Socio-economic impacts of rural electrification in Namibia

Report 2: The impact of electrification on rural health care facilities, education and small businesses

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DRAFT FINAL REPORT

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1999

Executive summary

This study is the second of two studies which have been conducted to examine the socio-economic impacts of rural electrification in Namibia. Whilst the first study focussed primarily on households, this study examines the impact of electrification on health care provision, education and small business development in the rural areas.

Health care facilities, schools and small businesses in Ohangwena, Oshikoto, Oshana and Omusati in the north, and Omaheke in the east, were included in the investigation.

Health care facilities and electrification

It was found that the energy requirements of clinics was limited to lighting (inside and outside), refrigeration, radio communication and powering some medical equipment. Although the grid electrified clinics used electricity for refrigeration, the solar clinics used gas. Except for three clinics which had telephones, all the clinics had separate solar systems for radio communication. Due to the expanded services provided at health care centres, especially with regard to admitting patients, the energy requirements are greater than those of the clinics. Electric lighting was considered to be an important component of providing care to patients at night and laundries and kitchens required electricity for washing, ironing, cooking and refrigeration. Health centres also tended to have more medical equipment than clinics. In contrast to health centres and clinics, electricity is critical for the effective functioning of hospitals as they are dependant on modern equipment, which ranges from office equipment to specialised medical equipment.

The benefits of electrification

The benefits of lighting at clinics

It was found that the extent to which clinics use and require lighting varies considerably. None of the clinics reported using lighting during the day, and only some of them left lighting on at night for security purposes. The principal use of lighting at night was for emergencies. Except for un-electrified clinics, all the clinics used lighting to provide an emergency service.

For clinics to provide effective emergency services good quality lighting is critical. Both solar and grid electricity are effective energy carriers for the lighting requirement of clinics. Although diesel generators can provide a similar quality of service, they can be unreliable and the long term operating and maintenance costs are high. Clinics without access to good quality lighting are clearly at a disadvantage. The provision of electricity to clinics for lighting will, however, not necessarily lead to an improved health care service. Where clinics have resident staff, the benefit of electric lighting is greatly enhanced through enabling the provision of emergency services, admission of over-night patients for observation and preparation of education programmes.

Improved technology

That electrification can facilitate the use of better technologies, especially at hospitals, is clear. However, it is worth highlighting the desirability of electrical suction machines to staff working at all the clinics (even those without grid electricity) and health centres. In almost every interview staff mentioned the use of electric suction machines as one of the benefits of grid electricity. In order to facilitate the need for suction machines which was expressed at the clinics, the Ministry of Health and Social Services should investigate the possibility of providing this equipment to clinics which are grid electrified. Suction machines which are vacuum operated off a gas supply are also available, and could be supplied to solar and un-electrified clinics.

Does electricity attract staff?

It is difficult to determine whether electricity attract well qualified staff to health facilities, as there are many factors other factors which also influence this. For instance, many of the nurses did not have the choice to decide where they would work as they were placed by the Ministry of Health and Social Services. There is little doubt, however, that electricity improves the quality of life of staff who are provided with accommodation at health care facilities. Although nurses may have limited choices with regard to where they work, doctors are more able to exercise choice and some of the doctors interviewed felt that it they were unlikely to be attracted to hospitals without electrified accommodation.

Does electricity improve security?

There is sufficient evidence to suggest that outside lighting does improve security, although in most cases this is not a sufficient deterrent for would-be-thieves. As a result of the number of burglaries, most of the health care facilities have employed security guards. However, it is important to point out that burglaries continue despite the presence of both outside lighting and security guards.

Problems and difficulties

Maintaining the vaccine cold chain at clinics

Vaccine fridges, which are mostly powered by gas in the solar and un-electrified clinics, are an essential component of an effective immunisation programme and require a reliable energy source to power them if the vaccine cold chain is to be maintained. However, in every case difficulties in ensuring that gas was delivered on time were experienced.

Although not always followed, the procedure for obtaining gas involves the clinic staff communicating its request for gas to the district hospital. If there is a gas supply at the hospital, and transport is available, the gas will be delivered to the clinic. However, due to a number of reasons, this process does not always run smoothly. Firstly, clinics experience problems with communicating with the district hospital. Secondly, there is not always gas available at the district hospitals and centres. The clinics are then forced to wait until gas arrives at the hospital. Thirdly, transport problems also create delays. Even in cases where clinics have managed to contact the district hospital and gas is available there may not be any form of transport to bring the gas to the clinic.

A further reason for the problem lies with the clinic staff's delays in ordering more gas. It is essential that the gas supply and delivery network is improved. The evidence from the research seems to suggest that the district hospitals are not the most appropriate point for gas delivery to clinics due to the limited available transport and the difficulties with radio communication. The possibility of sub-contracting these services to small gas agents throughout the different regions should be considered. The consumption of gas should also be fairly consistent at clinics and consumption data could be collected by the gas agents so that they can anticipate when a clinic will need gas. With dedicated transport, it is likely that minimal delays will be experienced.

The clinic electrification planning process should also consider the installation of solar systems which have the capacity to power a vaccine fridge in clinics. However, it is critical that an appropriate maintenance infrastructure is in place if solar is to be considered. With the current solar maintenance problems, it is possible that solar may be even more unreliable than gas

Radio communication at clinics

In terms of the system of referral which supports the Primary Health care function at clinics the ability to communicate with district hospitals is essential. All of the clinics experienced problems with radio communication, either because of problems with the solar systems or because of problems with the radio network.

The reason for problems with solar systems stems from the lack of maintenance In clinics where problems were experienced, it was evident that batteries had not been replaced for more than five years (where the average life span of a battery is 18 months to two years) which is almost certainly the cause of the problems they are experiencing as the capacity of batteries decreases over time. It is essential that appropriate maintenance support is given as the integrity of the primary health care system is compromised by the inability to communicate and easily refer patients to hospitals when necessary.

Solar systems maintenance problems at clinics

One of the most serious problems which has emerged from this investigation is the weak system of maintenance and support for solar systems at clinics. In a number of clinics it was found that solar systems which have been installed for lighting or water heating did not work at all. None of the clinics have had technicians doing routine checks of the clinic systems either. The Ministry of Works, Transport and Communication in Oshakati, the ministry does not have a programme of ongoing maintenance of solar systems at clinics. Rather, it responds to problems which are reported to them. Apparently, the clinics which are currently being electrified by sub-contractors appointed by the Ministry of Health and Social Services, are visited for an initial period to make sure that the systems are working. Thereafter, the responsibility for dealing with problems which may arise lies with the Ministry of Works, Transport and Communication.

From the Ministry of Works, Transport and Communication's perspective, it is impossible to envisage expanding their activities to ensure the ongoing maintenance and operation of the solar systems at clinics due to lack of skilled personnel, lack of finance for materials or spare parts and lack of transport. Clearly this situation is untenable, and with more solar systems being installed in clinics it can only get worse if attention is not given to devising an effective maintenance programme. Given the limited capacity of the Ministry of and Works, Transport and Communication and the inefficiency of the long chain of command for getting faults addressed, it is not appropriate that the sole responsibility for maintenance lies with the ministry. Experience elsewhere has shown that for solar electrification programmes to be effective, regular monitoring of the systems and capacity building of users and local technicians is essential.

It was suggested that a maintenance programme which seeks to build the capacity of clinic staff and local technicians be devised and implemented. This programme should ensure that clinic staff are able to use systems effectively, undertake first line maintenance and have basic fault finding skills. A sufficient number of local technicians should be sub-contracted to maintain the solar systems by undertaking routine tasks, such as ensuring that batteries are regularly changed and conducting annual checks on the systems, as well as dealing with faults as they arise There should be some integration between the training of local technicians for the *Home Power!* and clinic electrification programmes. Also, the need to ensure that the Ministry of Health and Social Services, with the assistance of the Ministry of Mines and Energy, take responsibility for over-seeing the programme was also identified.

The impact of supply interruptions

The extent to which supply interruptions disrupt the operation of the facility is dependant on its reliance on electricity, as well as the existence of a back-up system. One of the major impacts of supply interruptions on health centres and electrified clinics is the effect on the vaccine cold chain, especially when the electricity supply is interrupted for long periods. Supply interruptions also affect the health centres' ability to provide emergency services and nurse the patients in the wards at night.

Supply interruptions do not have an impact on the operation of some of the hospitals, as their generators provide reliable back-up. At the Onandjokwe hospital, however, the generator does not switch on automatically when the electricity supply is interrupted and a delay of approximately ten minutes is experienced. While this may not seem critical, the

ICU staff felt that it difficult to work under these conditions especially where patients were using life-support systems, such as ventilators or incubators for babies. The main problem in theatre is the loss of light, which makes it impossible to continue. Of all the health care facilities is it most critical for hospitals to have an uninterrupted supply of electricity. For this reason, it is essential that hospitals have back-up generators which are reliable, and efforts to repair faults and maintain them should be made. Until problems with the grid supply network have been resolved it is likely that the problems associated with supply interruptions will persist.

Education and electrification

The benefits of electrification

The need for lighting at schools

Except for those schools with hostel facilities, it was found that the schools made very limited use of their electric lighting. Only one school was found to give adult education classes in the evening, although a number of them did offer classes during the afternoons. In some cases, schools were used occasionally in the evenings for community and church meetings. At schools without hostel facilities none of the children had access to the buildings at night for studying purposes.

The principal use of lighting at most of the schools is for security purposes. As with the situation at clinics, it was also reported that outside lighting alone does not safeguard schools against theft. However, unlike the situation at clinics, security guards are not paid for by the Ministry of Basic Education and Culture, and those schools which employ security guards pay for them from their school fees.

Schools with hostels

Aside from the benefits associated with using electricity for kitchen equipment, student access to good quality lighting for studying purposes is the major benefit of electricity for schools with hostels. As there are no facilities for studying at most of the hostels, students are able to use the classrooms at night to study. However, it is impossible to quantify the benefits of students' access to good lighting. All the teachers interviewed argued that there was not a direct correlation between access to good quality lighting and the achievement of students, as this was dependent on a range of factors, including the aptitude of the students, whether they were sufficiently well nourished, facilities at schools, skill and qualification of teachers and the standard of teaching in the schools.

Teaching aids and administrative equipment

It was found that primary and combined schools in the northern regions have very little equipment, whilst those in the Omaheke region had a wide range of equipment for teaching and administrative purposed. Secondary schools in both regions had the most equipment. The government allocation of equipment favours secondary schools.

From the teachers perspective, teaching aids, such as overhead projectors, televisions, tape recorders and video machines enhance their ability to teach, making teaching 'easy', and more 'interesting' and 'exciting' for students. Teachers who had taught at schools prior to electrification, or at other un-electrified schools were particularly emphatic about the benefits of using teaching aids. Radio/tape recorders were considered important for language education as students are able to listen to the language as spoken by mother-tongue speakers. Television and video machines were especially used for history, geography and science subjects and were considered to be important educational aid as it made certain concepts, foreign environments and phenomenon more tangible for students. Those schools teaching grade 9 and 10 are also provided with science kits which provide equipment for experiments, including those concerned with understanding the concept of electricity. Although these kits can be powered with batteries, all the electrified schools used

electricity to power the equipment. No other laboratory equipment, such as microscopes, were found at the schools.

In terms of office equipment, photocopiers were considered to be the most useful and desirable items, and the need to photocopy materials has been established as a norm in both schools with and without photocopiers. With the result, schools which do not have photocopiers have to pay other schools and institutions for copying, often at highly inflated prices.

In the short term, those schools which have a range of electrical teaching aids and office equipment stand to gain the most from having electricity. However, even with limited resources schools do plan and budget for the acquisition of equipment. Many of the schools have managed to acquire equipment in addition to the items provided by the state. In the long-term it is possible that primary and combined schools will have more teaching aids and office equipment which will enhance their ability to teach.

Technology Enhanced Learning (TEL)

There is a strong argument to be made for exposing learners to sophisticated technologies, such as computers, so that they do not become further marginalised in the modern economy. Only one secondary school had acquired computers which were used to teach computer literacy to both students and teachers. Clearly, without electricity it is impossible to provide computer education. However, given the resource constraints facing schools and the need to address the lack of basic equipment and facilities in schools, expenditure on computers is not likely to be prioritised by the state. Without the support of private sector and donor funding to provide computers, this form of technology enhanced learning will not be facilitated by the provision of electricity to schools.

Does electricity attract staff?

It was also found that electrified staff accommodation was highly valued by teachers and in some cases, teachers emphasised this above the educational benefits associated with electricity. The teachers interviewed felt that electricity made their lives more comfortable as they were able to use appliances for entertainment, such as radios and televisions, as well as enjoy the benefits of cooking with electricity, which they were unable to do at their own un-electrified homes. Also, with access to lighting teachers were able to prepare lessons and mark work in the evenings.

As with the situation at health care facilities, it is important not to attribute the existence of well qualified teachers at school solely to the existence of electricity as teachers are not always able to exercise choice over where they are able to teach. Where teachers are able to determine where they will teach other factors besides electricity influence their decisions. For instance, many teachers choose to teach in schools in their villages so that they can be with their families or teachers move to other schools because of promotional opportunities.

Problems and difficulties

Replacing bulbs and reading bills

It was found that some of the schools did not know who was responsible for replacing light bulbs, and with the result, the bulbs had not been replaced. Schools were reluctant to use schools fees to pay for the replacement of bulbs due to their limited resources and the fact that different institutions had replaced them in the past. This situation can be resolved by informing schools of the correct procedure for bulb replacement.

Many of the principals interviewed in the northern regions expressed mistrust of Northern Electricity's tariffs. Although the Ministry of Basic Education and Culture pays for the bills the principals of the school are responsible for examining the bills before sending them to the Ministry for payment. The inclusion of a charge per kVA of maximum demand was the main reason for concern and one of the principals said that 'it seems as though Northern Electricity is charging us twice.' It is recommended that Northern Electricity informs school

principals of the way in which tariffs for large power users, such as schools, are devised and calculated. Information pamphlets, with accessible explanation, could be included with the bills which are sent to schools.

The effect of supply interruptions

In spite of the fact that supply interruptions lead to disruptions and equipment cannot be used, they do not have a major effect on teaching activities in schools. A few schools reported that equipment was sometimes damaged and light bulbs fused when the supply of electricity was restored. In general, teachers were of the view that it was better to have access to the grid and experience supply interruptions than have no electricity at all. Every school in the northern regions expressed satisfaction with the way in which Northern Electricity provided information of imminent shut downs and were able to make contingency plans if necessary.

Providing electricity with solar systems

One solar electrified school, the Onamunhama Combined School which forms part of the UNESCO demonstration solar village pilot project, was investigated. Although the school uses the electricity for powering teaching aids, such as a television and video machine which were provided by UNESCO, it does not seem as though the other systems are used very much. The community building is not used at night and the church is only used occasionally. According to the principal, night classes initially took place, but these fell away due to lack of funding. The lights are, however, left on during the night for security purposes.

The cost of providing the three solar systems was US$30, with additional UNESCO funding provided for building a fence and the school buildings. UNESCO subcontracted the Ministry of Mines and Energy, which appointed contractors to install the systems. While it is clear that electricity is especially beneficial for the school as it enables the use of teaching aids, it is important that these benefits are weighed up against the cost of the project. Within the context of the demands on the national education budget, the costs seem to outweigh the benefits of solar electrification, and it unlikely that such an electrification strategy could be implemented more broadly. However, without undertaking a detailed cost-benefit analysis and an evaluation of the project in general it is not possible to make such assertions with confidence.

A further issue which requires in-depth investigation concerns the maintenance of the solar systems. Both the technicians initially employed to do first-line maintenance on the project have left and there no routine maintenance by skilled solar technicians is being conducted. It is essential that these and other issues, such as the process of project implementation, be investigated in an in-depth evaluation of this project before considering the broad implementation of solar electrification for schools.

Conclusion: is electricity a priority for education?

If electricity is to have an impact on the quality of education in rural areas the following conditions must be met:

- Electricity provision to schools should be part of an integrated package of service delivery which includes water supply and sanitation, telephones, and improved transport facilities for learners.
- The lack of resources, such as classroom furniture, books, resource materials for teachers and other educational resources, must be addressed.
- School staff should have the capacity to manage and use the electricity supply systems and equipment.
- The security problems at schools should be addressed in order to safeguard equipment and other resources.

The extent to which these conditions have been met in the schools investigated varies greatly. Where schools have access to a wide range of equipment and have facilities to accommodate staff and students, the benefits of electricity are more significant. In the short-term, it is unlikely that similar benefits will be enjoyed by primary and combined schools without the necessary resources, infrastructure and equipment. The long-term view is more optimistic as schools are likely to gain access to equipment and have their facilities upgraded.

For those schools which are not likely to gain access to the grid, solar electrification is a possible strategy for school electrification. If solar electrification is deemed to be a viable strategy, it is essential that they are designed with the capacity to accommodate the use of equipment. Providing schools with schools with solar systems for lighting only is not a viable option.

Electrification and small businesses

Energy use and expenditure

In all the small businesses, the principal energy requirements were for refrigeration, lighting and entertainment, such as televisions, radios and hi-fis. It was found that the all electrified small businesses used electricity for these energy services, and in the larger businesses electrical cash registers were also found. While some of the businesses had stoves or micro-waves, these were used to cook meals for employees and owners who lived on the premises. No electrical stoves were used to cook food which was sold.

Like the electrified small businesses, the principal energy requirements at un-electrified cuca shops were for lighting and refrigeration. Although some had radios and hi-fis, un-electrified cuca shops tend to have fewer appliances than electrified ones. Both candles and paraffin lamps were used to provide lighting, all the fridges used gas, dry cell batteries powered radios and car batteries were used to operate hi-fis.

Reduction of energy expenditure

It was found that access to electricity has led to a reduction of energy expenditure in cuca shops which have switched to electricity for refrigeration, lighting, powering hi-fis and radios. In most cases, after electrification the required energy services remained the same or additional energy services, such as powering a radio or hi-fi which consume relatively little electricity, was evident.

Furthermore, where small businesses have shifted to using electricity for a number of non-thermal energy services, the extent to which energy expenditure is reduced is greater than for those with fewer energy requirements.

Comparing costs

Candles are a major expense at un-electrified cuca shops as lighting is considered essential for providing an environment in which customers 'can relax and enjoy a drink'. Although many of the un-electrified cuca shops closed around sunset, they often closed later if there were customers. Even where cuca shops closed relatively early they reported using at least one candles per day, and on many days more were used. Obtaining gas is one of the greatest difficulties facing the small businesses as gas in only available in the major centres, and the availability and cost of transport is considered to be a problem. Aside from these transport difficulties, most of the cuca shop owners felt that gas was too expensive.

It is evident that un-electrified businesses are paying more for the same energy services than electrified cuca shops are. The findings from this research suggest that the electrified cuca shop is likely to pay no more than N$50 per month for lighting, one fridge, powering a radio or/hi-fi, whilst the un-electrified shop is likely to pay between N$104 and N$158. Further, lighting was used for longer periods of time in electrified shops, as those without

electricity tended to close earlier, and so these comparative costs strongly favour the use of electricity for lighting.

Impacts on productivity and income

In terms of the productive impacts of electrification on small businesses the study examined the role of electricity in attracting customers, extending the number of hours worked and diversifying the goods and services offered.

Attracting customers

It was found that while electricity may contribute towards the quality of services which small businesses are able to offer, and play a role in attracting and keeping a client base, the ability to attract customers was not solely dependent on access to electricity. Other factors, such as the location, range of goods and services, condition of the building and quality of the service also played an important role in attracting customers.

Hours of business

While it was found that electrified cuca shops stayed open later than un-electrified cuca shops, other factors aside from electricity were found to contribute to this. This depended particularly on whether or not a shop had customers. Further, for some women owners it was found that responsibilities within the household prevented them from keeping their shops open late.

Diversification of the range of good and services provided

With few exceptions, very little diversification of goods sold and services provided was evident. It was argued that only those small businesses which are located favourably with access to a large potential client base and which have access to finance were able to diversify their services and make use of the competitive advantage of having access to electricity.

Impact on income

The impact of these benefits, however marginal, on the income generated and profit earned was also found to be minimal. While a comparison of the daily income of electrified and non-electrified small businesses showed a higher proportion of electrified businesses with higher earnings, it was argued that this cannot be attributed to access to electricity. None of the small businesses which had been established before electrification reported an increase in daily income after electrification. Even in the cuca shops which had managed to diversify their services, it was found that this was not necessarily accompanied by an increase in income. It was clear that other factors, such as access to finance and the location of the small business, were important determinants of the income earned.

Furthermore, it was clear that many of the poorer and more marginal small businesses had been established to ensure the survival of households – often a strategy adopted where no other form of income was available. Due to the constraints which these small businesses face, it is not likely that electricity will transform these businesses to the point where they contribute significantly towards poverty alleviation or economic growth.

Growth of small businesses

It is was found that a number of the small businesses investigated were established when an area was electrified or shortly thereafter. While this suggests that electricity provides a boost to the growth of small businesses, it was argued that this cannot be attributed solely to electricity. Conditions of increased economic development in some of the regions had played a major role in the establishment of small businesses. Also, rather than act as a catalyst electricity was found to inform the choice of location of a business, once the decision to establish one had been made. It is also important to point out that the increase in number of small businesses is not necessarily an indication of economic growth. This can

also be a manifestation of deepening rural poverty, where, for example, increased unemployment often leads to the establishment of small businesses.

Should the electrification of cuca shops be prioritised

The findings of this study suggest that in view of the innumerable constraints which confront rural small businesses, especially their limited access to markets, finance or information, electrification is a 'marginal issues.'

Electricity in isolation of other complementary inputs required to develop small businesses, which include access to finance and credit, markets, training and information, will have little effect on either poverty alleviation or economic growth. For this reason, it is critical that the electrification programme is integrated with the government's strategy and plans for developing small businesses. It is appropriate to prioritise the electrification of small businesses in areas which already display a growing and dynamic economy, as well as in areas where initiatives to improve small business access to complementary inputs. This will require a co-ordinated effort between government, through the Ministry of Trade and Industry and the Ministry of Mines and Energy, and the electrification planners and implementers. In the absence of such a strategy, it is likely that the benefits of electrification on small businesses will be limited.

Recommendations

Electrification of health care facilities

Grid electrification of clinics and health centres

- Where viable, grid electrification of clinics and health centres should continue to be prioritised by the national electrification programme in order to enable the provision of emergency services, maintain the vaccine cold chain, use electrical equipment and improve security.

Solar electrification of clinics

- Solar electrification is an effective energy carrier for the lighting and communication requirements of clinics. Extensive electrification of clinics with solar systems should be considered in areas where grid electricity is not viable.
- It is strongly recommended that solar electrification of clinics only takes place where an appropriate and effective maintenance support programme is in place.
- The clinic electrification planning process should also consider the installation of solar systems which have the capacity to power a vaccine fridge as this may overcome the problems associated with obtaining gas.

Provision of suction machines

- In order to facilitate the need for suction machines which was expressed at the clinics, the Ministry of Health and Social Services should investigate the possibility of providing this equipment to clinics which are grid electrified. Suction machines which are vacuum operated off a gas supply are also available, and could be supplied to solar and un-electrified clinics.

Maintaining the vaccine cold chain

- It is essential that the gas supply and delivery network is improved. The evidence from the research seems to suggest that the district hospitals are not the most appropriate point for gas delivery to clinics due to the limited available transport and the difficulties with radio communication. Sub-contracting the provision of gas to clinics and health centres to gas agents situated throughout the different regions should be considered.
- Clinic staff should be trained to recognise when their gas supplies are low in order so that they can order more gas in time and avoid delays.

- The Ministry of Health and Social Services should assess the possibility of supplying all clinics with a domestic fridge in order to prevent staff from storing food and other drugs in the vaccine fridge.

Integrated and co-ordinated planning and implementation

- The electrification of health care facilities should be part of a co-ordinated and integrated programme which aims at addressing the lack of facilities, such as water and transport, and infrastructural inadequacies, such as roads, buildings and communication, which constrain the health care provision in rural areas.
- Institutional mechanisms to ensure that integrated and co-ordinated planning takes place should be established, with representatives from the Ministry of Health and Social Services, the Ministry of Mines and Energy, electrification planners and implementers.

Electrification of schools

Providing schools with equipment

- A long-term strategy to ensure that schools acquire equipment, especially basic teaching aids, should be developed by the Ministry of Basic Education and Culture.
- One strategy which is worth assessing is ensuring that schools have access to equipment, such as fax machines, photocopiers, televisions and video machines, by making these available at central locations (for example, a community centre or one school), within settlements. In this way schools can share equipment and the benefits of electrification can be realised without placing undue demands on limited resources.

Upgrading hostels

- Where hostels are to be upgraded it is essential that energy planning for these facilities is undertaken in order to ensure that appropriate, affordable and efficient fuels and appliances are provided.

Solar electrification of schools

- For those schools which are not likely to gain access to the grid, solar electrification is a possible strategy for school electrification. However, it is imperative that an evaluation, which includes investigation of the maintenance support infrastructure and a cost-benefit analysis, of current solar electrified school projects is undertaken in order to assess the viability of such a strategy.
- If solar electrification is deemed to be a viable strategy, the findings of this study should inform the design of the systems. Given that the greatest benefit of electricity lies with the ability to use electrical teaching aids, such as televisions, video machines and overhead-projectors, and that schools make limited use of lighting it is essential that solar systems for schools are designed with the capacity to accommodate this. Providing schools with schools with solar systems for lighting only is not a viable option.

Integrated package of service delivery

- Electricity provision to schools should be part of an integrated package of service delivery which includes water supply and sanitation, telephones, and improved transport facilities for learners, as well as addresses the lack of resources, such as books, classrooms and furniture at schools.

Employing of security guards

- Although the employment of security guards are not a guarantee against theft at schools, together with outside lighting they do minimise the security risks. Consideration should be given to providing schools with resources to employ security guards, particularly where schools have valuable equipment.

Maintenance of solar systems and equipment at schools and clinics

Effective maintenance support for solar systems at clinics and schools

- As a matter of urgency a maintenance support programme for solar electrified clinics and schools, which ensures regular monitoring and capacity building of users and local technicians, should be developed.
- As part of the capacity building of users, clinics and school staff should receive training on how to use the systems effectively, undertake first line maintenance and find basic faults. It is important that the training of clinic staff is conducted on an ongoing basis, and not only targeted at newly electrified facilities as staff turn over is fairly high.
- A sufficient number of local solar technicians should be trained and be sub-contracted to maintain the systems. These technicians would take responsible for routine tasks, such as ensuring that batteries are regularly changed and conducting annual checks on the systems, as well as dealing with faults as they arise.
- Further solar technicians within the Ministry of Works, Transport and Communication should be trained in order to oversee the activities of the local technicians and provide a support function where necessary.
- Training of local solar technicians should be undertaken through a co-ordinated and combined effort of the different solar electrification programmes, especially the *Home Power!*, and clinics programmes, to avoid replication.

Maintenance of electrical equipment

- The possibility of training hospital maintenance staff more extensively in order to repair and maintain basic equipment, should be investigated
- Of all the health care facilities is it most critical for hospitals to have an uninterrupted supply of electricity. For this reason, it is essential that hospitals have back-up generators which are reliable, and efforts to repair faults and maintain them should be made.

Electrification and small business

Economic growth and improved productivity

- It is critical that the electrification programme is integrated with the government's strategy and plans for developing small businesses, and areas where initiatives to improve small business access to complementary inputs, such as finance, markets, information and training should be prioritised.
- Electrification of small businesses in areas which already display a growing and dynamic economy should also be prioritised, as the potential benefits of electrifying small businesses are more likely to be realised.

Poverty alleviation

- Only where viable and possible, electrification of small businesses should be undertaken regardless of their ability to contribute towards economic growth, as electricity will lead to a reduction in energy expenditure, thereby easing the lives of the poor.

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Acknowledgements

The research was sponsored by the Governments of Namibia and Germany (through GTZ's[1] programme of activities in Namibia).

In addition to the authors of this report, two fieldworkers, Gloria Shivute, and Bianca Katuuo, also conducted the fieldwork for the research. We would like to thanks them for their assistance.

1 Deutsche Gesellschaft für Technische Zusummenarbeit

1. Introduction

This study is the second of two studies which have been conducted to examine the socio-economic impacts of rural electrification in Namibia. Whilst the first study focussed primarily on households, this study examines the impact of electrification on health care provision, education and small business development in the rural areas.

This report is structured in five chapters. Following this introduction, chapter two examines the impacts of electrification on health care provision in the rural areas. Chapter three provides an assessment of the benefits of electrification of schools, whilst chapter four provides some insights into the role which electricity plays in improving productivity and income generation of small businesses. At the end of each of these chapters the key findings are summarised. Finally, chapter five provides a summary of recommendations which have been made.

1.1 Objectives of the study

The objectives of this study were:

1. to assess the impact of electrification, both grid and off-grid, on the provision of health care in rural areas by examining
   - the energy use of grid electrified, un-electrified and solar electrified health care facilities, which includes clinics, health centres and hospitals;
   - the need for electricity at the different types of health care facilities;
   - the improvements which are gained through electrification of health care facilities;
   - the problems which mitigate against the potential benefits of electrification being realised
   - the process of electricity provision of electricity to health care facilities, with particular regard to solar electrification; and
   - the perceptions of staff and patients on the benefits of electricity and the impact on their lives.
2. to assess the impact of electricity, both grid and off-grid, on education with a particular focus on schools, by examining
   - the energy use of grid electrified, un-electrified and solar electrified primary, combined and secondary schools;
   - the need for electricity at the different types of schools;
   - the improvement which are gained at schools through access to electricity;
   - the problems which mitigate against the realisation of the potential benefits of electrification;
   - the process of electricity provision of electricity to schools, with particular regard to solar electrification; and
   - the perceptions of staff and students on the benefits of electricity and the impact on their lives.
3. to assess the impact of electricity, both grid and off-grid, on small businesses in rural areas by examining
   - the energy use of un-electrified, grid electrified and solar electrified small businesses;
   - the improvements and problems associated with access to electricity;
   - the role of electricity in improving productivity and income generation; and

- the perception of small business owners and employees on the benefits of electrification.

1.2 Methodology

At the beginning of October a four day workshop to design the fieldwork and to train the researchers was held in Windhoek. During this workshop questions which were used to guide the interviews were developed and a range of qualitative methodologies were selected for different contexts.

The fieldwork was conducted during October and November, with twelve days spent in the northern regions of Ohangwena, Oshikoto, Oshana and Omusati (Four O's). A further five days were spent in the East in Aminius. Care was taken to ensure that the same settlements which were included in the quantitative component of the study were visited in order to ensure continuity, although this was not always possible, especially in the cases where solar electricity was used.

For investigation of health care facilities, in-depth interviews with the staff and patients were undertaken. At schools staff were also interviewed, and participatory group processes with the students at the school were conducted in order to gauge their perceptions on the impact of electricity on education. The small business interviews were conducted with both owners and employees. In all cases the in-depth interviews were open ended, giving scope for those being interviewed to also define the parameters of the issues being discussed. Three participatory research sessions, with separate groups of men and women, in order to discuss their perceptions of the impact of electricity were also held. Two of these sessions took place in the northern regions, at the un-electrified village of Othika and the electrified village of Elim, whilst the third took place in Aminius in the Omaheke region.

2. Health care facilities and electrification

Fourteen health care facilities, which included clinics, health centres and hospitals, were investigated in the study (refer to table 1). Only three of these facilities were located in the Omaheke region in the East due to the study's primary focus on the Omusati, Oshana, Ohangwena and Oshikoto regions. In addition to selecting health care facilities for investigation on the basis of whether they were solar electrified, grid electrified or un-electrified, attempts were made to visit settlements which were included in the study of the socio-economic impacts of rural electrification on households (Wamukonya & Davis 1999). This was not possible for the solar clinics as they were situated in other localities.

HEALTH CARE FACILITY	*REGION*	*SOLAR*	*ELECTRIFIED*	*UN-ELECTRIFIED*
HOSPITALS				
Onandjokwe hospital (Oniipa)	Oshikoto		✔	
Eenhana hospital	Ohangwena		✔	
Gobabis hospital	Omaheke		✔	
Total number of electrified hospitals	3			
HEALTH CENTRES				
Odibo	Ohangwena		✔	
Elim	Omusati		✔	
Ones	Omusati		✔	
Total number of electrified health centres	3			
CLINICS				
Ohangwena	Ohangwena		✔	
Othika	Omusati			✔
Omgulumbashe	Omusati	✔		
Onamandongo	Omusati	✔		
Oshandi	Ohangwena	✔	✔	
Onandjokwe (Oniipa)	Oshana		✔	
Onderombapa	Omaheke			✔
Aminius	Omaheke		✔	
Total number of solar clinics	3			
Total number of electrified clinics	3			
Total number of un-electrified clinics	2			
Total number of health care facilities	14			

Table 1: Health care facilities investigated

2.1 Clinics: un-electrified, solar and grid electrified

In terms of government health policy, with its Primary Health Care approach, clinics are required to provide the following services:

- immunisation against infectious diseases;
- treatment of common diseases;
- prevention and control of endemic diseases;
- reproductive health (maternal and child health, family planning); and

- health education and training with regard to prevailing health and social problems, basic housing and sanitation, and oral and mental health (Ministry of Health and Social Services 1998).

Together with health centres, clinics are the focal point of health care provision to communities. Health services are provided at district level with clinics and health centres organised under district hospitals. These hospitals support clinic operation through supplying medicines and equipment, ensuring that buildings, equipment and services to clinics are maintained and supervising and training staff. In addition, district hospitals are referral centres for clinics. Where patients are in need of treatment which is beyond the scope of the clinic they are referred either to the nearest health centre or the district hospital.

Most clinics see an average of 20-30 patients per day, although there is a marked increase in numbers (sometimes up to 40 a day) during the rainy season due to the high incidence of malaria. At Ohangwena clinic, however, patient numbers increase from 50-60 to 80-990 per day in the malaria season. In addition to malaria, the predominant diseases and conditions treated at all the clinics include acute respiratory infection (ARI), eye and skin diseases, diarrhoea, hypertension, sexually transmitted diseases (especially HIV and AIDs) and malnutrition. Clinics charged N$ 3 for a first visit and N$ 1.50 for a follow up visit. Clinics which offer an emergency after hours service, such as Onderombapa and Aminius charge N$4.50 for this service. If patients cannot pay they are not denied treatment and through an informal agreement between staff and patients, many facilities accept payment in kind, such as crops.

All the clinics were engaged in education and outreach programmes, although these differed from one clinic to the next. Programmes included targeting schools in attempts to decrease the high rate of teenage pregnancy, immunisation programmes in villages and general health and hygiene education on the prevention of diseases, especially HIV and AIDS. Some of the clinics, such as Oshandi, run very active programmes, whilst others find it difficult to gain community participation in these activities. The head-sister at Oshandi clinic has found that community members do not attend unless they couple their programme with a church service or social activity.

The physical condition of the clinics varied enormously. Some clinics are new and have been built since independence, such Omgulumbashe (1991) and Onamandongo (1992/3), while others, such as Aminius (1985) and Onderombapa (1960) are older. The Onderombapa clinic requires some attention as the building is not in a good condition. Both the Oshandi and Othika clinics were built by the community, although the Oshandi clinic had the advantage of donor funding and is in a good condition. The Othika clinic, on the other hand, was built in 1989 with limited church funding. It only started to operate as a clinic on the 6 June 1995 as there was no funding to resource the clinic with equipment, staff and medicine. Only once the building had been transferred from the church to the government had funding become available. The building is now in a state of disrepair which makes working conditions difficult.

The clinics in the North are not visited by doctors or dentists, although both clinics in the East (Aminius and Onderombapa) are visited twice a month by a doctor and once a month by a dentist. In the North, patients requiring doctors and dentists are referred to the district hospital or in some cases, to health centres which are visited by doctors.

There are a number of ways in which electricity may support the provision of health care at clinics. It has been suggested that the main benefit of electrifying clinics lies with better maintenance of the vaccine cold chain, ability to offer extended hours and emergency services, the ability to use more effective technologies, provide health education through the use of televisions and video machines, improve security at clinics and attract staff (Borchers & Hofmeyer 1997). All of these points have been investigated in this study, and some were raised in the interviews by the clinic staff. However, the provision of electricity

to clinics does not guarantee that these benefits will be realised as many factors mitigate against this. The report will now turn to exploring these issues, by discussing the energy use of the clinics, the benefits which have been derived from electricity, problems experienced with maintenance of solar systems, problems experienced with radio communication, theft of solar panels and difficulties in ensuring that the vaccine cold chain is maintained.

2.1.1 Energy use at clinics

Due to their focus on providing primary health care, all the clinics investigated had limited energy requirements (refer to table 2). Energy services at the clinics included lighting (inside and outside security), refrigeration, radio communication, powering medical equipment, as well as cooking and entertainment in staff accommodation.

	SOLAR			*UN-ELECTRIFIED*		*ELECTRIFIED*	
	Onamandongo (North)	*Omgulumbashe (North)*	*Oshandi (North)*	*Othika (North)*	*Onderombapa (East)*	*Ohangwena (North)*	*Aminius (East)*
Electrified	1992-3	1992	?	-	-	?	1995
Lighting	Solar (not working)	Solar	Solar	-	Generator	Grid elec & solar	Grid elec
Vaccine fridge	Gas	Gas	Gas	Gas	Gas	Grid elec	Grid elec
Domestic fridge	Gas	Gas	Gas	-	Generator	Grid elec	Grid elec
Radio	Solar	Solar	Solar	Solar	-	-	-
Medical equip	-	-	-	-	-	Grid elec (Suction machine)	Grid elec (Suction, BP monitor, kettle)
Water supply	Pipeline	Solar	Pipeline	Pipeline	Pipeline	Pipeline	Pipeline
Staff accomm	-	-	Solar (lighting) & gas (cooking)	-	Generator (lighting) & gas (cooking)	-	Grid elec (Electric stove, TV, radio, video)

Table 2 : Energy services and fuels used at clinics

Electricity is the principal form of lighting at all the clinics except for the un-electrified clinic of Othika where the staff use a torch for lighting when necessary. The solar system which has been installed to provide lighting at the Onamandongo clinic has not been working for over a year and the clinic staff do not use any other fuels for lighting. The clinic at Onderombapa has a diesel generator for lighting and candles are used when the generator is not working.

One of the main services provided at clinics which requires energy is immunisation against infectious diseases. For this, all the clinics are supplied with a standard World Health Organisation vaccine fridge which is run off gas in the solar and un-electrified clinics or grid electricity in the electrified clinics. Except for Othika clinic, domestic fridges are also provided and are used to make ice, store antibiotics and other drugs, as well as staff food. Ice is used during immunisation outreach programmes where vaccines are transported in cool boxes to outreach points.

Unlike hospitals and some health centres, the treatment and medical procedures undertaken at clinics are not reliant on the use of medical equipment. The electrified clinics in the sample did have some medical equipment which is powered by electricity, such as suction machines. The use of suction machines, however, is not dependant on access to grid electricity as some models are foot-operated. Only the Onderombapa clinic had a foot-operated suction machine.

With the exception of Ohangwena, Onderombapa and Aminius clinics which have telephones, all the clinics had solar powered radio communication. This includes Othika which is categorised as an un-electrified clinic[2].

Although separate staff accommodation is only provided at the Aminius clinic, the Onderombapa and Oshandi clinics each have a room inside the clinic where one nurse stays. The Aminius clinic staff are provided with an electric stove and use it for cooking. They are unaware of how much they consume and are not required to pay for electricity. The nurses at Onderombapa clinic use a gas stove to cook food. The staff at Aminius also use electricity for televisions and radios, while the staff at Onderombapa and Oshandi use battery operated radios. At all three clinics food is stored in the domestic fridges.

The Omgulumbashe clinic has a solar water pump which has been installed some 200 meters from the clinic premises. Although the solar pump works effectively, there is a large hole in one of the two storage tanks which has led to a shortage of water at the clinic. Despite the fact that the Ministry of Works, Transport and Communication has been informed of the problem, and have been to investigate the problem nothing has been done to fix the tank. The problem has persisted for four months.

Curiously, the Ohangwena clinic has both solar and grid electricity, with two solar systems providing electricity for lights and water heating respectively[3]. Aside from lighting, grid electricity is also used for refrigeration (both a vaccination fridge and a domestic fridge) and a suction machine. In order to prevent theft, the outside lights are left on all night and a security guard is employed – the clinic has never been broken into. Despite the additional costs, the fact that the clinic has both grid and solar electricity is useful as they are able to use electric lighting when the grid system shuts down.

None of the clinics had televisions and videos which were used for health education.

2.2 Grid health centres and hospital

2.2.1 Health centres: energy use

The services provided at health centres fall between those provided at clinics and hospitals, and are they also act as referral points for clinics. Compared with clinics health centres employ more staff to support the services which are provided. Onesi health centre has twenty three staff members, whilst Elim has twenty-seven and Odibo has forty. Onesi and Odibo health centres have facilities to admit patients, with small wards which can accommodate from thrity to forty patients, a laundry and a kitchen. Emergency services are also provided. Patients pay N$6 to visit the health centres during working hours (08h00 to 17h00) and N$9 for weekends and after-hours. There are no resident doctors or dentists and patients requiring specialised attention are referred to hospitals. The Odibo health centre has three vehicles which are used to transport patients to the Engela hospital. Each of the health centres also has a clinic attached to it. Staff accommodation is also provided at the Odibo and Onesi health centre.

Due to the expanded services provided at health care centres, especially with regard to admitting patients, the energy requirements are greater than those of the clinics (refer to table 3). It would also be very difficult to provide these services without electricity and the necessary electrical equipment. Electric lighting is considered to be an important component of providing care to patients at night. The laundries and kitchens also require electricity for washing, ironing, cooking and refrigeration.

[2] We are not sure if this is standard practice as attempts to locate either a clinic without radio communication or an official who could inform us of the situation did not meet with success.

[3] We were unable to find out why both solar and grid electrification of this clinic had occurred as the staff interviewed only started working at the clinic some time after electrification.

Medical equipment, such as scales, blood pressure monitors and suction machines also operate off electricity, whilst drugs and vaccines are kept in refrigerators. It is interesting to note that there does not seem to be a standard set of equipment provided to health centres. The Odibo health centre, for instance, did not have suction machine whilst the other two health centres did.

At both Onesi and Odibo there is a small mortuary, which requires electricity for refrigeration, the staff reported that it was not used very much. Electricity is also important for the administration of the centre as electrical equipment, such as a typewriters and faxes are used.

At Onesi health centre, there are five staff members who have accommodation on the centre's premises: three nurses, one cook and one clerk. The accommodation is electrified and the staff use electricity predominantly for radios, televisions and refrigeration. Gas is used for cooking as no electric stoves are provided and the staff felt that they could only afford gas appliances.

ELECTRIFIED HEALTH CENTRES			
	Onesi (North)	*Elim (North)*	Odibo [4](North)
Lighting	All rooms, outside	All rooms, outside	All rooms, outside
Refrigeration	Pharmacy, kitchen, mortuary		Pharmacy, kitchen (2), wards (2), mortuary
Medical equipment	Scale, blood pressure, suction, ventilator	Suction, blood pressure, lamps, sterilisation	Sterilisation &?
Staff accommodation (provided)	Lights	-	No information
Staff accommodation (own)	TV	-	TVs, radios – no other information
Laundry	Washing machine, tumble drier, ironing	-	Washing machine, ironing
Kitchen	Refrigeration, cooking	-	Refrigeration, cooking
Administration	Typewriter	-	Computer, fax, typewriter

Table 3: Electricity use at health centres

At Odibo, we were unable to find out how many staff live of the premises but, were told that the staff used their own televisions and radios. It was not clear whether any appliances, such as stoves or fridges were provided for staff.

As with clinics (and hospitals) no televisions and videos had been provided to health centres for education purposed.

[4] The interview at Odibo health centre was extremely difficult as the one nurse did not want to give us any information and attempted to disrupt the interview with other staff members. With the result, it was not possible to get information on certain issues and we were not permitted to walk through the centre in order to verify the information which we had been given. There may be inaccuracies as a result of this.

2.2.2 Electrified hospitals: electricity use

The benefits of electricity are obvious. What can we do without it?

(Onandjokwe hospital administrator)

Three hospitals were included in the research, with Onandjokwe and Eenhana hospitals situated in the North, and Gobabis hospital in the East. Although all of these hospitals are district hospitals, the services offered differ slightly (refer to table 4). Of these, Onandjokwe is the largest hospital with greater capacity and specialisation in some areas. For instance, the Onandjokwe hospital has the capacity to undertake major operations, which include surgical, neurological, urological, orthopaedic and gynaecological procedures. With three hospital theatres and skilled surgeons, many of the major medical procedures and operations done in the North take place at this hospital. At Eenhana, on the other hand, only minor operations, such as DNCs and lancing abscesses, are undertaken. Although there is one operating theatre, the hospital does not have resident surgeons or the necessary equipment and instruments to conduct major operations. Thus, Onandjokwe hospital has more specialised theatre equipment, such as a laproscope, than the other two hospitals.

Onandjokwe hospital also has a nursing school and is an important training hospital for both students from the University of Namibia and those nurses wishing to upgrade their qualifications. Currently there are ninety student nurses being trained at the hospital, most of whom live in the student dormitories which are electrified.

	ONANDJOKWE HOSPITAL	*EENHANA HOSPITAL*	*GOBABIS HOSPITAL*
No of beds	450 (official, 600 patients admitted)	120	150
Condition of building	1908 mission hospital, subsequent additions to building.	Established as mission hospital, new hospital built 1993, officially opened 1996	New hospital built in 1995
Doctors employed	18	2	3 (hospital), 5 (private)
Staff employed: total	381	100	119
Hours	24	24	24
Patients	500 per day	90-100 per day	150 per day
Services provided	Major operations, clinic, outpatients, maternity, general wards, nursing school, radiology, dental facilities, pharmacy, mortuary, laboratory	Minor operations & procedures, clinic, outpatients, maternity, general wards, radiology, pharmacy, mortuary, laboratory	Minor operations & procedures, clinic, outpatients, maternity, general wards, radiology, pharmacy, mortuary, laboratory
Staff accommodation	Student nurses, doctors, 18 nurses	8 nurses & 2 doctors	23 doctors & nurses
When electrified	?	1993	1995
Electricity consumption	N$40 000 per month	?	46 400 kWh per month (N$18 600)

Table 4: Profile of hospitals investigated

Clearly, electricity is critical for the effective functioning of these hospitals as they are dependant on modern electrical equipment, ranging from office equipment to specialised medical equipment (refer to table 5). It was found that the equipment at hospitals is fairly standard and dependant on the services which are provided.

	ELECTRICAL EQUIPMENT USED
Administration	Photocopier, fax machine, typewriters, computers, air conditioners
Laundry	Washing machine, tumble drier, iron machines, irons
Kitchen	Cooking equipment, refrigerators, walk in cold rooms, extractor fans
Specialised wards & services	ICU equipment (ventilators, defibrillators, suction machines), Maternity (incubators, suction machines), Dental equipment*
General wards	Refrigeration
Radiology	X-Ray equipment
Operating theatres	Specialised theatre equipment*, theatre lights, air conditioning
Sterilisation	Sterilisation equipment
Pharmacy	Refrigeration
Mortuary	Refrigeration
Nursing schools	Teaching equipment*
Accommodation	Lighting, geysers, sometimes stoves, refrigerators and fans are provided
Laboratory	Refrigerators, laboratory equipment, such as micro-scopes and centrifuges, air conditioning

* only at Onandjokwe hospital

Table 5: Electrical equipment used in the hospitals included in the research.

Despite the similarity in equipment and services provided by the hospitals important issues emerged, which if addressed, could enhance the impact of electricity and improve the conditions under which hospital staff work.

2.3 The benefits of electrification

2.3.1 The benefits of lighting at clinics

It was found that the extent to which clinics use and require lighting varies considerably. At the Omgulumbashe clinic, where a solar system was installed for lighting in 1992, the lights are only used in the case of emergencies at night and are never switched on during the day. Although the clinic staff do not live at the clinic, community members go to their homes at night to request assistance when emergencies arise. According to the head-nurse this happens no more than once a month. Further, the lights are not left on at night for security purposes.

Although clinic staff did not stay at the clinic lights were also used for emergencies at the Ohangwena clinic. The head-sister felt that electricity was especially essential when they had to deliver babies at night. However, the number of emergency cases seen at the clinic was less than at clinics which had resident staff.

The Oshandi clinic makes extensive use of their lights which are also powered by a solar system. The head-sister usually stays in one of the rooms at the clinic. She felt that the clinic is able to provide a better service if she is available for emergencies during the night. In addition, the quality of lighting provided enables her to do administrative work in the evenings, such as preparing statistics for the Ministry of Health and Social Services. She also is able to prepare for the outreach and training programme which is conducted from the clinic. Training of community health workers and traditional birth assistants, together with community health education in schools and in the villages are amongst the activities of this active programme. Unfortunately the emergency service has temporarily stopped as the head-sister has moved to her home, a two hour walk from the clinic, because of the rumours that UNITA soldiers from Angola have been breaking into clinics at night in order to steal medicine.

The un-electrified Onderombapa clinic also makes extensive use of lighting provided by a diesel generator which is switched on from 06h00 to 22h00. The major benefit of having a generator lies with the clinic's ability to offer an emergency and over-night service to

patients, as well as comfortable accommodation for the staff. As one of the two nurses lives in a room in the clinic an emergency service is also provided and, if necessary, patients can be admitted over-night. One of the rooms in the clinic is used to accommodate these patients. An outside security light is also left on until the generator is switched off. The generator is, however, not always reliable and it does breakdown. It usually takes three days from the time of reporting the fault to the Ministry of Works, Transport and Communication for technicians to arrive to repair it. With resident staff and electricity at the Aminius clinic emergency services are also easily facilitated.

In contrast to these clinics which have access to good quality lighting, the un-electrified Othika clinic experiences problems without lights. The clinic is not regularly used for emergencies at night, except for extreme cases. Patients either wait until the morning or attempt to get transport to the Elim health centre. When patients do come to the clinic a torch is used, making it extremely difficult to treat them. The problem of poor lighting also affects the daytime operation of the clinic as the clinic building has small windows which makes the interior dark. A torch is sometimes used to examine patients and always used when patients need stitches.

For clinics to provide effective emergency services good quality lighting is critical. Both solar and grid electricity are effective energy carriers for the lighting requirement of clinics. Although diesel generators can provide a similar quality of service, they can be unreliable and the long term operating and maintenance costs are high. Clinics, such as Othika, without access to good quality lighting are clearly at a disadvantage.

The provision of electricity to clinics for lighting will, however, not necessarily lead to an improved health care service. Where clinics have resident staff, the benefit of electric lighting is greatly enhanced through enabling the provision of emergency services, admission of over-night patients for observation and preparation of education programmes.

From interviews with clinic staff it was also evident that the attitude and commitment of individual staff also have an enormous impact on the extent to which the benefits of electric lighting are realised. The head-sister at Oshandi is a case in point.

2.3.2 Improved technology: electrical suction machines

That electrification can facilitate the use of better technologies has already been mentioned. However, it is worth highlighting the desirability of electrical suction machines to staff working at all the clinics (even those without grid electricity) and health centres. In almost every interview staff mentioned the use of electric suction machines as one of the benefits of grid electricity. In health centres and clinics which were electrified staff pointed to the difference between using foot-operated and electric suction machines. With foot-operated machines, such as the one at the Onderombapa clinic, it is much more difficult to ensure an even, steady suction. However, most of the clinics in the study did not have suction machines at all. At the Odibo health centre one of the nurses who had worked at a clinic without electricity stated that 'when babies are born nurses we did it manually. We slapped the child and sucked with our own mouths'. This practice was confirmed by other nurses who were interviewed.

In order to facilitate the need for suction machines which was expressed at the clinics, the Ministry of Health and Social Services should investigate the possibility of providing this equipment to clinics which are grid electrified. Suction machines which are vacuum operated off a gas supply are also available (Borchers and Hofmeyer 1997), and could be supplied to solar and un-electrified clinics.

2.3.3 Putting the benefits of clinic electrification in perspective

The Oshandi clinic is situated on the premises of a former mission hospital which was totally destroyed during the war and services some 20 000 people from 16 villages. Two

buildings, one used as a clinic and the other for general community activities, were built by the community. Although in a good condition, the clinic is small and the staff find it difficult to cope with the number of patients which visit the clinic. Many of the patients walk distances of 20 kilometres and further to reach the clinic.

During our visit to the clinic there were a number of patients with conjunctivitis, two of whom had walked for over 2 hours to get to the clinic. The treatment for conjunctivitis at the clinic necessitated that these patients stay at the clinic for the in order to have ointment put in their eyes three times a day. This had to be repeated for three to four days and because there was not enough eye ointment to give to each patient to take home with them, they had to return each day for treatment. Sometimes, the staff will keep the patients for observation before deciding whether they should be referred to Eenhana hospital. As there are no facilities to keep patients under observation, the patients sit under the tree at the clinic.

The situation at Oshandi clinic is not unique, and the difficulty of providing effective health care to rural people in Namibia, and elsewhere, should not be under-estimated. Although the next section of the report will deal with problems which pertain specifically to the energy requirements of clinics, difficulties are also experienced in other quarters, such as the lack of transport. The research has shown that while electricity has an important role to play in rural health care, it is important that we acknowledge that it is only one component of effective health care. Some clinic staff pointed to the critical need for water and well trained staff before electricity, although others placed electricity on par with them. In addition, good communication and a sufficient supply of medicines and equipment were also considered important.

As Thom (1997) argues, the impact of electricity on health in rural areas is dependant on electrification being part of a co-ordinated community based rural development programme which aims at addressing the needs of rural households and health care facilities. In other words, the benefits of clinic electrification are likely to be greater where other needs are also addressed.

2.4 Problems and difficulties

2.4.1 Maintaining the vaccine cold chain at clinics

Vaccine fridges are an essential component of an effective immunisation programme and require a reliable energy source to power them if the vaccine cold chain is to be maintained. As mentioned previously, vaccine fridges are run off gas in the solar and grid electrified clinics. Gas is known to be an effective fuel source for vaccine fridges and the World Health Organisation has a number of gas models on its list of tested and approved fridges (Borchers & Hofmeyer 1997). None of the clinics had experienced any problems with their fridges and were satisfied with their performance.

However, in every case difficulties in ensuring that gas was delivered on time were experienced. Although not always followed, the procedure for obtaining gas involves the clinic staff communicating its request for gas to the district hospital. If there is a gas supply at the hospital, and transport is available, the gas will be delivered to the clinic. However, due to a number of reasons, this process does not always run smoothly. Firstly, clinics experience problems with communicating with the district hospital (refer to section 2.4.2). When this happens, the clinic staff at the Omgulumbashe and Oshandi clinics travel to the nearest hospital to fetch gas. Secondly, there is not always gas available at the district hospitals and centres. The clinics are then forced to wait until gas arrives at the hospital. The administrator of the Oniipa hospital said that the gas supply for the hospital and clinics was obtained from Afrox in Tsumeb. If the hospital miscalculates the amount of gas needed, as it has done on occasion, a shortage is experienced.

The head-sister at the Omgulumbashe clinic said that there had been times when he had gone directly to Oshakati (more than 70km away) when there was no gas at the Tsandi hospital. Thirdly, transport problems also create delays. Even in cases where clinics have managed to contact the district hospital and gas is available there may not be any form of transport to bring the gas to the clinic. According to the head-sister at Omgulumbashe transport is a great problem as there are 'many clinics for one hospital to look after'. Where clinic staff fetch the gas transport difficulties are also experienced since they have to take the 48 kg gas bottles with them.

A further reason for the problem lies with the clinic staff's delays in ordering more gas. For instance, at the Othika clinic there are three 48kg bottles of gas which are used to power the vaccine fridge. When we visited the clinic they had just finished their gas supply which had been delivered in March, lasting seven months. Despite the fact that at any given time the clinic could have two spare bottles of gas, as only one gas bottle can be used at a time, the clinic had run out. It is unclear why the clinic staff wait until the gas is finished (or nearly finished) before contacting the Oshikuku district hospital.

Most of the clinics place the vaccines in an icebox, although the Omgulumbashe clinic had on occasion taken the vaccines to the district hospital for storage. Although these problems are not encountered every time that a clinic requires gas, it is difficult to maintain the vaccine cold chain with a gas delivery system which is not reliable. Clearly attention must be paid to securing a reliable energy source to power vaccine fridges.

It is essential that the gas supply and delivery network is improved. The evidence from the research seems to suggest that the district hospitals are not the most appropriate point for gas delivery to clinics due to the limited available transport and the difficulties with radio communication. The possibility of sub-contracting these services to small gas agents throughout the different regions should be considered. The consumption of gas should also be fairly consistent at clinics and consumption data could be collected by the gas agents so that they can anticipate when a clinic will need gas. (Only two of the clinics could tell us how long there gas supply lasted). With dedicated transport, it is likely that minimal delays will be experienced.

The clinic electrification planning process should also consider the installation of solar systems which have the capacity to power a vaccine fridge in clinics. However, it is critical that an appropriate maintenance infrastructure is in place if solar is to be considered. With the current situation, it is possible that solar may be even more unreliable than gas (refer to section2.4.3). In fact, Borchers and Hofmeyer (1997: 5) argue that 'there is no clear evidence which favours either PV or LPG, and possibly the main factor to be considered in choosing between them is the existence of an appropriate support infrastructure.'

Finally, it is important to point out that a good fridge with a reliable energy supply will not guarantee a successful vaccination programme. Ross et al (1997) argue that successful vaccination programmes are dependant on human interaction rather than solely on the technical components of the vaccine cold chain. In other words, unless staff are trained to monitor and record fridge temperatures, store the vaccines properly and use the fridge as a dedicated vaccine fridge only, it is likely that the cold chain will be compromised.

In only one of the clinics was the fridge used for storing the staff's food. It is unclear why this was the case as the clinic had a domestic fridge. However, it is important for clinics to have domestic fridges as this prevents staff from storing food and other drugs in vaccine fridges. Increased opening of vaccine fridges reduces the temperature, thereby compromising the integrity of the vaccine cold chain (Borchers & Hofmeyer 1997).

2.4.2 Radio communication at clinics

In terms of the system of referral which supports the Primary Health care function at clinics the ability to communicate with district hospitals is essential. As noted previously, four of the clinics investigated had solar powered radio communication systems, whilst three had

telephones. All of the clinics experienced problems with communication, although those reliant on radio communication were in a far worse position than those with telephones. The telephones were fairly reliable and difficulties were only experienced when the lines were down, which did not happen frequently. Two types of problems with radio communication were noted. The first concerns problems with the solar system at the clinic, whilst the second is a broader problem with the radio network.

The Othika clinic experienced problems with their radio, especially during the rainy season: "sometimes there is not enough energy from the sun, it is too weak and then we have problem as we cannot contact them". However, even if the clinic is able to contact the hospital there is no guarantee that an ambulance will be available. In instances where the clinic cannot get hold of the hospital or when there is no ambulance available there are two options. If there is a car in the community and someone is able to help the clinic private transport is arranged. Although not always, the ill person is often held responsible for the cost of this transport. If there is no car available, "the patient must take a hike on the road – there is no other alternative".

The system at the Onamandongo clinic was also unreliable as it works intermittently. In the case of emergencies, this posed great difficulties for the clinic. If there is someone in the village with a car they are asked to give the patient a lift to the hospital, but mostly the nurses go to the road nearby and wave down a car to assist them. As far as the nurses were concerned, poor communication was the greatest problem facing them in their work.

Although the exact date of the installation of these systems is not known, both clinics have had the systems for more than five years. In neither of the clinics have the batteries been replaced, which is almost certainly the cause of the problems they are experiencing as the capacity of batteries decreases over time (Borchers 1998).

The systems at the Omgulumbashe and Oshandi clinics, on the other hand, did not give any problems. However, they experienced difficulties with contacting their respective hospitals and other clinics in the area. The head-nurse from Omgulumbashe said that even if they were able to contact the Tsandi district hospital for emergency cases there was not always an ambulance available to fetch the patients. When this happens, someone from the village is asked to transport the patient, usually at a cost of N$5. At the Oshandi clinic the head-nurse said that the clinic usually communicated with the Eenhana hospital and the other clinics on channel 3. However, during our visit only channel 1 to Oshakati hospital was available, which meant that Oshakati had to relay the message to Eenhana. Both the Onamandongo and Othika clinic experienced similar problems when they were able to use their radios.

Problems experienced with the radio communication solar systems are due to the lack of maintenance support (refer to section 2.4.3). It is essential that these problems are addressed as the integrity of the primary health care system is compromised by the inability to communicate and easily refer patients to hospitals when necessary.

2.4.3 Solar system maintenance problems at clinics

One of the most serious problems which has emerged from this investigation is the weak system of maintenance and support for solar systems at clinics.

The Onamandongo clinic was built in 1992-1993, and although it seems that the solar system was installed shortly after it was built the nursing staff were unaware of the exact date of installation. The solar system has not worked for a year and although it has been reported to the district hospital no-one has come to attend to the problem. This clinic falls under the Tsandi district hospital, and according to one of the administrative staff from the hospital, it is not the only clinic in the district with a solar system which does not work at all. At the Omgulumbashe clinic two of the bulbs were not working, and although technicians came to replace the bulbs they still do not work, which suggests that the problem lies elsewhere. No problems have been experienced at the Oshandi clinic, although the outside

light bulb needs to be replaced. As mentioned previously, two of the clinics also have faulty radio communication systems.

Although the solar system for the lights has never given the Ohangwena clinic any problems, the solar water heating system has not worked for three years. This was reported through the appropriate channels to Engela hospital no-one has come to investigate the problem. The head-sister felt that it was unfortunate that the system had not been repaired as having hot water would help, especially when they have patients who stay over in the observation room and require the use of the bathroom or for certain procedure, such as delivering babies.

Although both the Oshandi and Omgulumbashe clinics have had technicians deal with problems, the other clinics have not. None of the clinics have had technicians doing routine checks of the clinic systems either. According to Peter Kalimba (personal communication 1998), the solar technician at the Ministry of Works, Transport and Communication in Oshakati, the ministry does not have a programme of ongoing maintenance of solar systems at clinics. Rather, it responds to problems which are reported to them. Apparently, the clinics which are currently being electrified by sub-contractors appointed by the Ministry of Health and Social Services, are visited for an initial period to make sure that the systems are working. Thereafter, the responsibility for dealing with problems which may arise lies with the Ministry of Works, Transport and Communication.

From the Ministry of Works, Transport and Communication's perspective, it is impossible to envisage expanding their activities to ensure the ongoing maintenance and operation of the solar systems at clinics. Great difficulties are experienced in dealing with the current work of attending to faults and problems. One of the major reasons for this is the lack of skilled staff in the ministry: there is only one skilled solar technician in the Ohangwena, Oshikoto, Oshana and Omusati region, who is based in Oshakati. Although there are another three offices in the region they are only staffed with 'workhands' and labourers who only have the skill to deal with very basic problems. Apprentices have also been employed but they too do not have sufficient skill to deal with the more complex problems. Furthermore, there is often no money to buy new materials and spare parts, such as inverters and regulators, which are needed. According to Peter Kalimba (1998), he has to wait until funds become available which sometimes means that clinics will have to wait a few months before their systems are repaired. Finally, transport difficulties are also experienced as there is only one car at the Oshakati office.

The system of fault reporting is also inefficient and unreliable. For instance, when asked why the Onamandongo system had not been repaired for over a year, Kalimba (1998) stated that they only attended to problems which were reported to them. So although the clinic had reported the fault to the Tsandi hospital this information had not been relayed to the ministry.

Clearly this situation is untenable, and with more solar systems being installed in clinics it can only get worse if attention is not given to devising an effective maintenance programme. Given the limited capacity of the Ministry of Works, Transport and Communication and the inefficiency of the long chain of command for getting faults addressed, it is not appropriate that the sole responsibility for maintenance lies with the ministry. Experience elsewhere has shown that for solar electrification programmes to be effective, regular monitoring of the systems and capacity building of users and local technicians is essential (Borchers 1998).

Although the importance of capacity building and training has been acknowledged by the Ministry of Works, Transport and Communication, attempts to do this have not materialised (Kalimba 1998). In general the clinic staff had a very poor understanding of how solar systems work. For instance, the nurses at the Onamandongo clinic did not even know that the system had batteries. In fact, during the interview we sat on a concrete box on the stoep of the clinic only to work out later that we had been sitting on the batteries!

The staff at the Ohangwena clinic did not know how the solar system worked, how to check whether the batteries were charged or how to use the system most effectively. They had not received any training and had not been aware of anyone coming to maintain or check the system. Where clinic staff had been employed when the solar systems were installed there seemed to be a better understanding of the system, although their knowledge seemed only to extend to reading the lights on the regulator.

As part of a capacity building programme it is essential that clinic staff receive training on how to use the systems effectively. This would include the need for staff to have an understanding of the limits of the system so that the life-span of the batteries is not shortened due to overloading, as well as an awareness of the need to regularly replace batteries according to the timeframe of their system design. Clinic staff can also be trained in first line maintenance, such as the need to check and top up distilled water in the batteries (for those models which require this) and clean the solar panels. It is also useful for clinic staff to have some basic fault finding skills so that they are able communicate with technicians and thereby avoid unnecessary visits to clinics (Borchers 1998). It is important that the training of clinic staff is conducted on an ongoing basis, and not only targeted at newly electrified clinics. Staff turn over is fairly high and new staff should also be trained.

The other important component of a solar electrification is the training of a sufficient number of local solar technicians. These technicians could be sub-contracted to maintain the systems, rather than be employed by the Ministry of Works, Transport and Communication in order to make the process of maintenance more efficient. These technicians would take responsible for routine tasks, such as ensuring that batteries are regularly changed and conducting annual checks on the systems, as well as dealing with faults as they arise (Borchers 1998).

More solar technicians within the Ministry of Works, Transport and Communication should also be trained in order to oversee the activities of the local technicians and provide a support function where necessary. It is also essential that there is integration of the training of local technicians for the *Home Power!* and clinic electrification programmes.

2.4.4 Theft of solar panels at clinics

With the exception of the Oshandi clinic, all the clinics with solar systems (radio and lighting) have had solar panels stolen. Solar panels have been stolen from the Othika clinic three times, the Omgulumbashe clinic once and the Onamandongo clinic twice. On all occasions these panels have been replaced.

All the clinics have subsequently employed security guards who stay at the clinic during the night. Although no thefts have occurred since the employment of the security guards at the Onamandongo and Omgulumbashe clinics, one of the thefts at the Othika clinic occurred whilst a security guard was employed. He was subsequently fired from his job with the security company and the clinic has a new guard and has not experienced any theft since then.

The theft of solar panels has informed the attitude of the Othika staff towards solar electricity. Although they felt that solar electricity would benefit the clinic they were concerned that the panels would be stolen if the clinic was provided with a system.

2.4.5 Maintenance of electrical equipment

The Eenhana hospital was built with the assistance of the French government which provided funding and some building materials and equipment. Light fittings and energy efficient compact florescent bulbs were part of this package of assistance. A lack of foresight has recently led to problems as the many of the bulbs need to be replaced and the fittings are not compatible with bulbs which can be ordered through the Ministry of Public Works, Transport and Communication. Although the maintenance supervisor thought that the bulbs could be ordered from Windhoek, appropriate maintenance procedures have to be

followed which often leads to extensive delays. As a result, some areas of the hospital, such as the maternity ward where a number of bulbs needed to be replaced, had not had sufficient light for over a month.

During our interviews with staff in the hospital, it became evident that the problem of ensuring that the electrical equipment is maintained and remains in operation is widespread. For instance, in the kitchen, only one of the two large cooker pots was working and the refrigerator had been broken for three weeks. In the laundry, the tumble drier had not been working for four months and the spin drier was leaking.

Maintenance problems or requests are reported to the Ministry of Works, Transport and Communication in Oshakati, which either sends one of their technicians or contacts the appropriate technicians and suppliers elsewhere. In some cases, the delays were caused by the need for technicians from Windhoek to attend to the problem. Despite these problems, the Eenhana hospital is clearly in a better position than before it was up-graded and electrified.

Problems with electrical equipment are clearly not unique to the Eenhana hospital and it is not realistic to expect that equipment will not give problems. Limited financial resources also means that it is not always possible to replace old or broken equipment, especially medical equipment which is very expensive. For instance, the x-ray processing machine at the Onandjokwe hospital does not work and the hospital budget cannot afford to replace it. Until external funding can be found, x-rays will continue to be developed by hand – a process which is both time consuming and toxic.

However, there are some basic things which can be done in order to improve the maintenance of electrical equipment. Although it is appropriate that there is state control over expenditure and that skilled technicians attend to faults, it is clear that there is a problem with the present system. From the hospital's perspective, great difficulties are experienced in actually reporting faults as it is not always easy to get hold of the Ministry of Works, Transport and Communication. Communication problems are experienced, attempts should be made to address these and to ensure that the procedures followed lead to action.

The maintenance supervisor at Eenhana hospital felt that it would be appropriate to train hospital maintenance staff more extensively so that some of the problems could be addressed immediately. Although he had basic skills in electricity maintenance and plumbing he was unable to repair even relatively simple equipment, such as stoves, washing machines or refrigerators. Given that Eenhana, and other health care facilities, are far from Oshakati, the possibility of decentralising some of the repair and maintenance activities to hospital or local contractors should be investigated.

2.4.6 The impact of supply interruptions

Electricity supply interruptions have an impact on clinics, health centres and hospitals. In all the interviews with electrified facilities, supply interruptions were identified as the only negative aspect of electrification. The extent to which supply interruptions disrupt the operation of the facility is dependant on its reliance on electricity, as well as the existence of a back-up system.

One of the major impacts of supply interruptions on health centres and electrified clinics is the effect on the vaccine cold chain, especially when the electricity supply is interrupted for long periods. The staff at the Onesi health centre said that supply interruptions were particularly frequent during the rainy season when they are often experienced twice a week and sometimes last for up to five hours. The Odibo health centre had experienced supply interruptions which lasted for longer than one day. When the electricity supply is interrupted, vaccines are sometimes removed from the fridges and placed in cooler boxes with ice-packs, although this is not always done. It was not clear how decisions were made

with regard to removing vaccines from the fridges in these circumstances. A similar situation was reported at the Ohangwena clinic.

Supply interruptions also affect the health centres' ability to provide emergency services and nurse the patients in the wards at night. During the supply interruptions at the Onesi Health Centre, candles are used for lighting and patients are given food, such as bread, which does not require cooking.

Supply interruptions do not have an impact on the operation of the Eenhana and Gobabis hospitals, as their generators provide reliable back-up. At the Onandjokwe hospital, the generator does not switch on automatically when the electricity supply is interrupted and a delay of approximately ten minutes is experienced. While this may not seem critical, the ICU staff felt that it difficult to work under these conditions especially where patients were using life-support systems, such as ventilators or incubators for babies. Although gas is used to power anaesthetic machines, the theatre staff also felt that it was stressful when the electricity supply was interrupted. The main problem in theatre is the loss of light, which makes it impossible to continue. Only one of the theatres has an emergency light, but this does not always work as it is very old. For this reason, the hospital administrator and other staff interviewed felt that the electricity supply is less reliable now than in the past when only a diesel-generator was used. Although power interruptions were experienced with the old generator, they had not been frequent.

Of all the health care facilities is it most critical for hospitals to have an uninterrupted supply of electricity. For this reason, it is essential that hospitals have back-up generators which are reliable, and efforts to repair faults and maintain them should be made. Until problems with the grid supply network have been resolved it is likely that the problems associated with supply interruptions will persist.

2.5 Does electricity attract staff?

One of the assumed benefits of electrifying health facilities is the ability to attract and retain staff. It is difficult to determine whether this assumption is valid, as there are many factors other factors which also influence this. For instance, many of the nurses did not have the choice to decide where they would work as they were placed by the Ministry of Health and Social Services.

There is little doubt, however, that electricity improves the quality of life of staff who are provided with accommodation at health care facilities. Given that the staff who were accommodated at health facilities were not able to stay with their families, access to electricity was considered to be an important employment benefit. At some facilities, such as Aminius clinic, staff are not charged for accommodation (or electricity). In the majority of cases, nurses and administrative staff were charged a nominal fee of N$ 16 per month, whilst doctors were charged four percent of their salaries. This was considered to be highly desirable and appropriate. At Aminius clinic staff were not provided with appliances, although other centres, such as the Eenhana hospital provided refrigeration and electric stoves. Being able to use electricity for television, radios and video machines was also considered to be a benefit. At the Onandjokwe hospital, nurses are also able to eat from the hospital kitchen.

While solar electricity is unable to meet thermal energy service needs, the nurse who stayed at the Oshandi clinic felt that access to lighting and refrigeration made her life 'more comfortable'. Staff from other clinics felt that access to solar electricity would also improve their quality of life as it could provide power for fridges, televisions, radios and lighting, but in all cases a clear preference for grid electricity was stated. Not everyone was in favour of solar electricity: one of the nurses at the Ohangwena clinic felt that 'solar was hopeless as you can't iron or put on your stove and sometimes it does not work for TVs and radios. I have seen some of them crying because it does not work.'

Although nurses may have limited choices with regard to where they work, doctors are more able to exercise choice and some of the doctors interviewed felt that it they were unlikely to be attracted to hospitals without electrified accommodation. Working in hospitals without electricity was also considered to be difficult by doctors. In fact one of the doctors at the Gobabis hospital stated that he would never work in a hospital without electricity. He had done this and felt that good health care was not possible without electricity. This seems to suggest that electricity does play an important role in attracting specialised staff to rural hospitals.

Not all the staff have access to accommodation. As shown, accommodation is not always provided, and those staff members who live in the villages where the health care facilities are situated are not given preference when it is. Although no-one showed any hostility towards this policy there did seem to be a feeling that the government should prioritise the provision of electricity to government employee homesteads.

2.6 Does electricity improve security?

As discussed, a high incidence of theft of solar panels was reported from solar clinics. However, security problems have also been experienced in every health care facility included in the research, except for the Onderombapa and Onamandongo clinics. There is sufficient evidence to suggest that outside lighting does improve security, although in most cases this is not a sufficient deterrent for would-be-thieves. As a result of the number of burglaries, all the health care facilities in the North and the Gobabis hospital in the Omaheke region have employed security guards.

Outside lighting and employment of security guards also have an important psychological effect on patients and staff who feel more secure at night because of their presence. As one of the patients at the Oshandi clinic said: 'Really, it is better to come to the clinic when the lights are on because then one can know who is around.'

However, it is important to point out that burglaries continue despite the presence of both outside lighting and security guards. At the Gobabis hospital, thieves entered the hospital through an entrance which was not patrolled by the two security guards. There are numerous accounts of similar events at other facilities. While lighting and security guards improve security, there are no absolute guarantees against theft..

2.7 Patients' perceptions of the benefits of electricity

2.7.1 Electrified health care facilities

In general, patients associated electrification of health care facilities with the provision of services beyond those offered by clinics. For instance, patients at the Onesi health centre felt that electricity had enabled the health centre to admit patients, nurse them at night and cook food. This type of service was valued above clinic services where 'you can just get medicine'. At Elim health centre, the patients felt that the quality of treatment was better than at clinics because better equipment was used. Lighting was also identified as an important benefit of electrification as patients were able to come to health care facilities at night for treatment.

At hospitals, patients felt that electricity improved the care they were given because they could have operations. They also felt more secure in the knowledge that emergency operations could also be done at night due to electricity. All the hospitals allow patients to bring radios and televisions with them in order to make their stay more comfortable. The patients felt that this was very important.

In a number of interviews with patients, other problems experienced with access to health care overshadowed the discussions about electricity. For example, one patient at Oshandi clinic said that 'we only have this clinic and there are too many people for only one clinic. I

feel that this thing can be solved by building more clinics in the area so that we do not have to travel such long distances'.

At solar clinics, patients were positive about the benefits of solar electricity particularly with regard to providing lighting at night which meant that they could come to the clinic is they had emergencies. Conversation quickly shifted towards the need for electricity in their homes, and questions on how to access solar electricity.

Although patients recognised the importance of electricity and felt that it did result in benefits, most patients felt that well trained and skilled staff were the most important ingredient for good health care.

2.7.2 Un-electrified health care facilities

Only patients views from the un-electrified clinic of Othika are included here as the Onderombapa clinic had a generator and the patients' perspectives are included in the previous discussion.

At Othika, the patients felt that electricity would be of great benefit to them in case of emergencies: "Now we just wait until the day or we go to Elim". Although unrealistic, some of the patients also felt that if the clinic had electricity it would be possible to ensure that doctors visited the clinic and that medical equipment, such as an X-ray machine, could be made available to the clinic. In this way they would not have to go to Elim health care centre or the district hospital.

The most important perceived benefit of electricity was considered to be lighting, both in terms of enabling the clinic to work at night and to improve security: "We really need electricity here. There is a lot of theft and if we come here at night we have to use torches. Even the church and the school have been broken into and there is a need for outside lighting so that we can stop this theft."

Although the patients felt that grid electricity was better than solar because "I'm not saying there is not enough power but you cannot use things like a stove which needs more electricity. I trust this (the grid electricity) better. But I wouldn't hesitate to get electricity, especially for lighting."

2.8 Conclusion and summary of recommendations

This section has provided information on the energy use at clinics, health centres and hospitals, examined the benefits of electrification, discussed problems which have been experienced and made some suggestions on how these difficulties could be overcome.

- ***Energy needs at clinics, health centres and hospitals***

  It was found that the energy requirements of clinics was limited to lighting (inside and outside), refrigeration, radio communication and powering some medical equipment. Although the grid electrified clinics used electricity for refrigeration, the solar clinics used gas. Except for three clinics which had telephones, all the clinics had separate solar systems for radio communication. Due to the expanded services provided at health care centres, especially with regard to admitting patients, the energy requirements are greater than those of the clinics. Electric lighting was considered to be an important component of providing care to patients at night and laundries and kitchens required electricity for washing, ironing, cooking and refrigeration. Health centres also tended to have more medical equipment than clinics. In contrast to health centres and clinics, electricity is critical for the effective functioning of hospitals as they are dependant on modern equipment, which ranges from office equipment to specialised medical equipment.

- ***The importance of lighting***

There are a number of important benefits of electrifying rural health care facilities. Firstly, it was found that the provision of lighting to clinics is an important benefit of electrification as clinics are more able to provide effective emergency services at night. Both solar and grid electricity are effective energy carriers for the lighting requirement of clinics. Clinics without access to good quality lighting are clearly at a disadvantage. The provision of electricity to clinics for lighting will, however, not necessarily lead to an improved health care service. Where clinics have resident staff, the benefit of electric lighting is greatly enhanced through enabling the provision of emergency services, admission of over-night patients for observation and preparation of education programmes.

- ***Electrical medical equipment***

Secondly, the ability to use electrical medical equipment, especially electrical suction machines was also considered to be an important benefit of grid electrification at clinics and health centres, while the use of specialised medical equipment at hospitals is only possible with electricity.

- ***Staff perceptions of quality of life***

Thirdly, electricity also improves the quality of life of staff who are provided with accommodation at health care facilities. Given that the staff who were accommodated at health facilities were not able to stay with their families, access to electricity was considered to be an important employment benefit. Although nurses have limited choices with regard to where they work, doctors are more able to exercise choice and it is was found that electricity does play an important role in attracting specialised staff to rural hospitals.

- ***Lighting and security***

Finally, there is sufficient evidence to suggest that outside lighting does improve security, although in most cases this it is necessary to employ security guards as well. However, it is important to point out that burglaries continue despite the presence of both outside lighting and security guards.

- ***Maintenance problems***

A number of problems, which militate against realising the full benefits of electrification were also identified and discussed. Due to the lack of an effective maintenance programme and an inefficient fault reporting system, clinics had experienced problems with solar systems provided for both radio communication and lighting. This has resulted in difficulties for clinics and limited the extent to which the benefits of providing solar systems is realised.

It was suggested that a maintenance programme which seeks to build the capacity of clinic staff and local technicians be devised and implemented. This programme should ensure that clinic staff are able to use systems effectively, undertake first line maintenance and have basic fault finding skills. A sufficient number of local technicians should be sub-contracted to maintain the solar systems by undertaking routine tasks, such as ensuring that batteries are regularly changed and conducting annual checks on the systems, as well as dealing with faults as they arise There should be some integration between the training of local technicians for the *Home Power!* and clinic electrification programmes. Also, the need to ensure that the Ministry of Health and Social Services, with the assistance of the Ministry of Mines and Energy, take responsibility for over-seeing the programme was also identified.

The maintenance of equipment at hospitals was also identified as a problem as it takes a long time for technicians from the Ministry of Works, Transport and Communication to visit hospitals to repair faults. The possibility of decentralising some of the repair and maintenance activities to hospitals or local contractors should be investigated.

- ***Problems with the gas supply and delivery network***

  The gas supply and delivery network which supports the use of gas vaccine fridges at all the un-electrified and solar clinics is not reliable and leads to difficulties in maintaining the vaccine cold chain. It is essential that the gas supply and delivery network is improved. The evidence from the research seems to suggest that the district hospitals are not the most appropriate point for gas delivery to clinics due to the limited available transport and the difficulties with radio communication. The possibility of sub-contracting these services to small gas agents throughout the different regions should be considered. Also, the clinic electrification planning process should also consider the installation of solar systems which have the capacity to power a vaccine fridges in clinics. However, it is critical that an appropriate maintenance infrastructure is in place if solar is to be considered.

- ***Impact of supply interruptions***

  Supply interruptions were identified as the only negative aspect of electrification by health care facility staff. The extent to which supply interruptions disrupt the operation of the facility is dependant on its reliance on electricity, as well as the existence of a back-up system. One of the major impacts of supply interruptions on health centres (and electrified clinics) is the effect on the vaccine cold chain, especially when the electricity supply is interrupted for long periods. Supply interruptions also affect the health centres ability to provide emergency services and nurse the patients in the wards at night. Supply interruptions should not have a negative impact on hospitals due to the existence of back-up generators. However, hospital staff find it stressful when generators are faulty and do not ensure that there is an uninterrupted supply of electricity. For this reason, it is essential that hospitals have back-up generators which are reliable, and efforts to repair faults and maintain them should be made.

3. Education and electrification

Teachers and pupils from fourteen schools, which included primary, combined, junior secondary and senior secondary were interviewed (refer to table 6). Four of these schools were in the Omaheke region, whilst the rest were in the Ohangwena, Omusati, Oshana and Oshikoto regions.

SCHOOL	*ELECTRIFIED*	*SOLAR*	*UN-ELECTRIFIED*
PRIMARY SCHOOLS			
Aminius Primary School (Omaheke)	✔		
Onderombapa Primary School (Omaheke)			✔
Naango Primary School (Elim – Omusati)	✔		
Total number of primary schools	3		
COMBINED SCHOOLS			
Onamunhama Combined School (Ohangwena)		✔	
Eembaxu Combined School (Ohangwena)			✔
Aminius Combined School (Omaheke)	✔		
Elim Combined School (Omusati)	✔		
Oniipa Combined School (Oshikoto)	✔		
Othika Combined School (Omusati)			✔
Eenhana Combined School (Ohangwena)	✔		
Total number of combined schools	7		
JUNIOR SECONDARY SCHOOLS			
Elim Secondary School (Omusati)	✔		
Aminius Junior Secondary school (Ohangwena)	✔		
Total number of junior secondary schools	2		
SENIOR SECONDARY SCHOOLS			
Hambili Haufiku Senior Secondary School (Eenhana – Ohangwena)	✔		
Ponhofi Senior Secondary School (Ohangwena – Ohangwena))	✔		
Total number of senior secondary schools	2		
Total number of electrified schools	10		
Total number of un-electrified schools	3		
Total number of solar schools	1		
Total number of schools	14		

Table 6: Schools investigated

Although the Omaheke region has fewer schools than the other four regions, the smaller population means that there are fewer pupils and a lower pupil/teacher ratio is evident (refer to table 7). The Ohangwena region, on the other hand has the highest number of schools and pupils, and the pupil/teacher ratio is fifteen percent higher than in the Omaheke region.

In all regions there are very few secondary schools, with the majority of pupils situated at primary school level. Since 1991 an increase in the number of secondary school pupils has

occurred and there is a decrease in the number of pupils leaving school without any secondary education (Ministry of Basic Education and Culture 1996). However, many of the teachers at the Combined and Secondary schools mentioned that there was a high 'drop-out' rate. In some cases, by October (when we conducted the interviews) the number of pupils had decreased by 70 from the initial enrolment for 1998.

Only a small number of schools in the northern regions have hostel accommodation for pupils, with most of the hostels attached to secondary schools. In contrast to this, the majority of schools in Omaheke have hostel accommodation. Almost all the Omaheke schools have access to facilities such as water, telephones and toilets, while very few of these facilities are provided in the Ohangwena, Omusati, Oshikoto and Oshana regions. Of the northern regions, the Ohangwena and Omusati regions face the biggest problems with the highest number of learners and schools, but the least percentage of schools with facilities.

	OHANGWENA	*OSHIKOTO*	*OMUSATI*	*OSHANA*	*OMAHEKE*
No of primary schools	144	107	140	51	20
No of combined schools	54	32	85	54	6
No of secondary schools	6	7	11	8	4
Total no of schools	204	146	236	113	30
No of pupils in secondary schools	1 789	1 677	4159	3 624	374
Total number of pupils	73 865	46 583	84 490	50 982	13 069
Pupil/teacher ratio	40	33	33	34	25
Percentage with electricity	13	21	14	20	97
Percentage with water	28	47	39	72	97
Percentage with staff housing	3	8	4	7	77
Number of hostels	5	9	9	5	27

Table 7: Regional education statistics (source Ministry of Basic Education and Culture 1997)

At best, the percentage of schools with electricity in the northern regions is 21%, whilst 97% of the schools in the Omaheke region are electrified. Although there are no available statistics to substantiate this, it is likely that secondary schools in the northern region comprise the majority of the electrified schools due to their location in relatively large centres. In contrast to this, all types of schools are electrified in the Omaheke region.

3.1 Primary and combined schools

3.1.1 School conditions and energy use

Primary schools offer schooling from grade 1 to 7, with some junior primary schools, such as Naango, reaching only up to grade 4 (refer to table 8). Combined schools, on the other hand, offer a combination of primary and secondary grades up until grade 10. In the northern regions, school fees for the lower grades are generally lower than those for higher grades. Although the fees are set by the schools, parent bodies are consulted when the fees need to be raised. The principal of the Naango Primary School said that it was difficult to get parents to agree to raise school fees at primary school level as it was considered to be less important than secondary school education. The fee structure of the schools investigated in the Omaheke region are slightly different, with a standard fee set for all grades at the Aminius and Onderombapa primary schools. Due to the fact that it is a mission school, the Aminius Combined school offers education for free. Although the state pays the teacher's salaries and provides some materials, such as books, resources are also available from the church (mostly through private donations) and it is possible to run the school without charging school fees.

With the exception of this mission school all the other schools investigated were government schools and schools fees are used buy equipment other than that which provided by the state, pay for the upkeep of the buildings (such as broken windows or painting) and, in some cases, pay for the services of security guards. While the low school fees are appropriate in terms of achieving equity in education, the schools face severe resource constraints as a result. In addition the schools fees, parents at some schools are also asked to contribute towards new equipment which is needed.

The Ministry of Basic Education and Culture pays the electricity bills of all the schools except the mission school at Aminius, where the mission takes responsibility for this. Most of the schools were not aware of the amount of electricity consumed, although some schools said that the bills were sent to the schools and the principals were responsible for checking the bill before it was sent to the ministry for payment.

The condition of the school building vary significantly, with those built more recently generally in a better condition than others. With competing demands for limited resources, there is not sufficient funding to ensure that schools are well maintained. Although Naango Primary School is in a fairly good condition there were a number of windows which had been broken. The principal informed us that school fees had to be used to replace them and she was hoping that there would be money from the 1999 fees to cover this. Many schools do not have sufficient classrooms and lessons are taught under trees or in 'traditional' or makeshift structures. The principal of the Eembaxu school, which does not have enough classrooms described the situation when it rains and two classes are put into one classroom: "then we do not teach, we hold rallies".

In light of the discussion in the previous section it is not surprising that the only primary and combined schools investigated which had hostel facilities are in the Omaheke region. In these schools, the majority of enrolled students are accommodated in the hostels which are highly subsidised to ensure students are not denied access to education.

			Year built	Year elec	Gr	No of pupils	No of teachers	Class-rooms	Hostel pupils	School fees/yr	Hostel fees/yr
PRIMARY	Un-elec	Onderombapa	1979	-	1-7	550	16	16	396	N$35	N$264
	Elec	Aminius	1974	1996	1-7	516	24	24	400	N$30	N$200
		Naango	?	1994	1-4	345	11	12	None	N$6	-
COMBINED	Solar	Onamunhama	1992	1997	1-10	452	13	4	None	Gr 1-3: N$10 Gr 4-7: N$20 Gr 8-9: N$40 Gr 10: N$60	-
	Elec	Aminius	1905	1995	1-10	500	18	18	470	Free	N$150
		Eenhana	1962	1993	1-10	800	21	17	None	Gr 1-3: N$5 Gr 4-7: N$10 Gr 8-10: N$20	-
		Elim	?	1993	5-7	292	10	12	None	N$10	-
		Oniipa	1972	1995	6-10	602	18	17	None	Gr 6-7: N$12 Gr9-10: N$20	-
	Un-elec	Eembaxu	?	-	1-10	621	16	14	None	Gr1-7: N$5 Gr8-10:N$20	-
		Othika	1929	-	1-9	480	20	15	None	Gr 1-4: N$3 Gr 5-7 N$5 Gr 8-9: N$20	-

Table 8: Primary and combined schools investigated in the study

Although four un-electrified primary and combined schools were included in the study, the Onderombapa Primary School has a diesel generator which provides electricity to the school. Aside from issues which pertain specifically to the generator (which are dealt with in section 2.4.3), the energy use of the school is therefore similar to electrified schools.

All the electrified schools use electricity for lighting, especially at night for security purposes. Un-electrified schools do not use any other source of energy for lighting. For schools with very little equipment and few teaching aids, such as Naango Primary and Elim Combined, electricity is predominantly used for lighting. The extent to which the cost of electrifying schools for such limited benefit can be justified will be discussed in section 2.3.1.

There is a significant difference between the energy requirements and electricity use of schools in the northern regions, and those of the Omaheke schools. There are two factors which account for this. First, only the Omaheke schools have hostel facilities. In order to accommodate students and provide an environment in which they can study, hostels require electricity for refrigerating food, cooking meals, and for lighting at night for studying purposes. Both schools in Aminius used electricity for cooking, whilst the Onderombapa Primary School used gas. Students are not allowed to bring any appliances, such as radios, to the hostels.

Secondly, with the exception of the Onamunhama school in Ohangwena, the Omaheke schools have more equipment and teaching aids than the schools in the northern region (refer to table 9). Without an understanding of the historical resource flows to these different regions it is difficult to determine why this situation exists. However, it is clear that the mission school (Aminius Combined) has more resources due to its ability to access funding other than that from the state. The Onamunhama school, one of the few solar electrified schools in Namibia, is also in a privileged position with regard to access to funding for school equipment and teaching aids as it forms part of a UNESCO demonstration solar village pilot project. UNESCO provided funding for the solar systems to the school, church and community building, as well as construction of the school buildings and school equipment, such as a television and video machine.

None of the combined and primary schools in the northern regions had televisions or video machines which could be used for educational purposes, whilst all the schools in the Omaheke region had at least one of each. With the exception of Elim and Naango, all the electrified schools had at least one overhead projector. Similar disparities with the allocation of office equipment was also evident. Some of the schools in the northern regions had duplicating machines, while all the schools in Omaheke had photocopiers and electric typewriters.

According to the principal of the Elim combined school, the Ministry of Basic Education and Culture only provides equipment to schools teaching secondary grades (grade 8-12). This means that the equipment at the other schools is purchased from the school fees or parents are requested to donate money toward this end. Both the Naango Primary School (Grade 1-4) and the Elim Combined school (Grade 5-7), only had a radio/tape recorder which they had purchased, while the Eenhana and Oniipa Combined schools had both radio/tape recorder and overhead projectors which had been provided by the state. The schools without any form of electricity only had battery operated radio/tape recorders, and manually operated duplicating machines.

According to the school inspector of the Ondangwa West (Omusati and Oshana) region the allocation of the national education budget has been skewed towards ensuring that secondary schools, and especially those teaching senior grades, are provided with equipment. It is standard practice for senior schools to be provided duplicating machines, televisions, video machines, tape recorders and overhead projectors. Other equipment is purchased with school fees. He stressed that it was difficult for the government to provide equipment to all the schools as many of these schools lack basic facilities and materials.

	PRIMARY SCHOOLS			COMBINED SCHOOLS						
	Un-elec	Electrified		Solar	Electrified				Un-electrified	
	Onderombapa	Aminius	Naango	Onamun-hama	Aminius	Eenhana	Elim	Oniipa	Eembaxu	Othika
ADMINISTRATION										
Photocopier	✔ (2)	✔			✔					
Typewriter	✔	✔			✔ (2)					
Duplicating machine	✔	✔				✔		✔	✔ (manual)	
Fax machine					✔					
Electric bell		✔						✔		
TEACHING AIDS										
Radio/Tape recorder	✔ (4)		✔		✔ (2)	✔	✔	✔	✔ (2) battery	✔ battery
Television	✔ (2)	✔		✔	✔ (2)					
Video machine	✔			✔	✔ (2)					
Overhead projector	✔	✔		✔	✔	✔		✔ (4)		
Stoves for home science								✔ (gas)		
LIGHTING										
Inside	✔	✔		✔	✔	✔	✔	✔		
Security	✔	✔		✔	✔	✔	✔	✔		
BOARDING FACILITIES										
Cooking Equipment	✔ (gas)	✔			✔					
Fridge	✔	✔			✔					
Washing machine	✔									
Iron	✔									

Table 9: Electricity use of primary and combined schools

3.2 Secondary schools

Of the four secondary schools included in the study, only one was from the Omaheke region and all of them are electrified (refer to table 10). Like most of the combined schools, junior secondary schools provide schooling up to grade 10, whilst grades 11 and 12 are offered at senior secondary schools. Schools fees at both junior and senior secondary schools are higher than those of primary and combined schools. The principal of the Hambili Haufiku school in the Ohangwena region felt that these fees were justified as secondary schooling was much more expensive to provide. School fees are also used to purchase equipment, although the state does provide secondary schools with more equipment than the primary and combined schools.

It is considered important for senior secondary schools to have a hostel as they accommodate students from different locations, some of which are too far to travel from. Although the secondary school at Elim used to have hostel facilities, it was closed down because of the poor conditions at the hostel. Similarly, the hostel's at Aminius and Ponhofi secondary schools are also in a state of disrepair. With an official capacity of 400, the hostel at Ponhofi does not have appropriate facilities for the 580 students who are currently accommodated. The building is old and made of asbestos, which is broken and cracked in

places, and the solar water heating system does not work. As a result of the lack of facilities, the hostel fees are nominal (N$24 per annum).

	JUNIOR SECONDARY		SENIOR SECONDARY	
	Aminius	*Elim*	*Hambili Haufiku*	*Ponhofi*
Year built	1935	1976, upgraded	1988	1975
Year electrified	1995	1992	1991/2	1994
Grades	8-10	9-10	11-12	11-12
No of learners	300	400	600	610
No of teachers	14	17	21	22
No of classrooms	9	34	20	16
No of learners at hostel	280	None	100	580
School fees/yr	N$80	N$40	N$140	N$120
Hostel fees/yr	N$200	-	N$152	N$ 24

Table 10: Secondary schools investigated in the study

At Aminius the beds are broken and there is not sufficient space to accommodate all the students. The solar water heating system at the Hambili Haufiku School's hostel is also not working and water is heated with a 'donkey' (a boiler heated with fuelwood). Except for the Aminius secondary school, the school building are in a better condition than the hostels.

The electricity use at secondary schools was found to be similar to that of the electrified primary and secondary schools, especially those in the Omaheke region (refer to table 11). However, in contrast to the primary and combined schools, all the secondary schools investigated had a wide range of electrical teaching aids and office equipment and used electricity more extensively. All except Elim Secondary School had computers which were available for the teachers and administrative staff to use. While the state provided some of the equipment, such as televisions, overhead projectors and video machines to the schools, other equipment was purchased from school fees or donations. The Ponhofi Secondary School had four staff computers donated and secured funding for twenty-six computers for students.

3.3 The benefits of electrification

It has been noted that the potential benefits of electrifying rural schools lie with the ability to offer Technology Enhanced Learning (TEL) and night classes for adult education, equip schools with basic equipment to fulfil teaching and administrative functions, and improve science education (Gordon 1997). In addition, electricity is also assumed to improve security of schools and attract well qualified staff. This section will examine whether electrification has led to the realisation of these benefits and provide some insight into the factors which may either lead to this or mitigate against it.

	Aminius	Elim	Hambili Haufiku	Ponhofi
ADMINISTRATION				
Photocopier	✔	✔	✔ (2)	✔ (2)
Typewriter	✔	✔	✔	✔
Duplicating machine	✔	✔		
Computer	✔		✔	✔ (4)
Fax machine		✔	✔	✔
Air-conditioning				✔
Electric bell			✔	
TEACHING AIDS				
Radio/Tape recorder	✔ (2)	✔ (2)	✔	✔
Television	✔	✔	✔	✔ (2)
Video machine	✔	✔	✔	✔
Overhead projector	✔	✔	✔ (11)	✔ (4)
Computers				✔ (26)
LIGHTING				
Inside	✔	✔	✔	✔
Security	✔	✔	✔	✔
BOARDING FACILITIES				
Cooking Equipment	✔		Gas	✔ (& gas)
Fridge/cool room	✔		✔	✔
Television			✔	

Table 11: Electricity use of secondary schools

3.3.1 The need for lighting at schools

Except for those schools with hostel facilities, it was found that the schools made very limited use of their electric lighting. Some of the schools, such as the Elim and Eenhana Combined Schools sometimes used their lights in the mornings during the rainy season, although most schools reported not to use them during the day at all. Except for the Onderombapa Primary School, which had a diesel generator, none of the schools were found to give adult education classes in the evening, although a number of them did offer classes during the afternoons. In some cases, schools were used occasionally in the evenings for community and church meetings. At schools without hostel facilities none of the children had access to the buildings at night for studying purposes. Most children's homes are situated far distances from the schools and it was considered in appropriate and unsafe to allow them to walk home in the dark.

The principal use of lighting at most of the schools is for security purposes. As with the situation at clinics, it was also reported that outside lighting alone does not safeguard schools against theft. However, unlike the situation at clinics, security guards are not paid for by the Ministry of Basic Education and Culture. The Naango Primary School employed a security guard when a radio was stolen from the school and the cost of N$70 per month is carried by the school. Of all the schools investigated, the Oniipa Combined school has the greatest security problems, and because of the constant threat of burglaries the four gas stoves and bottles used for home sciences are kept at a teachers house and brought to the school each time they were needed. No security guard is employed at the school as there are no funds for this. Some of the goods which have been stolen, such as the overhead projector, have been returned by community members who have found those responsible for the theft. The schools in Aminius had all experienced burglaries during the holidays when no-one was on the school premises.

3.3.2 Schools with hostels

As mentioned, most of the hostel facilities are not in a good condition. While electricity enables the use of certain equipment for cooking and refrigeration, some of the hostels still rely on other fuels, such as gas. As with the experience of clinics, the gas supply network is not reliable and at times, schools experience delays in getting gas. Ponhofi Secondary School also reported that their cool rooms do not always work as they are over twenty years old and have not been well maintained.

While electricity has the potential to circumvent the problems associated with obtaining fuels, such as gas, substantial upgrading of the hostel facilities is required before this can happen. Aside from the benefits associated with using electricity for kitchen equipment, student access to good quality lighting for studying purposes is the major benefit of electricity for schools with hostels. As there are no facilities for studying at most of the hostels, students are able to use the classrooms at night to study.

Students who were accommodated at the hostels felt that they were able to study for longer hours with electricity as they did not get headaches, and nor were they constantly worried about the amount of energy which they were using. Some students told us that they did not have unlimited use of candles or paraffin for lamps as their parents controlled their consumption due to the cost of these fuels. Other students stated that they also used electric lighting for recreational activities at night, such as needlework and reading of novels.

Given that most students do not have access to good quality lighting as few homes are gird electrified and only relatively wealthy households can afford solar home systems, the electrification of hostels is clearly beneficial. The principal of the Hambili Haufiku school felt that students staying in the hostel were able to study under better conditions than those who only had access to candles and paraffin lamps at home. However, it is impossible to quantify the benefits of students' access to good lighting. All the teachers interviewed argued that there was not a direct correlation between access to good quality lighting and the achievement of students, as this was dependent on a range of factors, including the aptitude of the students, whether they were sufficiently well nourished, facilities at schools, skill and qualification of teachers and the standard of teaching in the schools.

> Students do face difficulties studying at night because they do not have good lighting. But, there is not guarantee that one will see improvements if learners have electricity at home. There are many factors which produce achieving students. What is beneficial to students is if they can watch television as this can expose them to those things which are not in their environment and which we teach them about (principal of the Elim Combined School)

3.3.3 Teaching aids and administrative equipment

From the teachers perspective, teaching aids, such as overhead projectors, televisions, tape recorders and video machines enhance their ability to teach, making teaching 'easy', and more 'interesting' and 'exciting' for students. Teachers who had taught at schools prior to electrification, or at other un-electrified schools were particularly emphatic about the benefits of using teaching aids.

Radio/tape recorders were considered important for language education as students are able to listen to the language as spoken by mother-tongue speakers. This was considered especially important for English as most of the teachers are second-language English speakers. Television and video machines were especially used for history, geography and science subjects. Educational cassettes were given to schools when teachers attended upgrading courses. Many of the teachers felt that televisions were an important educational aid as it made certain concepts, foreign environments and phenomenon more tangible for students.

Those schools teaching grade 9 and 10 are also provided with science kits which provide equipment for experiments, including those concerned with understanding the concept of electricity. Although these kits can be powered with batteries, all the electrified schools used electricity to power the equipment. No other laboratory equipment, such as microscopes, were found at the schools.

It is interesting to note that some teachers equated the use of teaching aids with a higher standard of teaching: ' Having equipment makes better teachers'. However, it is important to stress that access to equipment does not necessarily lead to better quality education, as factors such as the skill and qualification of teachers, and access to resource materials and books also play a major determining role. While teachers at schools with very little equipment, such as Naango Primary and Elim Combined, felt that it teaching aids would improve their ability to teach, they also felt that they were able to provide a good standard of education without them. The perspective of teachers who taught higher grades was slightly different, as they felt that many of the concepts are difficult to teach without providing the students with visual input.

In terms of office equipment, photocopiers were considered to be the most useful and desirable items, and the need to photocopy materials (especially resource materials) has been established as a norm in both schools with and without photocopiers. With the result, schools which do not have photocopiers have to pay other schools and institutions for copying, often at highly inflated prices. Aside from the use of the fax and photocopying machines for school purposed, the secondary school at Elim also derives an income from charging other schools, institutions and individuals for copies made and faxes sent. The Naango Primary School uses the photocopying facilities of the secondary school at Elim which charges them fifty cents per copy. These costs place considerable stress on the limited school budget. The Oniipa Combined School, on the other hand has a duplicating machine, but no photocopier. They are charged N$1 per copy at a local printing business in Oniipa. Photocopiers are not always available in the centres where schools are located. For example, if the Othika school requires photocopies the teachers have to go to Oshakati to make them and are charged between 50 cents and N$1 per copy.

Those schools which have a range of electrical teaching aids and office equipment stand to gain the most from having electricity. If our analysis centres on the electricity use of schools, especially those with a limited range of equipment, one could argue that the benefits of electrifying schools are not great. In fact, for schools such as Naango Primary, Elim Combined and Eenhana Combined, electricity is principally being used for lighting for security purposes, which, of course, begs the question of whether scarce national resources should not be spent elsewhere. While such a perspective may be accurate in the short-term, it does not take account of the long-term benefits of electrifying schools.

Even with limited resources schools do plan and budget for the acquisition of equipment. As the principal of Elim Combined School suggested 'If we didn't have electricity then we wouldn't think and plan for what could be done.' Many of the schools have managed to acquire equipment in addition to the items provided by the state. With time it is possible that the schools which have been included in this study will have more teaching aids and office equipment which will enhance their ability to teach.

However, it is also possible to ensure that schools have access to equipment without actually owning them. It may be appropriate for equipment, such as fax machines, photocopiers, televisions and video machines, to be made available at central locations (for example, a community centre or one school), within settlements. In this way the benefits of electrification can be realised without placing undue demands on limited educational resources[5].

[5] We owe this idea to Mark Davis.

3.3.4 Technology Enhanced Learning (TEL)

> We need these computers. Without them we are lost because when we get jobs we will not know what to do. Really, it is important to for us to learn how to use computers at school. (Male student: Hambili Haufiku Secondary School)

At all the secondary schools pupils who participated in the research emphasised the need to learn how to use computers. As the with the student above, many felt that they would be in a better position to gain employment if they were computer literate. Interestingly, a number of students also expressed feelings of alienation because they lacked any knowledge about computers, and especially of the Internet – something which they had heard of but had little understanding of. These students' concerns centred mainly around 'being left behind'.

There is a strong argument to be made for exposing learners to sophisticated technologies, such as computers, so that they do not become further marginalised in the modern economy (Gordon 1997). Both principals from the Ponhofi and Hambili Haufiku secondary schools pointed to the importance of providing students which access to computers, stressing the need to equip students to cope with the demands of the 'modern world'. The computer laboratory at the Ponhofi Secondary School is currently used by grade 11 and 12 students for computer literacy classes. Computers are not yet used as teaching aids in other subjects, although the principal felt that this would gradually be introduced once teachers were more adept at using them. Recognising that many teachers are not computer literate, the school also runs a programme which aims to equip teachers with the requisite skills. Teachers from a number of schools participate in the programme, with the hope that they will introduce programmes into their schools.

Clearly, without electricity it is impossible to provide computer education. However, given the resource constraints facing schools and the need to address the lack of basic equipment and facilities in schools, expenditure on computers is not likely to be prioritised by the state. Without the support of private sector and donor funding to provide computers, this form of technology enhanced learning will not be facilitated by the provision of electricity to schools.

3.3.5 Does electricity attract staff?

It was also found that electrified staff accommodation was highly valued by teachers and in some cases, teachers emphasised this above the educational benefits associated with electricity.

	PRIMARY		*COMBINED*		*SECONDARY*		
	Aminius	*Onderom —bapa*	*Aminius*	*Aminius*	*Elim*	*Hambili Haufiku*	*Ponhofi*
No of staff	23	5	?	?	7	8	19
Type	House & hostel	Hostel	Hostel &staff housing	Hostel	House & classroom	Single quarters & houses	Single quarters & houses
Cost	Free	Free	N$40	Free	Free	Mostly free. 2 new houses – metered	Pre-payment meters
Appliances provided	None	None	Stove, fridge, TV video (shared)	Hotplates, fridges	Stoves	Only to volunteers (stoves & fridges)	None

Table 12: Staff accommodation at schools

All the schools in the Omaheke region provided some accommodation for teachers, whilst only the secondary schools in the northern regions had facilities for staff accommodation.

The only schools without hostel facilities which provides staff accommodation is the Elim Combined School (refer to table 12).

The type of accommodation provided varies greatly, with some staff accommodated in the hostel where they are required to supervise students and perform hostel duty, whilst others were accommodated in houses. At the mission combined school in Aminius, the staff housing is situated on the mission grounds next to the school, whilst at Elim Combined School some teachers live in classrooms which are not used by the schools.

With the exception of the mission school at Aminius, staff accommodation is free. Teachers do not pay for the electricity which is consumed, although meters were installed in the new houses built at Hambili Haufiku and those teachers are now required to pay their own electricity bills. This has caused some ill feeling as other teachers at the school do not have to pay. The teachers interviewed felt that electricity made their lives more comfortable as they were able to use appliances for entertainment, such as radios and televisions, as well as enjoy the benefits of cooking with electricity, which they were unable to do at their own un-electrified homes. Also, with access to lighting teachers were able to prepare lessons and mark work in the evenings.

As with the situation at health care facilities, it is important not to attribute the existence of well qualified teachers at school solely to the existence of electricity. In addition to the benefits associated with electrified staff accommodation we have shown that teachers attribute value to electricity at schools because it enables the use of teaching aids and those teachers at schools without electricity felt at a distinct disadvantage. In fact, one teacher at the Aminius Primary School felt that he would not teach at a school without electricity because the 'quality of education is bad'. However, teachers are not always able to exercise choice over where they are able to teach. Where teachers are able to determine where they will teach other factors besides electricity influence their decisions. For instance, many teachers choose to teach in schools in their villages so that they can be with their families or teachers move to other schools because of promotional opportunities.

3.3.6 Staff perspectives at un-electrified schools

The teachers of the un-electrified school of Othika felt that they were at a distinct disadvantage at the school because they could not use overhead projectors, televisions and radios. The principal of the Eembaxu school was insistent about the disadvantage which his school faced because it did not have electricity. The staff at Eembaxu feel particularly aggravated by the fact that the school is un-electrified as the school is approximately 200m beyond the 500m electrification cut-off point. In 1995, after measuring the distance to the electricity poles, the headmaster wrote to the Ministry of Basic Education and Culture and Nampower in order to gain access to electricity. According to him, some initial promises were made but he has not received any feedback or response to subsequent inquiries. As far as the staff are concerned, they should be given access to electricity as they are close to the power lines.

The staff at the Eembaxu Combined school felt that the lack of electricity made communication very slow as they were reliant on the postal services or physically travelling to see someone if they wanted to speak to them. They felt that a fax machine would enhance their ability to communicate. The first items that the school would purchase if it was electrified were an overhead projector and a photocopier.

3.3.7 Pupils perspectives

Pupils at the schools which were investigated participated in participatory processes which aimed at exploring their perspectives on the benefits of electricity for education, as well as the difficulties of studying without electricity.

All students were in agreement about the difficulty of studying without access to good lighting, and the issues which emerged are well captured in one student's creative endeavours:

> My mother wakes me and she wants to beat me because I woke up late. I go and fetch water. When I come back I start to cook breakfast for my brothers and sisters. I wash myself and eat my breakfast. I go to school and the teacher beats me because I am late. When I come back from school my mother is happy to see me. I take my books to the tree to read. I am reading a geography book and I study for two hours until four o'clock. I study under the tree because it is shady. I also study at night time between 8 and 9. I use candles but I get a headache because the light from the candles is not very good. I was busy studying and the candle was knocked over and burnt the whole room. (Female student: Othika Combined School)

Aside from the attitudes expressed with regard to computer education, students also felt that televisions and video machines were critical for their education as they were able to 'see things which we have never seen before' and also keep in touch with what is 'happening in the world'.

3.4 Problems and difficulties

3.4.1 Replacing bulbs and reading bills

It was found that some of the schools did not know who was responsible for replacing light bulbs, and with the result, the bulbs had not been replaced. Schools were reluctant to use schools fees to pay for the replacement of bulbs due to their limited resources and the fact that different institutions had replaced them in the past. The Naango Primary school has a number of bulbs which need replacement. According to the principal Northern Electricity had replaced the bulbs once before, but she was not sure whether they would do so again. At the Elim Combined School the Ministry of Works, Transport and Communication had replaced bulbs and the school contacted them when this was necessary. Bulbs are also in need of replacement at the Oniipa Combined school and the principal was unsure of who should replace these. This situation can be resolved by informing schools of the correct procedure for bulb replacement.

Many of the principals interviewed in the northern regions expressed mistrust of Northern Electricity's tariffs. Although the Ministry of Basic Education and Culture pays for the bills the principals of the school are responsible for examining the bills before sending them to the Ministry for payment. The inclusion of a charge per kVA of maximum demand was the main reason for concern and one of the principals said that 'it seems as though Northern Electricity is charging us twice.' It is recommended that Northern Electricity informs school principals of the way in which tariffs for large power users, such as schools, are devised and calculated. Information pamphlets, with accessible explanation, could be included with the bills which are sent to schools.

3.4.2 The effect of supply interruptions

In spite of the fact that supply interruptions lead to disruptions and equipment cannot be used, they do not have a major effect on teaching activities in schools. A few schools reported that equipment was sometimes damaged and light bulbs fused when the supply of electricity was restored. The Ponhofi Secondary School had purchased devices which enabled computers to shut down properly when the electricity supply is interrupted as a precautionary measure against damage. During the supply interruptions, the Hambili Haufiku school also experiences water shortages as the water is supplied to the school with an electric pump.

In general, teachers were of the view that it was better to have access to the grid and experience supply interruptions than have no electricity at all. Every school in the northern

regions expressed satisfaction with the way in which Northern Electricity provided information of imminent shut downs and were able to make contingency plans if necessary.

3.4.3 Providing electricity with solar systems or diesel generators

As mentioned, the Onamunhama Combined School forms part of the UNESCO demonstration solar village pilot project. The school moved from its previous location on the Angolan border to its present site in 1992. With additional UNESCO funding five classrooms have been built and a further four are under construction. Those classes without classrooms are taught under the trees or in makeshift structures which have been built. The school shares the premises with a church and a community building, which is will possibly be used as a clinic and is currently used for the payment of pensions. Together with the school, solar systems have also been installed in these buildings.

Although the school uses the electricity for powering teaching aids, such as a television and video machine which were provided by UNESCO, it does not seem as though the other systems are used very much[6]. The community building is not used at night and the church is only used occasionally. According to the principal, night classes initially took place, but these fell away due to lack of funding. There are plans to find funding and use the school for night classes and to provide a place for students, who have failed grade 12, to study at night. The lights are, however, left on during the night for security purposes.

As this school was only one of the schools investigated we have not examined all the details of the project. However, the cost of providing the three solar systems was US$30 000 (Entiman 1999), with additional UNESCO funding provided for building a fence and the school buildings. UNESCO subcontracted the Ministry of Mines and Energy, which appointed contractors to install the systems. While it is clear that electricity is especially beneficial for the school as it enables the use of teaching aids, it is important that these benefits are weighed up against the cost of the project. Within the context of the demands on the national education budget, the costs seem to outweigh the benefits of solar electrification, and it unlikely that such an electrification strategy could be implemented more broadly. However, without undertaking a detailed cost-benefit analysis and an evaluation of the project in general it is not possible to make such assertions with confidence.

A further issue which requires in-depth investigation concerns the maintenance of the solar systems. As with the solar clinics, problems with the maintenance infrastructure of the project have emerged. Given that UNESCO acknowledges the critical importance of building capacity to maintain the systems to the sustainability of the project, this is unfortunate (Entiman 1999). Two unemployed youths were trained to do first line maintenance and check that the systems were operating effectively. Apparently they were only paid for two or three months and after payment stopped they left the area to find employment elsewhere[7]. As a result, there is no-one in the village who has the understanding and skill to fulfil this role. The principal also informed us that government technicians used to conduct regular maintenance checks of the systems but, these have stopped. Although job creation is an appropriate strategy in development projects, paying people to do first line maintenance is not a viable or sustainable strategy. Rather, the staff of the school should be trained to do this. Also, the maintenance of solar systems at schools should be integrated into a broader programme which aims at capacity building and training of local solar technicians who also attend to systems at clinics and households

[6] Apparently, the systems were used extensively during a vaccination campaign conducted in the initial stages of the project (Marais 1999).

[7] It was expected that the regional education department would continue to finance the payment of these technicians (Entiman 1999).

(refer to section 2.4.3). It is essential that these and other issues, such as the process of project implementation, be investigated in an in-depth evaluation of this project before considering the broad implementation of solar electrification for schools.

Although classified as an un-electrified school, the Onderombapa Primary School enjoys the benefit of electricity, through the use of a diesel generator, in much the same way as schools with grid electricity. The generator at the school provides electricity to the school buildings, the hostel and the teachers accommodation and uses approximately 100l of diesel per day, at a cost of N$2 per litre. The cost of the diesel is borne by the Ministry of Basic Education and Culture. The water pump for the school water supply is also operated by the generator. When the main generator does not work, as it often does, the back-up generator is used to ensure a continual supply of water. However, this generator is very old and consumes approximately 1 500l per week. Clearly, providing schools with generators for electricity is not a viable option due to the high operating costs and the unreliable nature generators.

3.5 Conclusion: is electricity a priority for education?

Gordon (1997) argues that if electricity is to have an impact on the quality of education in rural areas the following conditions must be met:

- Electricity provision to schools should be part of an integrated package of service delivery which includes water supply and sanitation, telephones, and improved transport facilities for learners.
- The lack of resources, such as classroom furniture, books, resource materials for teachers and other educational resources, must be addressed.
- School staff should have the capacity to manage and use the electricity supply systems and equipment.
- The security problems at schools should be addressed in order to safeguard equipment and other resources.

The views of teachers interviewed concur with this assertion. Water provision to schools was consistently ranked above electricity, and the existence of adequate classroom facilities, teaching resources, basic equipment were considered to be as important as electricity. In addition, principals emphasised the need for suitably qualified and skilled teachers, and discipline in schools. Due to the security problems at his school, the principal at Oniipa combined stated that the employment of security guards was a critical ingredient for ensuring that schools can realise the benefits of electricity.

The extent to which these conditions have been met in the schools investigated varies greatly. Where schools have access to a wide range of equipment and have facilities to accommodate staff and students, the benefits of electricity are more significant. In this study it was found that the schools in the Omaheke region, as well as those schools teaching secondary grades in the northern regions all fall into this category. In the short-term, it is unlikely that similar benefits will be enjoyed by primary and combined schools without the necessary resources, infrastructure and equipment. However, one way of over-coming this would be to ensure that schools have access to equipment, such as fax machines, photocopiers, televisions and video machines, by making these available at central locations (for example, a community centre or one school), within settlements. In this way the benefits of electrification can be realised without placing undue demands on limited resources. In the long-term, it is possible to take a more optimistic view that schools are likely to gain access to equipment and have their facilities upgraded.

For those schools which are not likely to gain access to the grid, solar electrification is a possible strategy for school electrification. However, it is imperative that an evaluation, which includes investigation of the maintenance support infrastructure and a cost-benefit

analysis, of current solar electrified school projects is undertaken in order to assess the viability of such a strategy. If solar electrification is deemed to be a viable strategy, the findings of this study should inform the design of the systems. Given that the greatest benefit of electricity lies with the ability to use electrical teaching aids, such as televisions, video machines and overhead-projectors, and that schools make limited use of lighting it is essential that solar systems for schools are designed with the capacity to accommodate this. Providing schools with schools with solar systems for lighting only is not a viable option.

4. Electrification and small business development

In terms of the Namibian government policy on small business development small businesses are defined according to the following criteria:

- for the manufacturing sector the business should employ less than 10 people, have an annual turnover which is less than N$1 000 000, and annual capital employed should be less than N$500 000; and
- for other sectors the business should employ less than 5 people, have an annual turnover which is less than N$250 000, and annual capital employed should be less than N$100 000 (Ministry of Trade and Industry 1997).

Despite the fact that the small business sector provides over one-third of Namibia's workforce with some form of income generation and employment, its contribution to poverty alleviation and economic growth is minimal. The majority of small businesses are concentrated in the informal subsistence sector of the economy, where activities are survivalist in nature and incomes are low. The strong competition amongst these businesses keep profit margins low and the lack of capital prevents growth. Fifty percent of these small businesses are engaged in the retail sector, and a further thirty percent in the catering sector which includes the sale of alcohol. Due to the proliferation of cuca shops in rural areas the percentage of small businesses involved in 'catering' is inflated (Ministry of Trade and Industry 1997).

It is the aim of government policy to ensure that the small business sector is able to provide a 'social safety net' through attempting to 'substantially improve' incomes of small businesses. Government endeavours to shift the survivalist activities of small businesses to activities which result in 'self-advancement and fulfilment', where small businesses ultimately take the lead in creating jobs and increasing productive efficiency. To provide an enabling environment in which this can occur a government programme which sets out a number of strategies which are concerned with de-regulation and incentives, pro-active programmes (which include financing, marketing and training) and institutional support. The programme aims to target businesses which were historically disadvantaged and continue to face considerable constraints to their growth and development, through lack access to finance, markets, competitive purchasing, appropriate and affordable technology, training and managerial support. Women are considered to be particularly disadvantaged, with the formal sector providing employment for only thirty-one percent of women, and these are mostly low paid jobs (Ministry of Trade and Industry 1997).

4.1 Description of cuca shops investigated

The task of this section of the study is to assess the role which electricity can play in contributing towards the development of small businesses in the rural areas of Namibia. The study deliberately focused on survivalist small businesses as the difficulties and constraints facing these businesses are considerably higher than other small businesses which have managed to diversify their activities, have access to capital and markets, are not confined to the retail sector and are generally located in larger centres. Community income generation projects, such as brick-making and sewing projects, were also excluded as they do not reflect the 'normal' conditions surrounding the development of small business and income generating opportunity in the rural areas. Although attempts to include non-retail survivalist businesses were made as the energy requirements of manufacturing or service oriented businesses are different from retail businesses, this proved to be difficult. As expected, very few of these businesses existed, and when we did attempt to interview a hair salon, a small welding operation and a bakery this was not successful. In the end, only three small businesses which offered a telephone and fax service, photocopying and welding services, respectively, were included.

In contrast to the interviews conducted at health care facilities and schools, interviews with small business owners and employees proved to be difficult. Although the information obtained from twenty six small businesses has been included in this report, many more were visited. At these enterprises people were reluctant to be interviewed, mostly because the owners were not present, but sometimes the owners were not prepared to disclose any information. Even in those businesses where people were co-operative and helpful, there was great sensitivity to divulging information on income. It is our impression that the income data contained in the report should be viewed with a certain degree of scepticism, as it was sometimes quite clear that the information given on income was not always accurate.

Of the twenty-six small businesses included in the report, seventeen were from the northern regions, whilst nine were from the Omaheke region. Both electrified and un-electrified small businesses were included, and one solar electrified cuca shop was encountered in the Omaheke region (refer to table 13).

SMALL BUSINESS	*ELECTRIFIED*	*UN-ELECTRIFIED*	*SOLAR*
Omusati		7	
Ohangwena	6	1	
Oshikoto	3		
Total for northern region	9	8	
Omaheke	5	3	1
Total number	14	11	1

Table 13: Small businesses included in the study

With the exception of the three small businesses which offered respectively, a telephone and fax service, a welding service and the photocopying service, all the other small businesses were cuca shops which carried a limited range of goods. The principal goods sold at cuca shops were alcohol (predominantly beer, but some spirits too) and cold drinks, although most of the cuca shops carries a few other goods, such as basic food items (tinned food, biscuits, flour, onions, potatoes, sugar), toiletries (soap, hand cream), sweets and chips. In the smaller cuca shops it was not uncommon to find alcohol, cold drinks and one or two of these items, which is an indication of the limited capacity of cuca shops to diversify their stock due to the lack of capital. As one of the cuca shop owners in the Ohangwena region said "The people have been asking for sugar and we would like to get some sugar, but at the moment we cannot afford this". In general, the amount of stock carried of any one particular item was also limited, with items being replaced as they were sold.

In the northern regions, it was found that a number of cuca shops had absentee owners who left the operation of the business to an employee, who was usually a relative, whilst residing in urban centres, such as Windhoek and Walvis Bay. Some of these owners visited cuca shops as little as three times a year. In one case in the Omusati region, the cuca shop had been established by a man working in Walvis Bay in order to provide an income for his father and mother, and his father took responsibility for re-stocking the cuca shop and purchasing the gas for the refrigerator. While most of the electrified cuca shops employed at least one person, this was not always the case in the un-electrified cuca shops where the owners of the business also worked in them.

The cuca shops included in the study were located in different positions, with some located on the main roads from one centre to the next, such as those in the Ohangwena region, while others were situated in settlements, such as those in the Omusati region.

4.2 The impacts of electrification

4.2.1 Energy use and expenditure: electrified cuca shops

In all the small businesses, the principal energy requirements were for refrigeration, lighting and entertainment, such as televisions, radios and hi-fis (refer to table 15). It was found that the all electrified small businesses used electricity for these energy services, and in the larger businesses electrical cash registers were also found. While some of the businesses had stoves or micro-waves, these were used to cook meals for employees and owners who lived on the premises. No electrical stoves were used to cook food which was sold.

For most of the small businesses, expenditure on electricity was not more than N$50 per month, although those businesses with more than one fridge, or which used electricity for cooking had a higher monthly expenditure (refer to table 14). For instance, cuca shop 11, where the two employees who lived at the shop cooked on an electric stove, the monthly expenditure on electricity was N$500. The businesses which had other equipment, such as a welding machine (shop 6) and a photocopier (shop 7), also had slightly higher monthly expenditure. Interestingly, the owner of cuca shop 14 electrified his business by extending a wire from his neighbour's shop because he felt it would be cheaper.

	Yr estab	*Yr elec*	*Appliances*	*Expenditure/month*
1	?	1997	2 fridges, freezer, hi-fi, lights	N$100
2	1990	1992	radio, fridge, lights	N$10
3	1996	1997	6 fridges, lighting, TV, radio	N$450
4	1998	1998	fridge, radio, lights, stove (not used)	N$50
5	1990	1991	fridge, hi-fi, lighting, cash register, jackpot machine, photocopier	N$100 (1½months)
6	1994	1994	fridge, lighting, hi-fi, welding machine	N$100
7	1998	1998	fridge, lighting, jackpot machine, cash register, fax machine	N$50
8	1998	1998	lighting, fridge, hi-fi	N$50
9	1992	?	lighting, fridge	N$50
10	1992	1995	fridge, lighting (inside & outside) hi-fi, tape-recorder, TV, radio, cash register	N$25 (N$50 card - 2 months)
11	1997	1998	lighting (inside & outside), 2 fridges, cash register, stove, hi-fi	N$500
12	1993	1997	lighting (inside & outside) fridge, TV, tape recorder	N$50
13	1996	1997	lighting (inside & outside), 2 fridges, cash register, hi-fi, stove, disco lights	N$?
14	1996	1996	lighting (inside & outside), fridge, deep freezer, gas stove, micro wave	'self-electrified'

Table 14: Energy expenditure of electrified small businesses

4.2.1.1 Reduction of energy expenditure

It was found that access to electricity has led to a reduction of energy expenditure. For example, cuca shop 1 was electrified in 1997, and is owned by a woman who also works as an agent for an insurance company. The shop sells beer, wine, cigarettes, candles, sweets, toilet paper, cooked meat and ice blocks. Although it is open from 08h00 to 22h00, on weekends and holidays it sometimes stays open until 02h00 when the last customers leave. The cuca shop uses electricity for two fridges, a freezer, a hi-fi and lighting. Cards for the pre-payment meter are purchased at Ondangwa, and N$100 per month is spent on electricity. Transport to Ondangwa costs N$6 by taxi, and two cards are purchased each month. Prior to electrification the cuca shop used candles for lighting, and the cuca shop used to close at 20h00. The hi-fi was only purchased after the shop was electrified, which according to the owner, was good for attracting customers to the cuca shop as music was important for a good atmosphere. Aside from these benefits, there has also been a

reduction in the cost of energy. Three 49kg gas cylinders were used to power the 2 fridges and the freezer. According to the owner each cylinder cost N$250 to refill and lasted three months. Approximately two candles were used each evening, and if there were customers more were used. The owner estimated that she spent N$60 on candles each month. This means that her energy expenditure was approximately N$310 per month. When compared with the current cost of N$100 for electricity and N$12 for transport, there has been a substantial decrease in expenditure on energy.

Similarly, the other cuca shops which were well established prior to electrification (cuca shops 1,10, 9 and 12), have switched to electricity for refrigeration, lighting, powering hi-fi's and radios. As a result, there has been a reduction in expenditure on energy[8] in cuca shops where the required energy services have remained the same, or additional energy services, such as powering a radio or hi-fi consume relatively little electricity. Even in cuca shop 2, the only business which purchased a refrigerator after electrification, the energy expenditure decreased marginally. Prior to electrification, the only energy service required was lighting which was provided by candles at a cost of N$22 per month. The current electricity expenditure for both lighting and refrigeration is N$10 per month.

Theses findings also suggest that where small businesses have shifted to using electricity for a number of non-thermal energy services, the extent to which energy expenditure is reduced is greater than for those with fewer energy requirements. Clearly, this does not apply to cuca shops which use electricity for cooking, such a cuca shop 11 where the monthly electricity expenditure is N$500 as the two woman employees use an electrical stove for cooking their meals.

The extent to which electricity leads to a reduction in the energy expenditure of small businesses can also be ascertained by comparing the energy use and expenditure of electrified small businesses with un-electrified ones.

4.2.2 Energy use and expenditure: un-electrified cuca shops

Like the electrified small businesses, the principal energy requirements at un-electrified cuca shops were for lighting and refrigeration. Although some had radios and hi-fis, un-electrified cuca shops tend to have fewer appliances than electrified ones. Both candles and paraffin lamps were used to provide lighting, all the fridges used gas, dry cell batteries powered radios and car batteries were used to operate hi-fis (refer to table 15).

[8] In contrast to this, Wamukonya and Davis (1999) found that access to electricity substantially increased expenditure on energy in households. The reason for this difference is that unlike the cuca shops, households did not switch to electricity for all their energy services, and thus, expenditure on electricity occurred in addition to expenditure on other fuels.

	Lighting	Refrigeration	Entertainment	Cooking	Total exp
Un-electrified					
A	candles (N$30)	gas fridge 19kg (N$100 – 1½months)		paraffin stove (N$176)	~N$272
B	candles (N$40)	gas fridge 19kg (N$100 – 1½months)			~N$106
C	candles (N$60)	gas fridge 48kg (N$250-3months)	hi-fi: car battery (N$15)		~N$158
D	candles (N$42)	2 gas fridges 48kg (N$500-3months)			~N$209
E	candles (N$60)	gas fridge 9kg (N$49-50-20 days)	hi-fi: car battery (N$15)	fuelwood	~N$149
F	paraffin lamps (N$11)	ice blocks (N$50)			~N$55
G				dung	-
H	paraffin lamps (N$18)	ice blocks (N$83)		fuelwood	~N$101
I	paraffin lamp (N$21)	gas fridge 19kg (N$100 – 1½months)	radio – batteries (N$17)		~N$104
J		gas fridge 48kg (N$210 – 1½months)			~N$70
K	paraffin lamp (N$25)	gas fridge 19kg (N$100 – 1½months)	radio-batteries (N$23)		~N$114
Solar					
L	diesel generator (N$200)	gas fridge 19kg (N$100)	hi-fi: solar system B (N$175) generator (radio)		N$475

Table 15: Energy expenditure of solar & un-electrified small businesses

4.2.2.1 Cooking and boiling water

One of the few cuca shops selling cooked food was situated at Othika, an un-electrified village in the Omusati region. The shop was established in 1984 by a woman in order to supplement the household income, which was largely derived from the (sometimes unreliable) remittances from her husband who worked in Windhoek. The woman who owns the shop cooks macaroni and potatoes, which are sold predominantly to the staff and children from the school. Each week day the food is cooked on a paraffin stove, usually for four hours, and approximately three bottles of paraffin, which cost N$2.80, are used per day. On weekends, less food is cooked, although when there are community events, such as funerals and church gatherings, sometimes more is sold. Based on a calculation for week-days only, her expenditure on paraffin is at least N$176 per month, and it is likely to be higher due to the weekend business activity.

Other businesses also required energy for thermal applications: cuca shop E sold cooked fish, whilst cuca shops G and H sold hot drinks. Fires using fuelwood or dung were used in all cases to cook the food and boil water. Aside from the labour time involved in collecting either dung or fuelwood, there were no costs involved in using these fuels.

4.2.2.2 Lighting

Candles are a major expense at un-electrified cuca shops as lighting is considered essential for providing an environment in which customers 'can relax and enjoy a drink'. Although many of the un-electrified cuca shops closed around sunset, they often closed later if there were customers. Even where cuca shops closed relatively early they reported using at least one candles per day, and on many days more were used. Cuca shop owners and employees could not give exact figures for expenditure on candles as the candles were either taken from their stock, or were part of general stock purchases where they were not

sold. However, based on the information on the amount of candles used, conservative estimates of expenditure on candles have been made (refer to table 15). Where candles were not used by all the cuca shops for lighting, paraffin lamps were used and the expenditure per month on paraffin was found to be less than expenditure on candles. Only the un-electrified cuca shop G did not use any commercial fuels for lighting, as the owner could not afford them.

4.2.2.3 Refrigeration

Obtaining gas is one of the greatest difficulties facing the small businesses as gas in only available in the major centres, and the availability and cost of transport is considered to be a problem. This is especially the case for the cuca shops in the Omaheke region, where gas is only available at Gobabis and the cost of a return trip ranges between N$20 and N$40. In the cuca shops investigated in the northern regions, the distances to travel to centres, such as Oshikongo, Ondangwa and Oshakati, are not as great, and the transport costs range between N$12 and N$20 for a return trip. Aside from these transport difficulties, most of the cuca shop owners felt that gas was too expensive.

With the exception of three of the un-electrified cuca shops gas fridges were used to cool beer and cold drinks. In cuca shops F and H, ice blocks are used to keep drinks cold. When he lost his job, the owner of cuca shop F started his business in the un-electrified village of Othika. Energy is required for cooling drinks and boiling water for the hot drinks which are sold. The owner, however, cannot afford a fridge and uses a cooler box with ice blocks to keep his drinks cold. The ice blocks are bought from Oshakati for N$5, and one ice block lasts for three days. Depending on who he is able to get transport from, it costs him between N$5 and N$10 for a return trip to Oshakati. Thus, considering that he usually makes this trip approximately ten times a month, it costs him between N$100 and N$150 per month to keep his drinks cold. A similar situation was found in an un-electrified cuca shop some distance from the Othika village, on the main road to Oshakati. The owner, however, has a car he drives to Oshakati to buy ice blocks which last two days and cost N$5.50 each. In cuca shop G, however, the female owner cannot afford to keep her drinks cold at all and she sells them warm.

4.2.2.4 Energy expenditure of small business with solar system

Although only one cuca shop with a solar system was included in the study, the expenditure on energy was found to be high and comparable with the expenditure of electrified cuca shop 11, which made extensive use of electricity for cooking. While it is to be expected that the monthly instalment and the continued dependence on multiple fuels will result in a high energy expenditure, the findings at this shop are surprising.

Shortly after the cuca shop was built the owner obtained a solar system B through the *Home Power!* programme. He uses the solar system to power the hi-fi set only, as he found it did not have sufficient capacity to power the lights, radio and hi-fi, and currently pays an instalment of N$175 for the system. As a result of finding that the solar system could not meet all his energy requirements, he purchased a generator which provides power for lighting and a radio. The diesel costs him N$ 200 for approximately 180litres which is used per month. In addition to this, he uses a 19kg cylinder of gas for the fridge, which costs him approximately N$100 per month. In total, his expenditure on energy for lighting, entertainment and refrigeration is N$475.

It is unclear why the owner of this cuca shop has made the decisions he has with regard to the use of different fuels and energy providers, especially with regard to purchasing both a solar system and a generator. Although he expressed satisfaction with the performance of the system, it had not lived up to his expectations in terms of providing energy for lighting, a radio and a hi-fi system, despite the fact that he was aware of the capacity of the system prior to purchasing it. In his case, cost does not seem to have been a limiting factor in purchasing a bigger solar system as he is able to afford to pay N$200 a month for diesel. It

is unlikely that the situation at this cuca shop is widespread, but it does point to the need for the implementers of the *Home Power!* programme to assist individuals to purchase the appropriate size system.

4.2.2.5 Comparative costs

It is evident that un-electrified businesses are paying more for the same energy services than electrified cuca shops are. Compare, for instance, two cuca shops, one electrified and the other un-electrified, which require energy for one fridge, lighting and powering a radio or hi-fi. The findings from this research suggest that the electrified cuca shop is likely to pay no more than N$50 per month for these services, whilst the un-electrified shop is likely to pay between N$104 and N$158[9]. Further, lighting was used for longer periods of time in electrified shops, as those without electricity tended to close earlier (refer to section 4.2.3.2), and so these comparative costs strongly favour the use of electricity for lighting.

While these energy savings are fairly small they were welcomed by the cuca shop owners, especially those whose survival depended solely on the earnings from the cuca shop.

4.2.3 Impact on productivity and income

Through attracting more customers, working longer hours and offering a diverse range of goods for sale it is assumed that small businesses will increase their productivity and generate more income. These issues will be investigated below.

	Goods sold	*Hours*	*Customers*
1	alcohol, candles, cooked meat ice blocks	08h00-22h00	10
2	traditional beer, beer	08h00-19h00	10
3	frozen fish & chicken, sweets, cold drinks	08h00-19h00	20
4	cold drinks, beer, toiletries, basic food items	08h00-23h00	30
5	fabrics, alcohol, cold drinks, hot drinks, jackpot machine, photocopier	08h00-20h30	40
6	cold drinks, hot drinks, alcohol, pool table	08h00-22h00	50
7	telephone, jackpot machine, cold drinks, alcohol, basic food items, sweets, chips	08h00-17h00	50
8	hot drinks, cold drinks, sweets	08h00-20h00	30
9	coffins, alcohol, cold drinks, basic food items	08h00-21h00	10
10	cold drinks, alcohol, bread, soap, tin food	08h00-20h00	30
11	cold drinks alcohol, basic food items, toiletries, sweet, chips	08h00-20h00	40
12	cold drinks, beer, sweets, chips	07h00-21h00	50
13	night-club, cold drinks, alcohol	21h00-06h00	15
14	cold drinks, beer, toiletries, chips, biscuits	08h00-20h00	50

Table 16: Electrified small business: hours, customers and goods sold

4.2.3.1 Attracting customers

The number of customers visiting cuca shops per day varies considerably (refer to table 16). Although some of the electrified cuca shops stated that they felt that electricity had assisted them to attract customers, particularly through providing lighting and a more comfortable environment, this was not expressed as an *increase* in the size of the clientele. As one cuca shop owner argued: "Electricity is very good for attracting people to the shop, but really it all depends on how many friends you have." Another owner suggested that:

[9] Obviously, these costs cannot take account of the condition, age and efficiency of the different appliances used, but they are useful for a general comparison.

"The problem is that there is too much competition. Electricity is good if that month or that week we get a lot of customers and then it works for us."

Clearly, the location, range of services and goods offered, condition of the buildings and the service provided all have an impact on the ability of a business to attract customers. The small businesses in larger centres, such as Ohangwena (cuca shops 5, 6 and 7) and Aminius (cuca shops 11 and 12), are able to attract more customers due to the large number of people who visit these centres each day. These businesses also tend to offer a wider range of services and carry more stock, which will also affect the number of customers.

A comparison of the number of customers which visit un-electrified and electrified cuca shops also gives substance to this argument. The un-electrified cuca shops are located away from the larger centres, with a smaller concentration of potential customers and, thus, have a smaller clientele (refer to table 17).

.	*Goods sold*	*Hours*	*Customers*
Un-electrified			
A	cooked food, cold drinks, alcohol	11H00–17H00	20
B	alcohol, sweets, cold drinks	08h00 – 18h00	20
C	cold drinks, alcohol, toiletries, basic food items	09h00 –19h00	10-20
D	cold drinks, alcohol, basic food items, sweets, chips, pool table	11h00 – 18h00	30
E	alcohol, cold drink, basic food items, cooked fish	08h00 – 22h00	20
F	alcohol, cold drinks, basic food items, toiletries	11h00 – 17h00	20-30
G	cold drinks, hot drinks	13h00 – 17h00	10
H	cool drinks, hot drinks, basic items & toiletries	08h00 – 18h00	20-30
I	cool drinks, alcohol, basic food items, toiletries	09h00 – 21h00	30
J	cool drinks alcohol,	07h00 – 19h00	10-20
Solar			
K	cool drinks, alcohol, basic food items, sweets, chips	08h00 – 21h00	20
L	cold drinks, alcohol, basic food items vegetables, toiletries, sweets, chips	08h00 – 21h00	30

Table 17: Un-electrified and solar small businesses: hours, customers and goods sold

It is interesting to note, however, that in discussions of the impact of supply interruptions, all the electrified cuca shop owners bemoaned the fact that they lost customers because they were unable to supply cold drinks or provide lighting and were forced to close earlier. Further, an interesting situation emerged at un-electrified cuca shop G near Ohangwena, which could suggest that electricity does have an affect on the ability of small businesses to attract customers.

Before it was stolen, un-electrified cuca shop E near Ohangwena used a generator to provide power for lighting, refrigeration and a hi-fi. Approximately twenty-five litres of diesel, which cost N$50, were used per month. At present, the fridge is run off gas from a 9kg cylinder, which only lasts 20 days, after which a member of the household travels to Oshikongo to refill the cylinder for N$49.40. Transport to Oshikongo costs N$14 for a return trip. Similarly, the car battery which is used for the hi-fi, lasts one week and is taken to Oshikongo to be re-charged for N$15. Although the shop usually closes at 22h00, sometimes if there are customers it will close later. Candles are now used for lighting in the evenings.

Aside from the increase in energy expenditure, the cuca shop owner felt that they had lost clientele because they no longer have access to the generator: "We used to have many coloured lights outside and the customers saw the lights and came into the shop. Now we only have the candles inside and the number of customers has decreased. We used the

generator to play the radio very loudly to attract the customers, but now the battery is flat and we cannot always refill it because it costs too much. Now we do not make as much money as we used to."

It is important to take the location of this cuca shop into consideration when examining this case, as it is situated about 7 kilometres from Ohangwena on the main road from Ondangwa to Oshikongo, which is heavily trafficked. It was also situated some distance from other cuca shops. Although the coloured lights would possibly have attracted customers travelling on this road, the competitive advantage was only gained because other shops along the road did not have electric lighting and were, therefore, not visible. In a context where all the shops were electrified, it is unlikely that this situate would occur.

While electricity may contribute towards the quality of service which small businesses are able to offer, and play a role in attracting and keeping a client base, it is clear that the ability to attract customers is not solely dependent on electricity.

4.2.3.2 Increasing the number of hours worked

All the electrified cuca shops which had been established prior to electrification stated that they were able to stay open longer because they had access to electricity, as electric lighting was cheaper and created a better environment. However, most of the employees and owners stated that the number of hours worked depended on whether or not they had customers. When no customers were present, the shops closed earlier. As disco facilities are provided at cuca shop 13, the hours of opening are especially long and the facility only closes at 06h00.

In general, however, electrified cuca shops stayed open later un-electrified cuca shops (refer to table 16 and 17). The un-electrified cuca shop owners stated that the main reasons for this was lack of lighting and customers, but in some cases other factors also influenced closing time. Single women owned and worked in cuca shops G and J, and due to their additional household responsibilities are not able to keep their shops open late. In contrast to this, those owned by men tended to stay open later, either because they had employed someone in the shop, or because they were not required to fulfil any other responsibilities in the household, such as cooking the evening meal.

4.2.3.3 Diversifying the range of goods and services

With few exceptions, very little diversification of goods sold and services provided was evident. In one small business (5), the owner purchased a jackpot machine and a photocopier. These two items, and especially the photocopier, have enabled the business to offer services which are not available elsewhere. The business also has a much wider range of items for sale, such as fabrics, than other retail enterprises included in the study. However, the location of this business in Ohangwena and the fact that the owner is relatively wealthy has enabled him to use electricity to his advantage.

Similarly, cuca shop 6 offers welding facilities, where the largest share of this component of the business is concerned with repairing the metal work on cars, while shop 7 offers a telephone and fax service. Clearly, without electricity these businesses would not provide the service they do. However, only those with relative wealth have been able to take this competitive advantage and it is evident that most of the small businesses investigated lack the capital to do this.

4.2.3.4 Impact on income

This section will attempt to assess whether these benefits, however limited, as well as the energy savings gained from having access to electricity have had an impact on the income generated and profit of small businesses.

It is important, however, to emphasise the difficulty of undertaking such an analysis. As mentioned, the income data which is presented (table 18 and 19) should be viewed with a certain amount of scepticism. It was blatantly obvious that the information given to us in

some of the interviews could not be correct. In some cases this was due to employees not wanting to answer questions without the owners being present. In other cases, daily income was either deliberately inflated or lowered. Furthermore, most of the small businesses were run very informally, without any form of stock taking or basic accounting, and it was difficult for owners and employees to give us monthly income figures. Daily income figures were easier to obtain, but it was soon evident that there was a great range in the amount of income earned from one day to the next. For instance, the owner of cuca shop 1 stated that the shop generally earned N$150 per day, but there were 'bad days' when she made as little as N$4. When asked how many bad days were experienced in a month, she said that there were only one or two.

In addition to these problems of determining how much income was generated it is also difficult to assess how much profit was made by the small businesses. Owners and employees were unable to give a break down of expenditure in general, as the money earned was not only spent on the business needs, such as restocking, but was also used to pay for other items, such as school fees, food and livestock. Expenditure on these different items was not kept separate from business expenditure and nor was it accounted for.

	Income/day	*Expenditure*	*Gender of owner*	*No of employees*
1	N$ 150	business, food	woman	1
2	N$10-N$55	?	man	1
3	would not divulge	business	man	1
4	N$200	business, savings livestock	man	1
5	N$400	business, livestock	man	4
6	N$150	livestock, school fees, business	man	1
7	N$200	business, livestock	man	1
8	N$100	business, livestock	man	1
9	N$10-100	?	man	2
10	N$400	business, school fees, livestock	man	1
11	N$500-600	business, livestock	man	2
12	N$450	business, livestock	woman	1
13	N$300-400	business	man	2
14	N$200	business, school fees, livestock	man	1

Table 18: Electrified small business: income

Notwithstanding these problems, we are able to point to some issues which have emerged. A comparison of the daily reported income of electrified and non-electrified small businesses shows a higher proportion of electrified cuca shops earning more than N$200 per day (refer to table 18 and 19).

	Income/day	Expenditure on	Gender of owner	No of employees
Un-electrified				
A	N$30 - N$60	business, h/hold	woman	-
B	N$50-N$200	business & ?	man	1
C	N$100	business & ?	man	1
D	N$500	business & ?	man	2
E	N$100-N$300	business, h/hold	man	-
F	N$100	business, h/hold livestock,	man	2
G	N$50	h/hold, business	woman	-
H	N$100	business, household	man	-
I	N$400	business, school fees, livestock	man	1
J	N$50	business, livestock, school fees, h/hold	woman	-
K	N$200	business, livestock, school fees	man	-
Solar				
L	N$400	business, livestock	man	1

Table 19: Un-electrified and Solar small businesses: income

However, there is little evidence to suggest that this can be attributed to access to electricity. None of the cuca shop owners which had been established before electrification reported an increase in their daily earnings once they had access to electricity.

For instance, cuca shop 9, a small tin shack in a state of disrepair, was established by a man who currently resides in Keetmanshoop. Prior to electrification in 1992, the shop only used to sell traditional beer. Once electrified, however, the owner bought a fridge and they started selling beer as well. On a good day the business earns N$55, but "sometimes a whole day can pass without anyone buying" and it seems that "good days" are not frequent. The income generated in this cuca shop is very low. According to the employee, there are times when only one crate of beer is sold per month, and with the low mark up – where a crate of 24 beers is bought for N$40 and sold at N$66 - not much profit is made. While the sale of traditional beer has remained fairly constant as this shop is the only one in the cluster of cuca shops which sells it, having access to electricity has not resulting in a substantial increase in income.

This case above suggests that electrification on its own cannot lead to the creation of a viable and sustainable business, as there are other more important factors which constrain the operation of this cuca shop.

Even in cases where small businesses were able to diversify, there was not always a concomitant increase in earnings. The welding service offered by shop 6 does not seem to have a substantial impact on the income generated by the business, as compared with other enterprises the daily income is not substantially more. The small business (7) offering a telephone and fax service, on the other hand, has doubled its income since the addition of this service.

Furthermore, the relatively larger and more wealthy businesses (shops 5,7,11 and12) were in a better position to earn more as they are able to carry more stock. Once more, the location of these cuca shops in large centres, such as Aminius and Ohangwena, is also an important determining factor with regard to daily earnings. Cuca shops situated in areas some distance from these centres all reported substantially lower daily earnings.

4.2.3.5 Cuca shops: a marginal strategy

In order to understand the limitations of the impact of electricity on the poorer and more marginal cuca shops, it is worth examining the situation of some of these businesses.

Cuca shop G was established in 1989 by a young woman in order to provide an income for the household, as her husband could not find employment. Although cold drinks are sold there are no facilities to keep them cool as they cannot afford to buy a fridge. In order to make the hot drinks which are sold, water is boiled on a dung fire. In addition to these drinks, the cuca shop sells soap, matches and sweets and the income generated is N$50 per day. She is not sure how much profit is made as the money is used to buy more stock and for buying food for the household. Although electricity would be useful, especially if she could afford a fridge, she does not think that she would benefit much from having electricity as she is not sure how she would pay even to use it for lighting. At present she does not stay open after 17h00 because she cannot afford the candles for lighting.

In a similar position is cuca shop J situated near to Aminius in the Omaheke region. As the head of her household, the woman is solely responsible for generating income which is derived from the cuca shop. The cuca shop offers a limited range of goods: traditional beer, cold drinks and hot drinks and the daily earning is N$50. The money earned is used to re-stock the business, purchase energy (gas), pay for school fees and buy food for the household. It is interesting that despite the limited access to money, the woman owns twenty cattle and some of the income generated from the shop is used to buy livestock.

It is worth noting that of the four cuca shops which reported earnings of less than N$100 per day, three were owned by women. All of these women had established cuca shops because they had no other means of earning an income, and all of them had to use the money earned from the cuca shop to support their households. This means that very little money is available for re-investment in the business. With the exception of one woman, the relatively wealthier cuca shop owners were all men who did not face the same demands on the earnings from the cuca shops. In fact, most of these men reported that earnings from the cuca shops were spent on the business and livestock, with some reporting the payment of school fees as well.

Given that the establishment of a cuca shop is often the only means of survival for households which have few resources, it is neither realistic or appropriate to suggest that electricity can increase their productivity or income. While electricity can lead to energy savings, these will not be achieved where the businesses cannot afford appliances. At best, electricity can offer these businesses the convenience of lighting.

4.2.4 Growth of small businesses

Another assumed benefit of electrification is that it will result in the growth and establishment of new businesses. It is interesting to note that a number of the small businesses investigated were established when an area was electrified or shortly thereafter. While this suggests that electricity provides a boost to the growth of small businesses, it is worth noting that although some of the cuca shop owners felt that electricity was an important factor in the decision to establish the business, their decision was not based entirely on the existence of electricity. For instance, increased economic development in the areas close to the Export Processing Zone (EPZ) of Oshikongo had prompted the establishment of some of the cuca shops in the region.

Also, it is also likely that electricity, rather than act as a catalyst, was one of the factors which informed the *choice of location* of the business. For instance, it was one of the factors which led the owner of the Edano Fresh Produce shop to establish his business in a small electrified cluster of cuca shops near Oniipa in the Ohangwena region. He lives in a village some 25 kilometres away, and he felt that it was better to set up a business in an area which had 'many people passing through'. Although he would have preferred to establish a business in Oshikongo he said that the cost of gaining access to land there had increased significantly since it had become part of an Export Processing Zone (EPZ). He decided to sell frozen fish and chicken, as none of the other shops in the region sold these items, and for this reason it was important that he had access to electricity for refrigeration as he felt that gas would be too expensive.

4.2.5 Perceived benefits of electrification: un-electrified small businesses

The owners and employees of the un-electrified shops felt that electricity, and especially grid electricity, would improve their businesses.

Electricity was considered to be important because it would remove the dependence on gas, which was difficult to obtain and expensive, and other fuels. One of the cuca shops in the Omaheke region felt that electricity would 'solve the problem of getting gas', whilst many others suggested that 'we would be able to save the money spent on the taxis'. Others felt that electricity would 'boost the business as I would spend less as now I have to buy gas and candles and charge the car battery'. The ease of use which is associated with electricity was considered to be a major benefit: 'You have to operate one switch and then you have electricity'.

A further perceived benefit of electricity was the possibility of extending the business hours. Many of the cuca shop owners felt that that the light from candles and paraffin lamps was 'bad for your eyes' and only with good quality lighting could hours of business be extended.

Outside lighting was also considered to be an important benefit of electricity for improving the security: "Currently there is a lot of theft going on in the area. If we had electricity it would not be so bad." and "We have a lot of theft, someone broke in last week and took every item in the stock. I had to go to Oshakati and phone the owner in Windhoek. We don't report these thefts because we don't trust the police."

It is also interesting to note that electricity was considered to be a superior energy source for cooking, as cooking with electricity is 'healthier'[10] than with fuelwood or dung, and it was not as 'dangerous as cooking with gas'. One of the owners of the cuca shop which sells cooked food felt that she would like to have access to grid electricity, especially for cooking, as she felt that it would be 'much easier and more comfortable' than paraffin. However, she was unaware of the cost implications of using electricity for cooking and had not considered using gas because it was 'more dangerous and expensive' than paraffin.

For the most part, small business owners stressed the need to gain access to grid electricity, and were not in favour of solar home systems. Some felt that solar systems were not powerful enough, whilst other felt that they would not buy a solar system "because solar is sometimes expensive". There were, however, cuca shop owners in the Omaheke region who were in favour of purchasing a solar system, and felt that it was affordable.

Finally, solar systems were not favoured because of the risk of theft, an attitude which was prevalent amongst the cuca shop owners who did not have anyone staying at their shops. Although one of the cuca shops owners in Othika knew of solar electricity she was adamant that she would never consider it "There is a lot of theft here in Othika. I have had my tables and chairs stolen from the shop and the clinic has had its panels stolen many times."

4.2.6 Supply interruptions and access to electricity cards

As mentioned, supply interruptions were considered to be a problem as they often forced the small businesses to close earlier because of lack of lighting. In some cases, where supply interruptions were frequent and lasted for long periods, cuca shop owners and employees experienced problems with refrigeration. For those shops which only sold cold drinks and beer, this led to a the loss of customers as people did not want to purchase warm drinks. Most shops did not have gas to use as a back-up. For those shops selling frozen fish, chicken or meat, the consequences of supply interruptions were greater as the these goods tended to defrost, thereby increasing the risk of selling food which had gone off.

[10] It is interesting to note that the perception that cooking with electricity was healthier because it 'cooked food better' fuelwood or dung was consistently raised by people in the Omaheke region. It was difficult to establish why this attitude existed, but one of the reasons given suggested that due to fuelwood shortages there was sometimes not enough wood to cook food for the time required.

In some cases, bulbs fused when the electricity supply was restored. This was found to happen with regularity at the cuca shop which had been electrified by the owner, who also experienced more supply interruptions due to his illegal connection.

In the northern regions, access to electricity cards is not considered to be problem, despite the fact that most of the cuca shops had to travel to major centres, such as Oshikongo, Ondangwa and Oshakati to purchase cards. In the Omaheke region, however, people have to travel much further as their cards are bought in Gobabis since the agent in Aminius is no longer there. This leads to a substantial increases the cost of electricity as transport costs are between N$20 and N$40 for a return trip.

It is imperative that cards are more accessible, and the possibility of establishing local agents which sell electricity cards throughout the different regions should be examined. It is especially important for this to happen in the Omaheke region.

4.2.7 Conclusion: should the electrification of small businesses be prioritised?

The findings of this study are in agreement with the assertion argues that in view of the innumerable constraints which confront rural small businesses, especially their limited access to markets, finance or information, electrification is a 'marginal issue' (Rogerson in Thom 1997).

This study has found that electrification does lead to energy savings through the displacement of other fuels, notably gas for refrigeration and candles for lighting. It was evident that un-electrified small businesses paid more for the same energy services than electrified cuca shops.

In terms of the productive impacts of electrification on small businesses the study examined the role of electricity in attracting customers, extending the number of hours worked and diversifying the goods and services offered. It was found that while electricity may contribute towards the quality of services which small businesses are able to offer, and play a role in attracting and keeping a client base, the ability to attract customers was not solely dependent on access to electricity. Other factors, such as the location, range of goods and services, condition of the building and quality of the service also played an important role in attracting customers.

While it was found that electrified cuca shops stayed open later than un-electrified cuca shops, other factors aside from electricity were found to contribute to this. This depended particularly on whether or not a shop had customers. Further, for some women owners it was found that responsibilities within the household prevented them from keeping their shops open late.

With few exceptions, very little diversification of goods sold and services provided was evident. It was argued that only those small businesses which are located favourably with access to a large potential client base and which have access to finance were able to diversify their services and make use of the competitive advantage of having access to electricity.

The impact of these benefits, however marginal, on the income generated and profit earned was also found to be minimal. While a comparison of the daily income of electrified and non-electrified small businesses showed a higher proportion of electrified businesses with higher earnings, it was argued that this cannot be attributed to access to electricity. None of the small businesses which had been established before electrification reported an increase in daily income after electrification. Even in the cuca shops which had managed to diversify their services, it was found that this was not necessarily accompanied by an increase in income. It was clear that other factors, such as access to finance and the location of the small business, were important determinants of the income earned.

Furthermore, it was clear that many of the poorer and more marginal small businesses had been established to ensure the survival of households – often a strategy adopted where no

other form of income was available. Due to the constraints which these small businesses face, it is not likely that electricity will transform these businesses to the point where they contribute significantly towards poverty alleviation or economic growth.

It is was found that a number of the small businesses investigated were established when an area was electrified or shortly thereafter. While this suggests that electricity provides a boost to the growth of small businesses, it was argued that this cannot be attributed solely to electricity. Conditions of increased economic development in some of the regions had played a major role in the establishment of small businesses. Also, rather than act as a catalyst electricity was found to inform the choice of location of a business, once the decision to establish one had been made. It is also important to point out that the increase in number of small businesses is not necessarily an indication of economic growth. Rogerson (in Thom 1997) argues that this can also be a manifestation of deepening rural poverty, where, for example, increased unemployment often leads to the establishment of small businesses.

Electricity in isolation of other complementary inputs required to develop small businesses, which include access to finance and credit, markets, training and information, will have little effect on either poverty alleviation or economic growth. For this reason, it is critical that the electrification programme is integrated with the government's strategy and plans for developing small businesses. As Rogerson (in Thom 1997) argues, it is appropriate to prioritise the electrification of small businesses in areas which already display a growing and dynamic economy, as well as in areas where initiatives to improve small business access to complementary inputs. This will require a co-ordinated effort between government, through the Ministry of Trade and Industry and the Ministry of Mines and Energy, and the electrification planners and implementers. In the absence of such a strategy, it is likely that the benefits of electrification on small businesses will be limited.

5. Recommendations

5.1 Electrification of health care facilities

Grid electrification of clinics and health centres

- Where viable, grid electrification of clinics and health centres should continue to be prioritised by the national electrification programme in order to enable the provision of emergency services, maintain the vaccine cold chain, use electrical equipment and improve security.

Solar electrification of clinics

- Solar electrification is an effective energy carrier for the lighting and communication requirements of clinics. Extensive electrification of clinics with solar systems should be considered in areas where grid electricity is not viable.
- It is strongly recommended that solar electrification of clinics only takes place where an appropriate and effective maintenance support programme is in place.
- The clinic electrification planning process should also consider the installation of solar systems which have the capacity to power a vaccine fridge as this may overcome the problems associated with obtaining gas.

Provision of suction machines

- In order to facilitate the need for suction machines which was expressed at the clinics, the Ministry of Health and Social Services should investigate the possibility of providing this equipment to clinics which are grid electrified. Suction machines which are vacuum operated off a gas supply are also available, and could be supplied to solar and un-electrified clinics.

Maintaining the vaccine cold chain

- It is essential that the gas supply and delivery network is improved. The evidence from the research seems to suggest that the district hospitals are not the most appropriate point for gas delivery to clinics due to the limited available transport and the difficulties with radio communication. Sub-contracting the provision of gas to clinics and health centres to gas agents situated throughout the different regions should be considered.
- Clinic staff should be trained to recognise when their gas supplies are low in order so that they can order more gas in time and avoid delays.
- The Ministry of Health and Social Services should assess the possibility of supplying all clinics with a domestic fridge in order to prevent staff from storing food and other drugs in the vaccine fridge.

Integrated and co-ordinated planning and implementation

- The electrification of health care facilities should be part of a co-ordinated and integrated programme which aims at addressing the lack of facilities, such as water and transport, and infrastructural inadequacies, such as roads, buildings and communication, which constrain the health care provision in rural areas.
- Institutional mechanisms to ensure that integrated and co-ordinated planning takes place should be established, with representatives from the Ministry of Health and Social Services, the Ministry of Mines and Energy, electrification planners and implementers.

5.2 Electrification of schools

Providing schools with equipment

- A long-term strategy to ensure that schools acquire equipment, especially basic teaching aids, should be developed by the Ministry of Basic Education and Culture.
- One strategy which is worth assessing is ensuring that schools have access to equipment, such as fax machines, photocopiers, televisions and video machines, by making these available at central locations (for example, a community centre or one school), within settlements. In this way schools can share equipment and the benefits of electrification can be realised without placing undue demands on limited resources.

Upgrading hostels

- Where hostels are to be upgraded it is essential that energy planning for these facilities is undertaken in order to ensure that appropriate, affordable and efficient fuels and appliances are provided.

Solar electrification of schools

- For those schools which are not likely to gain access to the grid, solar electrification is a possible strategy for school electrification. However, it is imperative that an evaluation, which includes investigation of the maintenance support infrastructure and a cost-benefit analysis, of current solar electrified school projects is undertaken in order to assess the viability of such a strategy.
- If solar electrification is deemed to be a viable strategy, the findings of this study should inform the design of the systems. Given that the greatest benefit of electricity lies with the ability to use electrical teaching aids, such as televisions, video machines and overhead-projectors, and that schools make limited use of lighting it is essential that solar systems for schools are designed with the capacity to accommodate this. Providing schools with schools with solar systems for lighting only is not a viable option.

Integrated package of service delivery

- Electricity provision to schools should be part of an integrated package of service delivery which includes water supply and sanitation, telephones, and improved transport facilities for learners, as well as addresses the lack of resources, such as books, classrooms and furniture at schools.

Employing of security guards

- Although the employment of security guards are not a guarantee against theft at schools, together with outside lighting they do minimise the security risks. Consideration should be given to providing schools with resources to employ security guards, particularly where schools have valuable equipment.

5.3 Maintenance of solar systems and equipment at schools and clinics

Effective maintenance support for solar systems at clinics and schools

- As a matter of urgency a maintenance support programme for solar electrified clinics and schools, which ensures regular monitoring and capacity building of users and local technicians, should be developed.
- As part of the capacity building of users, clinics and school staff should receive training on how to use the systems effectively, undertake first line maintenance and find basic faults. It is important that the training of clinic staff is conducted on an ongoing basis, and not only targeted at newly electrified facilities as staff turn over is fairly high.

- A sufficient number of local solar technicians should be trained and be sub-contracted to maintain the systems. These technicians would take responsible for routine tasks, such as ensuring that batteries are regularly changed and conducting annual checks on the systems, as well as dealing with faults as they arise.
- More solar technicians within the Ministry of Works, Transport and Communication should be trained in order to oversee the activities of the local technicians and provide a support function where necessary.
- Training of local solar technicians should be undertaken through a co-ordinated and combined effort of the different solar electrification programmes, especially the *Home Power!*, and clinics programmes, to avoid replication.

Maintenance of electrical equipment

- The possibility of training hospital maintenance staff more extensively in order to repair and maintain basic equipment, should be investigated
- Of all the health care facilities is it most critical for hospitals to have an uninterrupted supply of electricity. For this reason, it is essential that hospitals have back-up generators which are reliable, and efforts to repair faults and maintain them should be made.

5.4 Electrification and small business

Economic growth and improved productivity

- It is critical that the electrification programme is integrated with the government's strategy and plans for developing small businesses, and areas where initiatives to improve small business access to complementary inputs, such as finance, markets, information and training should be prioritised.
- Electrification of small businesses in areas which already display a growing and dynamic economy should also be prioritised, as the potential benefits of electrifying small businesses are more likely to be realised.

Poverty alleviation

- Only where viable and possible, electrification of small businesses should be undertaken regardless of their ability to contribute towards economic growth, as electricity will lead to a reduction in energy expenditure, thereby easing the lives of the poor.

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