mbuluzi and Mbuluzane rivers and on the developing Ngomane scheme. Approximately 6 mcm is used in upstream areas. In the Upper Great Usutu basin, the largest water user is the Malkerns estate. The major consumptive users in the Lower Great Usutu basin are the sugar estates in the Lowveld region. Approximately 14 percent of the use is by small riparian users. The major user in the Ngwavuma basin is the sugar estate at Nsoko.

Table C.4 identifies the amount of land considered as potentially irrigable in each river basin. The identification of irrigable lands was based on land capability only and did not consider water availability. This examination, therefore, identified much more land as irrigable than could ever be irrigated by the available water in Swaziland. In the Lomati basin, the soils along the left bank have the highest soil suitability rating. The soils along the right bank are generally classified as average or poor. The irrigation potential of land adjacent to the upstream one-third of the Lomati river is considered to be limited.

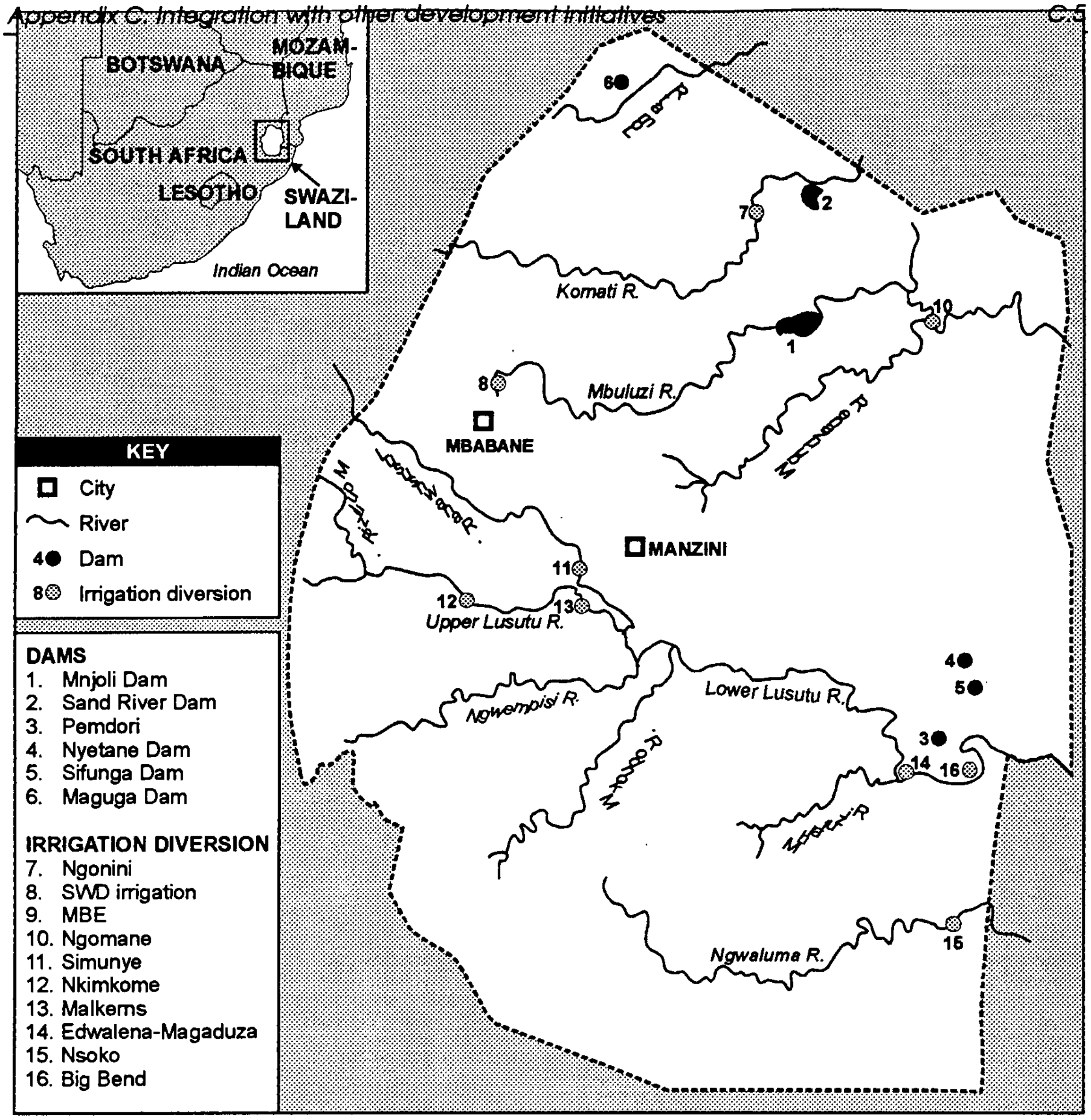

Figure 1: Map of main rivers, dams and irrigation schemes

In the Komati basin, most of the irrigation potential is in the Lowveld region. There are some small areas adjacent to the river in the Middleveld region which could be irrigated on a small scale. There is opportunity for major irrigation development on either bank. The soils, however, are poor for the most part and would require intensive management. There is a narrow band of good soil adjacent to the lower half of the river reach.

Table C.4: Maximum additional irrigation development potential

Basin	Irrigable Area in Hectares			
	Highveld	Middleveld	Lowveld	Total
Komati	0	5 934	40 604	46 538
Mbuluzi[1]/	251	1 613	29 136	31 000
Lower Great Usutu	0	0	37 700	37 700
Upper Great Usutu	1 899	3 899	0	5 798
Ngwavuma	5 033	0	23 304	28 337
Lomati	0	16 148	0	16 148
Ngwempisi	8 397	0	893	9 290
Mkondo	1 395	4 867	0	6 262
Little Usutu	5 110	9 439	0	14 549
Total	22 085	41 900	131 637	195 622

1/ After full planned irrigation at Ngomane.

The Komati Basin Water Authority (KOBWA) has been established as a bi-national agency under the terms of the Komati Basin Treaty between South Africa and Swaziland for the purpose of implementing Phase 1 of the development of the Komati River Basin. Phase 1 comprises the construction of the Maguga Dam on the Komati River in Swaziland. Water from the dam will be utilised for hydropower generation in Swaziland and by both Swaziland and South Africa to develop irrigable land; in the case of Swaziland an additional 7 200 ha of land for sugar cane and citrus fruit production. Future phases envisage a further three potential dams in the catchment.

Other potential areas for irrigation

In the Mbuluzi basin, there are small areas adjacent to the Black Mbuluzi river in the Highveld region and several areas in the Lowveld region along both the Black and White Mbuluzi rivers which are potentially irrigable land. In the Lowveld region this is found downstream from the Mnjoli dam. The majority of this land is classified as poor soil and would require intensive management. Some of the soils will have to be surveyed carefully for depth limitations as they are characteristically quite shallow. The best soils lie east of the Vuvulane scheme. There is also a large track of good soil along the Nkhalashane river in the Lebombo region north of the Mbuluzi river.

In the Little Usutu basin, there are several areas adjacent to the river in the Highveld region that have good soil and are potentially irrigable. The best soils in the basin, however, are in the lower Mtilane basin and the lower Little Usutu basin. These were identified in the 1970 UNDP Report as being irrigable.

In the Upper Great Usutu basin, there is limited irrigation potential. Two small areas adjacent to the river offer the best potential. One area is upstream from the confluence of the Dudusi river and the other area is opposite Malkerns estate.

In the Ngwempisi basin, there are several potentially irrigable areas adjacent to the river in the Highveld region upstream from the Ngwempisi Gorge. The majority of these soils are average and the best soils are located immediately adjacent to the river. Some of the average soils may be too shallow for irrigation. There are just a few areas downstream from the gorge which are potentially irrigable; these areas are located just upstream from the confluence of the Ngwempisi and Usutu rivers.

In the Mkondo basin, there is a large area along the Motane river and another large tract of land adjacent to the middle reach of the Mkondo river through its centre reach which are potentially irrigable. The Motane area is comprised mostly of good soils while the Mkondo area has both good and poor soils.

By far the largest area of potentially irrigable land is in the Lower Great Usutu basin. Generally the soils in this area are average or poor with some good soils scattered throughout. The best soils exist in the Mapobeni area. The soils south of the Usutu river are generally better than those north of the Usutu river.

The largest tract of good to excellent soils in the country lies south of the Ngwavuma river in the eastern Lowveld region. There are two other fairly large tracts of potentially irrigable land in the Middleveld region of the Ngwavuma basin. One tract is in the vicinity of the confluence of the Nsongweni river and the other is upstream from the confluence with the Mantambe river.

C.1.6 The link to rural electrification

The SEB estimates that the total number of rural homesteads connected to electricity is presently 6 047 or 5.3 percent of total homesteads[1], with new connections being made

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1 SEB "Rural Electrification Policy", February 1996

at a rate of approximately 2 000 per annum. SEB is of the opinion that "rural electrification cannot be undertaken on a purely economic basis, such as the return on capital employed, but primarily as a social programme in *Providing Power for a Developing Nation*" (p.1), the implication being for central government to source grant funding for much of the RE programme.

The objectives of the Board's RE programme are:

"a] *Providing the electricity to develop the Nation.*

b] Offering affordable costs for electricity connections.

c] Establishing realistic tariffs for all types of customers.

d] Bringing together all the participating organisations.

e] *Providing a sustainable, long term programme of electrification.*

f] Offering a complete customer service, before, during and after installing the electricity connection" (p.4, italics added for emphasis).

For the five year period 1987 - 1991, the economy of Swaziland benefited from both generally favourable climatic conditions, and a substantial increase in foreign direct investment inflows as sanctions against South Africa tightened. As a result, the annual real growth rate averaged 7.2 percent over the period - well above the rate of population growth - and real per capita income increased steadily.

However beginning in 1991/92, real growth began to slow as investment inflows eased and the ongoing recession in South Africa reduced the demand for Swazi exports. Swaziland was also affected by the severe regional drought in 1992, which resulted in an increase in agricultural imports. Another factor behind the slowdown in the economy has been the lifting of sanctions against South Africa which has coincided with a steady fall in direct foreign investment.

Whilst the country was able to undertake and finance a number of social and infrastructural programmes in the late 1980s, this is no longer the case. The immediate challenge facing the country will be to rationalise investment expenditure according to carefully targeted priorities. Levels of public expenditure can be expected to be lower in the next decade than they have been in the past. This calls for a more co-ordinated approach to location policies with respect to, for example, the siting of community facilities (in particular, health and education), the provision of electricity to rural communities, the paving of feeder roads, and the development of the agricultural production infrastructure (dip-tanks, irrigation schemes and similar).

Related to the above, if incomes per head decline in the future, as is anticipated, there will be need to strengthen the government social policies in order to address the issue of poverty alleviation. This could be achieved by proceeding with a careful restructuring of current expenditure toward the provision of essential services in the fields of education and training, and health and human services, decentralised throughout the country.

Ideally, priority should be given to electrification projects where services and productive enterprises are supported; where the provision of electricity is able to lever further economic and human resources development.

C.2 Planning and prioritisation process

The selection of areas for line extension under the RE Programme in the past has largely been in response to applications made by line-Ministries, in particular the Ministry of Education and Training, the Ministry of Health and the Ministry of Works and Construction (responsible for the construction and maintenance of public buildings).

Outside of the gazetted urban areas, the company towns and the border posts, there is no discernible, officially established human settlements hierarchy in the country. Swazi Nation Land areas are overlain by Chieftaincy boundaries; a gathering of chieftaincies (usually three to four, but in some cases as much as 11) form an entity known as the *inkundla*. There are 55 *tinkundla* covering the country but each varies considerably in the economic development of the centre and the role that it plays to its hinterland population.

In the past, both public and private sector investment has been made on an *ad hoc* basis with respect to location considerations. It is not unusual to find that three or more different line Ministries (Health, Education and Works and Construction) have constructed community facilities in three different locations separated by one kilometre or more. Equally, private entrepreneurs require only the authority of the local chief and the Commercial *Amadoda* before establishing shops or light industries in any area, including on agriculturally viable or environmentally sensitive land. The SEB has thus been faced with an array of applications from scattered locations and with limited numbers of potential consumers on the line extension.

C.2.1 Overall planning framework

National Economic Development Plan 1996-97 - 1998/99
The three year rolling National Development Plans prepared by the Ministry of Economic Planning and Development (MEPD), in consultation with the Ministry of Finance and the Ministry of Labour, comprehensively coordinates the capital expenditure programmes of sectoral Ministries. The document is particularly useful in identifying the capital programmes of potential electricity users, for example new irrigation schemes, rural water supply schemes, schools, clinics and similar, although SEB is not consulted during the planning or selection of these projects but requested to supply electricity after the facility has been constructed.

National Physical Development Plan 1996 - 2006 (Draft)
The draft National Physical Development Plan, 1996 - 2006 recommends that future development projects (including rural electrification) be more focused on the Lubombo Region, which although currently is the least densely settled of the regions, has the greatest future economic potential. The NPDP preferred spatial development strategy for the country, endorsed by the Ministry of Economic Planning and Development (MEPD), proposes the concentration of high levels of infrastructure provision within the existing east-west economic corridor and the northern sugar areas, and in addition, within a southern corridor, based on the development of irrigable lands in the Usutu River Basin. The proposal would not only ensure the country's long-term economic growth but this would in turn generate the wealth to finance future social objectives.

In addition to the axial corridor development, basic infrastructure provision (including electricity) and social facilities are to be extended to the population through an articulated human settlements hierarchy.

The draft NPDP proposes that a well-defined human settlement hierarchy be established throughout the country. An analysis of the smaller centres was carried out on the basis of a number of functional indicators varying on a continuum from growth generating pre-conditions (such as an economic base within the centre, a strong economic hinterland, the size of the population) to growth supporting criteria (such as the availability of infrastructure, the push-pull of nearer larger centres, the availability of public facilities, and the presence of a local lobbying power (often either an *inkundla* or the Commercial *Amadoda*.

The NPDP analysis found four distinctive characteristic types of settlements on SNL throughout the country:

1. ***Group 4 - Rural Growth Centres:*** Centres which have "export base" or value-added activities within them, supported by economically active and relatively wealthy hinterlands, (for example, Ntfonjeni). These centres provide valuable input/output functions to the community they serve and may be expected to grow into small towns in time.
2. ***Group 5 - Rural Commercial Centres:*** Centres which are primarily the nodal points for a vibrant tertiary sector (general dealers, fresh produce market, eating houses) - these centres are frequently located at cross-roads, near border-posts etc., (for example Maphoveni and Motshane). There is some wealth circulating in the town and this attracts further population growth, but not to the same extent as the input/output centres in (i) above.
3. ***Group 6 - Rural Service Centres:*** In the more remote regions of the country, for example southern Shiselweni and southern Lubombo, where one finds dispersed population concentration, there are centres which lack basic commercial facilities but do provide a number of public facilities - for example a school, health centre and protected water supply (for example Mliba).
4. ***Group 7 - Rural Shopping Centres:*** Finally there are small business nodes (called "shopping centres" in southern Hhohho) comprising two or three low order shops for the day-to-day needs of the rural communities (for example Forbe's Reef and Crossroads).

There are obviously a number of overlaps between the different categories of centres. Furthermore the nodes (in particular Group 6 centres) are organic outgrowths of *ad hoc* public sector location decisions.

The draft NPDP proposed the establishment of a clearcut human settlement hierarchy which would serve to:

- rationalise the future servicing requirements that will be made of government,
- protect agriculturally viable and environmentally sensitive land,
- reduce travel times and improved linkages for populations and the off-farm employment opportunities, goods and services that they are seeking, and
- provide a sense of place and social identity to population groupings.

One of the main coordinating proposals of the NPDP (with respect to rural electrification) is that Group 4 (Rural Growth Points), Group 5 (Rural Commercial Centres) and Group 6 (Rural Service Centres) should all, in time, be electrified (either on grid or stand alone systems) and that only these higher order centres on SNL be considered by SEB for electrification unless a strong case is made in the case of smaller centres. The recommendation is supported by similar siting proposals for high schools and primary schools, rural clinics and postal agencies.

The Select Committee on Rural Electrification (SCORE) has recently rationalised the criteria to be used in the selection of areas for line-extensions. The criteria overlap with a number of the NPDP criteria.

A final strategic location consideration of the NPDP is that Shiselweni Region is recognised as being the region of greatest social need and under-provided in terms of schools, clinics and employment opportunities in relation to other regions in the country. Any future investment priorities aimed at achieving equity in the provision of facilities should therefore specifically target Shiselweni.

C.2.2 Institutional framework

Appendix B.1 contains a discussion of institutional arrangements for rural electrification. One of the functions identified has been that of planning, and updating plans, of rural electrification. It is proposed that a sub-committee of SCORE be established to manage these functions. It is proposed that this sub-committee be comprised of representatives from SEB, the MNRE and the MEPD.

Although this planning project will propose a set of future line extension projects, as well as recommendations on the scheduling of reticulation schemes, it is important that this plan be flexible and able to change to changing circumstances.

The responsibilities of this group will be as follows:

1. to obtain more detailed information on the following year's line extension projects;
2. to monitor the line extension fund and estimate future revenues and Government subvention requirements;
3. to evaluate applications for a reprioritisation of the line extension plan, and to effect changes if necessary;
4. to monitor rural developments (particularly proposed irrigation schemes), and to ensure that the rural electrification plan takes adequate cognisance of these.

The following section details planning and prioritisation procedures which it is recommended this committee should follow.

C.2.3 Proposed planning and prioritisation procedures

Obtain more detailed information on line extension projects for each year
Each year, the planning committee should obtain detailed information for the following year's line extension projects. This is necessary to update the information collected in phase 1, and to more accurately estimate the revenue from line extension charges. Further, if the information gathered suggests that a centre does not warrant electrification, then changes to the plan should be made.

This document (in Appendix D.1???) sets out the proposed future line extension projects. On an annual basis, each of the following year's projects should be visited and the questionnaire presented at the end of this appendix (*"Information on rural electrification area"*) should be filled in.

Monitor the line extension fund
The line extension fund established by Government with SEB is used to finance the initial costs of distributor line extension projects. Revenue from connection fees is paid back into the fund and used to finance future projects. Although SEB will report on the status of the fund on an annual basis, the planning committee should investigate the likely effect of new projects on the fund.

Using detailed information collected on each site, it is possible to calculate the annual capital costs and expected revenues as follows:

- *For each project,*
  calculate the total capital cost expected
  calculate the connection fees per user category
  calculate the expected revenue from connection fees
  calculate the potential deficit (costs - revenues)
- *For the entire year's projects,*
  calculate the total capital cost expected
  calculate the total expected revenue from connection fees
  calculate the total potential deficit (costs - revenues)

This information should then be used to prepare Government budgets in support of the grid extension programme. Two factors should be considered: (1) whether there is sufficient capital in the fund to cover expected capital costs, and (2) whether new projects will result in a deficit which should be covered by Government allocations.

Evaluate applications for grid extension

It is likely that residents of certain places not on the medium term electrification list will apply for electrification. If circumstances merit it, then the prioritisation list should be adjusted to take account of these applications.

The evaluation process should start with the completion of the information form presented at the end of this appendix. This information should be used to determine the following:

1. whether the project will result in a net deficit after connection fees are accounted for; and
2. what group classification the centre is (according the MHUD criteria)

If the project does not result in a deficit, then approval for it should be given, and the project should be scheduled to fit with the capital expenditure programme.

If the project does result in a deficit, then establish what classification the centre is according to MHUD criteria. If the classification is group 4, 5 or 6, then the centre should be scheduled for distributor line extension within the next three years.

If the project results in a deficit, but residents are willing to pay for all costs, and make a substantial deposit towards the costs (for example, a deposit equal to the full deficit), then again the project should be scheduled for the medium term.

Lastly, if residents are unwilling to pay for the deficit, then the project should not be undertaken.

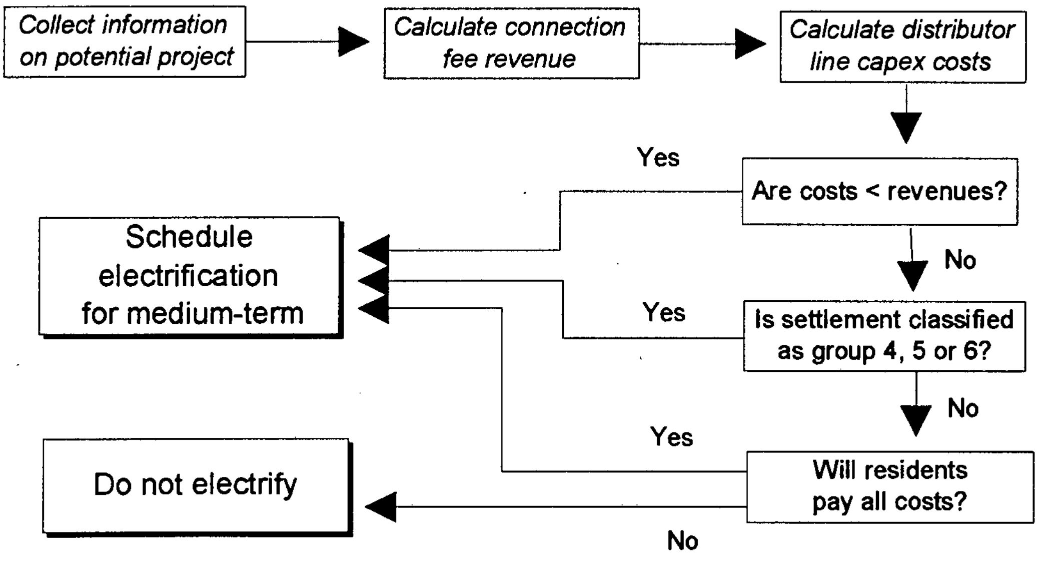

Figure C.2: Decision chart for new electrification applications

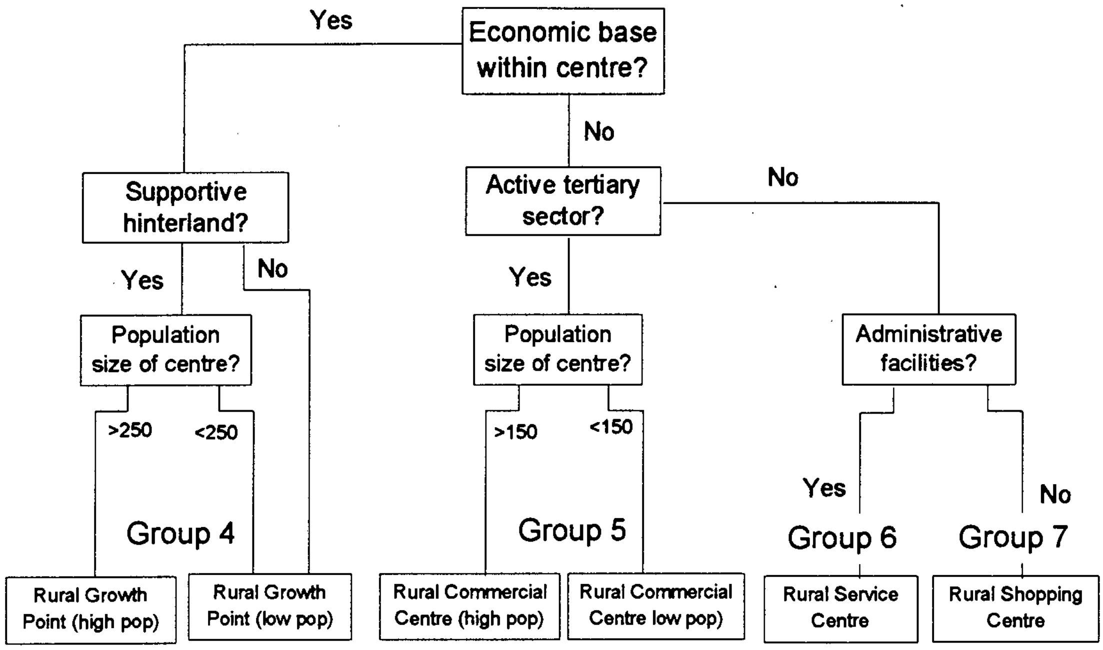

Figure C.3: Decision chart for grouping of settlement nodes

Monitor rural development initiatives and the implications for rural electrification

The planning committee should monitor rural development initiatives and assess their implication for rural electrification. This may require a reprioritisation of electrification projects if new opportunities are identified.

Particular attention should be given to productive agricultural applications on Swazi Nation Land. Opportunities for irrigation projects, as well as agro-processing applications should be considered.

C.3 Rural development initiatives and project prioritisation

This section will look at a range of rural development initiatives and present information which should be used when plannging the grid extension programme. Areas which will be considered include the links between rural electrification and services, services, physical infrastructure and productive activities.

C.3.1 Rural electrification and services

There are a number of unelectrified facilities which provide social services. These are clinics, schools and other Government services.

Rural clinics

Table C.5 and Table C.6 show the unelectrified Government and non-Government clinics. The list of unelectrified non-Government clinics is incomplete pending updated information from the Department of Biomedical Engineering.

Table C.5: Unelectrified Government Clinics

Area name	Distance from grid	Number of nurses' homes	Diesel Generator	Comment	Grid supply
Sincineni	9	4 houses	10 kVA		Not feasible
Musi	11	3 houses	n/a	Genset not working	Not feasible
Mpuluzi	10	4 houses	Large	Not yet perational	Not feasible
Makhava	6	3 houses	20 kVA		???
Jericho	10	3 houses	None	Clinic is not operational	Possible
Ntjanini	12	4 houses	20 kVA		Possible
Nkonjwa	5	2 houses	n/a		Feasible
Mashobeni	6		n/a		Feasible
Nkwene	8		n/a		Feasible

There are at least seven unelectrified non-Government clinics, although the list presented below is likely to be incomplete. Of this seven, four can be easily reached with the grid, and the others are further from the grid, making electrification fairly expensive.

Table C.6: Unelectrified non-Government clinics
(this list is incomplete)

Area name	Distance to grid	Number of nurses' homes	Diesel Generator	Comment	Grid supply
Sincaweni	12	2 houses	None	A small clinic with solar	Not feasible
Manyeveni	5	n/a	Has genset		Not feasible
Malindza	4	n/a	n/a	Has solar	Possible
Mafutsene	0.5	n/a	n/a	Has solar	Possible
Ngculwini	2	n/a	n/a	Has solar	Possible
Bethany	0.5	n/a	n/a	Has solar	Possible
Ikwezi Joy	0.5	n/a	n/a	Has solar, clinic is at school	Possible

The prioritisation of grid extension should, as far as possible, take these clinics into consideration. Electricity supply to rural health facilities is important for a number of reasons. Firstly, grid electricity improves the standard of health services provided. Importantly vaccine refrigeration can be run on electricity reliably, and 24-hour lighting improves security, facilitates response to emergencies (especially where there is a maternity wing), and allows a range of electrical equipment to be operated. In this way, the benefits of electrification are spread to all those who use the clinic, and hence are spread across the entire community, reaching even the poorest families. Secondly, electricity improves the quality of life of nurses who work in these often isolated and remote facilities. This is important in terms of improving staff morale and encouraging staff to work in rural area.

Rural schools

There are a large number of unelectrified schools in Swaziland, as shown in Table C.7. Access to electricity at secondary and high schools is important for a number of reasons. Firstly, electricity is required for the equipment which such schools would like to use. This includes teaching aids (such as overhead projectors), and equipment in science laboratories. It is inevitable that computers will be introduced to secondary and high schools, and this will require an electricity supply. Secondly, secondary and high schools may wish to run night classes, particularly as examinations approach, allowing students extra-tuition or self-study classes. Thirdly, electricity at teachers' houses improves their quality of life, provides good quality lighting when preparing lessons at night, and encourages teachers to remain working in rural areas. Lastly, it is not uncommon for schools to be used as community facilities (requiring lighting at night), and there are examples of schools using televisions and videos to raise money for the school and other community needs.

Electricity supply at primary schools is perhaps less important than at high schools, given the less sophisticated equipment at primary schools and the unlikelihood of evening classes. However, electricity for primary school teachers' houses is considered important by the Ministry of Education.

Table C.7: Government Schools in Swaziland

	Primary	Secondary	High	Total
Number of schools	538	63	107	708
without electricity	358	45	21	424
without water	196	30	16	242
without electricity or water	171	26	8	197

A number of unelectrified high/secondary schools are relatively close to existing electricity distribution lines. For these facilities, connection costs are likely to be fairly low. Table C.8 lists these facilities and it is recommended that the Ministry of Education arrange connection of these buildings with SEB.

Table C.8: Unelectrified secondary/high schools less than 1km from the grid

School	Region	Nearby primary schools	School	Region	Nearby primary schools
Edoropeni	Shiselweni	Edoropeni	Ikhwezi	Lubombo	Ikhwezi
Sibovu	Manzini	Sibovu	Mpompotha	Lubombo	none
Osuthu	Manzini	Osuthu Methodist	Lubuli	Lubombo	Lubuli
Mayiwane	Hhohho	Mayiwane	Malindza	Lubombo	Malindza

The full list of unelectrified secondary and high schools is provided below. Also included in the table is information on number of desks, teachers, teachers' houses, and the presence of a science laboratory.

Table C.9: Unelectrified secondary & high schools

Region	School name	Number of desks	Number of teachers	Number of science labs	Number of teachers' houses
Hhohho	Ejubukweni Secondary	141	6	1	1
	Ekubongeni Secondary	225	9	1	3
	Emagobodvo Secondary	92	6	0	1
	Ensingweni Secondary	300	0	1	7
	Fundukuwela Secondary		9	0	1
	Madlangempisi Secondary	140	5	1	1
	Mahwalala Secondary	120	5	1	1
	Maphalaleni Secondary	200	9	1	5
	Mayiwane Secondary	268	7	1	2
	Mbeka Secondary	125	6	0	3
	Mpofu High		13	1	0
	Mswati II Methodist High	232	14	1	3
	Nsukumbili High	295	20	2	11
	Zandondo Secondary	165	6	1	2
Lubombo	Hlutse Secondary		6	0	2
	Ikhwezi Secondary	185	10	1	8
	Ka-Phunga Secondary	120	7	1	2
	Lubuli Secondary	184	6	0	0
	Malindza High	266	11	1	4
	Maloyi Secondary	160	4	0	0
	Mpolonjeni High	350	18	2	7
	Mpompota High	280	11	1	3
	Nkonjwa High		9	1	3
	Phonjwane High	290	18	1	10
	Shewula Secondary	190	9	1	2
	Sidvokodvo Nazarene Secondary	189	8	1	4
	Sigcaweni Secondary	90	6	1	2
	Sitsatsaweni Secondary		5	1	2
Manzini	Ensenga High	349	16	1	9
	Gundvwini Secondary	260	11	1	1
	Malunge Secondary	250	10	1	5
	Mkhondvo Secondary	145	5	0	0
	Moyeni Secondary	220	10	1	1
	Mpuluzi High	230	14	0	4
	Mvimbeko High	520	24	1	12
	Ngcoseni Secondary	160	6	0	1
	Osuthu Methodist High	225	10	1	3
	Phumtile Secondary		10	1	3
	Sibovu Secondary	179	7	1	2

Table C.9: Unelectrified secondary & high schools (cont)

Region	School name	Number of desks	Number of teachers	Number of science labs	Number of teachers' houses
Shiselweni	Edoropeni Secondary	180	6	1	1
	Edwaleni High	500	18	1	7
	Elulakeni High	260	19	1	9
	Engudzeni Secondary		10	1	1
	Esandleni Secondary	160	4	0	2
	Ezindwendweni Secondary	80	4	0	0
	Hosea Secondary	180	6	4	2
	Jericho Secondary	160	5	1	2
	Jerusalem Secondary	220	8	1	3
	Madulini Secondary	230	10	1	3
	Mshengu Secondary	100	7	1	4
	Ndabazezwe High	320	21	2	11
	Ngololweni Secondary	120	6	0	3
	Nkwene High	450	14	1	6
	Ntjanini High	350	23	2	9
	Nzongomane Secondary	120	5	1	3
	Qomintaba Secondary	113	7	1	1
	Siyendle Secondary		9	1	1

The selection of grid extension projects should attempt to include as many unelectrified high and secondary schools as possible.

C.3.2 Electricity and physical infrastructure

Electricity can play an important role in supporting physical infrastructure such as telecommunications stations and water pumping sites. Attempts were made to identify such potential users in Swaziland.

Telecommunications sites

The rural telephone network in Swaziland operates on a system of microwave repeater and terminal stations. These have to be powered by electricity, either from the grid or a stand-alone supply. Where grid was not available (or too expensive), solar PV systems were installed. However, these have proved unsatisfactory due to the high occurrence of theft. STC would prefer grid supply to these stations.

Table C.10: Unelectrified telecommunication stations

Region	Station name	Station number	Region	Station name	Station number
Manzini	Lapanda	R2	**Shiselweni**	Luqolweni	R5
	Kapunga	R3		Nkondolo	R6
	Gudvwini	T2		Nkondwane	R7
	Ntondozi 1	T3		Kandzaneya	T23
	Ntondozi 2	T4		Nhletjeni	T25
	Maghubheleni	T9		Ntanjeni	T26
	Mahlangatsha 2	T10		Kubuta	T31
	Zindondo	T69		Bethany	T32
	Nyakeni	T75		Salitje	T34
	Ekuthokuzeni	T77		Nkweni	T36
	Kakhuphuka	T81		Makhava	T41
	Maliyaduma	T84		Ngudzeni	T42
Hhohho	Fire lookout	R8		Jerico	T44
	Malandela	R10		Mahlalini	T46
	Ndlozini	T57		New Warm	T48
	Nginamadolo	T60	**Lubombo**	Shewula	T86
	Luklangotsini	T61			
	Malandzela	T62			
	Maphaleni	T65			

A second phase to the rural telephone network has been proposed. However, it is uncertain when this will be implemented. If adopted, it is important that the rural electrification planning committee examine the implications and funding opportunities for rural electrification.

Water supply projects
Rural Water Supply Branch has planned a number of macro schemes for the next three years.

Table C.11: RWSB macro projects for 1997-9

Region	Scheme	Cost	Population	Pumping required
		1997 projects		
Hhohho	Magedla - phase 1	E400 000	2 000	Yes
Hhohho	Nhlanguyavuka	E345 000	2 210	Yes
Lubombo	Sitsatsaweni	E460 000	3 080	Yes
Lubombo	Gegebini	E320 000	2 420	Yes
Lubombo	Mpompota	E300 000	2 210	No
Shiselweni	Zindwendweni	E425 000	2 600	Yes
Shiselweni	Matsanjeni	E400 000	2 360	Yes
Shiselweni	Lavumisa	E666 000	1 660	Yes
Manzini	Ebugeleni	E260 000	1 800	Yes
Shiselweni	Ebenezer	E300 000	1 300	No
Lubombo	Mkhuzweni	E113 000	700	Yes
		1998 projects		
Hhohho	Mshingishingini II	E300 000	1 920	Yes
Hhohho	Mangedla phase II	E600 000	3 500	No
Lubombo	Mdumezulu II	E300 000	2 220	Yes
Lubombo	Makhwekhweti	E250 000	1 200	Yes
Lubombo	Mdumezulu I	E280 000	1 990	No
Lubombo	Lucaceni	E300 000	2 100	?
Manzini	Tjololo	E370 000	2 110	Yes
Manzini	Nsangwini	E300 000	1 990	Yes
Shiselweni	Bethel	E290 000	1 980	No
Shiselweni	Mambathweni	E280 000	1 860	?
		1999 projects		
Hhohho	Ekupheleni	E300 000	1 980	Yes
Hhohho	Sigangeni	E290 000	1 990	Yes
Hhohho	Ntshakabili	E260 000	1 000	Yes
Manzini	Ludzidzini II	E250 000	2 520	No
Manzini	Mawelawela	E330 000	2 380	?
Manzini	Sheleti	E150 000	1 500	?
Manzini	Bhadzeni	E300 000	2 010	?
Manzini	Nhlambeni	E350 000	2 800	?
Shiselweni	Mahlalini	E400 000	2 210	?
Shiselweni	Ngoloweni	E330 000	2 420	?

In addition to the pumping projects listed in Table C.11, there are also a number of unoperational diesel pumps, and a number of sites where it is recommended that hand pumps be upgraded to electrical pumps (see Table C.12). It is not clear when these upgrades will be conducted, but the planning committee should maintain contact with RWSB to determine the extent to which the rural electrification programme overlaps with pumping projects.

Table C.12: Existing water supply projects where a grid connection is recommended

Region	Scheme	Region	Scheme
Lubombo	Tsambokhulu	Hhohho	Mangweni
	Sigcaweni		
	Duze	Shiselweni	Dvulini (Gege)
	Encandweni		Magubheleni
	Mbadlane		Madvulini
	Mphembekati		
	Nkanyezini		

C.3.3 Rural electrification and economic activities

It is important that rural electrification be aimed at those places where productive uses of electricity can be expected. This is important not only from a financial point of view - greater consumption and revenues can be expected - but also from an economic perspective - greater economic benefits can be expected to accrue from the investment in electricity supply.

Potential growth centres

The MHUD has developed a methodology for the ranking of projects according to economic activities. They further recommend that settlements with a ranking of six or above should have access to electricity. In these centres, it is estimated that electricity can contribute positively to the economic development in that centre, and that likely future consumption will warrant the installation of electricity.

Table C.13 lists a set of settlements not yet electrified which have classifications of six or above. There are a total of 19 such centres, although the list may be incomplete. It is recommended that such centres, particularly those with classifications four or five, be given priority in the grid extension prioritisation.

Table C.13: Group 4, 5 and 6 centres not yet electrified (limited database)

Region	Centre	Centre classification	Region	Centre	Centre classification
Shiselweni	Mahlanya	4	**Hhohho**	Ebuhleni	4
	Matsampisi	6		Ngwenya	4
	Mhlosheni	6		Enkaba	5
	Ndabazezwe	6		Matsumo	5
	Nkwene	6		Nhlambeni	5
Lubombo	Ngomane	6		Bulanzani	6
	Siphojaneni	6		Emazulweni	6
Manzini	Hhelehhele	5		Emkhazaveni	6
	Mliba	5		Herefords	6
	Mafotseni/ Mpisi	5			

Irrigation projects

Section C.1 has highlighted the need to expand productive and income generating agricultural activities. One of the ways of doing this is to adopt irrigation farming practices where soil conditions are appropriate and water supply available. Table C.4 outlines the potential future irrigation areas on Swazi Nation Land.

However, it is potentially wasteful to provide electricity in the hope that irrigation projects will subsequently develop. It is preferable to encourage a demand-driven process whereby proposed irrigation projects approach SEB or SCORE for electricity supply. However, it is important that the planning committee monitor developments in irrigation projects, particularly in the nine identified river basins.

C.4 Optimisation of rural electrification projects

It is widely accepted that electrification can be a necessary but insufficient condition for development, particularly in rural areas. Generally, there are greater chances of maximising the potential benefits of electrification if complementary inputs, such as water supply, telecommunications, improved access roads etc. are present, or provide, in conjunction with electricity. For example, if electricity is to have a significant impact on agriculture through greater use of irrigation systems, it is also necessary to have access to good quality seed, fertiliser, farming equipment and access to markets or agro-processing industries.

Section C.3 has looked in some detail at the opportunities for rural electrification projects to link with other services (schools and clinics), as well as other forms of infrastructure (telecommunications and water supply) and economic activities (potential growth centres and irrigation projects). The prioritisation of distributor line extensions presented in Appendix D.1 has attempted to take the needs of these facilities into consideration. However, there are a number of other issues, which if addressed appropriately, can lead to greater benefits from rural electrification - both in a financial (greater utility revenues) and economic (greater benefits) sense. These are addressed below.

Appliance sales

Electricity is not desirable in itself, but only as a means to power end-uses. Electrical appliances are thus required to realise the benefits of electricity supply.

For households, the purchase of appliances can frequently present a hurdle to the greater use of electricity. Partly this is due to availability in rural areas (only a limited range of appliances may be stocked by local stores), but also the initial cost of such appliances.

Table 14: Electrical appliance penetration as a function of time since connected
(data includes both urban and rural areas for South Africa)

	0 - 6 mths	6 - 12 mths	1 - 2 yrs	3 - 4 yrs	5 - 9 yrs
Hotplate	28%	34%	30%	29%	18%
Stove	36%	31%	49%	63%	82%
TV	64%	69%	77%	77%	92%
Heater	27%	24%	37%	38%	60%
Fridge	42%	42%	65%	74%	91%
Radio/Hifi	56%	58%	75%	77%	82%
Iron	52%	47%	70%	72%	85%
Kettle	42%	43%	59%	67%	80%

Source: SAtoZ, Eskom, 1996.

In the South African electrification programme, there are two examples of utility involvement in appliance dissemination. Durban Electricity provides an electrical hotplate with each new domestic connection. Although the cost of this is recovered

through the connection fee (which is R100 greater than that charged by Eskom), it is aimed at encouraging new users to switch to electricity for cookers. A second example is where Eskom used its purchasing power to offer new customers "starter packs" of appliances at low cost. However, this arrangement has been discontinued, mainly due to the desire to promote appliance dissemination through local stores. Eskom now promotes appliance sales by encouraging appliance stores to hold "show days" in newly electrified settlements.

Although utility involvement in appliance dissemination may appear attractive, Eskom's experience suggests that there are complications. If appliance sales are to be continued over a longer period, it is necessary that local agencies be involved in selling appliances. If the utility offers low cost appliances to users on connection, this effectively undercuts local stores and discourages them from stocking appliances.

It is recommended that two strategies be pursued:

- When an area is first connected, appliance manufacturers/distributors should be encouraged to present a display and demonstration of electrical appliances. It is possible the SEB may be able to co-ordinate this, although the responsibility may well fit as well with the MNRE.
- Information sheets be prepared outlining the different appliances available, their typical initial costs and the likely costs of using them. The MNRE has made some progress here by compiling a database of appliances. Information from this can be presented in a suitable format and distributed to electrification areas through local stores.

Battery charging centres

The settlement pattern on most of SNL is very dispersed, meaning that reticulation projects are often prohibitively expensive without extensive resettlement. Even with a E2 000 discount on the initial cost of connection, it is likely that a large percentage of the population in areas close to an 11kV line will be unable to afford to connect. Further, the minimum fee which SEB charges may well be beyond the means of many rural households (even if this fee is affordable on average, many poor households prefer not to have minimum monthly financial commitments due to the irregular nature of income).

For these households which would still like access to some electricity (even if for only a few applications), one alternative option is to use a battery system with DC lights and a plug point for radio or television. A solar home system provides a stand-alone supply of electricity but has two disadvantages: firstly the cost of the solar module adds significantly to the overall cost; and secondly there is a risk of the solar module being stolen. An alternative is to use a battery charging system whereby a local agent with a grid supply (such as a local store) acts as a battery charging centre and also sells the kits required (battery, lights etc.).

The advantages of this system are that (1) initial costs are considerably lower than most reticulation projects (the smallest system costs in the region of E750); (2) monthly recharging costs are likely to be low; (3) households are not committed to a minimum monthly fee, and will not run up any arrears on electricity bills; and (4) there is potential for income generation within the community.

It is recommended that a battery charging centre be established in one of the pilot projects (possibly Kubuta) through co-operation with the private sector. Agents capable of supplying suitable systems have been introduced to Swaziland, and contacts with battery charging manufacturers have been provided.

Promotion of productive applications
The success or failure of rural electrification projects probably depends on the extent to which they can encourage productive uses of electricity. There are a large number of types of enterprises which can potentially be established when electricity is introduced into an area. Experience indicates that generally, enterprise formation in newly electrified areas tends to be mostly in the commercial and trading sectors - small shops, bar and entertainment centres. However, there are also examples of productive applications such as welders, millers, weavers and sewers, and so on.

It is recommended that when a line extension project is completed, a presentation be held in the area to inform residents of the potential business opportunities which electricity makes available, and to provide information on equipment suppliers, business training opportunities and sources of credit. It is recommended that this task be co-ordinated with the Swazi small business development group.

Load management
Rural electrification projects tend to have low load factors, leading to higher costs - both in terms of the variable costs of supply (peak demand charges, per unit of electricity consumed, are higher), and in terms of the initial costs of capital required to supply the peak (fewer users per transformer etc.). It is thus important that some attention be paid to load management strategies.

The options available are as follows:

- *Promotion of appliance sales* - as households' ownership of appliances grow, so the load is diversified. Households which own only a few appliances tend to have a very "peaky" load profile, whereas households with a greater range of appliances have a "flatter" profile.
- *Use of domestic load limiters* - a circuit breaker rated less than the standard 60A can have some effect on the load profile. However, where households own only a few appliances, the limit must be set very low - say 8A - to have any discernible effect. The resulting inconvenience and customer dissatisfaction may not warrant the advantages gained. One exception is where geysers are used, and load limits can encourage users to operate their geysers at night when other appliances are not in use.
- *Promotion of non-domestic uses of electricity* - as discussed above. As the diversity of users increases in an area, so the load profile and load factor is likely to improve.
- *Off-peak water pumping* - special rates for water pumping during off-peak hours can have an important effect on the load profile where water pumping constitutes a significant portion of the demand. This may be where water pumps are used for communal water supply, or where irrigation pumps are used.

C.5 Key recommendations

C.5.1 Planning and prioritisation process

The following recommendations are made:

- A ***planning sub-committee of SCORE be established,*** comprised of representatives from MNRE, SEB and MEPD. This sub-committee should be responsible for the following tasks:
- ***Information collection for line extension projects***: each year the following years' line extension projects should be visited and information collected as per the questionnaire at the end of this appendix.
- ***Monitor the line extension fund***: monitor the line extension fund and evaluate the impact which new projects will have on this fund. Use this information to inform Government budgets for rural electrification.
- ***Evaluate applications for grid extension***: if a community applies to be included in the line extension programme, the committee should collect information on the settlement and evaluate whether it should be included in the medium term electrification programme
- ***Monitor rural development initiatives:*** The planning committee should monitor rural development initiatives, with attention paid to future irrigation projects and the development of the "economic corridors". Future developments may mean that the line extension programme should be updated to take account of new initiatives.

C.5.2 Rural development initiatives

The prioritisation of the line extension programme should take consideration of the following factors:

Rural services: A number of unelectrified clinics have been identified. These should be considered for grid electrification. There are also a large number of unelectrified rural schools. A number of these can be electrified at low cost (i.e. they are close to existing distribution lines). The position of unelectrified high schools should be considered when planning future line extension projects.

Physical infrastructure: STC has 35 unelectrified telecommunication stations. Attempts should be made to include these in the grid extension programme. the RWSB is planning a number of macro projects over the next few years. A number of these require pumping - and electricity is the preferred fuel. In addition, there are a number of existing water schemes where electricity is required either to replace defunct diesel pumping systems or to introduce a pumped reticulation scheme.

Economic activities: The MHUD has developed a system of classifying rural centres according to their future economic growth potential. It is further recommended by the NPDP that centres with a classification of six and above merit electrification. A total of 19 such unelectrified centres have been identified and should be considered in the electrification programme. A irrigation potential in the major river basins was documented and it is clear that there will be pumping requirements in the future - mainly in the Lubombo region. The electrification planning committee should monitor irrigation developments.

C.5.3 Optimisation of rural electrification projects

It is widely accepted that electricity is a necessary but insufficient condition for development. The following strategies may assist in optimising rural electrification projects.

- *Appliance sales:* The promotion of electrical appliances will assist in broadening the benefits of electrification. It is recommended that SEB and the MNRE collaborate in introducing appliance distributors to newly electrified areas, with the intention of holding demonstrations and the promotion of appliance sales through local stores.
- *Battery charging centres:* It is recommended that a system of battery charging centres be piloted for the rural electrification programme.
- *Promotion of productive applications:* It is recommended that in newly electrified areas a demonstration be held by the MNRE, together with small business development agencies, on the potential business opportunities made possible by electrification.
- *Load management:* A number of load management strategies should be considered if rural load factors lead to unacceptably high cost increases.

Information on Rural Electrification area

Either place an X in the box that answers the question or else fill in a number.

General information

1 Name of centre ....

2 Grid Reference Location..

3 Name of region ....

4 Approximately how many households live in or near this centre (within a radius of 500 metres)? .... households.

5 Where do most people in this centre draw their drinking water? (You may put an X against more than one answer if appropriate).

- ☐ Water from a piped system
- ☐ Clean water from a small spring
- ☐ Water from a bigger river
- ☐ Water from a borehole
- ☐ Water from a protected well
- ☐ Water from an open, unprotected well
- ☐ Other (please say what) ....

6 How many diesel pumps are there here?...

7 How many hand pumps are there here? ....

8 What type of toilet do most people use? *(You may put an X against more than one* answer).

☐ Flush toilet ☐ The bush ☐ Pit toilet

9 What is the quality of the main road/s coming to this centre?

☐ Tarred ☐ Gravel/earth

10 Approximately how many buses stop at this centre every day?.........................

11 Is there a fresh produce market in this centre? ☐ Yes ☐ No

12 Are there telephones in this centre? ☐ Yes ☐ No

Potential commercial electricity users

For each category below, indicate the number of electrified and unelectrified places:

		With electricity	*Without electricity*	*Total*
13	Wholesalers/distribution depots	....	....	....
14	Brick/block makers	....	....	....
15	Hotels/gust houses	....	....	....
16	General dealers/supply stores	....	....	....
17	Butcheries	....	....	....
18	Bottle stores	....	....	....
19	Restaurants/bars	....	....	....
20	Hair salons	....	....	....
21	Petrol stations	....	....	....
22	Mechanic's workshops	....	....	....
23	Telephone terminal/repeater stations	....	....	....
24	CCU depot or Farmers' shed	....	....	....
25	Other commercial enterprises	....	....	....
26	**Total number of shops/businesses**	**....................**	**....................**	**....................**

Potential domestic electricity users

		With electricity	*Without electricity*	*Total*
27	No. of households in area	....	....	....

Potential Government electricity users

For each category below, indicate the number of electrified and unelectrified places:

		With electricity	*Without electricity*	*Total*
28	Primary schools	....	....	....
29	Primary school teacher's houses	....	....	....
30	Secondary/high schools	....	....	....
31	Secondary/high school teacher's houses	....	....	....
32	Nurses' houses	....	....	....
33	Churches	....	....	....
34	Clinic/health centre	....	....	....
35	Library	....	....	....
36	Swazi Royal Police Post	....	....	....
37	Post Office	....	....	....
38	Veterinary services office	....	....	....
39	Inkhundla centre	....	....	....
40	Other Government offices	....	....	....
41	**Total number of Government users**	**....................**	**....................**	**....................**

Appendix D.1
The distributor line extension programme

The proposed 11kV line extension programme is detailed inthe table below. The scheduling of this programme has attempted to take into account the factors outlined in Appendix C.

Table D.1.1: 11kV line extension programme

Year	Area code	Approx cost [E thous]	Approx distance [km]	Schools	Clinics	Tele-coms	Water supply	Shops	Tin-khundla
1997	S14	300	10	5	1	4		6	
	S02	210	7	2	1	1		6	Yes
	SW10	180	6	2	1			4	
	E11	50	5	3	1		1	9	
	N19	30	1				1	2	
1998	E06	200	10	3	1		1	4	
	S06	180	6	2	1			5	
	S23	180	6	1	1	1		5	
	N18	75	2.5	1				8	
	SW13	75	2.5					0	
	N22	60	2	2				10	
	C10	30	1	1				20	
	C12	15	0.5	1				7	
	C19	15	0.5					4	
1999	SW04	270	9	3		1	1	2	Yes
	NE09	210	7	2	1	1		6	
	E08	120	4	2				4	
	C11	60	2	3		2	1	12	
2000	W13	300	10	3		2		8	Yes
	SW06	180	6	5		1		1	
	N26	135	4.5	5	1	2			
	N08	90	3					11	
2001	N10	180	6	1	1			13	
	NE08	120	4				1	10	
	N21	90	3	4				8	
	NW03	60	2			1		2	
	N15	45	1.5	1				16	
	NW02	30	1					2	
	C16	30	1	4			1	11	
	W09	30	1					4	

Table D.1.1: 11kV line extension programme (cont.)

Year	Area code	Approx cost [E thous]	Approx distance [km]	Schools	Clinics	Tele-coms	Water supply	Shops	Tin-khundla
2002	W15	105	3.5					2	
	N24	90	3	3				3	
	N25	90	3			1		23	
	S12	75	2.5					8	
	C06	30	1					2	
	N29	30	1					2	
	C21	15	0.5			1		3	
2003	C02	180	6	1				9	
	SW09	60	2					2	
	N17	60	2					1	
	N14	45	1.5	1				15	
2004	S17	150	5	2				5	
	N12	150	5	1				3	
	S22	105	3.5	1				1	
	W21	90	3	1				2	
2005	W17	180	6	3				1	
	S08	180	6	2	1			1	
	W16	180	6	1				3	
	W18	150	5	1					
	W08	60 •	2					3	
	NW04	45	1.5					3	
2006	C27	180	6	1				11	
	SE01	180	6					5	
	N30	150	5	1				9	
	S16	120	4	5				3	
	SW08	90	3	1				1	

The line extension fund, as proposed, is designed to act as a revolving credit fund for these projects. Revenue from connection charges is paid into the fund on an annual basis. The calculation of these connection fees is so that the total cost is shared between Government facilities and commercial enterprise, with Government facilities paying 3.3 times the amount that commercial users pay, with an upper limit of E25 000 and E7 500 for Government facilities and commercial enterprises respectively.

Table D.1.2 shows the connection fees which Government facilities and commercial enterprises would have to make, for each of the line extensino projects. Also shown is the cost of the project, the total revenue from charges, and the expected deficit.

Table D.1.2: Connection charges and deficits

Year	Area code	No. Govt facilities	No. shops	Govt connect. fee	Shop connect. fee	Approx cost [E thous]	Total revenue [E thous]	Deficit [E thous]
1997	S14	10	6	E25,000	E7,500	300	295	5
	S02	4	6	E25,000	E7,500	210	145	65
	SW10	3	4	E25,000	E7,500	180	105	75
	E11	5	9	E6,494	E1,948	50	50	0
	N19	1	2	E18,750	E5,625	30	30	-
1998	E06	5	4	E25,000	E7,500	200	155	45
	S06	3	5	E25,000	E7,500	180	113	68
	S23	3	5	E25,000	E7,500	180	113	68
	N18	1	8	E22,059	E6,618	75	75	-
	SW13	-	-	E25,000	E7,500	75	-	75
	N22	2	10	E12,000	E3,600	60	60	-
	C10	1	20	E4,286	E1,286	30	30	-
	C12	1	7	E4,839	E1,452	15	15	-
	C19	-	4	E12,500	E3,750	15	15	-
1999	SW04	4	2	E25,000	E7,500	270	115	155
	NE09	4	6	E25,000	E7,500	210	145	65
	E08	2	4	E25,000	E7,500	120	80	40
	C11	6	12	E6,250	E1,875	60	60	-
2000	W13	5	8	E25,000	E7,500	300	185	115
	SW06	6	1	E25,000	E7,500	180	158	23
	N26	8	-	E16,875	E5,063	135	135	-
	N08	-	11	E25,000	E7,500	90	83	8
2001	N10	2	13	E25,000	E7,500	180	148	33
	NE08	1	10	E25,000	E7,500	120	100	20
	N21	4	8	E14,063	E4,219	90	90	-
	NW03	1	2	E25,000	E7,500	60	40	20
	N15	1	16	E7,759	E2,328	45	45	-
	NW02	-	2	E25,000	E7,500	30	15	15
	C16	4	11	E4,110	E1,233	30	30	-
	W09	-	4	E25,000	E7,500	30	30	-

Table D.1.2: Connection charges and deficits (cont.)

Year	Area code	No. Govt facilities	No. shops	Govt connect. fee	Shop connect. fee	Approx cost [E thous]	Total revenue [E thous]	Deficit [E thous]
2002	W15	-	2	E25,000	E7,500	105	15	90
	N24	3	3	E23,077	E6,923	90	90	-
	N25	1	23	E11,392	E3,418	90	90	-
	S12	-	8	E25,000	E7,500	75	60	15
	C06	-	2	E25,000	E7,500	30	15	15
	N29	-	2	E25,000	E7,500	30	15	15
	C21	1	3	E7,895	E2,368	15	15	-
2003	C02	1	9	E25,000	E7,500	180	93	88
	SW09	-	2	E25,000	E7,500	60	15	45
	N17	-	1	E25,000	E7,500	60	8	53
	N14	1	15	E8,182	E2,455	45	45	-
2004	S17	2	5	E25,000	E7,500	150	88	63
	N12	1	3	E25,000	E7,500	150	48	103
	S22	1	1	E25,000	E7,500	105	33	73
	W21	1	2	E25,000	E7,500	90	40	50
2005	W17	3	1	E25,000	E7,500	180	83	98
	S08	3	1	E25,000	E7,500	180	83	98
	W16	1	3	E25,000	E7,500	180	48	133
	W18	1	-	E25,000	E7,500	150	25	125
	W08	-	3	E25,000	E7,500	60	23	38
	NW04	-	3	E25,000	E7,500	45	23	23
2006	C27	1	11	E25,000	E7,500	180	108	73
	SE01	-	5	E25,000	E7,500	180	38	143
	N30	1	9	E25,000	E7,500	150	93	58
	S16	5	3	E20,339	E6,102	120	120	-
	SW08	1	1	E25,000	E7,500	90	33	58

As can be seen, a number of projects result in deficit for the fund, which must be met through annual subventions from Government. Table B.1.3 summarises these on an annual basis.

Table B.1.3: Summary of costs, revenue and deficits

Year	Total costs	Total revenue	Total deficit
1997	E870 000	E725 000	E145 000
1998	E930 000	E675 000	E255 000
1999	E660 000	E400 000	E260 000
2000	E705 000	E560 000	E145 000
2001	E585 000	E497 500	E87 500
2002	E435 000	E300 000	E135 000
2003	E345 000	E160 000	E185 000
2004	E495 000	E207 500	E287 500
2005	E795 000	E282 500	E512 500
2006	E720 000	E390 000	E330 000
Total	E6 540 000	E4 197 500	E2 342 500

Appendix D.2
The reticulation schedule

The following tables show the areas identified for reticulation projects by phase 1 of the project. Information on the number of schools and clinics does not always appear to be accurate, and the figures represent the total number of facilities, including those already electrified.

Table D.2.1: Reticulation projects initiated in 1997
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Tinkh-undla	Ave retic cost per connection
C04	222	11	2	1		E2,656
C07	177	6	5	2	Yes	E2,646
C09	340	8	6	1	Yes	E2,438
C10	422	17	5	0		E2,494
C12	55	0	1	0		E2,504
C15	257	8	3	0		E2,590
C25	79	24	3	1		E2,745
E02	98	3	2	0		E2,985
E03	125	4	0	1		E2,928
E11	259	4	6	1		E2,616
N18	101	6	5	1		E2,819
N22	236	6	1	2		E2,626
NW06	112	9	1	1	Yes	E2,618
NW10	182	40	5	1	Yes	E2,624
S15	121	11	2	0	Yes	E2,652
S20	107	9	4	0	Yes	E2,672
SE06	85	3	2	1		E2,529
SE07	173	6	2	1	Yes	E2,469
SW02	240	12	3	0		E2,584
W06	312	22	1	6		E3,419
W07	82	3	1	1		E3,133
W10	15	10	6	3		E2,862
W11	90	3	2	1		E2,862
W12	65	19	3	0		E2,549
W19	145	23	8	0	Yes	E2,687
Total	**4100**	**267**	**79**	**25**		**E2,708**

Table D.2.2: Reticulation projects initiated in 1998
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Tin-khundla	Ave retic cost per connection
C08	482	8	6	0		E2 495
E01	303	11	4	2		E2 698
N13	213	4	2	3		E2 394
SW04	164	7	4	0	Yes	E2 674
SW15	115	4	2	0		E2 608
Total	**1277**	**34**	**18**	**5**		**E2 574**

Table D.2.3: Reticulation projects initiated in 1999
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Tin-khundla	Ave retic cost per connection
C05	492	5	5	1		E2 517
C11	285	10	2	0		E2 855
C13	106	1	1	0		E2 460
C14	143	2	3	0		E3 227
C17	149	1	0	0		E3 321
C22	254	8	2	0		E2 774
C23	376	2	2	1		E3 264
E08	188	3	0	1		E2 556
N01	341	10	3	1		E2 534
N09	204	7	5	1		E2 605
N28	314	11	0	0		E2 560
NW07	155	4	2	0		E2 675
S02	110	3	3	1	Yes	E2 504
S11	310	16	7	0	Yes	E2 688
S13	228	16	4	1		E2 879
S21	530	30	6	1	Yes	E2 545
S25	193	9	4	2		E2 750
SW03	169	5	1	0		E2 435
SW07	350	13	4	1	Yes	E2 665
W13	227	11	2	0	Yes	E3 096
W14	241	9	6	1	Yes	E2 915
Total	**5365**	**176**	**62**	**12**		**E2 753**

Table D.2.4: Reticulation projects initiated in 2000
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Tin-khundla	Ave retic cost per connection
C03	192	3	0	0		E2 577
N04	361	13	4	2		E2 707
N06	101	3	0	0		E2 646
N07	148	5	2	0		E2 777
N23	174	8	2	1	Yes	E2 528
NE02	430	15	4	1		E2 703
S09	202	5	3	0		E2 557
S10	175	6	2	0		E2 634
SE05	67	1	0	1		E2 525
SW11	42	0	1	0		E2 499
SW16	968	26	7	0		E2 609
W20	105	2	0	0		E2 691
Total	**2965**	**87**	**25**	**5**		**E2 621**

Table D.2.5: Reticulation projects initiated in 2001
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Ave retic cost per connection
C01	164	4	2	0	E2 645
C24	259	3	4	1	E2 815
E09	135	2	2	0	E2 699
N03	166	3	2	0	E3 082
NW02	28	1	0	0	E2 447
NW03	190	9	1	0	E2 638
S27	110	1	3	0	E2 460
S28	110	6	1	0	E2 642
SW01	250	10	2	0	E2 837
Total	**1412**	**39**	**17**	**1**	**E2 696**

Table D.2.6: Reticulation projects initiated in 2002
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Ave retic cost per connection
C06	104	3	0	0	E3 033
C16	146	2	3	0	E4 023
C18	162	1	0	0	E2 661
C20	182	3	1	0	E2 624
C26	114	1	0	0	E2 562
E06	183	4	0	0	E2 617
N02	288	7	4	0	E2 633
N05	178	3	0	0	E2 526
N15	131	2	0	0	E2 612
N19	74	1	0	0	E2 765
S07	134	4	2	0	E2 724
S24	244	8	5	0	E2 812
SE03	75	2	2	0	E3 320
SW05	304	4	2	1	E3 073
SW06	180	1	2	1	E2 650
SW09	130	2	1	0	E2 527
SW10	185	3	2	1	E2 742
SW12	142	4	1	0	E2 925
SW17	467	5	5	0	E2 719
W15	247	9	0	0	E2 998
Total	**3670**	**69**	**30**	**3**	**E2 827**

Table D.2.7: Reticulation projects initiated in 2003
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Ave retic cost per connection
C02	97	0	0	0	E2 590
E10	331	7	4	0	E3 079
E14	174	2	2	0	E2 626
N14	143	2	0	0	E2 636
N17	132	1	1	1	E2 848
N20	201	2	4	0	E2 790
NE09	339	7	3	0	E2 845
NW09	66	1	0	0	E2 720
S14	309	6	3	1	E2 605
S23	191	5	2	1	E2 935
S26	150	7	2	0	E2 900
SE04	123	1	0	0	E2 583
SW14	366	6	2	0	E2 852
W01	172	3	0	0	E3 017
W03	289	5	0	0	E2 784
W04	23	1	0	0	E2 948
Total	**3106**	**56**	**23**	**3**	**E2 797**

Table D.2.8: Reticulation projects initiated in 2004
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Ave retic cost per connection
E07	78	1	0	0	E3 039
N10	77	1	1	0	E3 108
N12	267	4	0	0	E2 516
N16	304	1	0	0	E2 714
N21	229	2	0	0	E2 648
N26	242	4	2	1	E2 659
N27	145	2	0	0	E2 969
NE08	39	1	0	0	E2 975
NW08	51	1	0	0	E2 739
S01	102	4	0	0	E2 965
S04	309	6	1	0	E2 741
S06	89	1	1	1	E2 844
S17	129	2	2	0	E2 980
S18	86	1	0	0	E2 559
S22	78	2	2	0	E2 997
W09	230	4	0	0	E2 757
W21	52	1	0	0	E2 773
Total	**2507**	**38**	**9**	**2**	**E2 822**

Table D.2.9: Reticulation projects initiated in 2005
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Ave retic cost per connection
C21	38	0	0	0	E2 979
N08	54	1	0	0	E2 855
N11	267	4	0	0	E2 898
N24	275	3	0	0	E2 644
N25	69	1	0	0	E2 693
N29	53	1	0	0	E2 948
NW04	131	2	0	0	E2 932
NW05	33	1	0	0	E2 804
S03	79	1	0	0	E2 742
S05	132	2	1	0	E2 926
S08	185	3	5	1	E3 371
S12	44	0	1	0	E2 972
S19	73	1	1	0	E2 993
SE08	122	0	0	0	E2 531
SW08	81	1	0	0	E2 827
W02	161	3	0	0	E3 026
W08	117	2	0	0	E3 048
W16	59	1	0	0	E3 067
W17	111	2	0	0	E3 094
W18	69	1	0	0	E2 903
Total	**2153**	**30**	**8**	**1**	**E2 913**

Table D.2.10: Reticulation projects initiated in 2006
(based on phase 1)

Code	No. of households	No. of shops	No. of schools	No. of clinics	Ave retic cost per connection
C27	16	0	0	0	E3 419
N30	127	2	0	0	E3 090
S16	393	2	0	1	E2 583
SE01	103	0	0	0	E3 050
Total	**639**	**4**	**0**	**1**	**E3 035**

Appendix D.3
Assumptions Used in the Financial Analysis

The financial analysis relies on a number of assumptions. These are detailed below.

D.3.1 Connection rates

The figure below shows the annual connection rates for domestic and non-domestic customers. Non-domestic includes all schools, clinics, shops and water pumping stations. Three domestic connection rates are investigated corresponding to the three connection policies examined:

- Low connection fee (80% take-up rate): where only a E50 connection fee is levied, and no direct contribution to the reticulation cost is expected.
- Medium connection fee (60% take-up rate): where E2000 of the reticulation cost is paid by a Government loan.
- High connection fee: (30% take-up rate): where all of the reticulation costs must be paid by the customer.

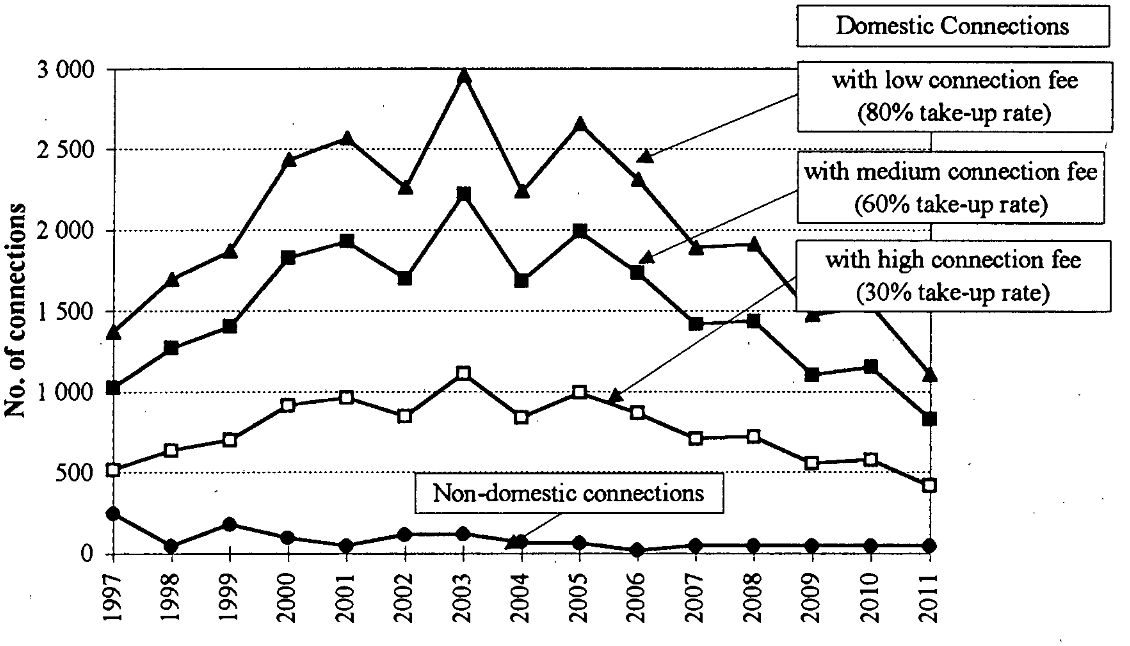

Figure D.3.1: Connection rates assumed

D.3.2 Consumption rates

Three different consumption levels are assumed for domestic connections, depending on the tariff policy.

- The base case is the "low connection fee" scenario.
- For the "business-as-usual" scenario, consumption levels are 10% higher since it is anticipated that higher income households will connect.
- For the "tariff-surcharge" scenario, a 10% lower consumption is assumed due to the sensitivity to higher prices.

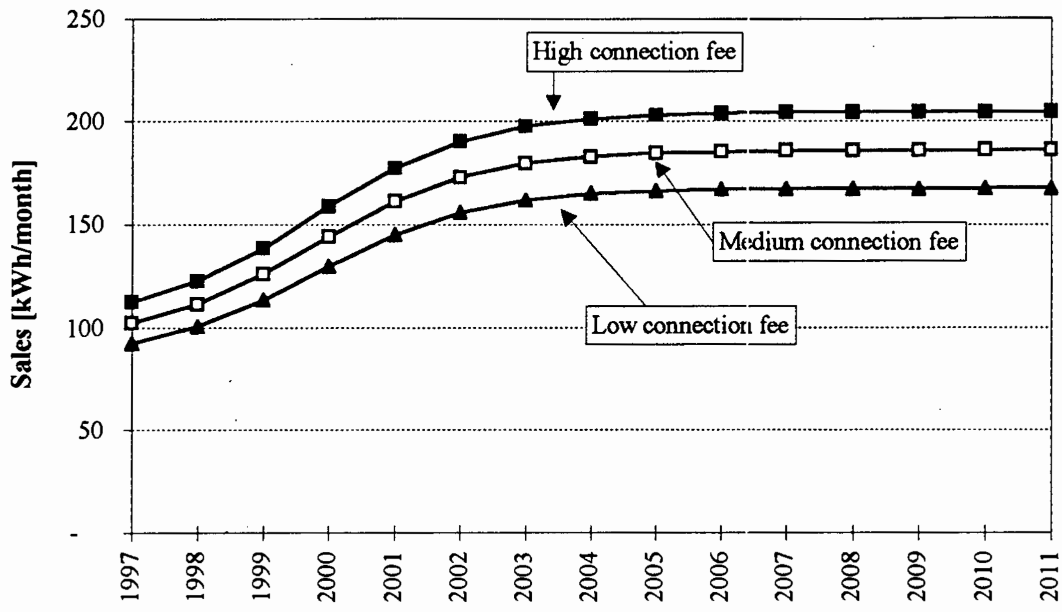

Figure D.3.2: Sales for domestic consumers

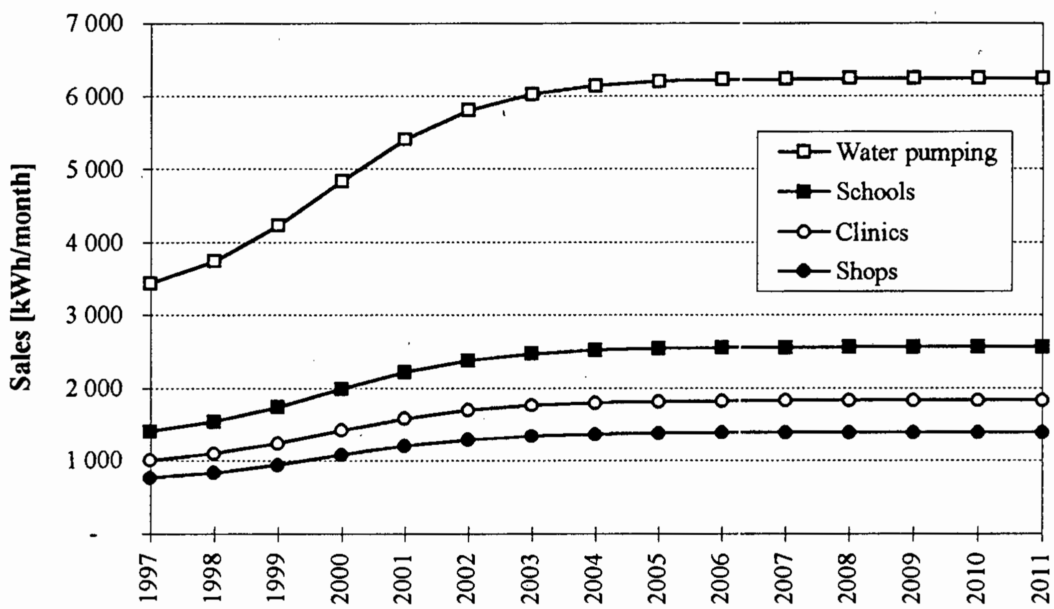

Figure D.3.3: Non-domestic sales

Actual electricity supply is a function of sales and losses. It is assumed that technical losses amount to 7% of consumption, and other losses (theft and arrears) amount to 15% of consumption by domestic consumers, and 5% of commercial consumption.

D.3.3 Supply costs

Supply costs are expressed in terms of a fixed cost (E per customer per month), which is incurred regardless of the size of sales, and a variable cost (c/kWh), which is incurred as a function of electricity supplied.

The fixed cost is set at E35 per customer per month. This includes meter reading, billing, maintenance and overheads associated with the distribution business. The variable cost is set at 15c/kWh supplied. This cost includes the cost of purchasing electricity, plus the overheads associated with the generation and transmission portions of the business.

For example, if a household consumes 100 kWh in a month, then

Cost of supply = E35 + 100 kWh * 15c/kWh = E50

Thus, for households consuming 100 kWh per month, the average cost of supply is 50c/kWh.

D.3.4 Tariffs

SEB tariffs, with an 8% increase assumed for 1997, are used.

Table D.3.1: Tariffs used in the analysis

Uses group	Scale	Basic	Energy
Domestic	S1	E5/month	26.8 c/kWh
Non-domestic	S3	E5/month	37.8 c/kWh

D.3.5 Other assumptions

All costs and tariffs were assumed to increase at a rate of 8% per annum.

The interest rate on Government loans was set at 10%, over 15 years.

The discount rate used was 16%, which is equivalent to an 8% real rate.

The analysis was conducted over a 15 year time period.

Appendix E.1
Summary for Ministry of Health

The distributor line extension programme over the next five years will allow 10 clinics to be electrified, as shown in Table E.1.1 below.

Table E.1.1: Clinics to be electrified as part of the distributor line extension programme

Year	Area	Clinic	Cost
1997	S14	Ntshanini	E25 000
	S02	Nkwene	E25 000
	SW10	Mashobeni	E25 000
	E11	Tikuba	E6 500
1998	E06	Sitsatsaweni	E25 000
	S06	Nkonjwa	E25 000
	S23	Jerico	E25 000
1999	NE09	Shewula	E25 000
2000	N26	Maphaleni	E16 875
2001	N10	Ndvwabangeni	E25 000

In addition, there are a number of clinics which can be electrified through reticulation projects, requiring very little distributor line extension. These clinics are Malindza, Mafutseni, Ngculweni, Bethany and Ikwezi Joy. It is likely that costs of approximately E3 000 per clinics should be budgeted.

The total costs for all Government clinics (which cannot be electrified) and Sigcaweni (the mission clinic with a solar system which cannot be electrified) are as follows:

Sincineni	Battery system installation	E45 000
	Wiring rehabilitation	E5 000
	PV supplement to batteries	E3 000
Makhava	Battery system installation	E45 000
Musi	Genset refurbishment	E20 000
	Battery system installation	E45 000
	PV supplement to batteries	E3 000
Mpuluzi	Battery system installation	E45 000
Sigcaweni	Upgrade to DC solar system (clinic & 2 nurses' homes)	E20 000
Subtotal		E296 000
Contingencies @ 10%		E29 000
TOTAL		**E315 000**

The total capital budgets which should be anticipated (in 1996 monetary terms) are as follows:

1997	Distributor line extensions	E81 500	
	Reticulation costs (9 clinics @ E3000)	E27 000	
	Off-grid projects (Mpuluzi & Singcaweni)	E65 000	
	TOTAL		E173 500
1998	Distributor line extensions	E75 000	
	Reticulation costs (3 clinics @ E3000)	E9 000	
	Off-grid projects (Sincineni & Makhava)	E98 000	
	TOTAL		E182 000
1999	Distributor line extensions	E25 000	
	Reticulation costs (1 clinic @ E3000)	E3 000	
	Off-grid projects (Musi)	E68 000	
	TOTAL		E96 000
2000	Distributor line extensions	E16 875	
	Reticulation costs (1 clinic @ E3000)	E3 000	
	TOTAL		E19 875
2001	Distributor line extensions	E25 000	
	Reticulation costs (1 clinic @ E3000)	E3 000	
	TOTAL		E28 000

Appendix E.2
Summary for Ministry of Education & Training

The distributor line extension programme, over the next five years, will allow 56 schools to be electrified, of which 17 are high or secondary schools. These schools are listed in Table E.2.1.

Table E.2.1: Schools to be electrified as part of the distributor line extension programme

Year	Area	School	Cost
1997	S14	Ntshanini high	E25 000
		Ntshanini primary	E25 000
		Engudzeni primary	E25 000
		Enguczeni high	E25 000
		Kombhebha primary	E25 000
	S02	Nkwene high	E25 000
		Nkwene primary	E25 000
	SW10	Mashobeni high	E25 000
		Mashobeni primary	E25 000
	E11	Matsanjeni high	E6 500
		Intuthuko primary	E6 500
		St Johns Primary	E6 500
1998	E06	Sitsatsaweni Nazarene	E25 000
		Sitsatsaweni Central	E25 000
		St Charles	E25 000
	S06	Nkonjwa High	E25 000
		Madubeni Primary	E25 000
	S23	Jerico Primary	E25 000
	N18	Nkambheni Primary	E22 000
	N22	Ekubhongeni High	E12 000
		Ebulanzweni Primary	E12 000
	C10	Mbekelweni Primary	E4 300
	C12	Bethany Primary	E4 800
1999	SW04	Mavovukati Primary	E25 000
	NE09	Majembeni High	E25 000
		Majembeni Primary	E25 000
	E08	Mpholonjeni High	E25 000
		Nyambo Primary	E25 000
	C11	Malunge High	E25 000
		Mpembokati Primary	E25 000
		Mallyaduma Primary	E25 000

Table E.2.1: Schools to be electrified as part of the distributor line extension programme (contd.)

Year	Area	School	Cost
2000	W13	Ntondoze High	E25 000
		Khalakingi Primary	E25 000
		Kananida Primary	E25 000
	SW06	Siyendle High	E25 000
		Siyendle Methodist Primary	E25 000
		Siyendle Apostolic Primary	E25 000
	N26	Mphalaleni High	E16 875
		Mphalaleni Sasm Primary	E16 875
		Khulahla Primary	E16 875
		Malandela Primary	E16 875
		Maphandieni Anglican Primary	E16 875
2001	N10	Mavulav Primary	E25 000
	N21	Ekubongeni High	E14 000
		Mphondia Primary	E14 000
		Nkamanzi Primary	E14 000
		Ebulanzeweni Primary	E14 000
	N15	Mangweni Primary	E7 750
	C16	Malindza High	E4 100
		Malindza Primary	E4 100
		Estweni Primary	E4 100
		Entandweni Primary	E4 100

The total capital budgets which should be anticipated (in 1996 monetary terms) are as follows:

1997 Distributor line extensions E244 500
Reticulation costs (12 schools @ E3000) E36 000
TOTAL E280 500

1998 Distributor line extensions E205 100
Reticulation costs (11 schools @ E3000) E33 000
TOTAL E238 100

1999 Distributor line extensions E250 000
Reticulation costs (10 schools @ E3000) E30 000
TOTAL E280 000

2000 Distributor line extensions E284 375
Reticulation costs (13 schools @ E3000) E39 000
TOTAL E323 375

2001 Distributor line extensions E105 150
Reticulation costs (10 schools @ E3000) E30 000
TOTAL E135 150

In addition, if schools and teachers' homes are not wired, these additional costs will have to be budgeted for.

There are a number of schools which are currently unelectrified, but close to existing power lines. These schools can be electrified at relatively low cost. The high and secondary schools which fall into this category are listed below. It is recommended that these schools be electrified within the next two years.

Table 2: Unelectrified schools less than 1km from existing grid

School name	Town	Region
Ikhwezi Secondary	Nsoko	Lubombo
Lubuli Secondary	Nsoko	Lubombo
Malindza High	Mpaka	Lubombo
Mpompota High	Kubuta	Lubombo
Osuthu Methodist High	Bhunya	Manzini
Phonjwane High	Manzini	Lubombo
Sibovu Secondary	Mankayane	Manzini

Appendix E.3
Summary for Swaziland Telecoms Corporation

The distributor line extension programme over the next five years will allow 16 telecom stations to be electrified, as shown in Table E.3.1 below.

Table E.3.1: Telecom stations to be electrified as part of the distributor line extension programme

Year	Area	Station	Cost
1997	S14	R5, T23, T42, T26	E100 000
	S02	T36	E25 000
1998	S23	T44	E25 000
1999	SW04	T10	E25 000
	NE09	T86	E25 000
	C11	T75, T84	E50 000
2000	W13	T3, T4	E50 000
	SW06	T9	E25 000
	N26	T62, T65	E33 750
2001	NW03	T61	E25 000

Appendix E.4
Summary for Rural Water Supply Board

The distributor line extension programme over the next five years will allow 16 telecom stations to be electrified, as shown in Table E.4.1 below.

Table E.4.1: Pumping projects to be electrified as part of the distributor line extension programme

Year	Area	Pumping station	Cost
1997	E11	Tikhuba	E100 000
	N19	Mangedla	E18 750
1998	E06	Sitsataweni	E100 000
1999	SW04	Nsangweni	E25 000
	C11	Malunge	E25 000
2001	NE08	Tsmabokhulu	E25 000
	C16	Gegebini	E4 100

EDRC REPORT SERIES

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