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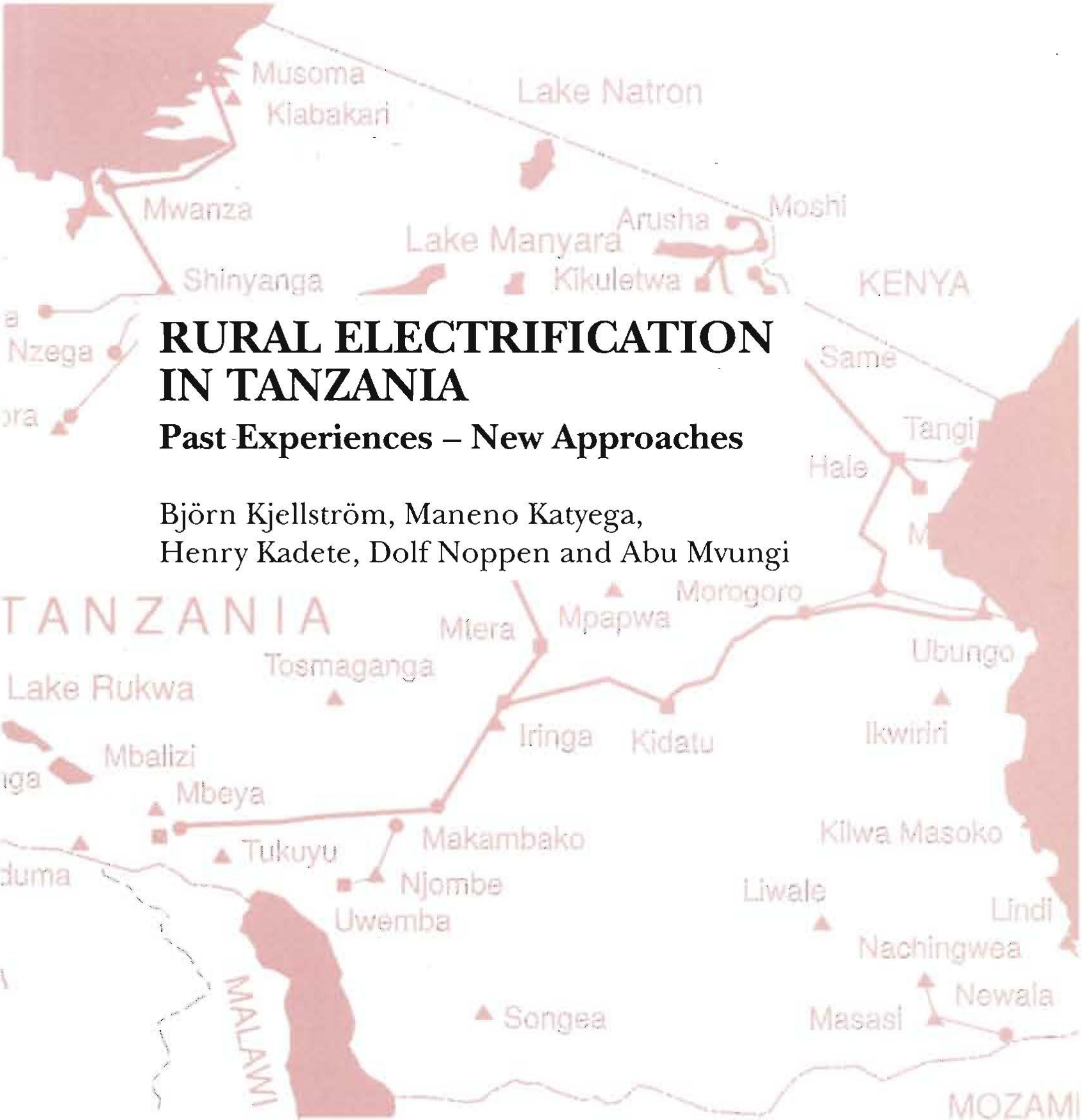

RURAL ELECTRIFICATION IN TANZANIA

Past Experiences – New Approaches

Björn Kjellström, Maneno Katyega,
Henry Kadete, Dolf Noppen and Abu Mvungi

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Report prepared within the research co-operation between

the Tanzania Electric Supply Company
and
the Stockholm Environment Institute.

SEI STOCKHOLM ENVIRONMENT INSTITUTE
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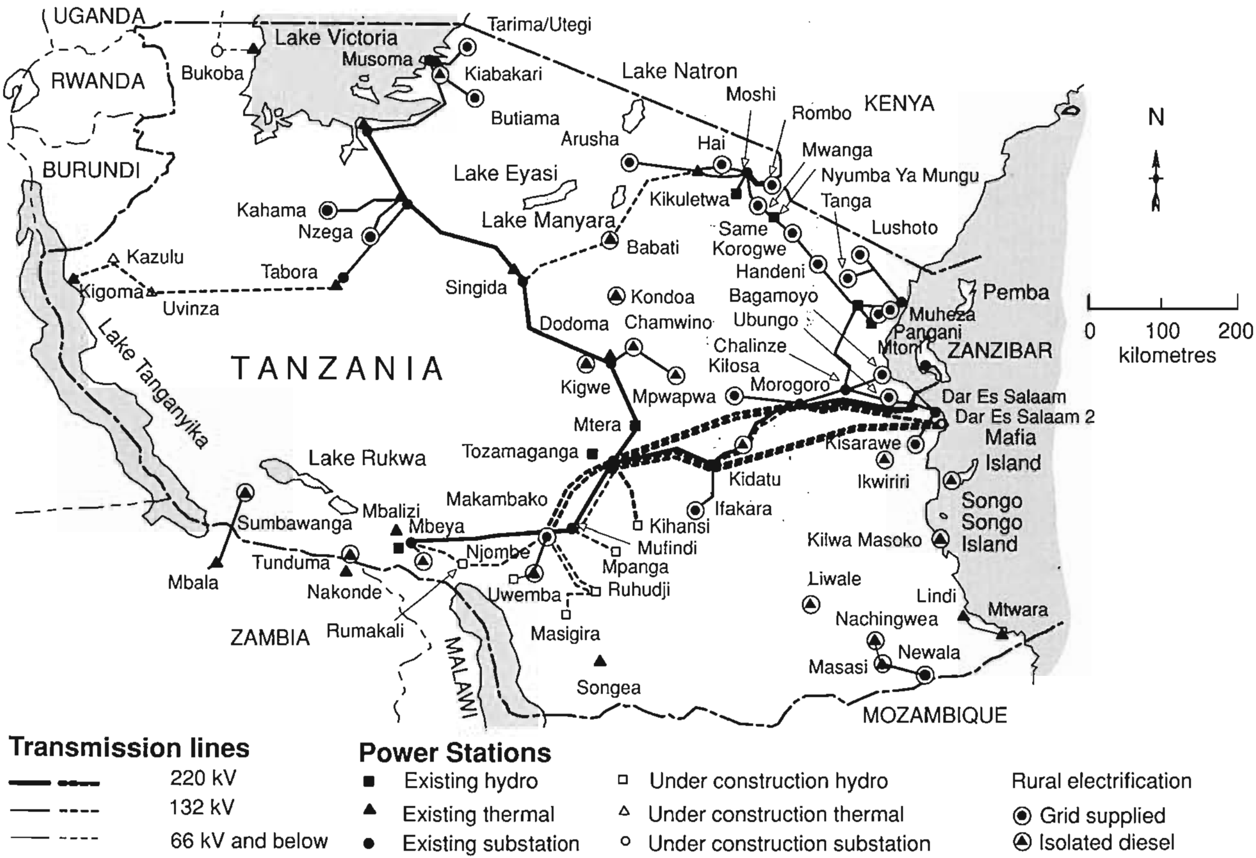

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Notice

This report is based on field work which was carried out in 1989 and 1990. One effect of the rapid inflation in Tanzania is that all cost data given in Tanzanian shillings are outdated when the report is printed. This is, however, of no consequence for the conclusions drawn from the study since relative costs have remained essentially the same.

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Acknowledgements

This report from the evaluation of the experiences from rural electrification in Tanzania should be considered to reflect the findings and judgements made by the five principal investigators, and shall not be regarded as a position paper of the two co-operating organizations.

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List of Abbreviations and Acronyms used in this Report

BRALUP	Bureau for Resource Assessment and Land Use Planning, University of Dar es Salaam
BS	British standard
CCM	Chama Cha Mapinduzi, the ruling political party in Tanzania
CWO	Capital works orders
DANIDA	Danish International Development Agency
duka	small shop (kiswahili)
ERP	Economic Recovery Programme
FINNIDA	Finnish International Development Agency
GDP	Gross Domestic Product
godown	storage shed, warehouse
GTO	Greenland Technical Organization
IEC	International Electrotechnical Commission
JICA	Japan International Cooperation Agency
KBO	Kagera Basin Organization
kV	kilovolt
kVA	kilovoltampere
kW	kilowatt
kWh	kilowatthour
kWh(t)	kilowatthour thermal energy
LF	Load factor
MCW	Ministry of Communications and Works
MEM	Ministry of Energy and Minerals
MW	Megawatt
MWh	Megawatthour
NBC	National Bank of Commerce
NIC	National Insurance Company
NJODECO	Njombe Development Company
NORAD	Norwegian Agency for International Development
OGL	Open General Licence
PC	Personal computer

PF	Power Factor
R&M	Repair and Maintenance
RIDEP	Regional Integrated Development Programme
RUBADA	Rufiji Basin Development Authority
SEI	Stockholm Environment Institute
SIDA	Swedish International Development Authority
STAMICO	State Mining Company
TANESCO	Tanzania Electric Supply Company Limited
TANWATT	Tanzania Wattle Company
TARECO	Tanzania Rural Electrification Company
TAS	Tanzanian Shillings
toe	ton of oil equivalent
TPDC	Tanzania Petroleum Development Corporation
TPTC	Tanzania Posts and Telecommunications Corporation
UNDP	United Nations Development Programme
USD	US dollar
WP	Works in Progress

Currency Exchange Rates

	TAS	USD
February 1988	90	1
July 1989	144	1
March 1990	195	1

Executive Summary

1. Introduction

This study was carried out to assess the technical performance, the financial performance and socio-economic impact of rural electrification projects implemented by the Tanzanian national electric utility TANESCO. The study was carried out jointly by TANESCO, the University of Dar es Salaam and the Stockholm Environment Institute (SEI) with funding from SIDA (Swedish International Development Authority) and TANESCO.

The TANESCO rural electrification programme is, at present, concentrated on bringing electricity supplies to small and medium sized provincial towns and to agro-industries such as cotton ginneries and sugar factories. These towns have populations ranging from 3 000 to 50 000 people. Out of the 66 towns in this category, a total of 34 remained to be electrified at the beginning of 1990. The electrification of small villages and isolated farmhouses is not being carried out on a significant scale at this stage.

A pilot study to develop the methodology for the present survey was conducted in July 1989. The isolated diesel supplied town Babati was selected for the pilot study. Based on this experience, detailed socio-economic and technical studies were carried out in February-March 1990 in a further three areas. Two of these, namely Njombe and Sumbawanga are isolated diesel supplied areas, whereas the third area, Same, is supplied from the national grid. Briefer technical reviews of another 30 areas were also carried out. Out of these, 15 are supplied from the national grid and 15 are isolated areas supplied with diesel generators. The results of the surveys have been documented in a number of topical reports *(2 – 8)*.

Since inflation in Tanzania is rapid, with an annual inflation rate approaching 20 per cent, cost data given in this report are outdated before the report is published. This is of no significance for the conclusions drawn, since the relative prices of various goods and services have not been greatly affected.

2. Public Electricity Supply in Tanzania

2.1 General

TANESCO, the Tanzania Electric Supply Company, is the national power utility and is responsible for the generation and distribution of electricity throughout Tanzania. The national grid links the main urban centres and has a total net installed generating capacity of 442 MW of which 333 MW is hydro and the remainder diesel. A further 28.5 MW of diesel generators have been installed to supply 15 isolated load centres. At present, about 4 per cent of the electricity is generated in the isolated diesel supplied areas.

2.2 Rural electrification

In Tanzania, rural electrification is defined as the supply of electricity to district townships, other small townships, villages, settlements, development centres, agro-based industries and other small industries outside of the regional towns. The aim of the rural electrification programme is to provide reliable and high quality electricity supplies which can be used for domestic, industrial and commercial purposes.

The power demand of a typical "rural area" served by TANESCO is between a few hundred kW and a few MW. The supply has been achieved either by an extension of the national grid or by installation of "an isolated generation system". All the present isolated generating systems of TANESCO are diesel power plants, but other technologies like small hydro power plants or biomass fuelled steam plants have also been considered. A small hydro power plant in Njombe has been installed and was commissioned in November 1991 after a long delay caused by a head race channel collapse shortly after completion of the construction work.

The TANESCO rural electrification programme has so far provided access to electricity in 37 rural towns (30 being district towns) and more than 14 rural villages. Although this is a significant achievement, most of the work still remains to be done. There are 34 district towns yet to be electrified. Out of the 8 600 villages, probably less than 1 per cent have so far been provided with electricity. More than 80 per cent of the households in the electrified rural areas are not yet connected.

2.3 Tariff system

Electricity is supplied under a uniform tariff for the whole country, see appendix 1. There are nine tariff groups. In many of the groups, the charge per kWh depends on the consumption.

A progressive tariff is used for the residential, light commercial and light industrial consumers. The average amount paid for a kWh consumed varies with the total monthly consumption. Small consumers, which represent the bulk of the electricity use in rural areas, pay significantly less than the actual financial cost of the service. At a very high consumption, above about 10 000 kWh/month, the average tariff for these types of consumers would exceed the cost for self-generation with a diesel generator set.

2.4 Financial performance

The average revenue of TANESCO per kWh delivered in 1988 was TAS 4.15 – about 2 US cents, whereas the cost per kWh delivered was TAS 5.03. The rate of return has been declining from 7.6 per cent in 1984 to – 1.7 per cent in 1988.

The financial performance of individual branches differs significantly, depending on the consumption structure, the size of the operation, the supply technology used and the investments made for transmission and distribution. All the isolated diesel supplied areas are loss-makers for TANESCO.

3. Expected Benefits of Rural Electrification

It is clear from an examination of project documents that a high level of social and economic benefits are expected from the rural electrification by the government, donor agencies and TANESCO.

Among the primary aims of the programme is the promotion of industrial development and increased agricultural production. Another objective is the reduction of woodfuel consumption, thereby preventing deforestation and increasing the energy supplies available to the poor. Rural electrification is also variously credited with improving living conditions, increasing employment, easing the burden of women's work, raising educational standards, providing higher levels of security at night and improving health services.

The expectation that rural electrification will bring such wider or macro socio-economic benefits is the principal justification for the heavy subsidies provided for the rural electrification programme.

4. Main Findings from the Survey

4.1 Socio-economic characteristics of consumers connected

In the areas studied, the rural electrification programmes had been implemented between 1978 and 1985. Each area had, therefore, had a public electricity supply for between 5 and 10 years. Before the TANESCO supply was provided, there had been a limited amount of private generation by businesses in each of the towns, but none of these had offered any electricity for sale to the public.

The survey found that the average proportion of households connected in the survey areas was 12 per cent. Of the total number of consumers, almost three quarters were households, about a quarter were small businesses such as shops, bars and guesthouses and just 3 per cent were light industrial consumers such as grain mills, welding shops and garages.

In its analysis of domestic energy use, the survey divided households into two main categories, electrified and non-electrified households. Each category was then divided into two sub-groups. The electrified households were divided into basic electricity users, utilizing electricity for lighting and not more than one appliance, and more advanced users, utilizing electricity for lighting and more than one appliance. The non-electrified households were divided into less affluent, owning three basic assets or less, and more affluent, owning more than three basic assets.

In order to be connected to the electricity supply, customers must meet a certain minimum dwelling standard stipulated by TANESCO. This automatically excludes most low income families. To obtain a connection, families must pay a proportion of the cost of bringing the supply to the house as well as the costs of internal wiring; in total these costs average around TAS 25 000. They must also put down a security deposit with TANESCO.

Although the household incomes could not be established in the survey, the results indicate that electricity connections are mainly found among the most affluent. A number of non-electrified households had houses of a quality acceptable to TANESCO but had other priorities than obtaining an electricity supply.

4.2 Overall energy consumption patterns

The main energy use for all households, is for cooking. Among the non-electrified households, in particular the less affluent, fuelwood is the main cooking fuel. These families collect all, or a high proportion, of their fuelwood. Moving up the income scale, the proportion of fuelwood which is purchased increases. Electrified households use a higher proportion of charcoal which is virtually always purchased.

Kerosene and electricity are used for cooking to a limited extent, particularly in electrified households. These energy carriers are mainly used for making tea and cooking snacks; their use for cooking main meals is relatively rare.

In non-electrified households, lighting is generally provided by kerosene lamps. In the less affluent of these households the only source of light is frequently the open fire. Families without electricity also spend money on batteries for radios.

Families with electricity typically have four or five light bulbs and one or two socket outlets. In these families, electricity is the main source of power for lighting. Kerosene is used during interruptions in the electricity supply which are frequent, particularly in the diesel supplied areas. Electricity is also used to provide power for the radio. The most common appliance is an iron. The majority of the more advanced electricity users also own a hotplate.

Total monthly expenditures on all forms of energy were found to fall in the range 1 000 to 3 500 TAS. There are clear variations between the areas studied and between the sub-groups. In Same and Njombe, the expenses increase from less affluent non-electrified households to those in the more advanced electricity users sub-group. In Sumbawanga, where the prices of fuelwood and charcoal are higher, and kerosene use less frequent among non-electrified households, the non-electrified households spend slightly more than the electrified. If it were not for the amount of kerosene used by electricity users during interruptions of the electricity supply, expenditures of the electrified households would have been lower and the difference greater.

In general, the subsidized electricity gives substantially lower cost per useful energy unit than charcoal and kerosene. The general effect of this is that families with low income pay more for their useful energy than those with a high income.

Small businesses were generally not found to depend on electricity. The average monthly electricity cost was 1 200 TAS, whereas on average about 3 300 TAS was spent for charcoal, firewood and kerosene.

Institutions were found to spend an average of 8 900 TAS/month on electricity and 2 400 TAS/month on other sources of energy, mostly charcoal, fuelwood and kerosene. The cost of fuel for stand-by diesel generators is included in the electricity cost which raises the average. Most institutions have monthly electricity bills ranging from 200 to 3 000 TAS.

For light industries, the monthly electricity expenditure showed a large variation. About 15 per cent showed monthly bills around 50 000 TAS, some 20 per cent averaged around 6 000 TAS/month and the remaining two-thirds just over 2 000 TAS/month. Other sources of energy were found to be financially less important with a monthly average cost of about 1 300 TAS.

4.3 Electricity consumption

In the towns surveyed in detail, namely Babati, Njombe, Same and Sumbawanga, residential and light commercial consumption is dominant. The fraction of the electricity consumed for productive purposes, i.e. within tariff groups 3 – 5, varies from below 7 per cent in Sumbawanga to about 45 per cent in Njombe. In Njombe, however, drastic load shedding is practised which means that the present consumption data do not properly reflect the demand pattern. Lighting is an important use for electricity in all tariff groups.

This is reflected in the daily load variation. There is a load peak in the morning, a lesser peak at lunchtime, a trough in the middle afternoon and a high evening peak. The morning and lunchtime peaks are almost certainly due to the use of hotplates. The evening peak occurs when the use of lights is at its maximum in households, bars and cafes; the use of hotplates for making tea and cooking snacks is also likely to be a contributing factor. The system load factor for those areas where significant load shedding does not distort the load variation, was found to be between 55 and 60 per cent, with a minimum demand amounting to about 30 per cent of the peak demand. About 60 per cent of the energy is consumed in the dark hours between 6 pm and 6 am.

Comparisons between actual and projected growth of the electricity consumption in the four rural areas surveyed in detail, show different results. In Babati and Sumbawanga, the consumption has now exceeded the projections. This has led to difficulties meeting the demand during peak hours. In Same, the consumption growth follows the projections well. In Njombe, failures of generator sets presently makes it impossible to meet the demand. For the first eight years, the load growth shows reasonable agreement with the projections. Upon closer examination of the data it is apparent that the growth of residential and light commercial use has generally been underestimated, whereas the growth of industrial use has been overestimated.

4.4 Technical status of diesel power plants

The status of the diesel power plants operated by TANESCO was assessed during the survey, which was carried out between July 1989 and April 1990. The situation was found to be satisfactory at six of the 17 sites visited, namely at Kiabakari, Kilwa Masoko, Masasi, Mpwapwa, Nachingwea and Tukuyu. At one site, Ndugurumi, the actual status of the diesel power plant was uncertain since the plant hasdnot been operated for many years due to lack of load. From one of the sites, Liwale, difficulties with the supply of fuel and lubricants were reported. At the other nine sites, there were more or less serious technical problems which resulted in significant reduction of the supply reliability.

At seven sites, namely Babati, Chamwino, Kondoa, Kigwe, Njombe, Sumbawanga and Tunduma, the available capacity was not sufficient to meet the peak demand. The situation was handled by load shedding, either during peak load hours or permanently. At all these sites, the installed capacity should be adequate but the available capacity was much lower as a result of breakdowns of generator sets. Many of the broken down generator sets had, in reality, been retired and lack of spare parts prevented repairs to others. At Ikwiriri and Mafia, the available capacity was able to meet the peak demand. However, there was only one generator set operational, which implies that there would be no supply when the unit is serviced and if a breakdown occurred.

It was noticed during the survey that most of the diesel power plants had no adequate storage facilities for consumables and spare parts. A suitable workshop area, a running stock of spare parts and tools for carrying out minor and major overhauls were not available at most of the sites. At many sites, in particular those with transferred sets, operation manuals for the generator sets are lacking, which makes service, maintenance and repairs more difficult. Several sites lack serviced fire extinguishers.

A programme for rehabilitation of diesel power stations based on Wärtsilä 624TS and 424TS diesel generator sets, with rated capacities 640 kW and 430 kW respectively is being implemented. This will solve the current capacity problems at Babati, Ikwiriri, Kondoa, Njombe, Mafia and Sumbawanga even though it is questionable whether this solution is optimal at some of the sites*.

4.5 *Technical status of transmission/distribution systems*

At all the areas surveyed, a visual inspection of the transmission and distribution systems was carried out. The results show that rotten wooden poles, vandalized stay wires, lack of fuses and silica gel for distribution transformers and faulty lightning arresters are common problems in the rural transmission systems. For the distribution systems, long single phase power lines, use of too small conductors and uncoiling of conductors feature as major problems.

Some cases of deviations from BS and IEC standards, including use of too small conductors for transmission, distribution and service lines, has been identified. The standards regarding maximum length for single phase service lines also appear to have been disregarded in a number of rural systems.

The street lights were found to be in poor condition in many rural areas.

4.6 *Technical performance*

No problems with frequency control were identified in the survey. Fluctuations appeared to be within the acceptable range of 1 per cent. Low voltage and voltage fluctuations outside the acceptable range of 5 per cent were, however, reported from all the four areas studied in more detail. Long and undersized conductors and loose connections are major factors for these problems. At Same, which is supplied from the national grid, it was noticed that large voltage fluctuations occur which are outside of the range the voltage control system at the substation could handle.

Records of supply interruptions appear to be incomplete for most of the rural areas. The available data show beyond doubt, however, that the supply reliability must be characterized as low in the diesel supplied areas surveyed in detail. At the substation level blackouts occur for 6 to 15 per cent of the total time. It was found that the number of annual blackout hours was generally higher for the diesel powered systems compared to those supplied

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* Grid connection appears a better solution for Njombe. For Babati, Kondoa, Ikwiriri and Mafia, the generator sets are apparently to be oversized. Cheaper temporary solutions could have been considered for Babati, which is scheduled for grid connection in 1993.

from the grid. There are, however, examples of grid supplied systems with very low supply reliability.

Load shedding features as the dominant reason for supply interuptions for the diesel supplied areas. At two of the sites, Babati and Sumbawanga, the load shedding is a consequence of load expansion over the years that cannot be matched with the installed generation capacity. In Njombe, the generation capacity has deteriorated as the combined result of break-downs with a long waiting time for spare parts and retirement of generator sets without adequate replacements.

Since a fair portion of the supply is for the lighting load, the power factor for most of the rural areas is expected to be in the order of 0.9 or better. However, observations made during the visit to Babati, and historical records from Njombe, show that very low power factors, i.e. down to 0.5, can be experienced. The most likely reason for poor power factors are machines which consume mainly reactive power such as welding sets and compressors being used prevalently in workshops, garages, blacksmiths etc. Sometimes, consumers in tariff 1 use such machines which are expected to be in tariff 3, 4 and 5. Since tariff 1 consumers do not have kVA meters, there will be no charge for the reactive power consumed.

Records which makes it possible to establish the losses in transmission and distribution as the difference between units sold and units imported or generated are not available for most of the rural areas surveyed. Data for areas that are separate branches can be found in the Finance Managers Reports. For those areas that were studied in more detail, i.e. Babati, Njombe, Same and Sumbawanga, sample comparisons between units sold and units imported or generated were made for a few months, using data in the consumers ledgers for determination of units sold. The available information indicates differences between units generated and units sold in the range 6 – 57 per cent, with about 20 per cent as an average. Part of this difference is internal consumption and therefore the technical losses are certainly less. Where technical losses have been reported these range between 2 and 16 per cent. A separate study for more accurate determination of the technical losses in rural systems was carried out in 1990 for Babati and shows technical losses in the range 11 – 19 per cent.

4.7 Administrative performance

Serious weaknesses in administration were observed in the survey, particularly in the case of the isolated diesel supplied areas . Meter reading and the issuing of bills is slow. In most rural areas there is no record of the number of units produced and sold. Communication between TANESCO head office and the rural areas also tends to be weak. There is poor feedback to head office on load growth and general technical performance. This has created a lack of awareness of local conditions at TANESCO head office which has, at times, led to an inappropriate choice of programmes or interventions by donor agencies.

4.8 *Financial performance*

The actual financial performance of the majority of the rural areas is difficult to evaluate since some costs are combined at the branch level and separate records for the rural areas are not available. However, five diesel supplied sites are separate branches , which makes an evaluation of the financial performance possible. For 1988, the average revenue for these areas was between 4.20 and 2.65 TAS/kWh whereas the cost per unit sold was between 11.20 and 22.82 TAS/kWh.

Generation cost, which is mainly fuel and lubricant costs, was between 10 and 14 TAS/kWh sold. On the basis of units generated the generation cost is reported between 8.8 and 13.9 TAS/kWh. As might be expected, the administration cost per unit is larger for small branches. Some variation in the costs for distribution, depreciation and interest is explained by the different conditions on the sites, where transmission line length is an important factor.

In the two diesel supplied areas that were studied in more detail and are not a separate branch, i.e. Babati and Njombe, the situation is similar. The average revenue per unit generated for 1988 was found to be 2.2 and 1.9 TAS/kWh respectively, whereas the quantifiable cost per unit generated amounted to 8.4 and 8.2 TAS/kWh. Fuel accounts for about 80 per cent of the quantifiable cost.

It can safely be concluded that all the isolated diesel supplied areas are loss-makers for TANESCO. The revenue collected generally does not cover even 30 per cent of the cost for fuel and lubricants.

None of the grid supplied rural areas is a separate branch. Complete cost data are therefore, not easily found. A special study was carried out for Same. The results for 1988 show a deficit of about 4.3 TAS/kWh. This is partly a consequence of fuel costs for the Arusha branch allocated to Same for electricity imported from Arusha. For 1989, a small surplus of 0.4 TAS/kWh was generated at Same. It is not possible on this basis to draw generic conclusions about the financial performance of grid supplied rural areas. Unless depreciation and interest costs are very high, as a result of large investments in transmission lines, the performance can be expected to be better than for the diesel supplied areas.

4.9 Benefits to individual electricity consumers

The benefits provided by the programme to individual consumers are clearly substantial. The use of electricity for lighting is not only significantly cheaper than kerosene, it provides a vastly improved standard of illumination. The availability of an electric power supply also enables families to use small power tools and welding kits to carry out small scale commercial activities.

The use of hotplates for making tea and cooking snacks is considerably more convenient than lighting a wood or charcoal fire for the same purpose. It is also cheaper, assuming that wood or charcoal is bought. The use of electricity for radios enables significant savings to be made in the purchase of batteries. Among commercial consumers, the availability of lighting and power for radio and cassette players is important in increasing the number of customers and the turnover in bars and restaurants.

Electric power for grain mills is cheaper, cleaner and more convenient than diesel. It therefore eases the workload and reduces the costs for mill owners.

4.10 Wider social and economic benefits

The surveys found little indication that the wider social and economic benefits expected from the rural electrification programme actually materialised. There was, for example, no indication that the availability of electricity encouraged industrial developments which would not have otherwise taken place. Although grain mill owners had cheaper running costs, the number of such mills was not increased since they tended to be in operation, and profitable, before the arrival of the electricity supply. In addition there was no impact on agricultural production in most of the areas studied in detail.

The impact on fuelwood consumption has been negligible. Cooking with electricity was mainly for snacks and tea and much less frequently for the main family meal. Families at all economic levels continued to use fuelwood or charcoal for at least some of their cooking.

There were, however, clear social benefits from public lighting. People generally felt that it provided increased security and reduced crime. Street lighting also enabled a variety of petty roadside traders to provide goods and services in the evenings. The availability of an electricity supply at hospitals was also seen as a benefit by hospital staff because it reduced the cost of diesel. In neither case, did these benefits depend upon the provision of a heavily subsided supply to private and commercial consumers.

The availability of electricity also had a noticeable overall effect in bringing about a degree of modernisation of the towns surveyed. Bars and cafes had lights and music. There was a wider variety of services available. This made the towns more attractive to those living in them and to visitors; in the case of Babati it made the town more attractive as an overnight stop for truck drivers and thus increased the amount of local business activity.

5. Main Problems and Possible Solutions

5.1 Overall assessment

It is evident from the evaluation of the present experiences from rural electrification in Tanzania that many of the expected wider social and economic benefits of rural electrification have not yet been achieved at most of the sites surveyed. It is also evident that the quality and the reliability of the supply is unsatisfactory at many sites and that this is a dis-incentive to industrial users of electricity to utilize service.

It is also evident that radical modifications of the TANESCO approach to rural electrification are necessary to improve the situation significantly in the areas that are already electrified and to meet the aims outlined in section 2.2 for additional areas to be electrified. The present difficulties are clearly a result of complex circumstances. The major reasons are discussed below.

5.2 Selection criteria partly incompatible with objectives

The strategy for rural electrification practised until now, is based on the following order of priority for electrification:

— district towns,
— agro-based industries,
— small towns,
— small industries,
— villages.

Although a few small towns and villages have already been electrified, primarily as marginal projects where transmission lines happen to pass a village, the programme has not yet reached below the district town level. Out of the 66 district towns that are considered as rural, 37 still remain to be electrified. This strategy is in line with the objective of improving the general living conditions in the rural areas of Tanzania. It is, however, not necessarily compatible with the objectives of supporting development of industry and agriculture, since many of the district towns are administrative centres rather than industrial centres. A revision of the criteria in order to give higher priorities to projects which would lead to productive use of electricity appears necessary.

It is suggested that such criteria should be based entirely on the anticipated economic and financial performance of the proposed projects. The minimum acceptable financial rate of return – which may in fact be negative for rural projects – remains to be defined as a part of company policy.

5.3 Productive uses of electricity not adequately supported

Utilization of the electricity for productive purposes is necessary if electrification is to bring economic development. The present portion of the electricity supplied in rural areas that is used for productive purposes is not satisfactory as discussed earlier in sections 4.3 and 4.10.

There are many possible explanations for this. The problems with supply reliability and quality, as well as the present tariff policy, probably contribute to a slow development of productive uses for electricity. However, other factors, that are outside of the control of TANESCO, such as shortage of capital, transport problems and lack of skilled labour are likely to be more important.

Unless such obstacles to expansion of productive uses of electricity in the rural areas are removed, the situation should not be expected to improve significantly. A possible stimulation of productive uses could arise from formulation and implemention of integrated development plans for rural areas already electrified and those that are candidates for electrification.

5.4 Inadequate technical and administrative support

Most of the area managers that the survey teams met during the survey were found to be competent and keen to provide a good service to the electricity consumers. However, for economic reasons, the number of technical and administrative staff was small. Many also experienced difficulties in hiring trained staff members. As a consequence, record keeping and evaluation of records were not carried out to the extent required for efficient operation. Also service, maintenance and repairs, particularly of diesel generator sets, could not be carried out or was done only after long delays with assistance from the regional headquarters or the main office in Dar es Salaam.

Organizational changes and strengthening of the organization for operation of the service in the rural areas are necessary to improve the situation.

5.5 *Inadequate financial resources allocated to rural areas*

There is no doubt that many of the present problems with supply quality and supply reliability in the rural areas are related to lack of funds. Funding for material, spare parts, tools, staff, vehicles, tele- and radio communication required to maintain and operate the system appear to be the main problem, although shortage of funds for grid expansion was reported from many sites.

TANESCO has been running in deficit in recent years. It is evident that the lack of funds indicates a need for an increase in the tariffs which, by international comparison, are very low.

A fundamental problem in the diesel supplied areas is the inevitable loss of income since the tariffs charged often cover less than 30 per cent of the operating costs. As a result, the more successful the programme in attracting new customers or increasing electricity consumption, the worse the overall financial impact. This is not only bad for the company's financial situation, but also provides contradictory signals to those trying to manage effectively.

Improving the financial results of the rural areas by increased revenues or creation of some kind of incentive system that will stimulate provision of acceptable services is necessary if the service is to be maintained in the future. This issue will be discussed below in section 6.

5.6 *Ineffective use of donor support*

There is no doubt that donor support has been of great importance for rural electrification in Tanzania. In fact most of the projects implemented after 1975 have been financed by donor agencies. The survey has shown, however, that donor financed projects have not always been organized in the most efficient way with respect to minimization of costs and maximization of the reliability of rural electricity supply.

Examples of this are:

— Diesel generator sets for which spare parts are not available locally have been installed without adequate supplies of spare parts for the expected lifetime of the engine.

— New diesel generator sets are installed at sites where grid connection or a mini-hydro power plant would be a better alternative.
— Large diesel generator sets are installed at sites where the capacity utilization will be very low.

It is possible that in such cases TANESCO has had no other option due to constraints imposed by donor policy or shortage of funds. It is also possible, however, that the donor agency involved in each case has been unaware of other options and the advantages these could offer TANESCO. Improvement of the situation will require routines for informing donors about TANESCO's long term plans and options and also for internal scrutiny of donor projects.

5.7 Unrealistic objectives

Conservation of natural resources through fuelwood substitution with electricity is one of the main objectives of rural electrification identified in the "Rural Electrification Policy Document" *(13)*. The findings from the survey show that this has only been achieved to a marginal extent. It is also clear that a significant impact of electrification on fuelwood use should not be expected in the next decade.

There are two reasons for this. First of all, only a small fraction of the households in the electrified areas are actually connected. Secondly, only few of those connected actually use electricity for cooking and all households use some charcoal or fuelwood for cooking. Deforestation, which is a serious problem in many parts of Tanzania, must, therefore, be fought with other methods.

5.8 Shortcomings of the present organization

Planning and design of rural electrification projects is presently handled by the Manager of Rural Electrification within the Directorate of Corporate Services of TANESCO. Otherwise, the rural areas are operated as an integrated part of the TANESCO organization through the respective Zonal Directorates and Regional Managers. Although there is no reason, in principle, why this type of organization would not be adequate, the findings of the survey do indicate that financial, technical and administrative support to the rural areas is given lower priority. This appears to be a common situation, see Foley *(28)*, who concludes that the problem can only be dealt with by creation of a separate agency or a separate division within the national utility, with rural electrification as its main task.

For Tanzania, it appears as if the most reasonable solution is to create a separate division under a new Director for Rural Electrification, with a separate budget and separate allocation of foreign exchange, to be responsible for planning of rural electrification as well as monitoring and support the operation of the rural branches.

5.9 Lack of incentives

It is quite clear that there is no corporate incentive at present, except perhaps political pressure, to provide and expand the services to the diesel supplied rural areas. Various possibilities to design such a system are discussed in the study. It is concluded however that the proposed organizational change, combined with a firm budget allocation for operation and development of the rural services and a personal incentive system for those employed in the new Directorate and the rural branches, should be tried before other schemes based on government intervention are considered. The incentive system should be based on units sold, but the details need to be worked out.

6. Improvement of the Financial Viability of Rural Electrification

6.1 General remarks

Improving the financial viability of rural electrification is a key element for elimination of the present problems with rural electricity supply in Tanzania. This issue, therefore, deserves special discussion.

The problems are most obvious for the isolated diesel supplied areas where the present revenues do not even cover 25 per cent of the costs. For the grid supplied rural areas, the situation cannot be assessed, since separate cost and revenue data are generally not available. However, the situation can be expected to be different in character for the grid supplied areas since capital costs constitute a relatively higher portion of the total costs in these areas. This may make losses less obvious and will in any case not lead to a negative marginal gain on every kWh delivered. An increase in revenues will still be necessary, however, to cover essential costs for improving the services.

The financial problems of rural electrification are not unique to Tanzania. Utilities all over the world are faced with similar problems of high costs and small revenues in rural areas.

6.2 *Reducing the costs*

For some rural branches the generation costs can be reduced by substitution of the diesel generator sets with other generation technologies like mini-hydro, biomass fired steam power plants, wood gas power plants or even solar power. This would require substantial investment and cannot be expected to be implemented quickly.

Other opportunities for reducing costs identified during the survey, such as reducing electric losses and optimization of the operation of diesel generator sets, can only diminish the present problem but not solve it. In addition, providing an acceptable service to the consumers will, for many areas, require strengthening of the staff, buying more material and spare parts, acquiring more vehicles, and other actions that will increase the operating cost rather than reduce it.

It is, therefore, obvious that increasing the revenues is the only possible route to improved financial viability.

6.3 *Increasing the revenues*

Although there are some theoretical possibilities to increase the revenues within the present tariffs by changes in the user structure, it is quite clear that in reality the only possibility to improve the financial results significantly is to increase the average amount charged per kWh delivered.

6.4 *Possible alternative tariff systems*

The ideal tariff system should not only cover the operating expenses and give an acceptable rate of return on invested capital, but should also be designed in such a way that a sound economic development is stimulated, by giving the correct economic signals to both the utility and the consumers. Tariffs reflecting the actual marginal long term and short term costs are generally accepted as meeting these requirements. Strict use of such tariffs will lead to large variations in the price per kWh between urban and rural grid connected areas and between grid connected and isolated diesel supplied areas. Even though this may appear as rational on the basis of economic theory, it will be contradictory to providing reasonably equal opportunities for economic development all over the country. It is, therefore, common, see Foley *(28)*, that marginal cost tariffs are not strictly applied even though many utilities practise the use of somewhat higher tariffs in rural areas.

Given the present conditions in Tanzania, it is considered important that the principle of a uniform tariff and a comparatively low "life-line" tariff for small consumers is maintained. There is no justification, however, for selling electricity at tariffs which are so low that energy costs for those who have not yet been connected are substantially higher than for those with access to electricity. Care should be taken that no customer would have to pay a unit charge that is above the marginal cost of running a diesel power plant for self-generation of power. Large consumers should be charged on the basis of the long term marginal cost for supplying the power from the national grid.

Within this frame-work the details of the tariff must be worked out so that the capital and operating costs are recovered and adequate profit is generated for the self-financing of further development of the system.

7. Recommendations

The recommendations presented in section 8 of the report have been grouped with respect to the time frame and cost for implementation in three categories, namely:

1. Recommendations which can be implemented within a short time frame (1 year) and which do not imply substantial investments.
2. Recommendations which may require longer time for implementation (2–5 years) but do not imply substantial investments.
3. Recommendations which may require longer time for implementation (2–5 years) and imply substantial investments.

Recommendations for implementation in the near future include restructuring of the organization, revisal of the tariff policy, introduction of an incentive system focussed on rural electricity supply, revisal of the criteria for project selection and some strengthening of administrative routines.

Recommendations for later implementation, requiring moderate investments include formulation of rehabilitation plans for all presently electrified rural areas, formulation of plans for diesel supplied rural areas for switch to cheaper supply alternatives, standardization of diesel power plants and introduction of recurrent training of area managers as well as technical and administrative staff in rural areas. Also in this category of recommendations is the implementation of pilot projects for testing a new approach to rural electrification, based on creation of electrification co-operatives.

Recommendations for later implementation requiring substantial investments include implementation of the rehabilitation plans, implementation of the plans to replace diesel generator sets with cheaper alternatives where this is possible, formulation and implementation of integrated development plans for new areas to be electrified as well as development of the capability in Tanzania to manufacture equipment for generation, transmission and distribution of electric power. In this time perspective, creation of a separate organization for rural electrification, partly financed by government tax on electricity generation for the interconnected system, can be considered.

8. Concluding Remarks

Even though this study has shown that many of the expected benefits of rural electrification have not yet been achieved and that the reliability and the quality of the present service to the electrified rural areas is far from satisfactory, there should be no doubt that electrification of the entire country remains a sound development objective.

The issue is, therefore, not *if* but *how* this shall be accomplished. The findings in this study indicate that the resources required, the difficulties involved and the complexity of the issues have so far generally been underestimated, whereas the importance of electricity as a promotor of economic development has generally been overestimated.

What is required now is a modified approach to rural electrification where repetition of past mistakes is avoided and the major part of the limited resources is concentrated on supplying the service where the maximum impact on economic development in the rural areas can be expected. Only then can additional economic resources be generated for expansion of the service to the whole of the country.

Electrification of rural Sweden started in about 1915 and was completed in the 1970s. Tanzania started in 1975 and still has a good chance of completing its rural electrification faster.

1
Introduction

1.1 Background

Tanzania is among the countries which puts a high priority on rural development. Rural health care, education, water supply, agricultural and industrial development and electrification are important parts of the rural development programmes. Most of the rural electrification projects in Tanzania have been carried out by the national utility, TANESCO, with financial and technical support from foreign aid agencies. The programme has been focussed on population centers like regional towns and district towns.

Although the rural electrification programme has been going on since the early 1970:s, it has not been possible to cover more than the most important population centres. It is estimated that over 85 per cent of Tanzania's population lives in areas where there is no public electricity supply. These areas include not only the countryside but also many district towns and most of the villages. Industries and some institutions located in these areas, together with the very affluent, such as plantation managers, use their own generator sets for electricity generation. Except for a few that use kerosene for lighting, the majority of the rural population still depend on biomass fuel for all their energy requirements. Most of the task of electrifying the rural areas of Tanzania, therefore, remains undone.

It is becoming more and more obvious, however, that the continued electrification efforts must follow a new strategy. The high costs carried by TANESCO for the services to the rural areas are a major reason for this. These costs can be expected to be even higher for additional areas. Most of the projects have already been justified on the basis of their anticipated social benefits and their potential contribution to economic development, rather than on their financial feasibility for TANESCO.

As a first step in establishing a new policy for rural electrification, the Government of Tanzania has decided that a parastatal other than TANESCO shall be set up to look after rural electrification. The new parastatal, which is expected to be a subsidiary of TANESCO, will be called the Tanzania Rural Electrification Company (TARECO). Lack of funds has, however, prevented TARECO from continuing the rural electrification activities started by TANESCO. In the near future TANESCO will, in reality, still be the main agency involved in rural electrification.

This study, which is an evaluation of the past experiences of rural electrification in Tanzania, will hopefully contribute to a better understanding of the nature of the present problem and its causes and stimulate a constructive discussion about the future policy for rural electrification.

1.2 Objectives

The overall objective of this study was to provide information which will allow decision makers to design and implement rural electrification projects more successfully in the future. The intended results of the study were:

- documentation of rural electrification experiences in Tanzania with identification of problems associated with the past and present programme;
- proposed criteria for selecting and implementing rural electrification projects;
- a tool/model for evaluation of different rural electrification strategies; and
- recommendations on relevant policy and decision making needs, such as organizational matters, appropriate technologies for development, pricing policy, and project implementation techniques.

1.3 Justification

The potential benefits of rural electrification are obvious. Electricity is a versatile form of energy. Its availability in the rural communities can significantly improve the conditions for socio-economic development. Experiences from early rural electrification of the industrialized countries show that electricity can be used to increase the productivity of agriculture and agro-based industry, it can provide convenient lighting, it allows the possibility to utilize modern electrical appliances and machinery which may pave the way to small and cottage industries, it can release the burden on muscle power such as for grain milling and for fetching fuelwood and water, and it can be used to facilitate communications.

Electrification can, therefore, contribute not only to economic development but also to a general improvement in the quality of life in the rural areas. Rural women and children can be liberated from the yoke of carrying heavy loads of fuelwood and water and thereby find more time for other tasks or some time for leisure. Electrification can contribute significantly to improvement in the health situation. Water-borne diseases can be reduced by water supply and water cleaning systems powered by electricity. Health hazards caused by smoke from the use of biomass cooking fuel can be eliminated by electric cooking. Storage of vaccines and medicines in dispensaries is also facilitated if an electricity supply system is available.

The possibility of using electrical and electronic equipment can extend modernization to the rural areas through mass media communication with radios, TVs and videos. Timely relief during floods, hurricanes and other natural catastrophes is possible with improved radio-communication.

It must be realized, however, that a rural electrification programme diverts large resources which could have been used for other priority needs in the rural areas. Some of the major obstacles which impede rural electrification programmes in the country include high investment and operation costs of the infrastructure, shortage of capital for financing of the projects, and difficulties in rationalizing the merits and priorities of rural development schemes. The economic feasibility is also often difficult to evaluate since the benefits are frequently social in nature rather than strictly monetary.

Access to electricity alone will seldom be sufficient to bring economic development. It follows that rural electrification programmes need to have well defined and evaluated linkages to other priority needs of the rural society. It is also clear that the benefits of rural electrification can only be realized if the electricity is affordable and is supplied with high reliability. It is, therefore, necessary that the resources allocated to rural electrification are used efficiently and adequately balanced against other developmental efforts. This requires a factual basis, which at the time when this study was initiated in 1988, was not available in Tanzania.

The following information gaps were defined by the research and development department of TANESCO:

1. Extent to which present rural electrification projects cover the energy needs of the people living in the area;
2. Actual costs for rural electricity supply for different technologies (grid extension, mini-hydro, diesel and other);

3. Actual reliability of the power supply, and reasons for downtime;
4. Financial and economic soundness of the various rural electrification schemes; and
5. Impact of rural electrification on the rural society and its economy.

The large potential benefits of rural electrification, in combination with the difficulties involved in a continuation of the present programme and the lack of information about how well the development goals have been achieved, justifies this study. The findings from the study will make it possible to replicate and improve on past successes rather than repeating past mistakes.

1.4 Scope of Work and Study Procedure

It was decided at an early stage that the study should cover, to the extent possible, all the rural electrification activities in Tanzania but with an emphasis on the TANESCO programme.

The study started with collection of basic facts and documentation available at the TANESCO headquarters in Dar es Salaam and related to the rural electrification programmes in Tanzania. The documentation scrutinized included reconnaissance and feasibility studies, tender and contract reports, project implementation/management reports, commissioning reports and consultancy reports. After this, a pilot field study of two weeks was carried out for one of the areas which had been electrified and which was expected to be reasonably representative. The diesel supplied district town Babati was selected for the pilot study. Before the pilot study a standardized questionnaire/checklist for collection of technical and financial information during field trips as well as a standard questionnaire for the socio-economic evaluation, had been designed. Based on the experiences from the pilot field study some amendments to these documents were introduced.

Short, 2 – 3 day visits to all sites electrified by TANESCO followed together with technical and financial data collection according to the improved standardized checklist/questionnaire. Based on the findings from these short visits three more electrified rural areas were selected for in-depth field studies. These areas were selected to illustrate the range of conditions under which rural electrification has been carried out in Tanzania. The in-depth field studies included more detailed technical fact collection than was possible during the short visits, as well as a socio-economic survey of electricity consumers and non-consumers. The three areas surveyed in detail were Njombe, Sumbawanga, and Same.

In order to give some background perspective to the findings, documents on experiences from other countries were also studied.

Finally, an attempt was made to summarize all the findings and prepare recommendations for the future. Partly because of the remaining gaps in the information and partly because of the difficulties of the issues raised, this part of the study required considerable time and effort, which delayed completion of this final report. One consequence of this and the rapid inflation in Tanzania is that most of the cost data given in the report do not reflect the present cost level. However, this is of no significance for the conclusions from the study.

Tables 1-1 to 1-3 lists the areas that were visited and gives some key data for each site. Question marks in the tables indicate that data could not be established.

1.5 Organization of the Study

The study was done jointly by two teams, one from TANESCO, the other from the Stockholm Environment Institute (SEI). The coordinator of the SIDA FoM programme at the Stockholm Environment Institute[1] acted as project director.

The following persons participated as principal investigators:

TANESCO team

The Chief Technical Engineer R&D TANESCO, Mr M Katyega (team leader)

Sociologist/development planner, initially Dr C Lwoga, later Dr A Mvungi, both from the University of Dar es Salaam.

Technical consultant, Dr H Kadete, University of Dar es Salaam.

SEI team

Technical specialist, Dr B Kjellström, Exergetics AB, Trosa, Sweden (team leader).

Sociologist/development planner, Mr D Noppen, the Nordic Consulting Group, Denmark

1 Originally Dr Arne Kaijser, later Mr Sven Hunhammar

Consultant on international experiences of rural electrification, Mr G Foley, the Nordic Consulting Group, Denmark.

1.6 Chronology of the Study

The study was started in the beginning of March 1989. The first pilot field study was carried out in Babati, July 1989. Short visits to most of the rural electrification projects of TANESCO were carried out during the period October 1989 – May 1990. The three in-depth studies, in Sumbawanga, Njombe and Same were done during January – March 1990.

Project meetings for preparation of the final report were held in Trosa, Sweden during May 1990 and in Dar es Salaam, Tanzania in September 1990, September 1991 and February 1992.

1.7 Documentation of the Results

The main results of the study are documented in this report. More details can be found in the technical reports from the site visits, see *(2)* and *(4) – (7)*, and in the reports from the socio-economic evaluations, see *(3)* and *(8)*.

A proposed tool/model for financial and economic evaluation of different rural electrical strategies is documented in *(20)* and consists of a spreadsheet model for personal computer use, adapted to the EXCEL computer programme.

Results of some related, but separate studies, initiated after this study had identified special problems, can be found in *(30) – (31)*.

Tables 1-1, 1-2 and 1-3

Table 1-1 Grid connected rural electrification projects visited during the survey

Site District/Region	Date of visit	Electrified year	Installed capacity at time of visit kVA	Number of consumers (date)	Population Town (District)	Units sold 1989 kWh	Transmission/distribution line distances km 33 kV	11 kV	0.4 kV
Bagamoyo Bagamoyo/Coast	Oct 11 1989	1979	1 500	768 (July 1989)	23 409 (173 918)	?	44	6	11
Hai Hai/Kilimanjaro	Apr 23, 1990	1984	2 500	1 849 (March 1990)	25 975 (200 136)	?	21	70	60
Handeni Handeni/Tanga	Apr 11, 1990	1984	?	520 (March 1990)	16 000 (251 855)	?	88	–	9
Kahama Kahama/Shinyanga	Apr 20, 1990	1983	1 150	471 (March 1990)	17 299 (503 204)	861 888	75	8	?
Kiabakari/Butiama Musoma rural/Mara	Apr 17, 1990	1974	1 000[1]	118 (Dec 1986)	42 628 (247 106)	?	40	30	?
Kibaha Kibaha/Coast	Jun 22, 1990	?	1 500	1 572 (May 1990)	37 638 (83 018)	?	151	9	?
Kisarawe Kisarawe/Coast	June 1, 1990	?	5 000	273 (May 1990)	10 000 (153 470)	?	–	50	40

Table continued

Table 1-1 Continued

Site District/Region	Date of visit	Electrified year	Installed capacity at time of visit kVA	Number of consumers (date)	Population Town (District)	Units sold 1989 kWh	Transmission/distribution line distances km 33 kV	11 kV	0.4 kV
Korogwe Korogwe/Tanga	Apr 14, 1990	?	7 000	1 655 (March 1990)	28 089 (217 810)	?	190	98	?
Lushoto Lushoto/Tanga	Apr 18, 1990	?	7 150	1 445 (March 1990)	17 456 (357 255)	?	–	188	140
Muheza Muheza/Tanga	Apr 9, 1990	?	3 300	741 (Dec 1989)	12 739 (231 394)	?	99	44	?
Mwanga Mwanga/Kilimanjaro	Apr 21, 1990	1984	?	1 031 (March 1990)	7 242 (98 260)	1 593 256	54	44	?
Nzega Nzega/Tabora	Apr 22, 1990	1983	500	696 (March 1990)	15 495 (295 613)	1 125 600	33	8	?
Pangani Pangani/Tanga	Apr 12, 1990	?	1 500	568 (March 1990)	5 369 (37 867)	?	43	51	?

Table continued

Table 1-1 Continued

Site District/Region	Date of visit	Electrified year	Installed capacity at time of visit kVA	Number of consumers (date)	Population Town (District)	Units sold 1989 kWh	Transmission/distribution line distances km 33 kV	11 kV	0.4 kV
Rombo Rombo/Kilimanjaro	Apr 20, 1990	1984	?	687 (Dec 1989)	21 055 (200 855)	1 445 304	54	–	45
Same Same/Kilimanjaro	Feb 25 - Mar 3 1990	1976	2 000	1 205 (Dec 1989)	31 097 (170 053)	1 475 700	52	?	?
Tarime/Utegi Tarime/Mara	Apr 14, 1990	1983	1 350	580 (March -90)	43 988 (341 148)	No data in monthly reports	50	–	?

[1] Also 2*200 plus 125 kW stand-by diesel generator sets

Table 1-2 Diesel genset supplied rural electrification projects visited during the survey

Site District/Region	Date of visit	Electrified year	Installed capacity at time of visit kVW	Number of consumers (date)	Population Town (District)	Units generated (year)	Transmission/distribution line distances km 33 kV	11 kV	0.4 kV
Babati Babati/Arusha	July 11 – 19 1989	1981	525	477 (June 1989)	21 800 (208 385)	979 000 (1988)	–	9	15
Chamvino Dodoma/Dodoma	March 24 1990	1975	80	46 (March 1990)	19 507 (203 883)	155 472	–	3	11
Ikwiriri Rufiji/Coast	Oct 19, 1989	1975	270	130 (June19-89)	4 605 (152 316)	121 330 (1988)	44	6	11
Kigwe Dodoma/Dodoma	April 1990	1975	80	? (?)	20 105 (353 478)	Units out of service since February 1988	–	–	?
Kilwa Masoko Kilwa Masoko/Lindi	Oct 20, 1989	1977	700	334 (June 1989)	10 456 (150 212)	443 900 (1988)	–	3.2	4.2
Kondoa Kondoa/Dodoma	March 24, 1990	1980	525	578 (Feb 1990)	340 554 (340 554)	1 066 800 (1988)	–	5	15

Table continued

Table 1-2 Continued

Site District/Region	Date of visit	Electrified year	Installed capacity at time of visit kW	Number of consumers (date)	Population Town (District)	Units generated (year)	Transmission/distribution line distances km 33 kV	11 kV	0.4 kV
Liwale Liwale/Lindi	Oct 27, 1989	1975	97	122 (June 1989)	15 208 (52 311)	42 600 (1988)	?	?	?
Mafia Mafia/Coast	Mar 29, 1990	1971	1 040	362 (Dec 1989)	5 559 (33 054)	987 760 (1989)	–	16.3	6
Masasi Masasi/Mtwara	Oct 23, 1989	1985	4 500	284 (Apr 1989)	47 810 (335 428)	2 590 000 (1988)	–	12.4	9.7
Nachingwea Nachingwea/Lindi	Oct 26, 1989	1975	980[1]	751 (June 1989)	14 580 (118 017)	Supplied from Masasi	?	19	12
Newala Newala/Mtwara	Apr 12, 1990	1984	–[2]	227 (June 1989)	32 415 (307 988)	Supplied from Masasi	?	40	10
Mpwapwa Mpapwa/Dodoma	Mar 20, 1990	1986	1 000	1 228 (Feb1990)	34 405 (339 954)	1 743 913 (1989)	–	11.1	25.2
Ndurugumi Mpwapwa/Dodoma	Mar 21, 1990	1975	80	0 ( )	? (?)	Sets not operated since commissioned	–	?	?

Table continued

Table 1-2 Continued

Site District/Region	Date of visit	Electrified year	Installed capacity at time of visit kVA	Number of consumers (date)	Population Town (District)	Units generated (year)	Transmission/distribution line distances km 33 kV	11 kV	0.4 kV
Njombe Njombe/Iringa	Feb 2–9 1990	1981	1 105	1 401 (Dec 19 89)	25 894 (315 976)	2 220 000 (1989)	18	about 10	10
Sumbawanga Sumbawanga/Rukwa	Feb 10–17 1990	1980	1 500	1 557 (Dec -1989)	47 878 (438 437)	4 456 800 (1989)	–	11	20
Tukuyu Tukuyu/Mbeya	Dec 8–9 1989	1975	1 200	1 031 (Dec 1989)	5 507 (272 008)	4 922 820 (1988)	–	50	16
Tunduma Mbozi/Mbeya	Dec 6–7 1989	1979	384	386 (Dec 1989)	16 100 (330 282)	915 200 (1988)	–	4	5.5
Urambo Urambo/Tabora	Feb 1990	1983	255	199 (Feb 1990)	12 663 (187 436)	No records are available	–	?	?

[1]Stand-by units. The town is normally supplied from Masasi via a 33 kV line and a 2 500 kVA transformer
[2]Supplied from Masus via 33 kV line and a 5 000 kVA tranformer

Table 1-3 Mini-hydro power plant supplied rural electrification projects visited

Site District/Region	Date of visit	Electrified year	Installed capacity at time of visit kW	Number of consumers (date)	Population Town (District)	Units generated (year)	Transmission/distribution line distances km 3 kV	0.4 kV
Uwemba Njombe/Iringa	Febr 1990	1972	100	125 (Feb 1990)	10 976 (315 976)	438 000	4	5

2
General Information on Tanzania and its Energy Sector

2.1 Demography and Economy

The total population of Tanzania, according to the 1988 census, is 23.2 million. The mainland population was 22.5 million while that of Zanzibar was 0.64 million. This implies an increase of the mainland population density in the period 1978 to 1988 from 19 to approximately 26 persons per square kilometre.

The population growth rate which was about 2.2 per cent per year in the 1960's, increased in the 1970's to between 3.0 and 3.3 per cent per year. During the 1978 – 1988 period, the average annual growth rate of the population on the mainland decreased again to a level of 2.8 per cent. Meanwhile the growth rate for Zanzibar increased slightly to 3.0 per cent. At the present growth rate, a mainland population of around 31 million by the year 2 000 can be projected.

There has been an increasing trend towards urbanization in Tanzania. In 1960, about 95 per cent of the population of Tanzania lived in rural areas. The annual growth rate of the urban population in the decade from 1960 – 1970 was 6.3 per cent rising to 8.5 per cent in the decade from 1970 – 1980. Despite the urbanization trend, the population remains overwhelmingly rural, as an estimated 85 per cent of the people still live in the about 8 600 villages.

Table 2-1 shows population projections for the five big towns, Dar es Salaam, Dodoma, Mwanza, Arusha and Moshi presented in *(29)*. These projections indicate that the fraction of the population living in these five urban areas will increase from about 10 per cent in 1986 to roughly 25 per cent in 2006. One implication of this is obviously that the energy demand of the urban areas can be expected to grow rapidly in the next decades, with a possible conflict between investments for urban electricity supply and rural electrification.

The primary economic activity of the rural areas of Tanzania is agricul-

Table 2-1 Population projection for Tanzania and four urban areas (million people)

	Actual data	Projections	
	1986	1996	2000
Tanzania	22.3	28.5–31.5	36.5–44.4
Urban areas			
Dar es Salaam	1.50	3.05	6.24
Dodoma	0.19	0.30	0.54
Mwanza	0.26	0.75	2.16
Arusha/Moshi	0.35	0.51	0.75
Percentage living in the four urban areas	*10.3*	*14.6–16.2*	*21.8–26.5*

ture. In 1985, agriculture accounted for about 56 percent of the country's export GDP and over 75 percent of the country's export earnings. About six million hectares are under cultivation with marginal farmers (less than 1 hectare of holding) accounting for about 60 percent of the farmland.

Shortage of "free" foreign exchange is still one of the country's main economic problems. This shortage has contributed to falling agricultural production and low utilization of industrial capacity. Beginning in July 1986, the Government launched a three year Economic Recovery Programme (ERP) aimed at revitalization of the key sectors of the economy. It is worth mentioning that the real GDP growth recorded for 1986 was 3.8 per cent, which is slightly higher than the annual population growth rate of 3.3 per cent. This seems a positive sign for the programme and the economy.

2.2 The Energy Situation in Tanzania

The energy situation in Tanzania is characterized by a low per capita consumption of industrially supplied energy carriers (petroleum, coal and electricity) and a relatively large importance of biomass fuels in the form of fuelwood or charcoal.

The comparison of the structures of the energy use in Sweden and Tanzania, shown in Table 2-2, illustrates the large difference (both in the level and the structure) of the energy use in an industrialized and developing country. The total per capita energy use in Tanzania is only 12 per cent of that in Sweden.

Table 2-2 Comparison of per capita energy use in Tanzania and Sweden 1986 (GJ/cap).

	Tanzania	Sweden
Use of different energy carriers		
Petroleum fuels	1.64	73
Electricity	0.15	51
District heating	0	16
Coal	Insignificant	7
Charcoal	0.8	Insignificant
Fuelwood	17.7	24
TOTAL	20.3	170
Use per sector		
Industry	1.0	62.9
Transport	2.2	35.7
Households and other	17.1	71.4

The differences in per capita use are particularly large for the industrial sector and for transportation. These are obvious consequences of the less developed industry and infrastructure of Tanzania. Fuelwood appears as the dominant energy source in Tanzania. It can be observed, however, that even the per capita use of wood for energy is less than in Sweden.

The historical development of the energy use and the projections for the future, see Table 2-3, indicate no dramatic changes in the relative importance of different energy carriers. It can be observed from Table 2-3, how-

Table 2-3 Actual and projected use of different energy carriers in Tanzania.

	Actual							Projection (1984)		
	1975	1977	1978	1979	1980	1981	1982	1986	1991	1996
Total use (PJ)										
Fuelwood	*	*	*	*	*	339	*	399	474	565
Charcoal	*	*	*	*	*	15.3	*	17.9	21.4	25.5
Petroleum products	26.1	*	26.7	*	29.3	28.3	27.2	36.5[1]	44.3[1]	60.6[1]
Coal	*	0.02	*	0.14	*	0.10	0.18	*	*	*
Electricity	*	1.86	*	*	2.62	2.70	2.54	3.2	4.6	6.4
TOTAL	*	*	*	*	*	385.4	*	56.6	544.3	657.5
Per capita use (GJ)										
Fuelwood and charcoal					*	18.5	*	18.5	18.5	18.5
Industrially supplied energy carriers					1.72	1.62	1.52	1.76	1.83	2.1
TOTAL					*	20.1	*	20.3	20.3	20.6

Notes:
*Data not available
1) Includes a small amount of coal.

Energy conversion factors (to GJ):

Fuelwood, 1 m^3 roundwood	10.2
Charcoal, 1 ton29.3	
Petroleum, 1 ton	42.7
Coal, 1 ton	23.4
Electricity, 1 MWh	3.6

ever, that the oil price shock caused a drop in the use of petroleum and electricity and that an increase in the use of these energy carriers is now projected.[2] It is evident that the shortage of petroleum fuels resulting from the need to cut down on petroleum imports in the beginning of the 1980's must have caused large difficulties for rural development in Tanzania, since

2 Later projections indicate a somewhat faster increase in the use of petroleum fuels, see Section 2.5.1, giving a consumption of about 58 PJ in 1990.

transportation is completely dependant on petroleum fuels and agro-based industries are largely dependant on such fuels.

There are three major problems in the energy sector of Tanzania, namely:
— petroleum import takes large share of export earnings,
— fuelwood supply for the largest cities is not sustainable,
— affordable power sources are lacking in many rural areas.

The problem with the high relative costs of petroleum imports is illustrated in Table 2-4, which shows that despite the fall in world market petroleum prices, fuel imports account for an increasing share of the total import as well as of the export earnings.

This, in combination with the large dependance on petroleum fuels for electric power generation in rural areas as well as for transportation and rural industries, makes it a matter of great importance to find indigenous alternatives to petroleum fuels. Biomass is certainly one of the possibilities. The financial and economic aspects of using biomass for rural electrification is subject to separate studies within the research co-operation programme of TANESCO and SEI.

Table 2-4 Cost of fuel imports as a percentage of total external imports and total export earnings.

		Fuel import	
Year	Export earnings M USD	Percentage of total external imports	Percentage of total external export earnings
1970		8.0	9.5
1973		10.6	13.7
1980	555.6	22.9	56.6
1981	614.4	25.2	49.7
1982	455.8	22.4	55.6
1983	383.3	20.6	41.9
1984	284.8	16.8	37.9
1985	244.2	17.6	61.9
1986 (to June)		25.7	64.0

Source: Bank of Tanzania Economic and Operations Report, December 1981 and June 1986.

The fuelwood supply problem is created by the large dependence on charcoal as cooking fuel in the large cities. The fuelwood used for the charcoal production is obtained from the cutting of natural forests at a rate which appears to exceed the regrowth. A substantial part of the wood is obtained as a result of land clearance for expanding agricultural activities, which contributes to a development towards steadily increasing transportation distances for wood and charcoal, ultimately leading to a supply crisis. The possible solutions include increased fuelwood production by establishment of plantations, introduction of more energy efficient technologies and substitution of fuelwood and charcoal by other energy carriers. However, all these options involve substantial investments. If for example electricity would be used to eliminate the need for cooking charcoal in the five large urban areas, expansion of the generating capacity by at least some 400 MW[3], or about a doubling of the present generating capacity of TANESCO would be required. This is clearly not realistic in the near future.

The lack of affordable power sources in rural areas is partly related to the limitations of the present national electricity supply system, and partly to the potentially severe short term economic implications of increased petroleum import for productive use in the rural areas. Again, expanded use of indigenous energy sources might be a solution.

2.3 Energy Sector Plans

When this study was conducted in 1989 and 1990 Tanzania did not have a comprehensive national energy policy. Nevertherless, specific policies had been articulated over the years to guide the exploitation, production, distribution and utilization of the commercial energy carriers. The most important of these in Tanzania are electricity, petroleum and coal. Planning and formulation of policies for each of the energy carriers is the responsibilitiy of several parastatals. For example, planning for the electricity subsector is essentially the responsibility of TANESCO. Other organizations such as RUBADA (Rufiji Basin Development Authority) and KBO (Kagera Basin Or-

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3 This is an optimistic estimate based on the charcoal consumption for 1986 given in *(29)*, a charcoal stove efficiency of 20 per cent, an annual utilization time of 1 000 hours for the electric cooker and a diversity factor of 0.6 for the cooking load.

ganization) also plan for the same subsector, but only for the Rufiji and Kagera basins respectively. STAMICO (State Mining Company) plans the development of coal resources and TPDC (Tanzania Petroleum Development Corporation) is responsible for the importation, marketing, exploration and development of natural gas and petroleum.

In spite of the fact that biomass is the dominant source of energy for more than 90 per cent of the population of Tanzania, no specific policy for the exploitation and utilization of biomass fuels has been formulated. There is an increasing awareness, however, that there is a growing "woodfuel crisis" in the country. This crisis is manifested by the rapid increase in charcoal and fuelwood prices in urban areas. Local deforestation around major fuelwood and/or charcoal consumption centres in both urban and rural areas can also be observed. The pressure on the land to feed a fast growing population aggravates the problem because it necessitates transfer of land previously containing woodfuel resources into agricultural land.

The need for planning in this sector has been acknowledged by the Ministry of Energy and Minerals and has resulted in efforts on two levels. At the local level, where the problems are most obvious for the urban areas, a study on urban wood fuel supply has been initiated. An interim report of phase 1 is available *(29)*. At the national level it has been realized that the woodfuel problem has to be solved in an integrated manner by considering through a national energy master plan, local demand and supply patterns for all fuels, fuel substitution possibilities, inter-region and intra-region fuel import and export possibilities, conservation measures and environmental impacts. Currently a detailed data base on energy supply transformation and demand patterns and on land use patterns is being developed as a prerequisite for using computer models to analyse various energy policy scenarios.

Available information indicates that previous efforts at formulating a national policy, emphasize reduction of petroleum products consumption by harnessing indigenous energy resources e.g. hydropower, coal, natural gas, and biomass. Emphasis has also been placed on promoting and encouraging energy conservation and efficient energy usage. Such efforts have been directed at the commercial energy sector. For the non-commercial energy sector, there have been difficulties modelling supply and consumption of biomass energy resources due to deficiences in the data base, as well as difficulties determining or predict the effects on woodfuel supply and demand of adopting improved biomass technologies.

2.4 Electricity Generation and Distribution

2.4.1 The public supply system

At present, the electric supply system operated by TANESCO consists of an interconnected grid system serving the major towns and a number of isolated grids, serving smaller towns or areas which are located far from the main grid, see Figure 2-1. The large grid system serves primarily the towns of Dar es Salaam, Arusha, Dodoma, Iringa, Mbeya, Morogoro, Moshi, Musoma, Shinyanga, Singida, Tabora and Tanga. So far, nearly all the electricity generated is consumed in urban areas. In 1987, for example, Dar es Salaam alone consumed about 50 per cent and the six big urban centres of Dar es Salaam, Tanga, Mwanza, Arusha, Iringa and Morogoro about 87 per cent of all the electricity generated. It is estimated that less than 15 per cent of the population live in areas that are served by TANESCO. Disaggregation of the consumption by sector shows that the industrial sector accounts for the largest consumption, i.e. about 52 per cent. Residential consumption amounts to about 26 per cent.

The development of the electricity subsector has emphasized the exploitation of the country's ample hydropower resources and the extensions of the transmissions network to all major load centres which had hitherto been supplied with thermal electricity. The objective at national level has been to reduce the outlay of foreign currency needed to import petroleum products, whereas from TANESCO's viewpoint the reason for the emphasis on hydro-electricity is mainly economic.

In January 1989, the interconnected system had an installed generating capacity of 442 MW and a 420 MW rated capacity. Of the rated capacity 333 MW is hydropower plant and the rest i.e. 92 MW is existing thermal plants, see Table 2-5 for details. The grid systems consist of 220 kV, 132 kV and 66 kV lines for energy transmission and uses 33 kV, 11 kV and 0.4 kV lines for energy distribution. The frequency of the supply is 50 Hz.

The isolated load centres supplied by TANESCO are scattered throughout the country. They have a total installed capacity of 28.5 MW and a rated capacity of 27.1 MW of diesel power plants see Table 2-6. This excludes a 6 MW_e mine mouth coal fired power plant near Tukuyu, Mbeya, operated by STAMICO and built under a Chinese grant. The transmission and distribution systems at the isolated centres operate at 33 kV, 11 kV or 0.4 kV. The frequency is 50 Hz. More details about the power plants serving the isolated load centers are given in Table 3-6.

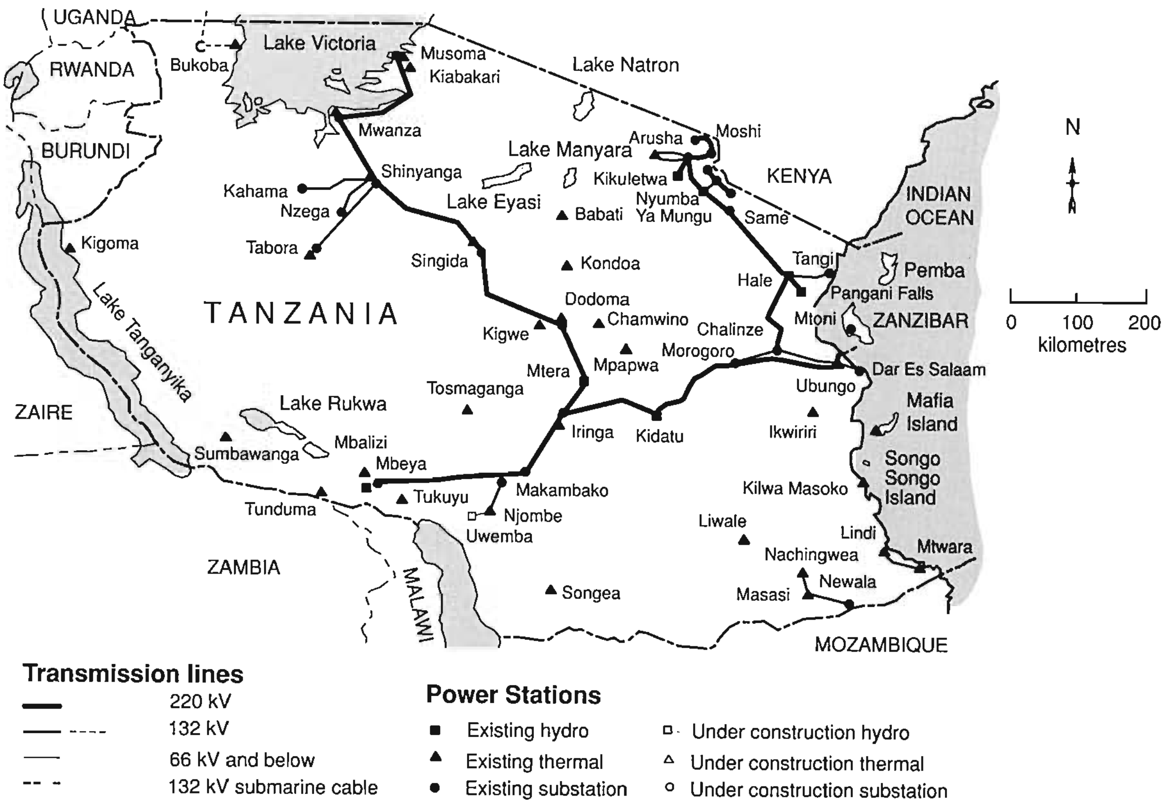


Figure 2-1 Existing generation and transmission system in Tanzania.
Based on material produced for TANESCO by ACRES International

Table 2-5 Existing generation facilities on the interconnected system (January 1989)

	Commissioning Year	Installed Capacity (MW)	Rated Capacity (MW)
(a) *Hydroelectric*			
Pangani River Basin			
Kikuletwa	1935	1.16	1.16
Nyumba Ya Mungu	1969	8.00	8.00
Hale	1964	21.00	21.00
Pangani Falls	1934	17.50	12.50
Subtotal		47.66	42.66
Great Ruaha River Basin			
Mtera	1988	80.00	80.00
Kidatu	1975	204.00	204.00
Subtotal		284.00	284.00
Other			
Tosamaganga (Iringa)	1951	1.22	1.22
Mbalizi (Mbeya)	1958	0.34	0.34
Subtotal		1.56	1.56
Subtotal Hydroelectric		333.22	328.22
Total Firm Capacity[1]		300.00	
(b) Thermal Generation (diesel)			
Arusha	1956	3.70	2.50
Dodoma Zuzu		2.58	2.58
Mbeya	1982	15.38	13.50
Musoma	1979/1985	7.350	7.350
Mwanza Nyakato[2]		13.50	12.00
Ubungo	1963	40.50	30.50
Ubungo (combustion turbine)	1973	14.77	12.50
Shinyanga		2.44	2.33

Table continued

Table 2-5 Continued

	Commissioning Year	Installed Capacity (MW)	Rated Capacity (MW)
New Singida		1.28	1.28
Tabora	1983	5.080	4.980
Subtotal Thermal		109.16	92.10
(c) Total Generation		442.38	420.32

[1] Under critical drought condition with reservoirs at minimum generating level and all units in service.
[2] Excludes Unit 3.

The isolated, thermal power stations are large loss makers. In 1987, for example, the thermal stations caused a loss of 373 million shillings to TANESCO, see Table 2-7. The total cost for this power generation was then more than twice as high as the revenues. Since then the situation has deteriorated, see section 3.12. The high cost of operating thermal power stations has serious implications for TANESCO's rural electrification programme as will be discussed in more detail later.

2.4.2 Private power generation

There are a large number of small private power generators in Tanzania, both in areas supplied by TANESCO and outside of these areas. Licenced electricity generators are registered at the Ministry of Energy and Minerals. Appendix 2 shows an overview of the installed capacities of licenced private power generators on a regional basis. Unfortunately it has not been possible to establish how complete the list is, or to what date it has been updated.

2.4.3 Plans for future public power generation and supply

Future plans include continued efforts to phase out diesel power plants (for firm energy generation) and replace them with indigenous hydroelectricity, coal and/or natural gas where it is economically attractive. Currently, detailed feasibility studies are in progress for a 60 MW Pangani Falls redevelopment in Tanga region and for the 160 MW Kihansi Hydropower Project in Iringa region. All these projects are to feed the national grid. Besides, a number of medium voltage transmission lines (mostly 33 kV), ex-

Table 2-6 Existing generating capacity at isolated locations (April 1989)

	Commissioning year	Station Capacity (MW) Installed	Rated
Babati	1981	0.525	0.525
Ikwiri	1974/1989	0.330	0.295
Mafia	1971	0.780	0.690
Chamwino		0.398	0.364
Kigwe	1974	0.078	0.070
Kondoa	1981	0.525	0.525
Mpwapwa	1970/1987	0.330/1.000	1.295
Njombe	1981	1.590	1.590
Bukoba	1961/1984	1.150/1.280	2.130
Kigoma	1956	1.630	1.590
Kilwa Masoko	1977	0.700	0.620
Lindi	1986	1.424	1.424
Liwale		0.152	0.142
Masasi	1986	4.500	4.500
Nachingwea	1954	0.750	0.650
Tukuyu	1975	1.700	1.520
Tunduma	1980	0.384	0.384
Mitwara	1969	3.838	3.350
Sumbawanga	1980	1.760	1.680
Songea	1974/1986	1.135/2.560	3.610
TOTAL		28.519	27.134

Source: Chief Generation Engineer (draft 1987 Annual Report).

Notes:
Where two commissioning dates are shown, the latter one is for the second station in the same town.

Not all rated capacity is available for use due to machines being out of service awaiting spare parts.
Tukuyu scheduled to be connected to grid system in 1991.

Table 2-7 Financial results of power generation and distribution in Tanzania (TANESCO finance managers report Dec. 1987)

Branch	Units produced and imported kWh	Units sold kWh	Losses and own cons. %	Diesel cons. kg/kWh	Production cost TAS/kWh generated	Distribution cost TAS/kWh sold	Capital cost TAS/kWh sold	Other costs TAS/kWh sold	Total costs TAS/kWh	Sales TAS/kWh sold	Surplus (+) Deficit (-) TAS/kWh sold
Total	975 111 303	946 501 700	2.93		0.64	0.18	1.26	0.46	2.56	3.94	1.38
Interconnected systems	875 366 490	865 742 020	1.10		0.14	0.16	1.23	0.41	1.94	3.89	1.94
Isolated branches:											
Bukoba	5 651 510	4 483 433	20.67	0.27	4.31	0.25	1.11	0.90	7.71	2.59	-5.11
Kigoma	6 055 979	4 451 488	26.49	0.24	4.51	0.43	1.14	1.12	8.82	6.19	-2.63
Kilwa Masoko	364 979	339 336	7.03	0.85	23.91	0.58	3.98	6.13	36.40	10.83	-25.56
Lindi	3 949 385	2 548 507	35.47	0.21	4.05	0.68	0.88	2.22	10.06	3.48	-6.58
Mafia	980 887	989 543	-0.88	0.33	9.89	0.73	1.45	1.87	13.85	3.37	-10.47
Mwpapwa	1 241 507	900 014	27.51	0.27	6.81	0.17	1.02	1.33	11.91	3.18	-8.74
Mtwara	6 039 352	4 000 004	33.77	0.30		0.65	1.88	1.64	19.24	4.77	-14.46
Musoma	9977661	7 238 181	27.46	0.32	5.50	1.14	1.31	1.25	11.27	6.44	-4.84
Mwanza	34049655	29 954 731	12.03	0.33	3.77	0.32	1.25	0.58	6.43	1.87	-1.55
Nachingwea	2049094	753 948	63.21	0.24	5.38	1.01	1.22	2.17	19.01	5.21	-13.81
Shinyanga	5057324	5 804 049	-14.77	0.28	7.04	0.17	1.04	1.22	8.56	4.49	-4.07
Songea	5255865	3 591 004	31.68	0.21	6.64	0.67	0.68	1.30	12.37	3.16	-9.21
Sumbawanga	2049336	2 658 811	-29.74	0.38	8.90	0.52	0.83	0.94	9.14	2.57	-6.57
Tabora	12456840	9 511 352	23.65	0.22	3.25	0.12	3.85	0.89	9.11	4.21	-4.90
Tukuyu	4565439	3 535 279	22.56	0.29	5.40	0.17	1.12	0.84	9.11	2.17	-6.94
TOTAL	99 744 813	80 759 680	19.03	0.29	5.04	0.41	1.52	0.99	9.15	4.53	-4.62

tending from the grid to the district towns and agro-based industries, are either under construction or under study.

The supply of hydro-electricity to Bukoba from Uganda has been found to be economically attractive and the Italian Government has shown interest in financing the project. Agrobased industries, district towns and small towns in the Kagera region will benefit from this project. A number of other possibilities for importing electricity from neighbouring countries are being evaluated. This includes studies of the techno-economic implications of electricity importation from Zambia to supply Tunduma and Sumbawanga townships and import of power from Burundi to supply Kibondo, Kasulu, Uvinza and Kigoma.

A feasibility study for the export of hydroelectricity to Mombasa, Kenya from Tanzania is also underway.

2.5 Present and Future Fuel Supply

2.5.1 Petroleum and Natural Gas

Data and projections for the consumption of petroleum products in Tanzania are shown in Table 2-8. From 1965 to 1974, the consumption increased at about 7.5 per cent annually. The growth rate then declined to 3.1 per cent – less than half the growth rate between 1965 and 1974. The projected consumption in 1990 is 1 357 390 tons, representing an average annual growth rate of about 5.7 per cent between 1980 and 1990. This projection is slightly higher than that shown in Table 2-3.

The distribution of consumption of petroleum products by economic sectors for 1986 is shown in Table 2-9. Transportation accounted for over half the consumption of petroleum products.

The importation of petroleum products has consumed an increasing share of Tanzania's total export earnings – consuming less than 10 percent of total export earnings in 1970 and rising to 64 percent of total export earnings in the first half of 1986, see Table 2-4.

In recent years, Tanzania has found it impossible to acquire credit facilities for the importation of oil and oil products. It has been necessary to finance such purchases exclusively by the export earnings. Since export earnings have been on a declining trend, as illustrated by Table 2-4, Tanzania's ability to import oil products is necessarily very limited. Dramatic increases in the importation of oil and oil products are, therefore, not

Table 2-8 Actual and projected consumption of petroleum products in Tanzania 1965 – 1990 (ton).

	Actual	Projection		
Oil product	1980	1988	1989	1990
LPG		11 820	11 820	12 530
Premium gasoline		121 300	129 600	138 400
Regular gasoline		45 000	45 000	45 000
Kerosene		139 890	148 280	157 180
Aviation fuel		92 820	99 320	106 270
Gas oil		435 300	462 550	494 930
Industrial diesel oil		71 120	74 820	76 510
Furnace oil		299 480	312 730	326 570
TOTAL	779 120	1 282 730	1 284 120	1 357 390

Source: TPDC 1988

foreseen. TPDC forecasts for the consumption of petroleum products are shown in Table 2-8.

Efforts to reduce the need for petroleum fuel imports have included exploration for petroleum and natural gas, development of the proven gas reserves at Songo Songo and conservation measures to reduce the rate of increase of the consumption of petroleum products.

Table 2–9 Consumption of petroleum products by economic sectors in Tanzania (1986)

Sector	Percent consumption
Transportation	51.1
Industrial	25.8
Household	10.5
Agriculture	7.4
Others	5.2

Exploration for natural gas and petroleum has been going on along the coastal strip of Tanzania since the 1950s. In the past few years, interest in exploration has shifted to the hinterland – areas around Lakes Rukwa, Tanganyika and Nyasa. Policies for government exploration are embodied in the Petroleum Exploration and Production Act of 1980.

The development of the natural gas at Songo Songo will lead to either using the gas to produce ammonia fertilizer or piping the gas to Dar es Salaam for use as a source of energy in industries and possibly, for power generation.

2.5.2 Coal

Tanzanian coal reserves are estimated at about 1 500 million tons of which about 200 million tons are considered proven. Development of the coal fields is expected to yield an indigenous energy source which can partly substitute for imported petroleum. Currently two coal mines are being worked. The older one at Ilima produces about 10 000 tons annually to supply nearby tea factories, burnt brick making activities, hotels and hospitals. Another coal mine with an eventual annual production capacity of 150 000 tons started operation in 1988. The main consumers of this coal are the cement factory at Mbeya, the pulp and paper mill at Mufindi, and a 6 MW_e thermal power plant at the mine mouth. There are currently no plans to build additional coal fired power plants.

2.5.3 Biomass

For the 85 per cent of the population of Tanzania living in rural areas, the main source of energy is biomass in the form of fuelwood. Although biomass as an energy source has been ignored in national energy planning in favour of commercial sources (mainly petroleum and electricity), its importance in the energy balance is very great. In 1986, fuelwood and charcoal accounted for 91.3 per cent of the final energy consumption compared to 0.7 per cent for electricity and 8.0 per cent for petroleum.

The use of fuelwood by the majority of the people, coupled with the lack of afforestation efforts, has precipitated a crisis of supply near centres of population. There fuelwood supply areas have "receded" further each year and in some cases have disappeared altogether. In the worst affected parts of the country – Shinyanga and Dodoma regions – it is not uncommon to have to travel up to 40 km in search of fuelwood.

The problems of scarcity of fuelwood in rural areas are being addressed by modest efforts at the creation of village woodlots and also by publicity campaigns urging villagers to plant two (or three) trees for each tree they cut down. Introduction of agro-forestry can be mentioned among other measures currently at the research and demonstration stage.

2.5.4 Hydropower

The hydroelectric potential of Tanzania ranges from the 1 400 MW potential at Stiegler's Gorge to microhydro power stations of a few kW. The total hydropower potential of the country has been estimated to about 48 000 MW. Many rivers, particularly in the west have not been studied and their potential energy yields are only guesses. The firm national hydroelectric power potential at sites with a potential capacity exceeding 40 MW has, however, been estimated to be about 20 000 GWh/year, which is equivalent to a capacity of 3 800 MW at a load factor of 0.6, see *(10)*. Existing hydroelectric power plants, supplying the national grid, are listed in Table 2-5. Their firm capacity is 300 MW. Apparently only a small fraction of the total potential has yet been exploited.

The total potential for mini- and microhydropower generation is less well known. About 20 plants are in operation with a total installed capacity of about 4 MW. A survey made by Katyega *(25)*, covering the capacity range up to 2 MW, has identified 75 additional potential sites, with an estimated total potential of 35 MW. Of these 75 sites, 13 have been investigated at the prefeasibility level, seven at feasibility status and two are under construction.

2.6 Capacity for Manufacturing of Equipment for the Energy Sector

Since it is a national interest to minimize the amount of foreign currency spent on imports, local manufacturing of equipment required for the energy sector is of great interest to Tanzania. Manufacturing of equipment for the electricity sector has until now been limited to components for the transmission/distribution system such as impregnated wooden poles, conductors, transformers and switch gear, to components for installations such as conductors and fuse boxes and to appliances like hot plates, light bulbs, fluorescent tubes, radios and refrigerators.

3
TANESCO's Rural Electrification Programmes

3.1 Overview

In Tanzania, rural electrification is defined as the supply of electricity to district townships, other small townships, villages, settlements, development centres, agro-based industries and other small industries outside of the regional towns. The supply can be achieved by an extension of the national grid or by installation of "an isolated generation system". All the present isolated generating systems of TANESCO are diesel power plants, but other technologies like small hydro power plants, wind power plants or biomass fuelled steam plants are also a possibility. The power demand of a typical "rural area" served by TANESCO is between a few hundred kW and a few MW.

It is not easy to define the exact date when the rural electrification programme started in Tanzania under the above mentioned definition of rural electrification. Yet it is believed that the earliest beneficiaries of rural electrification under TANESCO were the sisal estates located in the present Tanga and Morogoro regions. Serious discussion on implementing a rural electrification programme appeared in the first five years development programme for 1965 to 1970. This resulted in feasibility studies for several rural population centres in the early 1970s. A few years later, the first projects were completed. By the end of 1989 the number of rural "areas" electrified by TANESCO had reached 38. See Table 3-1 for an overview of the implementation history and Tables 1-1 and 1-2 for overviews of the present status.

More than one population centre may be covered by each electrified "area". Makambako is, for example covered by the Njombe electrification project. Likewise, the townships Gonja Maore and Ndungu and a couple of villages are included in the electrification of the Same area. The TANESCO rural electrification programme has so far provided access to electricity in 37 rural towns (30 being district towns) and more than 14 rural villages.

Table 3-1 List of planning and financing organizations for rural electrification projects

Project	Planner	Commissioned	Financier (project)
Babati	TANESCO 1971 O v. Miller 1975, GTO 1977	1980	DANIDA
Bagamoyo	O v. Miller 1975	1979	FRG
Butiama	MEM & TANESCO 1972	1974	TANESCO
Chamwino	MEM & TANESCO 1972	1975	TANESCO
Hai	JICA 1981	1984	Japan
Handeni	O v. Miller 1975	1984?	KfW
Ifakara	O v. Miller 1975	1985?	Japan
Ikwiriri	MEM & TANESCO 1972	1975	FRG
Kahama	O v. Miller? 1975	1983	FRG
Kiabakari		1974	
Kibaha	O v. Miller 1975		FRG
Kigwe	MEM & TANESCO 1972	1975	FRG
Kilosa			
Kilwa		1977	
Masoko			
Kisarawe			
Kondoa	O v. Miller 1975 GTO 1977	1980	DANIDA
Korogwe			
Liwale	MEM & TANESCO 1972	1975	
Lushoto			
Mafia	TANESCO	1971	
Masasi	Preace Cardiew 1981	1986	
Mikumi	O v. Miller 1975	1983?	FRG
Monduli		1984	
Mpwapwa		1970	
Muheza			
Mwanga	JICA 1981	1984	Japan
Nachingwea	Preace Cardiew 1981	1986	

Table continued

Table 3-1 Continued

Project	Planner	Commissioned	Financier (project)
Newala	Preace Cardiew 1981	1984	
Ndurugumi	MEM & TANESCO 1972	1975	
Njombe	O v. Miller 1975, GTO 1977	1981	DANIDA
Nzega	O v. Miller? 1975	1983	
Pangani			
Rombo	JICA 1981	1984	Japan
Same	TANESCO 1969 O v. Miller 1975 JICA 1981	1979?	Japan
Sumbawanga	O v. Miller 1975	1980	
Tarime/Utegi	O v. Miller 1975	1983	FRG
Tukuyu	TANESCO 1974?	1975	TANESCO
Tunduma	MEM & TANESCO 1972	1979	

3.2 Planning and Design of Projects

There are two levels of planning to consider in the rural electrification projects. The first level involves TANESCO staff at the head office, co-ordinated by the rural electrification department. This planning can be characterized as a preliminary desk plan supplemented by field visits to the target areas. In the process, rough cost estimates and a socio-economic evaluation are carried out and implementation plans are formulated.

The second level of planning involves foreign or local consultants commissioned to carry out feasibility studies for the selected areas. The studies involve more detailed forecasts for energy and power demand, including forecasts for daily load curves, estimations of infrastructural requirements, and socio-economic and financial analyses. If the project is deemed attractive, financing arrangements are made, often through a foreign development aid agency.

When finance is available, a consultant is requested to prepare detailed designs up to the level of tender and contract level which are reviewed to the satisfaction of TANESCO.

Depending on the size and complexity of the project, tenders can be invited for the complete installation and construction or the tenders can be split to consist of the following components:

1) Power house – erection of generation plant, the control equipment, switchgear, construction of the house, and fence.
2) Construction of access road to power house and/or main substation.
3) Erection of substations – transformers and protective gear.
4) Erection of transmission and distribution lines – poles, conductors, insulators, and accessories including protective gear.
5) Supply of vehicles and basic construction equipment.

Sometimes the list can include construction of office and staff quarters for TANESCO. Tenders indicated above can be limited to the supply of materials needed for the necessary construction and erection works. In such cases, a separate tender item for erection and construction of part of the works, or the whole works, has to be specified accordingly.

The above procedure is used particularly when foreign finance is involved. In the case of internally financed projects, planning and design has often been undertaken by TANESCO staff.

Table 3-1 shows which planning and finance organizations have been involved in the completed rural power projects in Tanzania. It can be seen that TANESCO was very much engaged in the planning of early projects but that foreign consulting companies have dominated the planning of projects since 1972.

3.3 Project Implementation

Tenders for completion of various components of the project are floated by TANESCO or the financier, world-wide or locally. Many modes of restricting the invitations are applied, including invitation by short listing, restriction to countries specified by financiers etc. In some cases TANESCO tenders to carry out erection and construction works for certain components of the project. Examples of this are the electrification of the Ifakara and Kilimanjaro regions.

The tenders received are evaluated by TANESCO and/or the financiers and the overall best offer is awarded the contract, following which supply of material, erection and construction work can commence.

The works are supervised and co-ordinated by TANESCO rural electrification staff to ensure that workmanship, quality and time of completion fall within specifications and the accepted and prescribed working regulations. When the erection and construction of the works is complete, TANESCO (together with staff from the financing agency where applicable) should supervise the commissioning of the works. Commissioning and final inspection procedures are generally specified in the tendering documents. These procedures cover test runs, tolerances, robustness, workmanship, quality and general soundness of the works.

It appears, however, that official commissioning of the works has sometimes not been carried out, or been completed. In other cases, documentation of commissioned projects has not been carried out or information has been stored in a place where it is not easily retrieved. Consequently, commissioning reports are missing for many rural projects.

After successful commissioning and final inspection, the project can be handed over to TANESCO, often climaxing in a very exciting ceremony ushered by a prominent politician and celebrated by the local people.

3.4 Financing of Projects

As indicated in section 3.3 above, there are three types of financing for rural power projects. The first involves foreign finance which can be in various forms from a 100 per cent grant to a soft loan e.g. interest free loan. The second type of finance is from internal resources, either from Treasury coffers or raised internally within TANESCO. "Self help" financing through consumers contributions, in the form of cash or necessary material for the works, has also been practised as a third form.

The above information is relevant for development of power houses, energy transformation, transmission and distribution works. In the case of service lines to the consumers, the consumers are also required to contribute a "fair" portion of the costs of the works.

3.5 Production and Distribution Technologies

In the TANESCO rural electricity programme, the electricity supply to the rural areas is achieved either by transmission from the hydro power supplied national grid or by local generation with a diesel generator set. Of the 34 TANESCO supplied rural power projects that were visited, 19 are diesel powered and the rest grid supplied, see Tables 1-1 and 1-2. The diesel power plants are equipped with at least two generator sets which feed power to main transformers at 400 V or 3.3 kV which is stepped up to 11 kV or 33 kV. There are normally two such transformers connected in parallel, with one unit being standby.

Diesel power generation has been favoured where grid connection is found more expensive. In certain cases, the diesel units have beeen installed as a temporary solution where cheaper alternatives, such as mini-hydro power generation exists. The capacity rating of the diesel power plants is chosen on the basis of the results of the feasibility studies and normally allows about 10 years projected load growth without capacity expansion. In some cases this has resulted in installations with a large over-capacity for many years after commissioning.

Transmission lines consist of an overhead single circuit, three wire at 11 kV or 33 kV. They involve simple 9–11 m wooden poles with provision of lightning arresters at the important nodes. Distribution lines consist of single circuit, four wire at 400 V. Where street lighting is involved, a fifth wire is included. Simple 7 – 9 m wooden poles are used for the distribution lines. Limited cases of underground transmission and distribution lines occur at the power houses, major substations and necessary road crossings.

There is no strict TANESCO standard for design and construction of the transmission and distribution systems. The standards used vary between projects and are generally either BS, IEC or an equivalent standard (usually of the financing country). Deviations from the standards have been noticed during the evaluation, see section 3.10.

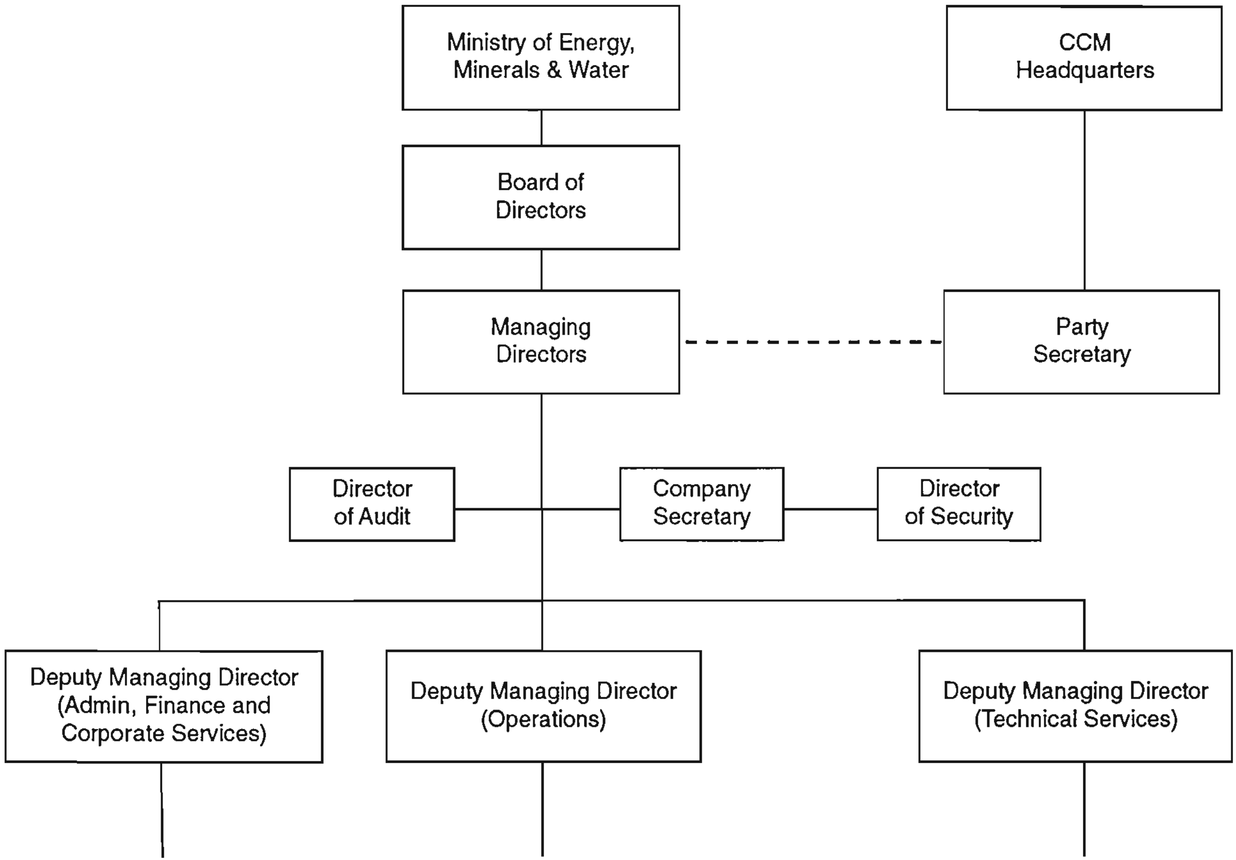
3.6 Organization of Operation, Service and Maintenance

The organization chart of TANESCO is depicted in Figure 3-1. Matters pertaining to rural electrification are handled by several directorates as follows:

— *Directorate of Corporate Services* (through the Manager of Rural Electrification) for planning and design of the projects.

— *Directorate of Projects, Design and Construction* (through the Manager of Projects and the Manager of Construction) supervises erection and construction of power houses, transmission and transformation works, staff offices and quarters.

— *Directorate of Diesel Plants* (through the Managers of Generation and


Ministry of Energy, Minerals & Water
CCM Headquarters
Board of Directors
Managing Directors
Party Secretary
Director of Audit
Company Secretary
Director of Security
Deputy Managing Director (Admin, Finance and Corporate Services)
Deputy Managing Director (Operations)
Deputy Managing Director (Technical Services)

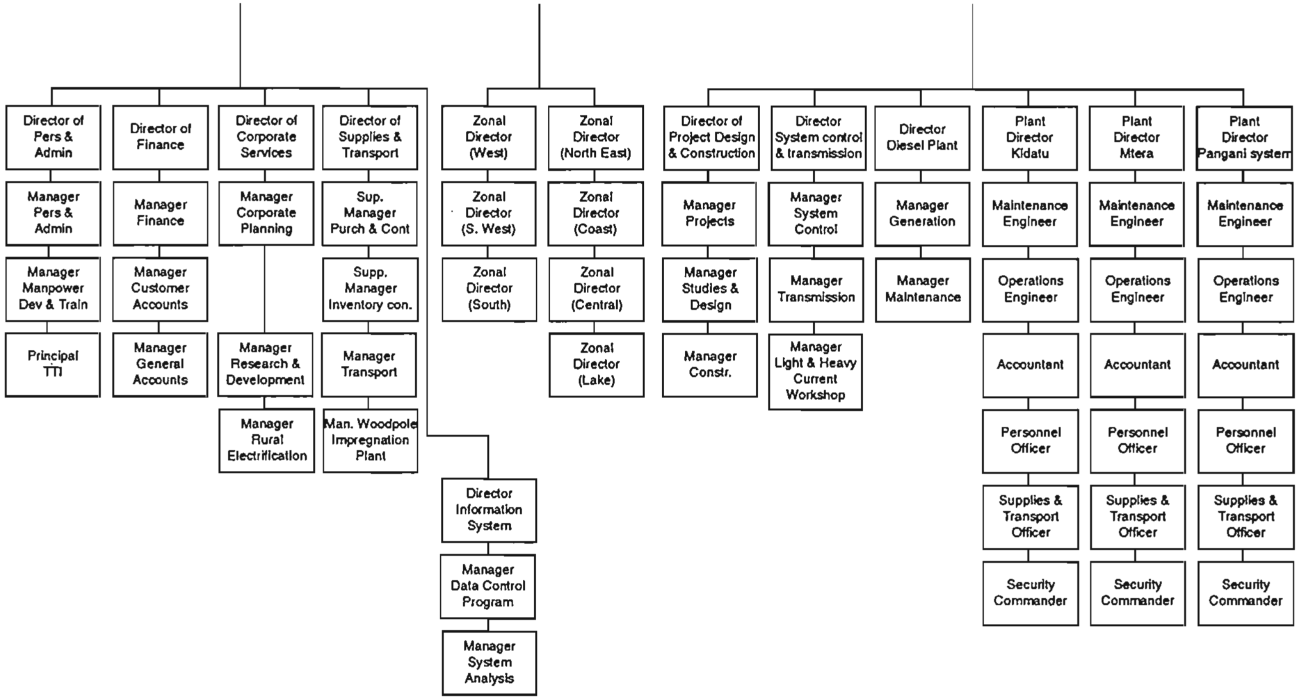


Figure 3-1 Organization chart for TANESCO

Maintenance) assists when needed for the operation of diesel power plants.

— *Directorate of Supplies and Transport* (through the Manager of Supplies) purchases fuel, lubricants, spare parts, office equipment, stationary, furniture etc; and through the Manager of Transport for the transport of the above mentioned items.

— *Zonal Directorates* (through Regional Managers and functionally through the Area Managers) for day to day operation of the rural power plants, transmission and distribution systems.

The actual service to the customers is provided by the lowest units in the organization, the "Areas". The organization charts for the "Rural Areas" are similar to the one shown in Figure 3-2, which is valid for Babati.

The Area Managers are the key persons in the day to day operation of the rural systems. The Power Station Supervisors, directly answerable to the Area Managers, run and maintain the power plants. The Mains Foremen, which are also answerable to the Area Manager, operate and maintain all the distribution systems. The "Areas" also take care of local administrative tasks like revenue collection and accounting.

The "Areas" rely on the Regional Office, the Zonal Office and the Headquarters for various services. The Manager of Generation is, for example, often contacted for co-ordination of timely supply of fuel, lubricants and spare parts via the Supplies Department. In the case of major breakdowns, the Manager of Maintenance is the one who is contacted to send a repair crew.

The "Areas" send monthly reports to the Headquarters covering the operation, progress of distribution line extensions and major events like breakdowns, repairs and supply interruptions.

3.7 Tariff Policy

TANESCO maintains a uniform tariff over the whole country, see appendix 1. There are nine tariff groups, some of which are divided into subgroups, namely:

1. **Residential**

   Applicable to premises used exclusively for domestic and private residential purposes.

2. **Light commercial**

   Applicable to shops, restaurants, theatres, hotels, clubs, harbours,

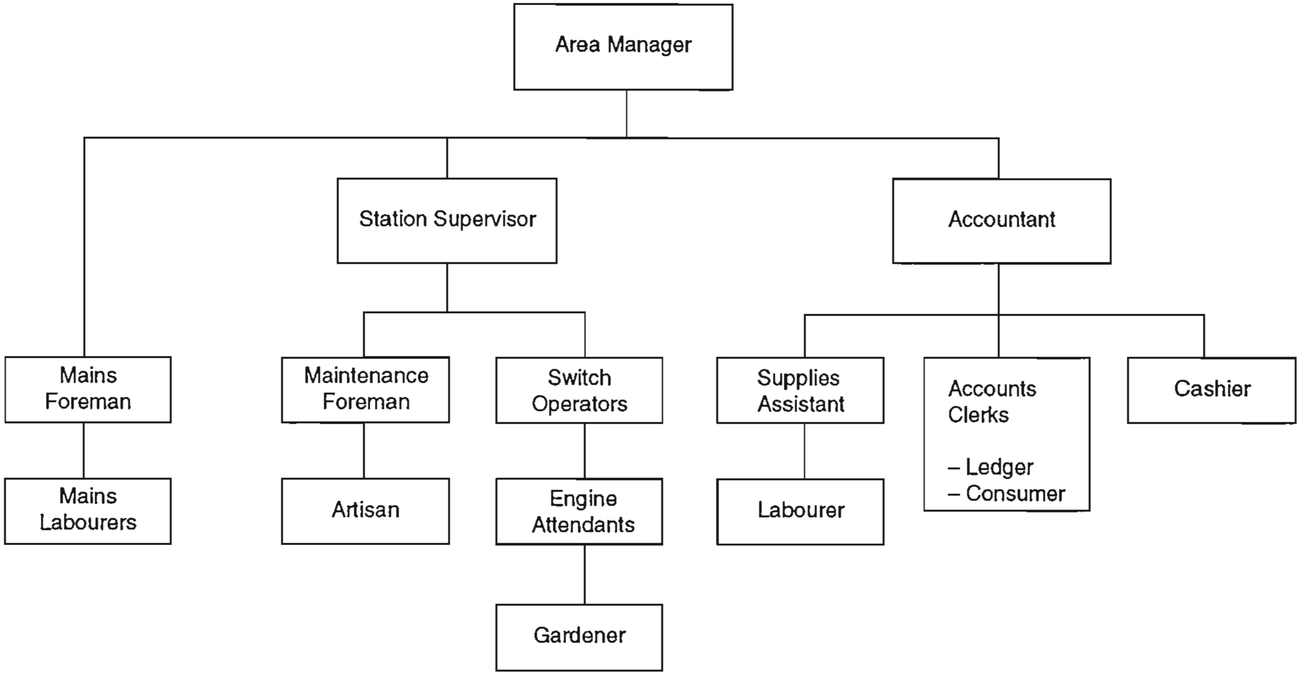


Figure 3-2 Organization of the operation in a diesel supplied area (Babati)

schools, hospitals, airports, lodging houses, groups of residential premises with only one meter, premises where similar business or trade is conducted and where the consumption is less than 10 000 kWh per meter reading period and temporary supplies.

3. **Light industrial**
Applicable to premises engaged in production of any article/commodity or industrial processing where the main use of electricity is for motive power or an electrochemical or electrothermal process *and* where the consumption is less than 10 000 kWh per meter reading period.

4. **Low voltage supply**
Applicable for general use where the consumption is more than 10 000 kWh per meter reading period.

4a. **Agricultural consumers**
Applicable to agricultural consumers engaged in direct farm production and/or processing and whose consumption is more than 5 000 kWh per meter reading period.

5. **High voltage supply**
Applicable for general use where power is metered at 11 kV or above.

5a. **High voltage supply, energy intensive customers**
Applicable to high tension consumers whose demand is above 5 000 kVA or consumption above 800 000 kWh per meter reading period.

6. **Public lighting**
Applicable to public lighting and places of worship.

7. **TANESCO**
TANESCO internal consumption and residential consumption of TANESCO staff.

8. **National Urban Water Authority**
Applicable to all installations of the National Urban Water Authority pumping installations with a consumption above 10 000 kWh per meter reading period.

9. **Zanzibar supply**

In many of the tariff groups, the tariffs are progressive, meaning that the marginal cost per kWh is higher for the users with a high consumption than for those with a small consumption. If the service charge is included, the average cost per unit consumed for users in tariff groups 1 – 3 first drops with increasing consumption at low monthly use and then increases as the progression of the tariff becomes more important. This is illustrated in Figure 3-3 which is based on the June 1989 tariff level.

The distribution of the consumers over the tariff groups in the rural areas reviewed is shown in Table 3-2. Residential and light commercial consumers are dominant. Many of the rural areas have no consumers on tariffs 4 or 5.

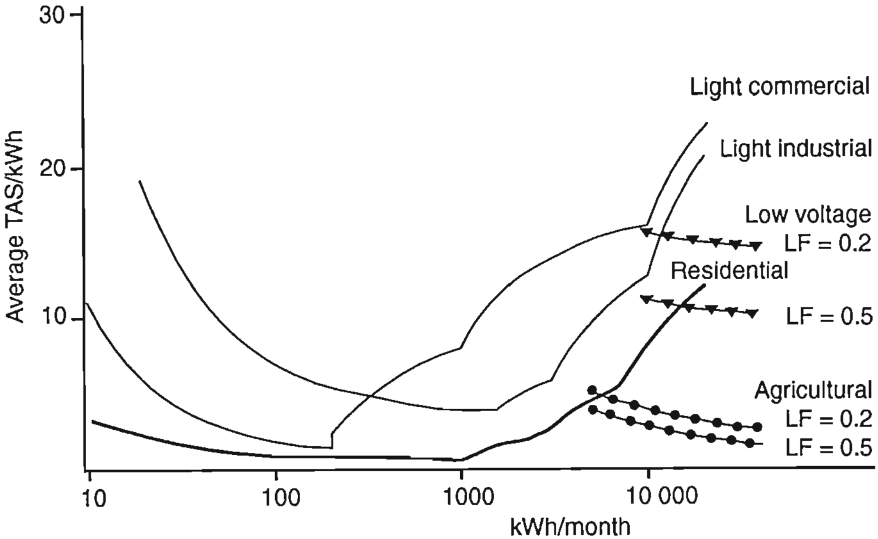


Figure 3-3 Average tariff charged by TANESCO for consumption in tariff groups 1–4 (June 1989)

3.8 Electricity Use

3.8.1 Distribution over tariff groups

Data which make it possible to compare directly how the consumption is distributed over the tariff groups in rural and urban areas, are not easily available. Some indication can be obtained, however, by comparisons between the national average distribution and the distributions established for the four rural areas reviewed in detail.

Table 3-3 shows an overview of the national electricity consumption by tariff category. Residential consumption is about 30 per cent and light commercial about 10 per cent. Consumption for various productive purposes accounts for about 60 per cent of the total consumption.

Table 3-2 Consumption structure in rural areas 1989/90 (number of consumers by tariff group)

	Tariff							
Project	1	2	3	4	5	6	7	8
Babati	262	192	14	0	0	8	1	0
Bagamoyo	614	124	0	3	0	15	4	0
Chamwino	40	4	0	1	0	30	0	0
Hai	1 088	137	42	0	1	21	1	0
Ifakara	185	106	35	1	0	10	2	0
Handeni	369	119	23	0	0	8	1	0
Ikwiriri	81	37	3	0	0	6	3	0
Kahama	255	184	21	0	0	10	1	0
Kiabakar/ Butiama	84	28	6	0	0	0	0	0
Kibaha	1 076	388	65	5	13	17	5	3
Kigwe	–							
Kilosa	733	310	76	11	0	29	3	0
Kilwa Masoko	236	82	9	0	0	3	4	0
Kisarawe	212	46	2	6	0	6	1	0
Kondoa	350	202	20	1	0	6	1	0
Korogwe	973	267	297	0	0	25	93	0
Liwale	84	31	2	0	0	25	93	0
Lushoto	884	431	62	26	0	38	4	0
Mafia	284	67	1	1	0	6	2	1
Masasi	160	110	6	0	0	7	1	0
Mikumi	96	54	9	0	0	8	1	0
Monduli	192	65	10	3	0	5	0	0
Mpapwa	738	409	55	2	0	21	3	0
Muheza	504	206	26	0	0	0	5	0
Mwanga	801	162	29	1	0	37	1	0
Nachi-ngwea	449	240	15	2	0	8	7	0

Table continued

Table 3-2 Continued

Project	Tariff 1	2	3	4	5	6	7	8
Newala	129	86	2	3	0	6	1	0
Ndrugumi								
Njombe/ Makambako	1 025	291	82	0	0	20	3	0
Nzega	493	174	20	0	1	6	2	0
Pangani	431	95	11	5	0	25	1	0
Rombo	498	217	52	0	0	13	1	0
Same	722	405	53	2	0	20	3	0
Sumbawanga	1 038	444	50	0	0	20	5	0
Tarime/ Utegi	332	200	36	1	0	10	1	0
Tukuyu	820	183	24	4	0	13	3	0
Tunduma	272	102	11	0	0	6	2	0
TOTAL	16 510	6 198	1 177	78	15	467	167	4

Table 3-3 Overview of electricity consumption in Tanzania

Tariff group	TANESCO total supply: Units sold (MWh)	Fraction of total (%)
1. Residential	310 972	29.3
2. Light commercial	113 077	10.7
3. Light industrial	44 208	4.2
4. Low voltage supply	133 666	12.6
4a. Agricultural	59 426	5.6
5. High voltage supply	149 840	14.1
5a. Energy intensive use	144 194	13.6

Table continued

Table 3-3 Continued

Tariff group	TANESCO total supply	
	Units sold (MWh)	Fraction of total (%)
6. Public lighting	4 363	0.4
7. TANESCO		
8. National Urban Water Authority	46 568	4.4
9. Zanzibar supply	54 441	5.1
TOTAL	1 060 755	100.0

For the four areas reviewed in detail, namely Babati, Njombe/Makambako, Same and Sumbawanga, the distribution is shown in Table 3-4. For all these areas, the consumption for productive purposes, i.e. within tariff groups 3 – 5, is much less than the national average. There are large variations between the areas, however, with Njombe and Same showing the largest proportion of productive consumption, ranging between 36 and 45 per cent. Babati and Sumbawanga show relatively low consumption of about 12 per cent and 7 per cent, respectively for productive use.

3.8.2 Utilization of the electricity

The structure of utilization within each tariff group is discussed in chapter 5 on the basis of the observations made during the socio-economic field studies.

3.8.3 Load variations

Data on daily load variations were collected for the four areas where detailed reviews were made, i.e. for Babati, Njombe/Makambako, Same and Sumbawanga. For Njombe/Makambako and Sumbawanga, the information is of limited value for studies of the variation in the demand, since considerable load shedding was practised. Smoothed load curves for the other two areas are shown in Figure 3-4[4].

4 Some load shedding during the evening peak, estimated to less than 10 per cent of the peak demand was also practised in Babati. Adjusting the load curve for this would not lead to a dramatic modification.

Table 3-4 Overview of electricity consumption in the areas studied in detail

Total units sold/month	Babati about 68 000 kWh		Njombe and Makambako about 300 000 kWh		Same about 685 000 kWh		Sumbawanga about 375 000 kWh	
Tariff group	Fraction of total %	Units per month and consumer	Fraction of total %	Units per month and consumer	Fraction of total %	Units per month and consumer	Fraction of total %	Units per month and consumer
1. Residential	44.4	125	34.3	141	32.5	168	60.4	274
2. Light commercial	44.0	144	19.5	200	30.0	338	32.1	364
3. Light industrial	11.6	439	45.4	2004	28.3	2024	6.6	916
4. Low voltage supply					7.6	10400		
4a. Agricultural								
5. High voltage supply								
5a. Energy intensive use								
6. Public Lighting			0.5	100	0.5	89	0.8	234
7. TANESCO			0.1	150	0.8	1458		

Notes:
The data for Njombe are not necessarily comparable with those for other sites, since substantial load shedding is practised.

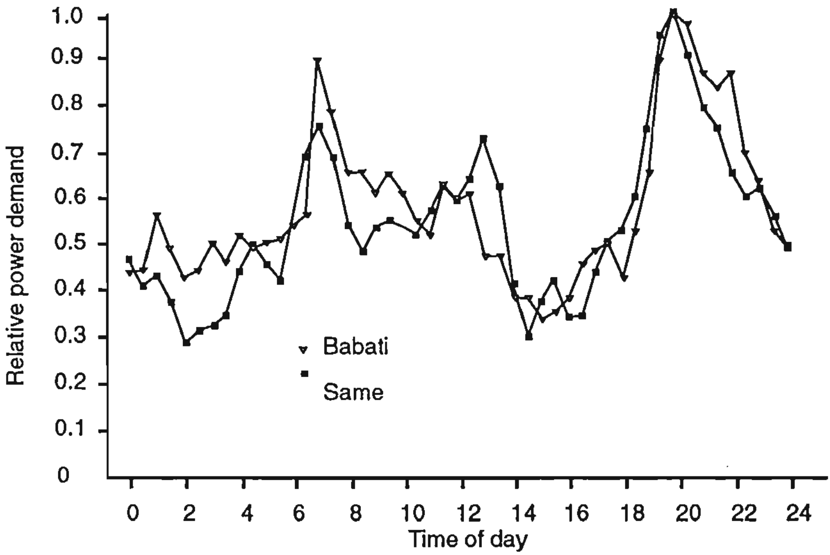


Figure 3-4 Examples of daily load curves for rural areas

Although the consumption structure is different for these two areas, see Table 3-4, the daily load variations are quite similar with a morning peak around 8 a.m. and an evening peak around 8 p.m. Other important characteristics of the daily load curves are given in Table 3-5.

Table 3-5 Some characteristics of daily load curves in two rural areas

	Babati	Same
System load factor	0.58	0.55
Minimum demand relative to peak demand	0.33	0.29
Fraction of electricity consumption between 1800 and 0600 hours	0.61	0.60

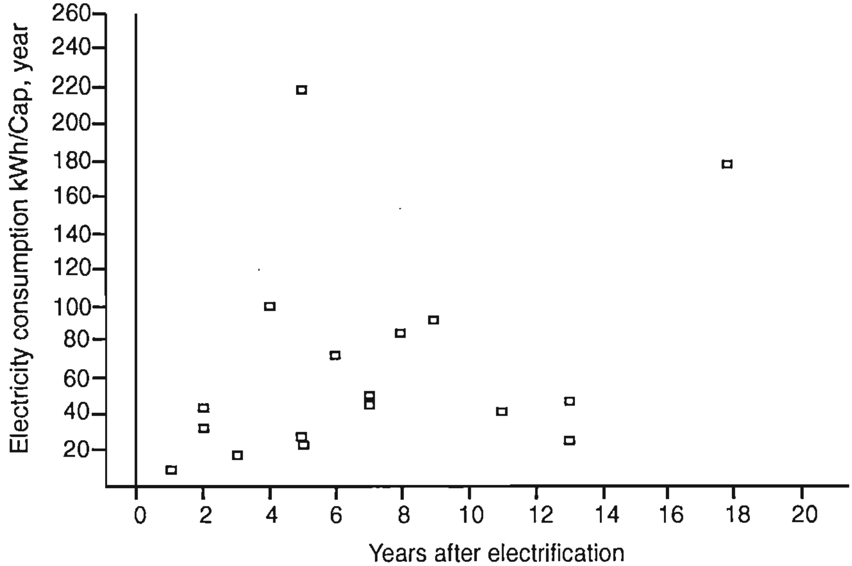


Figure 3-5 Development of per capita use of electricity in rural areas

3.8.4 Load growth

Since separate records of the units sold are not available for many of the areas, a complete picture of the load development in the rural areas can not easily be obtained. From the data that are available, it is evident, however, that the load development is very dependant on local circumstances. This can be illustrated simply by Figure 3-5, where the per capita consumption of electricity in those electrified areas where data are available, is shown as a function of the number of years after electrification. The entire population of the electrified town or village was used as a basis for the calculation of the per capita consumption[5]. Mwanga and Mafia are examples of areas with a relatively high per capita use, 220 and 177 kWh/cap,year respectively. Mwanga is also an example of extremely rapid growth. Rapid growth of the per capita use was also experienced initially in Njombe where about 100 kWh/cap,year was reached after only four years. Ikwiriri, at about 25

5 Per capita consumption data calculated in this way must be compared with some caution since the administrative boundaries used for the census data do not always coincide with reasonable boundaries of electrified areas.

kWh/cap,year after 13 years, is an example of an area with slow development in electrification.

Comparisons between projected and actual electricity consumption also show the importance of local circumstances. Figure 3-6 illustrates this for the four areas that were reviewed in detail. In the case of Same, the agreement between projections and the actual development is reasonable. It can be observed that the demand is actually higher than indicated by the amount of electricity delivered. There is a waiting list of consumers which if connected would increase the number of connections by about 10 per cent. The backlog is caused mainly by lack of material.

For Babati the load growth has exceeded the projections significantly. Examination of the data shows that this is caused mainly by major under-estimations of the specific consumption of the residential consumers. The industrial consumption was, however, grossly over-estimated.

For Sumbawanga and Njombe, the circumstances are more complex. In Sumbawanga the initial development followed the projection well. However, a fire in the power house cut down production after four years. With new capacity added, the production could again be increased and is now exceeding the original projection. Load shedding is practised which shows that the actual demand is even higher. In Njombe, the generation has developed slower than the projections. The primary reason is a major overestimation of the industrial load. The difference between reality and projections would be very large if the over-estimation of industrial load had not been compensated partly by an under-estimation of the specific consumption of the residential consumers. In the last years, production has dropped as a result of various problems with the diesel generator sets, see section 6.9 for more information. Drastic load shedding has been practised since 1989.

3.9 Status and Performance of Diesel Power Plants

3.9.1 Overview

Table 3-6 gives an overview of the status of the diesel power plants operated by TANESCO at the time of the survey, which was carried out between July 1989 and April 1990. As can be seen from the table, the situation was under control at six of the 17 sites visited, namely at Kiabakari, Kilwa Masoko, Masasi, Mpwapwa, Nachingwea and Tukuyu. At one site, Ndurugumi, the actual status of the diesel power plant is uncertain since the plant has not been

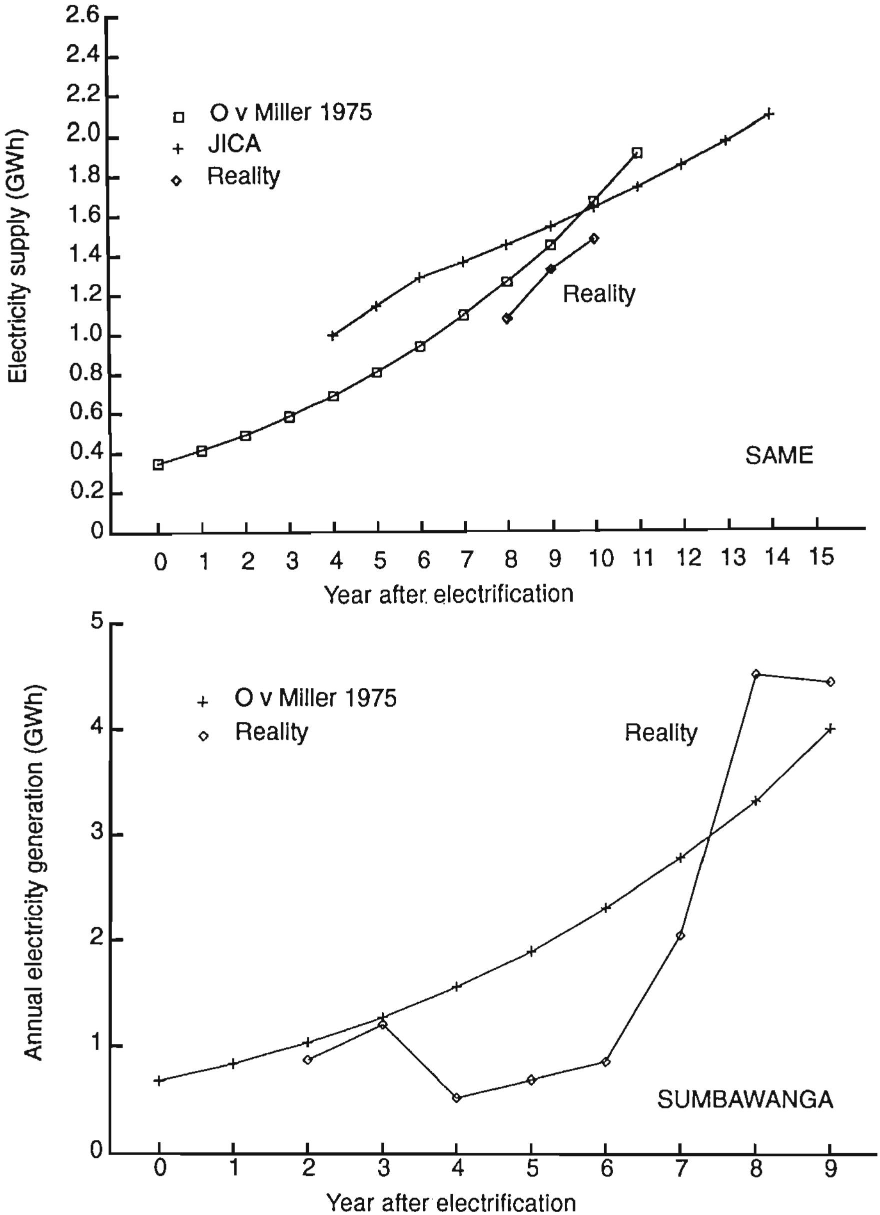
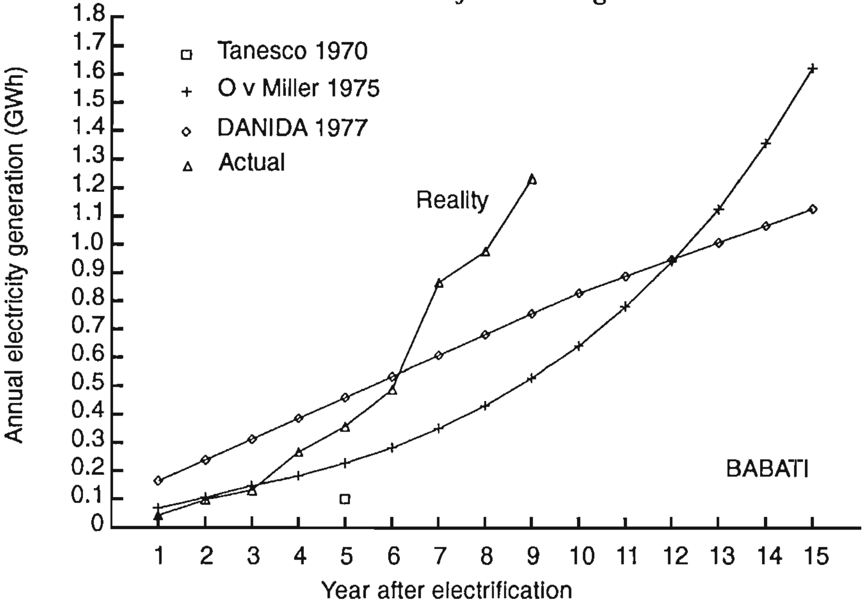


Figure 3-6 Comparisons between projected and actual load development in rural areas



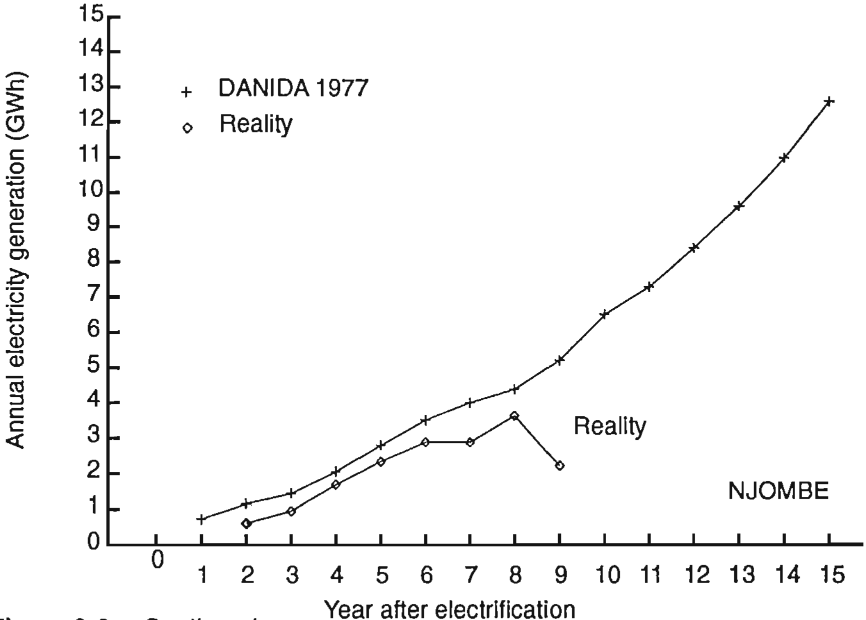


Figure 3-6 Continued

Table 3-6 Status of Diesel Power Plants

Project	Installed capacity (kW)	Available capacity (kW)	Peak demand (kW)	Remarks
Babati	3x175	2x175	380	Two sets awaiting spares
Chamwino	57 + 87	57	80	Sets awaiting spares
Ikwiriri	3x39.2+ 150	150	38	3 Sets broken down from overload. Two units of 475 kW to be installed
Kiabakari	125+2x200	200	45	Since 1985 connected to Musoma
Kigwe	2x39.2	0		No spares
Kilwa Masoko	2x350	700	260	Power station is well kept
Kondoa	3x175 + 200	170	310	Sets awaiting spares. Two units of 430 kW to be installed
Liwale	40+57.3	40+57.3	50	Difficulties with supply of fuel and lubricants
Mafia	2x345+ 100+250	345	280	No standby unit, no spares for other sets. Two units of 475 kW to be installed
Masasi	3x1 500	4 500	920	Sets in good order
Mpwapwa	2x625	1250	490	Sets in good order
Nachingwea	2x350 + 1x170+ 1x110	2x350 + 1x170	380	Sets to be moved away. Power is being imported from Masasi
Ndurugumi	2x39.2	78	0	Not operated since commissioning - no load
Njombe	3x530+ 2x220+375	140	880	Sets awaiting spares. Two units of 640 kW to be installed
Sumbawanga	2x500	1 000	above 1 000	Two 640 kW units being installed
Tukuyu	2x350 + 2x500	1 510	200	One set under repair
Tunduma	2x104 + 176	205	290	Spare parts needed

operated for many years due to lack of load. From one of the sites, Liwale, difficulties with fuel and lubricant supplies was reported. At the other nine sites, there were more or less serious technical problems which resulted in significant reduction in the supply reliability.

At seven sites, namely Babati, Chamwino, Kondoa, Kigwe, Njombe, Sumbawanga and Tunduma, the available capacity was not sufficient to meet the peak demand. The situation was handled by load shedding, either during peak load hours or permanently. At all these sites the installed capacity should be adequate, but many of the broken down generator sets had, in reality, been retired. For others, lack of spare parts prevented repairs.

At Ikwiriri and Mafia, the available capacity was still able to meet the peak demand. However, there was only one generator set operational which implies that there would be no supply when the unit is serviced and if a breakdown occured.

It was noticed during the survey that most of the diesel power plants have no adequate storage facilities for consumables and spare parts. A suitable workshop area and a running stock of spare parts and tools for carrying out minor and major overhauls is not available at most of the sites. At many sites, in particular those with transferred sets, operation manuals for the generator sets are lacking, which of course makes service, maintenance and repairs more difficult. Several sites lacked serviced fire extinguishers.

A programme for rehabilitation of diesel power stations based on Wärtsilä 624TS and 424TS diesel generator sets, with rated capacities 640 kW and 430 kW respectively, is being implemented. This will solve the current capacity problems at Babati, Ikwiriri, Kondoa, Njombe, Mafia and Sumbawanga even though it is questionable whether this is the best solution at some of the sites[6].

3.9.2 Fuel and lubricant consumption

For the diesel power plants, the costs of fuel and lubricants dominate the cost of the electricity supply. Table 3-7 presents a summary of the data relating fuel and lubricant consumption collected from the operating records of the power plants. Where comparisons with rated specific consumptions are possible, the recorded data are generally 10 to 20 per cent higher.

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6 Grid connection appears as a better solution for Njombe. For Babati, Kondoa, Ikwiriri and Mafia, the generator sets appear to be oversized. Cheaper temporary solutions can be considered in Babati, which is scheduled for grid connection in 1993.

Table 3-7 Fuel and lubricants consumption for diesel gensets in rural electrification projects

Site	Rated capacity kW	Units generated MWh/year	Plant load factor	Engine manufacturer speed and rated power of the gensets	Fuel and lubricant consumption Period recorded	Diesel (kg/kWh)	Lubr. oil (kg/kWh)
Babati	525	979	0.32	Dorman, 1500 rpm 3*175 kW	1985 – Jun '89	0.364	0.0038
Chamvino				????, 1500 rpm, 57 + 87 kW	1988 – 1989	0.611	0.0196
Ikwiriri	270	121	0.05	Polyma, 1500 rpm 3*40 kW	1988 – 1989	0.403	0.0530
Kilwa Masoko	700	444	0.07	Ruston, 500 rpm, 2*338 kW	1988 – 1989	0.455	0.0123
Kondoa	525			Dorman, 1500 rpm, 3*175 kW	1987 – 1990	0.372	0.0085
Liwale	97	30	0.04	Polyma/Deutz, 1500 rpm, 40 kW	1988 – 1990	0.412	0.0150
				Dorman, 1500 rpm, 57 kW			
Mafia	1040	988	0.11	Mirrless, 750 rpm, 2*345 kW	1988 – 1989	0.323	0.0132
				Deutz, 1500 rpm, 100 kW			
				Caterpillar, 1500 rpm, 250 kW			
Masasi	4500	2590	0.07	Blackstone/Mirrless, 500 rpm, 3*1772 kW	1988 – 1989	0.264	0.0015
Mpwapwa	1000	1744	0.20	Wärtsilä, 750 rpm, 2*500 kW	1987 – 1990	0.273	0.0020
Njombe	1590	3130	0.22	Dorman 1000 rpm, 3*530 kW	1986 – 1988	0.281	0.0028
Sumbawanga	1000	4492	0.51	Wärtsilä, 750 rpm, 2*500 kW	1988 – 1989	0.249	0.0018
Tukuyu	1200			Wärtsilä, 750 rpm, 1*500 kW, 2*350 kW	1988 – 1989	0.309	0.0069
Tunduma				Cummins, 1500(?) rpm	1988 – 1989	0.401	0.0079

There are large variations between the installations. These can partly be explained by differences in technology, the condition of the engines and the load conditions. Howver, some installations show very high specific consumptions of fuel and lubricants and an investigation of the reasons for this appears to be justified.

At the three diesel supplied areas which were reviewed in more detail, i.e. Babati, Njombe and Sumbawanga, attempts were made to measure the fuel consumption for the load conditions prevailing during the visit. The fuel consumption data obtained in this way are in good agreement with the data retrieved from the operating records.

3.9.3 Operating personnel

Table 3-8 shows examples of lists of operating personnel for diesel power plants operated by TANESCO. It is apparent that it is difficult, even for installations with a small capacity, to maintain a continuous supply with a technical crew of less than nine persons. Problems caused by a lack of qualified personnel for service and maintenance were reported at several sites.

3.9.4 Technical reliability

Due to difficulties in retrieving accurate data from the operating records, evaluations of technical reliability[7] were only attempted for the three sites that were reviewed in detail, i.e. Babati, Njombe and Sumbawanga.

Only for Babati was it possible to use the records to estimate the technical reliability for the generator sets. This was found to bean average of 63 per cent for the eight year period from 1981 to 1988, with small variations between the years. Engine failures accounted for 65 per cent of the downtime and generator failures for about 35 per cent. It is interesting that the total experienced downtime of about 77 000 hours was caused by only 12 failures. Difficulties with spare parts supplies resulted in very long downtimes for fairly trivial failures, which could have been repaired in less than a week if spare parts had been available. Although it has not been possible to collect quantitative data at other sites, the observations made during the survey indicate that the situation is similar for most of the diesel power plants operated by TANESCO. The low technical reliability has also resulted in a low supply reliability as further discussed in section 3.10.4.

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7 Reliability is used here as synonymous with availability, the term more commonly used in technical literature.

Table 3-8 Operating personnel for diesel power plants

Installed capacity Site kW	Liwale 97	Ikwiriri 267	Babati 525	Kilwa Masoko 700	Sumba- wanga 1 000	Mafia 1 040	Masasi 4 500
List of personnel:							
Station supervisor		1	1	1	1	1	1
Switchboard operators	1	1	4	4	1	4	4
Engine attendants	3	3	4	5	3	4	8
Maintenance foremen				1			1
Auto diesel technicians					1	1	1
Fitters	1			3	3	2	3
Technicians					1		1
Workshop foremen							1
Welders							1
Cleaners			2	1	2		3
Security guards	7	4	8	4	9	4	8
TOTAL	12	9	19	18	21	15	30

3.9.5 Lifetime of generator sets

Operating records for individual generator sets were only evaluated for the three sites reviewed in more detail, i.e. Babati, Njombe and Sumbawanga. Table 3-9 gives an overview of the operating records of the generator sets at those sites. Five of the generator sets installed at these sites have been retired, four after break-downs and one after a fire. Those which were retired after break-downs, presumably "beyond repair", had accumulated between 16 000 and 34 000 hours. This is much less than should be expected with proper service and maintenance. The reason for the short lifetimes is, without doubt, that scheduled major overhauls are not carried out. In the case of the Dorman/Kosan Frichs engines in Njombe, a major overhaul is scheduled for

Table 3-9 Operating records of diesel generator sets in Babati, Njombe and Sumbawanga

Engine type and speed	Accumulated operating hours: Earlier	On site	Total	Status at time of survey
Babati				
Dorman 6QT, 1 500 rpm	0	14 527	14 527	Waiting for spare parts
Dorman 6QT, 1 500 rpm	0	22 097	22 097	Operational
Dorman 6QT, 1 500 rpm	0	11 995	11 995	Operational
Njombe				
Dorman/Kosan Frichs, 1 000 rpm	0	17 349	17 349	Retired
Dorman/Kosan Frichs, 1 000 rpm	0	25 329	25 329	Retired
Dorman/Kosan Frichs, 1 000 rpm	0	34 289	34 289	Retired
Rolls Royce, 1500 rpm	unknown	233	unknown	Retired – cannibalized for spares
Rolls Royce, 1 500 rpm	unknown	5 392	unknown	Operational
Deutz, 1 500 rpm	unknown	1 975	unknown	Waiting for spares
Sumbawanga				
Cummins NTA	0	11 476	11 476	Damaged by fire. Brought to Dar es Salaam for repair
Cummins VTA	0	16 004	16 004	Retired
Paxman 6RPH Mk3	unknown	8 194	unknown	Transferred to Mafia
Paxman 6RPH Mk3	unknown	97	unknown	Damaged by fire
Caterpillar D353	unknown	4 346	unknown	Transferred to Ikwiriri
Wärtsilä 424TS, 750 rpm	0	26 776	26 776	Operational
Wärtsilä 626TS, 750 rpm	0	21 341	21 341	Operational

every 10 000 hours. This had not been carried out for any of the three engines although accumulated operating hours far exceeded this number. A similar situation was reported from Babati, where the engines were still not retired.

The following reasons were given why major overhauls had not been carried out:

— lack of replacement spares such as seals, big end bearings, piston rings;
— lack of working tools;

— lack of lifting equipment; and
— lack of qualified personnel to carry out such jobs as servicing of fuel injector pumps and turbochargers.

3.9.6 Environmental impacts

The survey of the diesel power plants did not include measurements of emissions from the installations. It was observed, however, that oil leakage occurred at several sites. Babati, Liwale, Mafia, Mpwapwa, Njombe, Sumbawanga are examples. Due to lack of functioning oil interceptors and incinerators, the oil leaks into the ground outside the power plant. Mafia is an example of a highly oil littered premises.

A separate study of environmental impacts from TANESCO diesel plants was carried out in July – August 1990 as another part of the TANESCO/SEI research co-operation, see *(31)*. The study covered Babati, Kondoa, Mpwapwa, Tukuyu and Mafia and shows oil spills with potential water pollution as the major external problem and noise as the main occupational health problem. Oil spills were found to range from 0.02 to over 10 liters/hour. Noise levels in the machine rooms of the power houses were generally found to be in the range of 100 dB(A). Atmospheric emissions were comparatively small in absolute quantity and cannot be considered a problem at the present level of operation.

The study points out that solutions are possible for the oil spill problem and the noise problem. The oil spills could be collected with proper drainage systems and the effluents incinerated, for example in incinerators of the types used on ships. Ear-mufflers could be used to reduce the risk of engine noise causing damage to the operators' hearing.

3.10 Status and Performance of Transmission and Distribution Systems

3.10.1 Overview

Tables 3-10 and 3-11 summarize data for the transmission and distribution systems of the rural areas. A comparison of line lengths per MWh delivered annually is given in Figure 3-7, which shows that the length of 33 kV transmission lines ranges from 29 to 87 m/annual MWh, the length of 11 kV transmission lines from 2 to 27 m/annual MWh and the length of distribution lines from 4 to 48 m/annual MWh. The latter number must be con-

Table 3-10 Status of transmission and distribution systems

	Main transformer stations (kVA)				Line length (km)		
Area	0.4/11 kV	11/33 kV	33/11 kV	132/33 kV	33 kV	11 kV	.4/.23 kV
Diesel supplied							
Babati	2*400					9	14.9
Chamwino	315					3.7	2.5
Ikwiriri	300				0	2.1	3.2
Kigwe					0		
Kilwa Masoko	1 500				0	3.2	3.2
Kondoa	725					15	59
Liwale	250						
Mafia	400				0	16.3	6
Masasi		2*500			0	12.4	19.5
Mpwapwa	2*625				0	11.1	25.2
Nachingwea			2 500		47	18.9	12
Ndurugumi					0	1.8	0.8
Newala			2 500		65	39.8	9.8
Njombe/ Makambaku	2*1 000	1 000			78	27.6	107.3
Sumbawanga	2*800					11.3	20
Tukuyu	500					50.2	15.7
Tunduma	315					4	5.5
Urambo					0	2.3	7.4
Grid supplied							
Bagamoyo			1 500		44	6	11.3
Kiabakari/Butiama	656		100		40	30	
Hai			2 500		21.5	70.1	59.8
Handeni					87.9	0	9.3
Kahama			100		75	8	6
Kilosa			300				
Kisarawe			5 000				

Table continued

Table 3-10 Continued

	Main transformer stations (kVA)				Line length (km)		
Area	0.4/11 kV	11/33 kV	33/11 kV	132/33 kV	33 kV	11 kV	.4/.23 kV
Korogwe			7 550		189.8	98	
Lushoto			3 000		188		
Mikumi			500				
Monduli					45		
Muheza			3 450		99.8	44	
Mwanga					54	44	15
Nzega			500		33	8	12
Pangani			1 500		43.2	50.7	
Rombo					54.5	0	25
Same			3 025	5 000	52		
Tarime/Utegi					150	0	8

Table 3-11 Capacities of booster and distribution transformers in rural areas (kVA)

	Booster transformer stations				Distribution transformer stations							
Branch	.4/.4 kV		33/33 kV		33/.4 kV		11/.4 kV		33/.23 kV		11/.23 kV	
	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity
Babati							6	550				
Chamwino							4	275				
Ikwiriri							3	350				
Kigwe							0	0				
Kilwa Masoko							4	750				
Kondoa							8	550				
Liwale							3	138				
Mafia	1	300					4	500				
Masasi							11	615				

Table continued

Table 3-11 Continued

	Booster transformer stations				Distribution transformer stations							
Branch	.4/.4 kV		33/33 kV		33/.4 kV		11/.4 kV		33/.23 kV		11/.23 kV	
	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity
Mpwapwa							9	1 030				
Nachingwea							14	1 945				
Ndurugumi							0	0				
Newala							10	1 650				
Njombe/ Makambaku					4		9					
Sumbawanga							14	1950				
Tukuyu							33	3 075				
Tunduma							3	175				
Bagamoyo							9	600				
Kiabakari/Butiama							11	1 580				
Hai					7	3 715	45	2 950	2	50		
Handeni					12							
Ifakara					12	1 300						
Kahama					1	50	6	450				
Kibaha					24	5 585	15	2 150				
Kisarawe							17	1 700			2	50
Kilosa					18	4 215	3	400				
Korogwe			2	4 000	14	2 850	48	6 000			32	650
Lushoto					5	1 200	37	5 650			25	390
Mikumi					1	50	7	815				
Monduli							15					
Muheza					4	600	30	3 950	2	50	13	260
Mwanga					11		17					
Nzega							7	715				
Pangani					4	800	18	1 800			12	205
Rombo							30	2 000				
Same					4	200	22	1 875				
Tarime/Utegi					14	1 350						

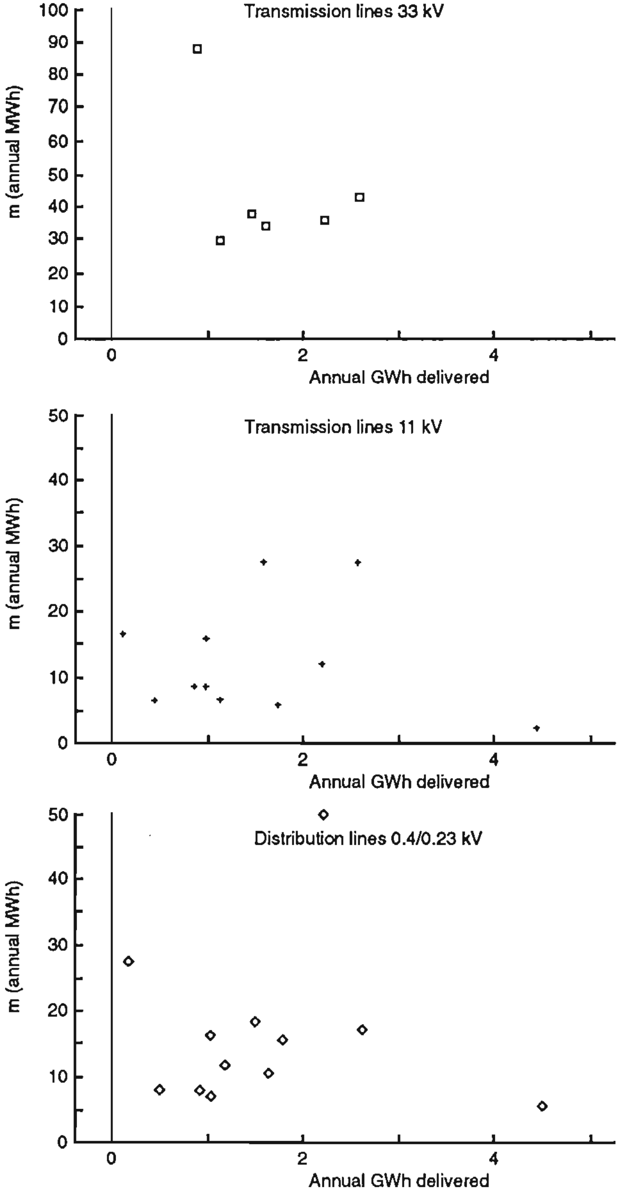

Figure 3–7 Transmission and distribution line length per annual number of units delivered

sidered as uncertain since it is possible that the records on distribution line length are not always kept up to date.

3.10.2 Condition of transmission and distribution systems

At all the areas surveyed, a visual inspection of the transmission and distribution systems was carried out. The results are summarized in Table 3-12. As indicated in the Table, rotten wooden poles, vandalized stay wires, lack of fuses and silica gel for distribution transformers and faulty lightning arresters are commonly found problems in the rural transmission systems. For the distribution systems, long single phase power lines, use of too small conductors, and uncoiling of conductors feature as major problems.

Some cases of deviations from BS and IEC standards, including use of too small conductors for transmission, distribution and service lines, has been identified. The standards regarding maximum length for single phase service lines also appear to have been disregarded in a number of rural systems.

The street lights were found to be in poor condition in many rural areas.

3.10.3 Supply quality

No problems with frequency control were identified in the survey. Variations appear to be within the acceptable range of 1 per cent. Low voltage and voltage fluctuations outside of the acceptable range of 5 per cent were, however, reported from all the four areas studied in more detail. Long and undersized conductors and loose connections are a major contributor to these problems. At Same, which is supplied from the national grid, it was noticed that large voltage fluctuations occurred, outside of the range the voltage control system at the substation could handle.

There were no records at the local TANESCO offices of consumers demanding compensation for damage to appliances caused by voltage fluctuations. However, in Njombe it was noticed that there are shops in the town specializing in rewinding and repairing damaged appliances.

3.10.4 Supply interruptions

Apparent supply interruptions recorded in the rural areas surveyed are summarized in Table 3-13. The records are very incomplete for most of the diesel supplied areas and, therefore, data have only been included for the three diesel supplied areas studied in detail. From the table it can be seen that there are usually more interruptions for the diesel powered systems than for

Table 3-12 Condition of transmission and distribution systems in rural areas

Project	Sub-station meters	Line clear-ance	Wooden poles	Conduct. sizes	Conduct. condn	Trafo condn	Service Lines	Protect gadgets	Street lights
Babati	na	ok	ok	ok	tr-ok dr-ok sl-not	ok	lines too long no line taps conduct uncoiled	fuses missing	bad cond
Bagamoyo	exist	ok	ok	ok	tr-ok dr-ok	ok	fair	fairly good	
Butiama	na	ok	ok	ok	tr-ok	silica	ok	light arresters	poor
Chamwino	na								
Hai	none	poor	ok	ok	tr-ok dr-ok	ok	ok	ok	
Handeni	none		rotten	?	?	??			
Ifakara	none	poor	poor stay wire	ok	tr--ok dr-ok	ok	ok	fuses & light arresters	poor
Ikwiriri	na	ok	rotten	ok	dr-poor	ok	lines too long	light arresters	
Kahama	exist - broken	ok	rotten stay wire	small	ok			fuses damaged	
Kiabakari	none	ok	ok	ok	ok	silica	ok	light arrested	fair
Kibaha	exist	ok	ok	ok	ok	silica	lines too long		
Kigwe	na	?	?		?		?		
Kilosa	none	ok	rotten	ok	ok	silica	fair	fuses, light arresters	
Kilwa Masoko	na	ok	ok	ok	ok	silica	cond uncoil	fuses missing	

Table continued

Table 3-12 Continued

Project	Sub-station meters	Line clear-ance	Wooden poles	Conduct. sizes	Conduct. condn	Trafo condn	Service Lines	Protect gadgets	Street lights
Kisarawe	none	poor	ok	ok	ok	silica	lines too long	light arresters	
Kondoa	na								
Korogwe	none	?							
Liwale	na	ok	rotten	ok	ok	silica	ok	ok	
Lushoto	none	?							
Mafia	na	fair	ok	too small	ok	ok	ok	light arrested	poor
Masasi	na	poor	ok	ok	ok	ok	ok	ok	
Mikumi	none	ok	ok	ok	ok	silica	ok	fuses, light arresters	poor
Monduli	none	?	?						
Mpwapwa	na	?		too small					
Muheza	none	?	rotten	?	?				
Mwanga	none								
Nachi-ngwea	exist	poor sags	rotten	ok	ok	silica	lines too long	fuses	
Newala	exist	ok	ok	ok	ok	silica	ok	ok	
Ndurugumi	na	?	?	?					
Njombe/ Makamb	na	ok	ok	ok	ok	?	?		
Nzega	broken	ok	stay wire	tr-ok dr-not	ok	over-load silica	lines too long strands uncoiled	fuses missing	
Pangani	none	?	?						
Rombo	none	poor	ok	ok	ok	?			
Same	inadequ.	ok	ok	ok	ok	ok	lines too long	fuses missing	
Sumbawa-nga	na								

Table continued

Table 3-12 Continued

Project	Sub-station meters	Line clear-ance	Wooden poles	Conduct. sizes	Conduct. condn	Trafo condn	Service Lines	Protect gadgets	Street lights
Tarime/ Utegi	none	ok	stay wire	ok	ok	silica	ok	light arresters	poor
Tukuyu	na	poor	stay wire	ok	ok	silica	fair	light arresters	
Tunduma	na	fair	rotten stay wire	ok	ok	silica	fair	fuses	

Notes:
na not applicable
ok okay
tr transmission
sl service line
dr distribution
inadeq inadequate

those supplied from the grid. There are, however, some examples of grid supplied systems very low supply reliability.

It should be noted that the black-out data for the diesel supplied systems are given for the substation level. Therefore, the reliability of supply for the average consumer is better. For the grid supplied systems, the data refer to complete black-outs since data for the substation level could not be retrieved. An interesting point highlighted by Table 3-13 is that the grid supply does not necessarily guarantee better reliability. This issue is discussed further in section 6.9.3.

Reasons for supply interruptions in the diesel supplied systems are shown for the most recent year in Table 3-14. As can be seen, load shedding is the main contributor for all the three sites reviewed. At two of the sites, Babati and Sumbawanga, the load shedding is a consequence of load expansion over the years that cannot be matched with the installed generation capacity. In Njombe, the generation capacity has deteriorated as a result of retirement of generator sets without adequate replacements, and break-downs with a long waiting time for spare parts.

Table 3-13 Supply interruptions for grid and diesel supplied systems

Site	Year 1986	1987	1988	1989	Black-out time fraction of recorded period
Grid supplied					
Bagamoyo	142	131	99	46	0.0119
Hai	189	48	34	30	0.0086
Handeni	205	203	102	461	0.0277
Kahama			1 388	1 489	0.1642
Kiabakari	No records available				
Korogwe	943	1 393	960	2 104	0.1541
Lushoto	1 002	646	586	697	0.0836
Muheza	41	15	19	25	0.0029
Mwanga			142	110	0.0144
Nzega		841			0.096
Pangani	99	308	94	342	0.0241
Rombo	No records available				
Same		339	200		0.0308
Tarime/Utegi				[1]	0.181
Diesel supplied isolated grids [2]					
Babati			501	[3]	0.0572
Njombe [4]	189	197	1 245	2 955	0.1309
Sumbawanga [5]	1 400	1 540	1 220	1 250	0.1544

Notes:

[1] Incomplete records. 925 black-out hours during June - December 1989

[2] Data refer to total substation outage hours. Supply reliability to average consumer is higher.

[3] Regular load shedding is practised of two substation phases since June 1989

[4] Part of the load is permanently shedded

[5] Load shedding not included in the records. Estimated as 2.6 hours/day and included here.

Table 3-14 Reasons for supply interruptions in diesel supplied systems

Site	Interruption hours distributed by reason for interruption			
	Mechanical failure	Tripping	Load shedding	Lack of fuel or lubricants
Babati 1988	50	57	394	0
Njombe 1989	524	141	2 245	45
Sumbawanga 1989	213	77	936	30

3.10.5 Power factor

Since a fair portion of the supply is required for the lighting load, the power factor for most of the rural areas is expected to be about 0.9 or better. However, observations made during the visit to Babati and historical records from Njombe show very low power factors, i.e. down to 0.5. Later information, see *(30)*, indicates that, at least for Babati, the observations may have been misleading due to faulty meters.

The most likely reason for poor power factors are machines which consume principally reactive power such as welding sets and compressors used mostly in workshops, garages, blacksmiths etc. Sometimes, consumers in tariff 1 use such machines which are supposed to be in tariffs 3, 4 and 5. Since tariff 1 consumers do not have kVA meters, there is no charge for the reactive power consumed.

3.10.6 Energy losses

Records which make it possible to establish the losses in transmission and distribution, as the difference between units sold and units imported or generated, are not available for most of the rural areas surveyed. Data for areas that are separate branches can be found in the Finance Managers Reports. For those areas that were studied in more detail, i.e. Babati, Njombe, Same and Sumbawanga, sample comparisons between units sold and units imported or generated were made for a few months, using data in the consumers ledgers to determine units sold. The available information on the energy losses in the rural areas is summarized in Table 3-15. It should be noticed that differences between units sold and units imported or generated are the sum of:

— electricity used in works,

Table 3-15 Electrical losses in transmission and distribution systems

Grid supplied sites		Sites supplied with diesel gensets	
Site	Difference between imported and sold units	Site	Difference between generated and sold units
Bagamoyo	Comparable data for imported and sold units not found	Babati	25–30 % difference between units generated and sold
		Chamvino	No data available
Hai	Data for units imported and sold are missing	Ikwirire	Data for units sold missing
		Kigwe	No data. Units out of service since Feb. 1988
Handeni	Data for units imported and sold are missing	Kilwa Masoko	Data error expected. Units sold exceed units generated
Kahama	Less than 1% difference between recorded units imported and sold	Kondoa	Data for units sold missing
		Liwale	Data for units sold missing
Kiabakari	Data for units imported and sold are missing	Masasi	Data for units sold missing
		Mafia	6 –10 % difference between units generated and sold. 2 % reported lost in distribution 1988
Korogwe	Data for units imported and sold are missing		
Lushoto	Data for units imported and sold are missing	Mpwapwa	18 % losses in distribution reported for 1988
Muheza	Data for units imported and sold are missing	Njombe	36–57 % difference between units generated and sold
Mwanga	Data for units imported and sold are missing	Ndugurumi	Generator sets never operated since commissioning
Nzega	No records of units sold. Area manager estimated more than 80% difference	Sumbawanga	18–21 % difference between units generated and sold. 7% reported lost distribution 1988
Pangani	Data for units imported and sold are missing	Tukuyu	21 % difference between units generated and sold. 16 % reported lost in distribution 1988
Rombo	No records of units imported		
Same	7 - 17 % difference between units imported and sold	Urambo	Generated and sold units are not recorded
Tarime/Utegi	Data for units imported and sold are missing		

— electricity supplied to own premises,
— transmission/distribution losses, and
— other losses.

The few quantitative data available indicate that the losses are significant for some areas. Although observations made during the inspections of the distribution systems do give reason to expect high technical losses, the estimates of the losses presented in Table 3-15 must be considered as uncertain. A later pilot study for more accurate determination of the technical losses in rural systems made for Babati (as part of other research co-operation between TANESCO and SEI), indicates technical losses in the range 11 – 19 per cent, see Arnborg et al. *(30)*. Most of the losses, about 12 per cent, arise in the 400 V distribution system. The losses in the 11 kV system were found to be about 2 per cent.

This study showed that the load was very asymmetric. All consumers of one tariff group were often connected to the same phase at the substation. The magnitude of the current could differ by a factor of 30 between the phases.

3.11 Rehabilitation Needs

As a result of the poor condition of some of the rural power systems, a national rural rehabilitation programme is required. Table 3-16 summarizes the various shortages and rehabilitation requirements for the systems.

It can be seen that some form of rehabilitation of the distribution systemis required in 20 of the areas. Street lights needs rehabilitation in 21 areas, the voltage protection system in 13 areas and the lightning arresters in 11. This indicates clearly that maintenance of the systems has been inadequate.

3.12 Financial Performance

3.12.1 Available data

It has not been possible to get a complete picture of the financial performance of the rural areas. For those areas that are separate branches, i.e. Mafia, Mpwapwa, Nachingwea, Kilwa Masoko and Tukuyu, information can be retrieved from the Finance Managers Reports. These areas are all diesel supplied. For the other areas, separate accounts are not kept and although

Table 3-16 Shortages and rehabilitation requirements in rural areas

Branch	Shortages	Rehabilitation needs
Korogwe	Store, meter for system	Rehab MV and LV lines and street lights
Liwale	Transport, store, one oil tank 30,000 l; technicians	Rehab gensets, fire extinguishers and 0.4 kV line wooden poles
Lushoto	Store, meter for system	Rehab MV and LV lines and street lights
Mafia	Transport	Replace conductors for 11 and 0.4 kV lines, provide protective gear light arresters and street lights
Masasi		Improve line clearance for Masasi-Nachingwea line
Mikumi	Meter for system	Rehab protective equipment- silica gel and fuses
Monduli	Transport, permanent staff meter for system, and oil interceptor	Improve voltage protection system
Mpwapwa	Working tools for power plant; oil interceptor	Improve street lights, replace conductors for service lines
Muheza	Meter for system	Improve voltage protection system and street lights
Mwanga	Transport, store and meter for system	Improve voltage protection system
Nachi-ngwea		Redesign and erect MV and LV lines, rehab protective gear light arrester and improve street lights
Ndurugumi	Provide transport	Improve street lights, fire exstinguishers and gensets
Newala	Staff - area manager and mains technicians	Rehab security lights at substation and street lights

Table continued

Table 3-16 Continued

Branch	Shortages	Rehabilitation needs
Njombe/ Makambako	Transport and one storage tank 27 000 litres	Protective equipment - silica gel, Fuses; improve street lights
Nzega	Distribution transformers	Replace stay wires/poles for lines, power meter, silica gel, lightning arresters, security lights for substation, and improve 1 phase lines
Babati	Radio call system	Rehab 0.4 kV line conductors and street lights
Bagamoyo		Replace fuses, lightning arresters and improve street lights
Chamwino		Rehab gensets and improve streetlights
Hai	Meter for substation	Improve line clearance
Handeni	Store, meter for system	Replace rotten wooden poles for MV and LV lines, improve street lights
Ikwiriri	One water tank and 2x4 500 l oil tanks; plant technicians	Improve 1 phase service lines and security lights at the plant, rehab lightning arresters, and street lights
Kahama		Replace stay wires/poles for lines, power meter, silica gel, lightning arresters, and security lights for substation, replace conductors for service lines
Kiabakari /Butiama	Meter for system	Rehab gensets and move them to another area, replace silica gel and lightning arresters, rehab the lines stay wires

Table continued

Table 3-16 Continued

Branch	Shortages	Rehabilitation needs
Kibaha		Rehab 1 phase distribution lines and improve street lights
Kigwe	Transport	Rehab the gensets and provide fire extinguishers
Kilwa Masoko	Oil storage tank 30 000 liters	Rehab gensets, service line conduct and protective equipment - fuses, silica gel and fire extinguishers
Kisarawe	Permanent staff	Improve line clearance, provide more breakers on 11 kV line to Kisarawe, protective equipment silica gel and light arresters and street lights
Kondoa	2 oil storage tanks @ 2 700 litres	Rehab gensets, fire extinguishers and improve street lights
Pangani	Store, meter for system and more office space	Rehab MV and LV lines and street lights
Rombo	Meter for s/s	Clear the lines
Same	Provide kW/kWh meter for s/s, working tools, store	Improve street lights
Sumba-wanga	Oil storage tank 54 000 litres, oil interceptor	Rehab fire extinguishers, protective equipment- silica gel, fuses; improve street lights
Tarime/ Utegi	Meter for system and radio call communication system	Rehab lines stay wires/insulators protective equipment - fuses and light arresters
Tukuyu	Workshop facilities Oil interceptor	Rehab gensets and control system, protection equipment- silica gel, light arresters; improve line poles clearance

Table continued

Table 3-16 Continued

Branch	Shortages	Rehabilitation needs
Tunduma	Workshop and store	Replace wooden poles and stay wires, rehab protection equipment- fuses, silica gel; provide security lights at power plant and street lights
Urambo	Workshop and store; and transport	Redesign and erect MV and LV lines to TANESCO standards

some cost data can be retrieved locally, complete data cannot easily be found.

3.12.2 General financial performance of TANESCO

The information available regarding the financial performance of TANESCO is somewhat inconsistent. According to the Finance Managers Report for 1988, the average revenue per unit sold was 4.15 TAS/kWh, whereas the cost per unit sold was 3.97 TAS/kWh. Overall, TANESCO should have generated a small surplus in 1988. According to more recent information presented by the Managing Director in *(26)*, the total cost per unit sold was 5.03 TAS/kWh, which implies a loss of almost 1 TAS/kWh sold. Direct comparison between the two documents is difficult because of differences in structure. It appears, however, that the discrepancy can be explained mainly by higher "corporate taxes" in the latter presentation.

The results for individual branches differ, mainly as a result of differences in the cost per unit sold. Data on individual branches are only available in the Finance Managers Report. The variations in average revenues per unit sold in 1988 are not very large and range from 6.24 for the Musoma branch to 2.65 TAS/kWh for Sumbawanga. For Dar es Salaam the average revenue was below the national average, i.e. 3.79 TAS/kWh. The variations in cost per unit sold are much larger, from 22.8 TAS/kWh for the isolated diesel supplied branch of Kilwa Masoko to 1.43 TAS/kWh for the grid supplied Morogoro branch. Grid supplied branches show costs ranging from 1.43 TAS/kWh to 4.02 TAS/kWh. The latter applies to the Dar es Salaam branch which, alone, consumes 51 per cent of the electricity.

High fuel costs explain the high costs for diesel supplied branches. Dif-

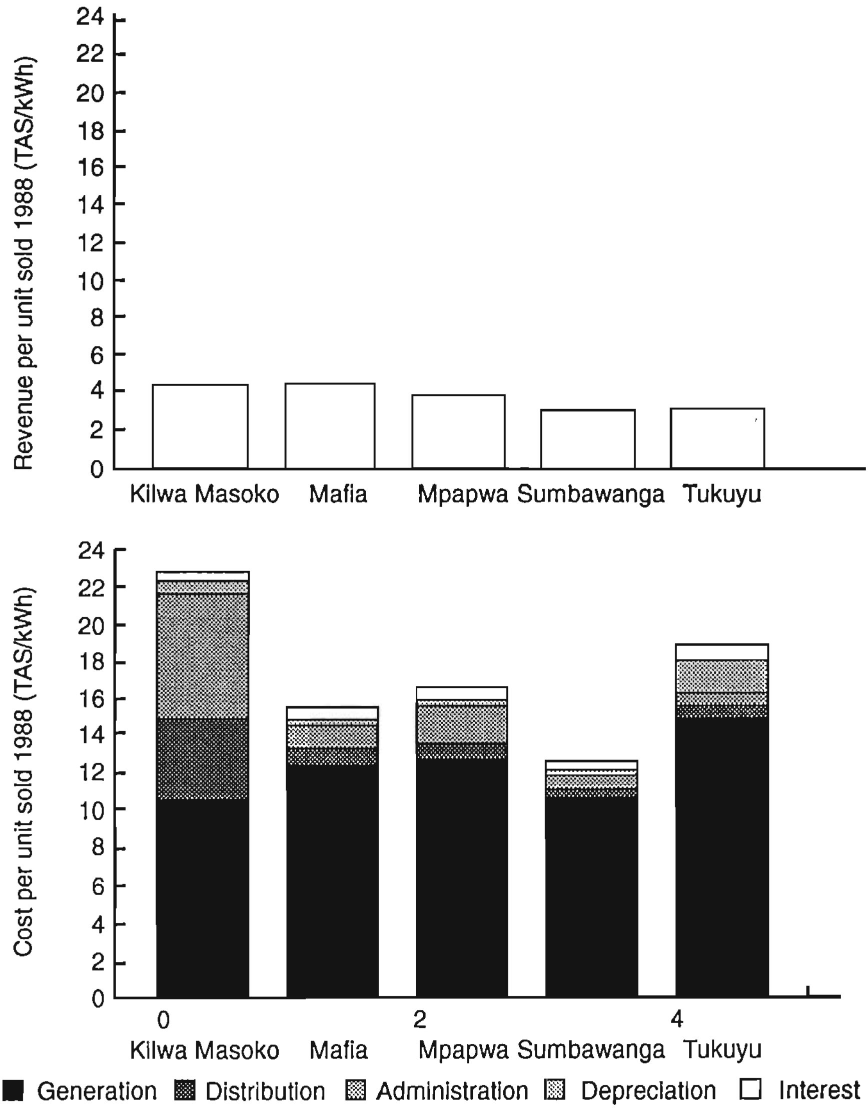

Figure 3-8 Financial performance of some rural areas

ferences between grid supplied branches appear to be caused mainly by differences in costs for depreciation.

3.12.3 Diesel supplied rural areas

There is no doubt that all the diesel supplied rural areas make a loss for TANESCO. Figure 3-8 summarizes the situation for 1988 for some areas that are separate branches. The average revenue ranges between 4.20 and 2.65 TAS/kWh whereas the cost per unit sold ranges between 11.20 and 22.82 TAS/kWh.

Generation cost, which is mainly fuel and lubricant costs amounts to between 10 and 14 TAS/kWh sold. In terms of units generated, the generation cost is reported between 8.8 and 13.9 TAS/kWh. As might be expected, the administration cost per unit is larger for small branches. Some variation in the costs for distribution, depreciation and interest is explained by the different conditions on the sites, where transmission line length is an important factor.

In the two diesel supplied areas that were studied in more detail and are not a separate branch, i.e. Babati and Njombe, the situation is similar. The average revenue per unit generated for 1988 was found to be 2.48 and 1.87 TAS/kWh respectively, whereas the quantifiable cost per unit generated amounted to 11.4 and 8.2 TAS/kWh. Fuel costs account for about 80 per cent of the quantifiable cost.

As shown in Figure 3-3, the domestic tariff at a low consumption level is substantially lower than any other tariff. Essentially this means that small residential use is subsidized, primarily by the larger commercial and industrial consumers.

3.12.4 Grid supplied rural areas

None of the grid supplied rural areas is a separate branch. Complete cost data are, therefore not easily found. A special study was carried out for Same and he results are summarized in Table 3-17.

Table 3-17 Financial performance of the grid supplied Same-area (TAS/kWh sold)

Cost component	1988	1989
Generation		
Fuel and lubricants	0.85	0
Other	0.35	0.40
Distribution	0.61	0.49
Administration	1.22	0.83
Depreciation	4.81	2.78
Interest	1.82	1.72
Total cost	9.65	6.21
Average revenue	5.32	6.58
Profit	-4.33	0.37

From a comparison of the overall average revenue per unit sold by TANESCO and the average revenue collected for Dar es Salaam, (see section 3.12.2), it is clear that Same is above the national average. For 1988 a deficit of about 4.3 TAS/kWh was obtained. This is partly a consequence of fuel costs for the Arusha branch allocated to Same for electricity imported from Arusha. For 1989, a small surplus of 0.37 TAS/kWh was generated at Same.

It is not possible on this basis to draw generic conclusions about the financial performance of grid supplied rural areas. Unless depreciation and interest costs are very high, as a result of large investments in transmission lines, the performance can be expected to be better than for the diesel supplied areas.

3.13 Present Rural Electrification Plans

As of early 1990, there were 34 district centres, and many agro-based industries which were yet to be electrified. Although previous studies indicate that most of the unelectrified district towns have transmission from the grid as the least costly alternative, a number of them still have no option other than diesel. Currently efforts are being made to study development of geothermal, biomass, wind, solar, mini-hydro and other renewable indigenous resources where these sources prove to be technologically and economically more competitive.

At present projects under implementation include those to supply the agro-based industries in the regions of Mwanza, Shinyanga and Tabora with power from the national grid. The projects involve a number of cotton ginneries, grain/oil mills, district towns and villages and are being financed by the Spanish and Italian governments. Another set of projects to supply agro-based industries from the national grid include those in Iringa and Mbeya regions where tea estates, district townships and villages will benefit. The government of the United Kingdom will finance the projects.

TANESCO, using funds from the treasury, is financing projects to electrify Mpanda and Tunduru with diesel sets removed from other towns which are currently being supplied by the national or local grids. Other projects on the list include power importation as follows:

— From Zambia:
  Supply of Tunduma and Mbozi by a 33 kV line
  Supply of Sumbawanga by a 66 or 33 kV line
— From Uganda:
  Supply of Kagera sugar factory, Kyaka, Muleba, Biharamulo and Bukoba by combined 132 and 33 kV lines.
— From Burundi:
  Supply of Kibondo, Kasulu, Uvinza and Kigoma by 66 and 33 kV lines.

4
Rural Electrification Beside the Tanesco Programme

4.1 Overview

Rural electrification outside the TANESCO programme in Tanzania includes efforts by the government, non-government organizations and private people to supply power to areas similar to those defined to be "rural" in section 3.1 above. The types of projects considered include the following:

— Government financed projects implemented through the Ministry of Works and Communication, e.g. Urambo, minor settlements, district hospitals, remote secondary schools, border posts, police stations, etc.,

— Projects financed through co-operative organizations, e.g. cotton/grain mills dotting many parts of the country, e.g. Muhunze-Shinyanga, Manongi-Tabora, etc,

— Large farms and estates projects, e.g. sisal estates, tea estates, coffee estates, wheat farms, wattle estates, diary farms, sugar plantations (Kiru valley),

— Projects implemented by mission organizations, e.g. Benedictine Fathers at Uwemba, Kitai, Litembo and Peramiho which are just some of their mini-hydro based power systems,

— Private people such as construction companies, workshops, small scale industries, saw mills, garages, shops, bars, hotels, petrol stations, etc., and

— Large industrial/mining projects, e.g. TANWATT, Mwadui Diamond Mines, Kiwira Coal Mine, Geita Gold Mine, etc.

The exact extent of rural electrification outside of the TANESCO programme is difficult to assess as information on the plants owned in the rural areas is not easy to retrieve, although data should be registered at the Ministry of Energy Minerals and Water (MEM). It has been estimated that rural electrification through non-TANESCO projects has covered more than 22 rural villages. A list of diesel sets licenced by MEM and the Ministry of Communication and Works can be found in appendix 2. The list also includes power plants located in areas where the TANESCO service is available. These plants are essentially standby systems. Some of them have been installed because of supply reliability problems and some were installed before electrification and have been kept operational.

4.2 Planning and the Design of Projects

For projects financed by the Government, the Ministry of Communication and Works does the planning and design. For privately financed projects at large enterprises like agricultural estates, plantations, mines, mission establishments, large industries and co-operatives, the planning and design is done either in-house or in collaboration with local/foreign consultants.

For small enterprises like shops, bars, small workshops and small plantations, the plants which can meet their power demand are bought "off the shelf", installed and operated, usually with little reliance on expert advise.

4.3 Project Implementation

For large enterprises, the standard procedures for project implementation are usually followed, i.e. tendering, selection of the contractor, erection and construction of the plant. In the case of government institutions, it is normally the Ministry of Works which carries out the implementation. Only in rare cases are tenders floated for such projects. Small scale enterprises carry out their projects as outlined in section 4.2.

4.4 Financing

The financing of large scale enterprise projects follows the normal trends of external and/or internal financing, with the limits depending on the size of the investment and the risk involved. For government projects, the funds normally have to be allocated from the treasury. Foreign financing is common even for small projects. Private financing is most common for small scale enterprises. Commercial banks e.g. the Cooperative and Rural Development Bank (CRDB) and the National Bank of Commerce (NBC) are also important sources of finance for such projects.

4.5 Production and Distribution Technologies

4.5.1 General

For large scale enterprises and government schemes, the technological requirements for production of electricity appeared the same as in TANESCO programmes. A notable difference from TANESCO (and government) programmes is the large extent to which alternative energy sources are harnessed, particularly mini-hydro and biomass systems.

However, there are some differences in transmission and distribution networks with respect to their extent and standards – voltage levels, conductors, insulators, transformers, and line distances. Some of the reasons for the differences include lack of procedures for standards in the country and foreign financed projects with material components from donor countries without restrictions for local standards, etc.

In the case of small scale enterprises, generation, transmission and distribution technologies tend to be different from those of TANESCO. Transmission is often not required since power generation is located close to the consumers with the exception of mini-hydro power plants. Transmission lines from these range from a few hundred meters to 24 km in an exceptional case. Diesel generators are most common but alternative sources of energy are more widely used for small scale power generation than in the TANESCO programme. Techniques used include mini-hydro, biomass, and solar energy.

4.5.2 Use of mini-hydropower generation

An inventory completed in 1978, see Kadete and Reichel *(23)* and Kadete *(24)*, identified 17 mini-hydro plants outside the TANESCO programme. The capacity ranges from 6 to 180 kW. Most of these plants were installed by mission stations. The dam construction was undertaken by trained engineers, technicians or missionaries. The labour could be obtained through self-help schemes. The time required for dam construction ranged from three weeks to two years. All turbines and generators were imported from abroad.

4.6 Organization of Operation, Service and Maintenance

The organization of large private enterprises is very different from TANES-

CO programmes. Power generation is often only a minor part of the activities. Hence, technical staff have other functions besides electricity generation, depending on the nature of the enterprise. Some installations, e.g. Uwemba mini-hydro plant, have no full time person to run them. This is usually the case for electric generators at small enterprises, and in extreme case, the owners run them. The same is true for service and maintenance of the plants.

It was noted that the availability of spare parts was reported to be good in private enterprises visited. A method of avoiding large maintenance costs is practised by TANWATT. Their diesel gensets are usually run for five years and then disposed of at prevailing market values, thereby avoiding costs associated with major overhauls.

The maintenance requirements of mini-hydros and solar plants are generally marginal.

4.7 Tariff Policy

Most of the non TANESCO projects produce electricity for their own needs only. When there is excess power, they can consider providing the excess to plants located nearby. There is no tariff policy for the private enterprises. Each enterprise sets its own tariff. For example, TANWATT sells power to its workers and nearby Kibena hospital at the marginal cost of production, which in February 1990 was TAS 17/kWh.

Other cases include the missions which own mini-hydro plants and sell their excess power. For example, Uwemba mission charges a flat rate of TAS 2/kWh, whereas the production costs are estimated at TAS 10–12/kWh.

Government projects provide electricity free of charge to important institutions and government staff. The only area which differs in this respect is the Urambo township project.

4.8 Electricity Use

Government projects normally have a specific requirements for electrical energy. Often it is power supply to secondary schools, hospitals, military posts, police stations and border posts etc.

Large scale private enterprises use electricity for industrial purposes, irrigation and for the domestic needs of the workers. Small scale private enterprises use electricity for lighting, refrigeration, to power their radios, in their workshops, garages and occasionally for videos.

4.9 Financial Performance

Most of the Government projects are service schemes financed by the Treasury. No revenue collections are made. It has not been possible to establish data for the operating costs of such projects.

For large scale private enterprises, electricity is just one of the inputs to their industrial production. Therefore, sales of their products are expected to recover the production costs which include electricity. For small scale private enterprises, either the production costs have to be realised from the revenues generated from their business or combined as part of the domestic costs.

Experiences from the mission projects, where electricity is sold to those living in the neighbourhood, indicate that the missions subsidize it heavily in order to make it affordable to the people. This implies that the costs of operation are met with sources other than the revenues collected from the sale of electricity.

4.10 Present Rural Electrification Plans

There are no coherent plans which integrate the rural electrification of small and large private enterprises, government, and missions. Hence, the contribution of projects outside TANESCO to rural electrification in Tanzania, can not presently be estimated.

5
Socio-economic Characteristics of the Electricity Use in Four Selected Areas

5.1 Selection of Study Areas for the Socio-economic Evaluation

Four areas were included in the socio-economic study. The first area studied, Babati, was treated as a pilot project and was covered in July 1989. Three more areas were visited in February 1990, namely Njombe, Same and Sumbawanga.

Of the areas studied, Babati, Njombe and Sumbawanga are diesel supplied. This emphasis on diesel supplied areas for the socio-economic study was intentional since these isolated population centres were believed to be more representative of villages and towns which have not yet been electrified. Same is grid supplied and was selected because it was reported to be a good example of successful rural electrification.

Of the diesel supplied areas, Babati was selected for the pilot study primarily for reasons of convenience, since this town is easily accessible. Njombe was selected because of its local transmission grid and the nearby, privately-owned and managed, electrification activities. Sumbawanga was chosen primarily for its remoteness and its status as a regional capital.

It should be pointed out that the results of the first study (Babati) are not entirely comparable with the three later studies (Njombe, Sumbawanga and Same). The pilot study of Babati was made six months earlier and a number of modifications of the procedures were made as a result of the experiences gained there. Nevertheless, wherever possible, the results from the Babati study will be included in the present analysis.

5.2 General Characteristics of the Study Areas

5.2.1 Common features

The economy of all the areas covered by the socio-economic studies is based primarily on agriculture. Generally it is estimated that 90 per cent of the population in these areas are engaged in crop and livestock production, which can be compared to the national average of 85 per cent.

Each of the areas studied consists of a town and a surrounding rural domain with scattered population and smaller villages. The town is the administrative and commercial centre for the surrounding countryside. It may be noted that the study areas are all in zones of relatively high agricultural production. The Southern Highlands (Njombe) together with the Ufipa Plateau in Rukwa (Sumbawanga) account for the highest marketed outputs of maize which is based on the relatively intensive use of fertilizer. The most intensive agricultural systems based on high population densities are found in the Kilimanjaro and Arusha Regions, including the Pare Mountains (Same). These highland systems were not affected by the development of villages and are characterized by the coffee-banana cultivation system.

Finally, Babati (the site of the pilot study) lies in an area where maize production is substantial.

Women form the most important source of agricultural labour in the study areas. In addition to domestic chores such as cooking, caring for the children, cleaning the house and its surroundings, women's activities include: tilling the land, grain milling, fetching water and fuelwood. The business activity that women are most likely to engage in, is the brewing of local beer which, traditionally, has been the women's way of re-circulating the cash in the men's pockets back to the women. These are typically "back-yard" businesses, not necessarily requiring electricity and not always licensed.

Men appear to have a much lighter share of the work load, which includes cattle herding (which they share with the children), attending meetings and engaging in undefined "business" in the village or town centre.

Despite their central role in the economy of the rural areas, women occupy a low status within the household. Many women showed a reluctance to be interviewed because they did not regard themselves as the spokespeople of the households. It was traditionally/culturally established that the men own the house/family and that, therefore, the men shall give information about the households.

5.2.2 Prices of fuels and electrical appliances

The electricity tariffs are uniform all over Tanzania as explained in section 3.7. However, fuel prices, prices of electrical appliances and costs for installation of electricity in a house vary as a result of differences in transportation costs and the local supply and demand situation.

Information about the current prices at the time of the study is given in Table 5-1. Although these data might be useful, for example in understanding the reasons behind variations in household energy expenses between the areas studied, it should be realized that the prices for wood and charcoal, in particular, fluctuate seasonally.

The equivalent energy costs for charcoal, kerosene and radio batteries are also given in the table. These might be compared with the costs for electricity, see section 3.7. This comparison is discussed further in section 5.4

Table 5-1 Fuel prices

		Njombe	Same	Sumbawanga	Dar es Salaam
Fuelwood	TAS/piece	5	20	10	5
Charcoal	TAS/bag	300	550	700	800
	TAS/kWh(t)	1.3	2.3	2.9	3.3
Kerosene	TAS/gal.	300	275	230	275
	TAS/kWh(t)	6.9	6.3	5.3	6.3
Battery	TAS/piece	75	75	70	85

Table 5-1 indicates that the variations in prices for imported energy in the form of kerosene or batteries are much smaller than the variations in the prices of the indigenous fuels, fuelwood and charcoal. Also the information collected about prices for some appliances, electrical installation material and complete electrical installations in a house indicate a fairly uniform cost level, except for complete installations, see Table 5-2.

5.2.3 Specific features of Babati

Babati is the district town of the Babati district in the Arusha region. It is located about 600 km from Dar es Salaam at an altitude of about 1 300 m along the main road from Arusha to Dodoma at the crossroad to Singida. Both roads are in fairly poor condition but carry a substantial through traffic. Rehabilitation of the Arusha road is ongoing and had reached as far as Makuyuni in July 1989.

The climate is dry, but with a rainy season in the months December to March. The average annual rainfall is about 770 mm.

Table 5-2 Prices for electrical appliances and installations (all prices in TAS)

	Njombe	Same	Sumbawanga	Dar es Salaam
Hot plate	–	20 600	19 000	18 000
Electric kettle	–	–	17 000	20 000
Immersion heater	–	2 000	2 500	2 500 –4 800
Electric iron	–	5 900	5 000	3 000 – 7 500
Light bulbs 60 W	–	140	150	130
200 W	–	–	500	150
Tube light	–	–	500	1 400
Insulated wire 1.5 mm, 1 roll	–	15 000	14 000	15 000
Switch socket	–	360	450	550
Junction box	–	200	300	150
Electric installation in a house with material and labour	30 000 to 50 000	15 000 to 27 000	65 000 to 120 000	32 000 to 37 000

The population of the town according to the 1988 census was 22 000, whereas that of the district was some 208 300. The population has been growing rapidly and the population of the town has almost doubled in ten years from 12 000 in 1978. The rapid population growth is typical of the Arusha region. Annual growth figures for the region are given as 3.8 per cent which can be compared to the national average of 2.8 per cent. The reason for the rapid population increase in the region is partly migration but also lower than average mortality rates and possibly higher fertility rates.

The main economic activities in the district are agriculture and animal husbandry. Maize is the principal crop grown and there are several maize mills in Babati town. The nearby Kiru valley is an area of intensive agricultural production. About 12 large estates are located in the valley, where the principal production is sugar cane and maize.

One of the consequences of the increased population reported in other studies, see Lindstrom *(32)*, is increasing pressure on the available land resources resulting in declining productivity. With encroachment of agriculture into pastoral areas, traditional systems of livestock production are breaking up. Meanwhile, agricultural yields are falling because of incursions from livestock and wildlife. Forests are being destroyed to provide fuel to the growing population and the accompanying economic activities.

As a result of its location on a major crossroad, many travellers are using Babati town as a stopping point. This is reflected in the commercial sector with its many bars, restaurants, guest-houses and garages with automobile repair services.

5.2.4 Specific features of Njombe-Makambaku-Uwemba

The towns Njombe and Makambaku and the village Uwemba are all located within Njombe district in the Iringa region. Njombe is the district town and is located between the towns of Mbeya and Iringa along the road from Dar es Salaam to Songea at an altitude of about 1 900 m. It is the administrative and commercial centre of the district. It is possible to reach Njombe by light aircraft since it has a small airstrip.

Makambaku, about 60 km north of Njombe is located along the Tanzania-Zambia road and railway, which makes it easily accessible. Due to its location its importance as a commercial centre is growing, and the population of Makambaku is expanding more rapidly than its district capital, Njombe. Its altitude is about 1 800 m.

Uwemba village is located about 25 km southwest of Njombe town at an altitude of 2 200 m. Uwemba is the home of The Benedictine Fathers Catholic mission and has been for more than a century.

The climate of Njombe, Makambaku and Uwemba is typical of a high mountainous location with cool temperate weather and high rainfall. The average annual rainfall is about 1 200 mm.

All three centres show a rapid growth in population. From 1978 to 1988 the population of Njombe town increased from 16 000 to 25 200 and that of Makambaku from 14 100 to 26 900. In Uwemba, the population grew from 9 800 in 1985 to 11 000 in 1989.

The main economic activities in the district are agriculture and animal husbandry. The main crops are pyrethrum, tea, maize, wheat and sweet potatoes. Animal husbandry is of minor importance around the towns but large herds, valued for dowry and as an investment and indicator of wealth, can be found in other areas of the district. Farm sizes vary considerably, but except for the large tea and wattle estates owned by foreign companies and the Lupembe Tea Estate owned by Lupembe Farmers Co-operative Society Ltd, the average acreage can be considered as medium. Most farmers use ox or tractor drawn ploughs, and tractors are often hired. A few of the wheat farmers use combine harvesters.

About 5 km east of Njombe town lies the factory of the Tanganyika Wattle Company (TANWAT), which employs about 1 000 people permanently and provides over 2 000 persons with casual or seasonal employment. The main products from the factory are chemicals needed for production of shoe polish and which are extracted from the bark of wattle trees. A large sawmill produces timber from the stems of the wattle trees as a by-product.

The District Council owns some commercial projects in Njombe town which include grain milling, oil processing and a wattle plantation where the bark is sold to TANWAT for processing. Other economic activities in Njombe town include guest houses and bars, which are generally privately owned, hotels, some woodworking activities, welding shops, garages and service stations. In addition there are government service institutions and commercial parastatal organizations. The economic activities in Makambako are similar but expanding more rapidly as a result of its location.

In Uwemba, the mission operates a hospital, maize mills, carpentry workshops and a laundry.

All three population centres have water pumping plants.

5.2.5 Same

Same is the district capital of the Same district in the Kilimanjaro region. It is located about 500 km northwest of Dar es Salaam at an altitude of about 900 m along the main road from Dar es Salaam to Moshi. The road is in bad condition and rehabilitation work was in progress at the time of the visit. It is also possible to reach Same by train on the Dar es Salaam to Moshi line or by air via the Kilimanjaro International Airport located about 105 km from Same town.

Same district is in the southernmost part of the Kilimanjaro region and includes the Pare mountain range stretching from north to south in the central part of the district. Flat lands extend to the west and the east of the mountain range. The climate in Same is tropical with an average rainfall of about 600 mm. The main rainfall is received occurs in October to December and March to May.

The population of Same town, according to the 1988 census, was 10 700 and that of the district 170 100. Comparisons with the 1978 census are obscured by creation of new enumeration areas and sub-division of the former Pare district into the Same and Mwanga districts. It appears, however, that the population growth is in the order of 2.5 per cent or slightly below the national average of 2.8 per cent. The population is concentrated in the town of Same, a number of settlements along the main road and the northern base of Pare mountains, and in the uplands of the Pare mountains. This pattern of settlement is explained primarily by the infertile soils with erosion and low rainfall in the flatlands. The largest population centres along the northern base of the Pare mountains are Gonja Maore (population 10 000 in 1988) and Ndungu (population 10 400 in 1988). In the mountains at Bombo, there is an important Roman Catholic Mission hospital.

The main economic activity in the region is mixed farming. Those few inhabiting the flatlands engage primarily in animal husbandry because of the abundance of grazing lands. Crop cultivation is practised along the northern base of the Pare mountains where the Japanese-funded Mkomazi valley irrigation project[8] and the Ndungu sisal plantation are located and in the highlands where most of the farms are very small.

In Same town, a ceramic industry owned by the Kilimanjaro Industrial Development Company (KIDC) and a cotton ginnery, oil seed press and grain mill owned by Pare Development Corporation (PADECO) can be found. Same town shows many of the characteristics of a road-side service centre and is, in many ways, similar to Babati. Economic activities in Same town include typical shops, bars and hotels, garages, blacksmiths and carpentry workshops as well as government and parastatal service and commercial undertakings.

A magnesite mine is located outside of the town. The rich timber forests in Same district supply some sawmills.

5.2.6 Sumbawanga

Sumbawanga is located in the Sumbawanga district and is the regional capital of the Rukwa region. It is situated 1 130 km southwest of Dar es Salaam at an altitude of about 1 500 m between Lake Tanganyika and Lake Rukwa in the western rift valley. Sumbawanga can be reached by travelling by tarmac road or railway to Tunduma and then by earth road from Tunduma to Sumbawanga. Alternatively, it is possible to go by railway to Mpanda and then again by earth road to Sumbawanga. Occasionally, the earth roads are vir-

8 The project includes the Gonja, Kisiwani, Igoma, Ndungu and Kihurio schemes with production of paddy, maize and beans.

tually impassable during rainy season. A small airstrip for light aircraft is available.

The climate in Sumbawanga is cool. June and July are the coldest months when temperatures can decline below 17 °C. There are two rainy seasons, September to February and May to June. The average annual rainfall is about 1 000 mm.

The region is endowed with good soils. Apart from agricultural land the vegetation around Sumbawanga town is bushland, which is the combined result of land clearing during the colonial times for creation of tsetse fly free zones, shifting cultivation, fuelwood collection and forest fires. The construction projects related to the upgrading of Sumbawanga to the status of regional capital have also contributed to the deforestation around Sumbawanga, with vast quantities of fuelwood being used for brick making. The terrain towards Lakes Tanganyika and Rukwa is very rugged due to the rift valley topography.

The population of Sumbawanga town, according to the 1988 census, was 47 900 and that of the new urban district 92 000. Comparisons with the 1978 census have been made difficult by the creation of new enumeration areas. It appears, however, that the population growth is of the order of 4.3 per cent or much higher than the national average of 2.8 per cent.

The main economic activities in the region are agriculture and animal husbandry. The main crops are maize, finger millet, cassava, sorghum, wheat, paddy, beans, groundnut and Irish potatoes. Others are pigeon peas, seed potatoes, bananas, sim-sim, castor, sunflower, vegetables and citrus fruits. The average acreage is generally small and traditional hoe cultivation is the most common method. There has been an increase in cattle farming as a result of migrant farmers moving into Sumbawanga in search of greener pastures for their herds.

Exploitation of the large agricultural potential of the region is hindered by the very poor infrastructure. As mentioned above, the region is virtually isolated from the rest of the country during rainy seasons. The region is self-reliant in food production. Given proper agricultural inputs and improved management within the transport sector, the region could probably produce a considerable surplus. As a result of low prices and late payments from the national institutions, a large part of the local agricultural production is now sold through the black market to neighbouring countries, especially Zambia and Zaire.

Fishing is practised in both Lake Tanganyika and Lake Rukwa.

Being a regional capital, Sumbawanga is the centre of all government activities in the area and, therefore, accommodates a number of government offices. Important parastatal service organizations like TPTC (Tanzania Posts and Telecommunications Corporation), NBC (National Bank of Commerce)and NIC (National Insurance Company) have their branch offices in Sumbawanga. Luwa National Service Camp is situated 5 km from the centre of the town. SIDO has established a small industrial estate where nails, nuts, screws and bolts are made. Other economic activities in the town include the usual shops, bars and hotels, garages, blacksmiths and carpentry workshops.

Gold and sulphate deposits are known to exist in the region. However, only some small scale gold mining is currently going on.

5.3 Electricity Supply and Use in the Study Areas

5.3.1 General

The main data on electricity supply and use in the four areas covered by the socio-economic evaluation can be found in chapter 3. Some supplementary information of particular importance for the socio-economic findings is provided in this section.

5.3.2 Electricity supply and use in Babati

As can be seen in Table 3-6, Babati is supplied by an isolated diesel power plant equipped with three generator sets, each with a rated capacity of 175 kW. It is not possible to operate more than two in parallel and the maximum capacity of the power plant is, therefore, 350 kW.

The distribution grid covers the Babati town with a transmission line to Singe secondary school located just outside the town. Since Babati was electrified in 1981, the demand has been increasing. The peak demand at the time of the visit was estimated at about 380 kW, i.e. exceeding the capacity of the power plant. This situation was handled by the load shedding of certain phases on some substations on a rotating basis in the evening, at the time of peak demand.

As can be seen from Table 3-3, the majority of the consumers belong to the residential or commercial tariff classes and the number of industrial consumers is few. The main consumption is also in the residential and commercial tariff groups, with industrial consumption accounting for about 12 per cent, see Table 3-4.

One example of regular self-generation of electricity in the area served by TANESCO was found, namely TPTC, which operated 2 small diesel gensets, each with a capacity of 1.75 kW. More details are available in the topical reports *(2)* and *(3)*.

5.3.3 Electricity supply and use in Njombe-Makambako-Uwemba

The electricity supply situation in the Njombe-Makambako-Uwemba area is complex and clearly unsatisfactory, as a result of difficulties carrying out the original plans. There is a TANESCO power plant equipped with diesel generators in Njombe. This power plant was intended to supply not only Njombe but also Makambako, which is connected with a 60 km transmission line. In addition to TANESCO, there are two major suppliers of electricity, namely TANWAT and the Benedictine Fathers' mission station, which supply their own independent grids.

When electrification by TANESCO auspices was implemented in 1981, with a diesel power plant, the intention was to use it as a temporary solution, to be replaced within five years by a mini-hydro power plant. A change in donor resulted in a change of strategy and the original hydropower project was shelved. A new site for a mini-hydropower plant on the Hagafiro river near Uwemba was selected under the new programme. The planned firm capacity of this installation is 360 kW. The construction and installation work has long since been completed but a part of the head-race channel collapsed in 1988 before commissioning and had still not been repaired at the time of the visit.

All the original diesel gensets had been grounded by the end of 1989 and so had two out of three used gensets brought in from other TANESCO sites. Only one genset with a maximum capacity of 140 kW was still operational at the time of the visit.

The national grid passes right through the town of Makambako but no connection to the local grid has been made. As a result of the decline of the capacity of the TANESCO power plant, considerable load shedding is practised in the TANESCO grid. In Njombe, the industrial consumers are given priority. Makambako and all the villages along the transmission line connecting Njombe and Makambako are permanently load shed. Although not covered in the survey, the effects of this permanent cut in power have probably had major consequences for the expansion of commercial and industrial activities in Makambako.

The TANESCO consumer structure shown in Table 3-3 is similar to that of Babati. As can be seen from Table 3-4, the industrial part of the consumption is, however, much larger which is a consequence of the priorities used for load shedding. These data give no information on the actual fraction of industrial demand in the area.

The TANWAT installation consists of a 312 kW wood fired steam power plant and two diesel gensets rated at 364 and 315 kW respectively. The power is used primarily for the factory but is also supplied to workers' homes and the Kibena hospital, which is the district hospital for Njombe. The electricity is sold at a rate of 17 TAS/kWh.

The installation at the Benedictine Fathers' Mission Station in Uwemba consists of a mini-hydro power plant rated at 100 kW and a stand-by diesel genset. The power plant is mainly used for the mission itself which operates a hospital, sisters' houses and convent, domestic school, workshops and a garage. Some electricity is also supplied to nearby houses. A total of 125 families in 60 houses are connected. It is estimated that about 90 – 98 per cent of the generation during daytime is used at the mission, whereas about 80 per cent of the night-time load is taken by the village. A flat rate is charged based on the size of the house and estimated as equivalent to 2 TAS/kWh, which is less than the estimated operating cost of 10 – 12 TAS/kWh.

A number of other examples of self-generation of electricity were found in Njombe town. Apart from the Bank and the Post Office, a number of private consumers (especially light industrial) had been obliged to install their own generators as a result of the constant power cuts and load shedding. More details are available in the topical reports *(4)* and *(8)*.

5.3.4 Electricity supply and use in Same

Same is served through the national grid and was connected in 1976. Besides the town itself, the substation serves a power line to the magnesite mine and a line extending along the northern edge of Pare mountains up to Ndungu connecting a number of villages and a major irrigation project. The Same distribution system was provided through donor assistance within the context of an integrated regional development programme, which included a large-scale irrigation component as well as support for the establishment of a number of industries.

As in Babati and Njombe-Makambako-Uwemba, the majority of the consumers connected in Same belong to the residential or commercial tariff classes. The main consumption is also in the residential and commercial tariff groups but the industrial fraction of the consumption is much larger, i.e. about 28 per cent, see Table 3-4. One industrial consumer in Same, a construction company under RIDEP (Regional Integrated Development Programme), was identified to use TANESCO services as a tariff 2 consumer and to use its own generator set for supply to three-phase power tools. More details are available in the topical reports *(6)* and *(8)*.

5.3.5 Electricity supply and use in Sumbawanga

As can be seen from Table 3-6, Sumbawanga is supplied by an isolated diesel power plant. Since electrification in 1980, a number of generator sets have been used in Sumbawanga, these have broken down and been damaged by fires and then been replaced by others. At the time of the visit two gensets of 500 kW each were available and installation of two additional sets of 640 kW each was ongoing.

The domination of residential and commercial consumers found at the other areas is even more evident in Sumbawanga as can be seen from Table 3-3. The industrial fraction of the consumption is the lowest of all the areas studied in detail, only about 7 per cent, see Table 3-4. More details are available in the topical reports *(5)* and *(8)*.

5.4 Use of Electricity and Other Energy in Households

5.4.1 Methodological remarks

Due to time and budget constraints, the areas chosen for the socio-economic evaluation could not be visited by the sociologists before the actual surveys. Therefore, it was not possible to get a clear impression of the study areas prior to the fieldwork, to carry out the sampling prior to the main fieldwork period. One consequence of this was that the surveys focused almost exclusively on the townships instead of including a wider area. For example, it would have been valuable to include the TANWAT consumers in Njombe and the consumers in Ndungu supplied from the Same substation.

Sampling of the household consumers was based on experiences gained during the pilot study in Babati. In order to be able to draw a comparable sample, the households in the study areas were divided into two categories; those connected to the electricity supply and those not. Sampling of households was then based on the CCM (Chama Cha Mapinduzi)party structure in a two step procedure where ten-house cell leaders were first sampled and then the individual connected and non-connected households. Of the 295 households interviewed, 174 households were not connected, and 121 had a domestic connection.

The ten-house cell leaders were used to introduce the interviewers to the selected households where any person at home, above the age of 15, was interviewed according to a standard questionnaire. Caution was taken to ensure as much as possible that the interviews were conducted in the absence of the ten-house cell leader or any other person who might influence the answers. The total number of households interviewed was:

	Non-electrified	Electrified
in Njombe	53	47
in Sumbawanga	61	31
in Same	60	43
Total	174	121

Connected households interviewed in Uwemba and Ndungu are included under Njombe and Same, respectively.

More details on the methodology and a sample questionnaire can be found in the relevant reports *(3)* and *(8)*.

5.4.2 Household profiles

As discussed above, the sampling was divided between electrified and non-electrified households. For the purpose of analyses, each of these two samples were divided into two sub-groups. The electricity users were grouped with respect to the number of purposes for which electricity was used in the household. The non-users of electricity were grouped with respect to possession of "basic assets", defined here as a kerosene lamp, a kerosene stove, a charcoal stove, a bicycle, a vehicle, a sewing machine and a wheel barrow. The sub-groups were defined as follows:

Electrified households	Not electrified households
Basic electricity users: Households using electricity only for lighting and perhaps a single appliance.	Less affluent: Households owning only three basic assets or less.
More advanced electricity users: Households using electricity for lighting and more than a single appliance.	More affluent: Households owning more than three basic assets.

Sociological characteristics of households belonging to these sub-groups are summarized in Table 5-3. No serious attempt was made to establish the actual income of the households, but it is reasonable to assume that among the electrified households, the more advanced users can generally be expected to have higher incomes since these households were able to afford to buy many different appliances. Similarly, for the non-electrified households those with more than three basic assets can generally be expected to have a higher income than those with three or less.

The differences in income between electrified and non-electrified households are more difficult to assess, but it is evident from Table 5-3 that the electrified households are, in general, better houses. It should be noted that TANESCO requires an iron sheet roof before connection can be made. Households with thatched rooves cannot, therefore, appear in the electrified group. The information given in Table 5-3 that might be used for an assessment of household wealth is the distribution of the highest quality iron sheet roofed houses between the electrified and non-electrified households. The data show that 42 per cent of the electrified households are in houses made from burnt bricks or cement, whereas only 12 per cent of the non-electrified

Table 5.3 Socio-economic characteristics of the households

	Electrified households			Non-electrified households		
	Electricity used for more than lights and more than one appliance	Electricity used only for lights and perhaps one appliance	All electrified households	Household owns more than three basic assets	Household owns three basic assets or less	All non-electrified households
General information:						
Number of sample households in category	63	58	121	100	74	174
Average size of household, persons	6.3	5.8	6.1	6.7	5	6,0
Information on household head:						
Age of household head	41	45	43	44	44	44
Sex of household head						
% male	92	83	88	90	58	76
% female	8	17	12	10	42	24
Education of household head:						
None or primary %	57	72	64	82	91	86
Secondary or higher %	43	28	36	18	9	14

Table continued

Table 5.3 Continued

	Electrified households			Non-electrified households		
	Electricity used for more than lights and more than one appliance	Electricity used only for lights and perhaps one appliance	All electrified households	Household owns more than three basic assets	Household owns three basic assets or less	All non-electrified households
House type:						
Wooden poles, mud and thatch %	0	0	0	2	7	4
Wooden poles, mud and iron sheet %	5	2	4	28	41	34
Mud bricks and iron sheet %	42	67	56	50	51	50
Burnt bricks or cement blocks and iron sheet %	52	31	42	20	1	12

households are constructed this way. This would indicate that the electrified households can generally be expected to have higher incomes than the non-electrified[9]. The most striking differences between electrified and non-electrified households appearing in Table 5-3 are the educational level and the sex of the head of the household. There is a clear tendency for the non-electrified households to have female and less educated heads of the household. There is also a clear tendency for the less affluent non-electrified households to have female and less educated heads of the family.

The fractions of the two samples found in each sub-group for the different study areas is given in Table 5-4. The samples were found to be reasonably evenly split between the sub-groups except in Sumbawanga where the more affluent have a much larger share of the non-electrified households. A possible explanation for this is the lack of capacity of the Sumbawanga system to accommodate new connections.

Table 5-4 Distribution of sampled households over sub-groups

	Electrified households		Non-electrified households	
Area	More advanced users	Basic users	More affluent	Less affluent
Njombe	49%	51%	51%	49%
Same	53%	47%	52%	48%
Sumbawanga	55%	45%	69%	31%

5.4.3 Fraction of households connected

Not all the households in the electrified areas are actually connected to the distribution network. The fraction of the households in the study areas that

9 It could be argued that the electrified households have had to pay for the wiring of the house (between 10 000 and 100 000 TAS depending on its size) and the connection fee of 10 000 TAS, which also indicates that these households have a higher income. However, there are many reasons for non-connection which are outside the control of the households, such as location and TANESCO priorities. Therefore, connection of electricity as such is questionable as an indicator of high income.

are connected can be estimated from the number of tariff 1 consumers (December 1989) and the number of households according to the 1988 population census. The results are shown in Table 5-5. The situation varies between the four areas studied, with a maximum fraction of 26 per cent in Same and a minimum of 10 per cent in Sumbawanga. The overall average can be calculated as 11.6 per cent.

Table 5-5 Penetration of electrification among the households in the study areas (based on December 1989 domestic connections (Tariff 1) and the 1988 Population Census Figures)

	Njombe	Uwemba	Sumbawanga	Same	Babati
Total Tariff 1 connections	629	125	1.038	616	312
Number of households	5.704	554	10.251	2.341	4.637
Connected households as a % of total households	11.0%	22.6%	10.1%	26.3%	14.9%

The reasons for the variations are not clear. It is possible that the higher degree of connection in Same is due to the fact that Same was electrified about four years earlier, or that the power supply is more reliable in Same. It is also possible, however, that the numbers are not entirely comparable, since the census areas may include larger or smaller parts of rural areas with low population densities.

The reason for lack of connection was investigated through the interviews. A number of reasons were given by the non-connected households and these responses are illustrated in Table 5-6.

As is apparent from this table the principal reason given was related to expense. Half the non-connected households felt that the costs involved in having electricity installed was simply too high.

There were some complaints about long delays between making applications and having the TANESCO technicians complete the connection – this was particularly true for Sumbawanga. Lack of electrical materials and the distance from the distribution lines were not seen as a major problem.

Therefore, for various reasons but mostly because of high costs, over half the non-electrified households are unlikely to take steps to have electricity installed in their houses. However, a number of households have taken steps – either applied for connection or improved the standard of their houses –

Table 5-6 Reasons for non-connection of electrical supply

Reason given:	Percentage of non-electrified households
Too expensive	50%
Improving house or building new house	18%
Long delays before connection	14%
Lack of electrical materials	3%
Too far from distribution lines	2%
Other	13%

to install electricity. It should be noted that making the necessary improvements may take many years and some may never be completed.

5.4.4 Household energy use

Within households, energy is used primarily for cooking and lighting. The options available for cooking in the study areas are mainly fuelwood, charcoal, kerosene and electricity. For lighting, kerosene and electricity are the main alternatives.

Households in the sample were asked which sources of energy they used for cooking and lighting. In the case of electricity and kerosene there were four possible responses namely cooking only, lighting only, both or neither. For fuelwood and charcoal, the options given were cooking or not at all. The responses are summarized in Table 5-7.

The non-electrified households – as is to be expected – rely heavily on a combination of fuelwood and charcoal for cooking. Just above 80 per cent of households use fuelwood, slightly less use charcoal. Kerosene tends to be used principally as a source of lighting although about one quarter of the households use kerosene for both cooking and lighting. Non-electrified households do not use kerosene only for cooking purposes.

Electrified households meet their energy requirements through a combination of a number of energy sources. Although all these households use electricity for lighting, only 43 per cent also used electricity for cooking. As in the non-electrified households, cooking is done using a number of energy sources. Thus many electrified households still use a combination of fuelwood, charcoal and kerosene for cooking, although the use of charcoal as a cooking fuel is more popular than fuelwood in this category. This is most

Table 5-7 Energy sources used in households

	Fuelwood	Charcoal	Kerosene	Electricity
Non-electrified households				
Lighting only	0%	0%	72%	–
Lighting and cooking	0%	0%	27%	–
Cooking only	81%	72%	0%	–
Electrified households				
Lighting only	0%	0%	35%	57%
Lighting and cooking	0%	0%	36%	43%
Cooking only	56%	91%	20%	0%

marked in Same where 27 per cent report using fuelwood while 90 per cent of electrified households use charcoal.

Only 9 per cent of electrified households reported that they did not use kerosene at all. The use of kerosene for lighting in the electrified homes is most probably a consequence of the frequent power cuts experienced in most of the areas studied, see section 5.6. Therefore, it could be expected that the use of kerosene would be more frequent in the areas with a low supply reliability. This can be observed if the data for grid supplied Same (with a higher supply reliability) and diesel supplied Njombe/Sumbawanga (with a much lower supply reliability) are analyzed separately, see Table 5-8. However, even in Same almost 90 per cent of the electrified households use kerosene for either cooking, lighting or both.

The use of fuelwood for cooking differs between users and non-users of electricity, see Table 5-9, which also shows some differences between the basic and more advanced users of electricity. Fuelwood is the principal fuel used by non-electrified households (81 per cent) for cooking, either exclusively or in combination with charcoal and/or kerosene. While this high figure was not unexpected, it is more surprising that over half of the electrified households (56 per cent) report that they still use fuelwood.

Table 5-8 Use of kerosene by electrified households in grid connected and diesel supplied areas

Use of kerosene	Whole sample	Same (grid supplied)	Njombe and Sumbawanga (diesel supplied)
Lighting only	35%	12%	48%
Cooking and lighting	36%	21%	44%
Cooking only	20%	55%	2%
Not using kerosene	9%	12%	6%

Table 5-9 Use of fuelwood for cooking

	Electrified households		Non-electrified households	
Fuelwood use	More advanced users	Basic users	More affluent	Less affluent
Use	48%	66%	82%	80%
Do not use	52%	35%	18%	20%

The data suggest that there is no appreciable difference between the more and less affluent non-electrified households with respect to the use of fuelwood. The difference between the more advanced and basic users of electricity is more significant. Two-thirds of the households that only use electricity for basic functions use fuelwood, whereas slightly less than half of the more advanced users of electricity use it. The latter, which presumably have a higher income, are more likely to substitute the use of fuelwood with charcoal, kerosene or electricity.

The number of households not using fuelwood at all appears to increase with income. A reasonable explanation is that those with higher income are more willing to pay the higher cost of charcoal, both for its convenience and its higher status, while lower income households simply cannot afford to buy charcoal in any great quantity.

There are some variations among the study areas as energy use among the non-electrified households. This is illustrated in Table 5-10, which shows that kerosene is used much less for cooking in Njombe and Sumbawanga than in

Same. The table also shows that only very few of the non-electrified households are not using any kerosene.

Table 5-10 Energy use in non-electrified households

Energy form	Njombe	Same	Sumbawanga	All areas
Fuelwood	83%	80%	79%	81%
Charcoal	83%	51%	84%	72%
Kerosene used for:				
lighting only	81%	56%	79%	72%
cooking and lighting	19%	41%	20%	27%
not used at all	0%	3%	1%	1%

5.4.5 Electrical appliances used in households

As many as 34 per cent of the households among the basic electricity users reported that electricity is used only for lighting. More than half (54 per cent) own a radio as the single electrical appliance and 9 per cent are evenly distributed over ownership of hotplates, kettles or irons.

The more advanced users of electricity, by definition, consist of households that own several electrical appliances. A radio is owned by 94 per cent, an iron by 86 per cent and some cooking equipment, such as a hotplate or a kettle, by 67 per cent. More than half (51 per cent) report a combination of both iron and cooking equipment, together with a radio. Apparently many of these households could switch to cooking with electricity entirely, but few do so. Electricity may be used for making tea and heating snacks, while the main family meal continues to be prepared over charcoal or wood. Similar conclusions were drawn by Foley *(28)*.

5.4.6 Monthly energy expenses

Households were asked how much they spent every month to cover their energy requirements. This covered expenditures on electricity, fuelwood, charcoal and kerosene, but also batteries for radios, candles, gas, etc. The results are summarized in Table 5-11 and shown graphically in Figure 5-1.

There are many similarities between the observations for Njombe, Same and Sumbawanga but also some interesting differences regarding household energy costs. In all the areas, the more advanced electricity users

Table 5.11 Average monthly expenditure on energy by households (in TAS)

	Electrified households				Non-electrified households	
	Advanced users Electricity used for more than lights and one appliance		Basic users Electricity used only for lights and perhaps one appliance		More affluent Household owns more than three basic assets	Less affluent Household owns three basic assets or less
Study area	Total expense	Expense for electricity	Total expense	Expense for electricity	Total expense	Total expense
Njombe	2 927	151	2 254	157	2 327	1 471
Same	1 968	328	1 300	159	1 250	950
Sumbawanga	2 163	253	2 450	92	3 417	2 253
Uwemba	1 037	147	1 143	89	No data collected	
Gonja	1 594	328	1 537	130	No data collected	

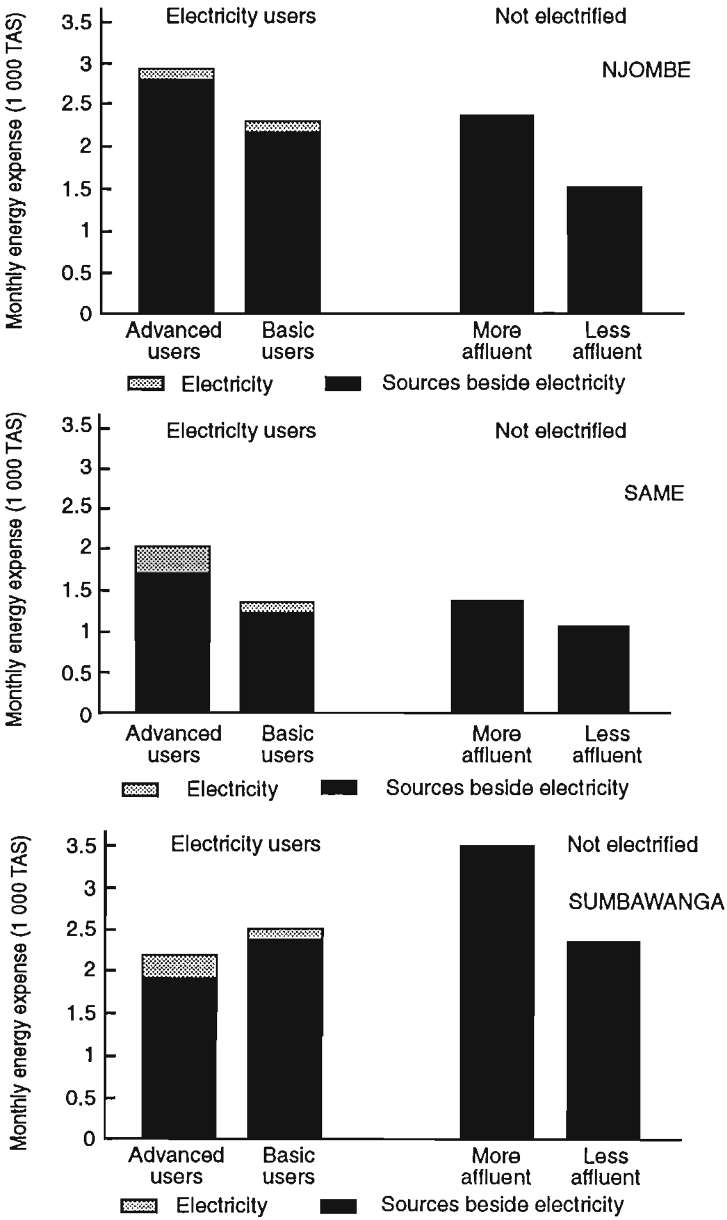

Figure 5.1 Household energy expenditure

tended to spend more money on electricity than the basic users, which is not unexpected. Less affluent non-electrified households generally spent less on energy than the more affluent[10], which also could have been expected. With a remarkable discrepancy in Sumbawanga, the expenditure on other types of energy than electricity does not vary a lot between the subgroups.

The two most interesting differences between the areas are the remarkably lower cost level in Same and the comparatively high expenses reported by the more affluent non-electrified households in Sumbawanga. It has not been possible to find the exact reasons for these discrepancies. The lower cost level in Same cannot be explained by lower fuel prices, see Table 5-1, and must, therefore, be related to a different use structure or different user habits. It can be seen from Table 5-10 that in comparison to Same, fewer of the non-electrified households in Njombe and Sumbawanga use kerosene for cooking. This would imply that more charcoal and wood is used by these households in Njombe and Sumbawanga. The much higher prices for these fuels in Sumbawanga could explain why the highest monthly expenses for the non-electrified households is found there.

The difference between energy costs for non-electrified households in Njombe and Sumbawanga can easily be explained by the higher prices for fuelwood and charcoal in Sumbawanga, see Table 5-1. It is less obvious why, in Sumbawanga, the electrified households spend less on other forms of energy than electricity than the non-electrified households.

It is clear that electricity users get more energy for their money. The energy cost of electricity for household use is of the order of 1 TAS/kWh, whereas the cost for energy from charcoal is in the range 1.3 – 2.9 TAS/kWh, and from kerosene in the range 5.3 – 6.9 TAS/kWh. These energy forms are only totally exchangable for cooking, where the lower efficiencies for stoves using charcoal and kerosene must be taken into account when costs are compared. Considering the efficiency differences, the energy cost for cooking with kerosene is 12 – 15 times higher than with electricity. For charcoal, the cost is 4 – 14 times higher depending on charcoal price and stove design. If households use the same amounts of useful energy, electrified households would, therefore, end up paying less. However, the basic electricity users in Sumbawanga have not substituted charcoal with electricity. Therefore, this

10 This is not true for Njombe, where the load shedding apparently affects the consumption, particularly of the more advanced users of electricity.

does not explain the higher expense for the more affluent non-electrified households.

The effect of fuelwood use on the monthly energy expenditures is illustrated in Table 5-12, which shows that those who obtain fuelwood at least partly by gathering spend on the average 4.5 hours per day on this activity and save on the average about 1700 TAS monthly compared to those who only buy this fuel.

Table 5-12 Influence of fuelwood use on energy expenses

Category	Fraction of sample	Monthly energy expenses	Time spent for gathering fuelwood
Non users of fuelwood	29%	1 586 TAS	0 hours
Fuelwood users, buying only	37%	3 008 TAS	0 hours
Fuelwood users, gathering and buying	34%	1 293 TAS	4.5 hours

5.5 Electricity Use in Commerce and Industry

5.5.1 Methodological remarks

Sampling of other than residential consumers, was divided according to tariff group. In the four areas included in the socio-economic study, only two consumers belonged to class 4, both of which were in Same, see Table 3-3. Therefore, the sampling of consumers in commerce and industry was done mainly in tariff classes 2 and 3. The consumers selected by sampling were visited and the person in charge was interviewed according to a standardized questionnaire. The total number of consumers in this category interviewed were:

	Tariff 2 light commercial	Tariff 3 light industrial
Njombe	38	13
Sumbawanga	38	11
Same	53	13
Babati	11	7

It should be noted that 12 light commercial enterprises and six light industrial enterprises from Gonja are included in the Same totals. Interviewing in Uwemba did not reveal any businesses and, hence, does not influence the Njombe figures.

More details on the methodology and a sample questionnaire can be found in the topical reports *(3)* and *(8)*.

5.5.2 Consumer profiles

The "light commercial" Tariff 2 consumers are either institutions, shops, restaurants, bars or hotels. There were also a few mechanical workshops and welding enterprises still using single phase equipment, but in the process of upgrading to Tariff 3.

Businesses falling into Tariff 2 are not necessarily dependent on electricity. They can continue to operate using kerosene for lighting and charcoal and fuelwood for cooking (in the case of restaurants, guesthouses, etc.). Hence many licensed businesses falling into this category (especially small shops and bars selling local liquor) are not connected. Most institutions fall into Tariff 2. In principle most can function without electricity as work is carried out during daylight hours. However, banks and post offices have certain equipment which needs a constant power supply and which, in a number of cases, is provided by a stand-by generator.

The "light industrial" Tariff 3 consumers can generally be categorized as "agro-processing", (usually meaning grain milling), or engaged in woodworking or welding. Enterprises falling into Tariff Group 3 are dependent on electricity; hence all are either connected to the TANESCO distribution system or operate their own power supply.

The businesses and industries tend to be privately owned. About 85 per cent can be described as being family enterprises. About 20 per cent of those interviewed report owning more than one business. Another important type of owner is churches and missions, covering 7 per cent of the consumers interviewed. Churches and mission societies were often found to engage in a complex of activities, combining educational facilities, vocational training, small agro-processing activities, medical service and housing programmes as well as purely religious activities.

There appears to be a tendency for owners of businesses to own the premises. This was the case for 72 per cent of those interviewed whereas 24 per cent rented premises. There is some difference between business types, with shop-owners more likely to rent than others with about 33 per cent of the shops operating from rented premises.

Owners of businesses are rather mobile. While 18 per cent reported coming from the town itself, 22 per cent came from the district and 17 per cent from the region. About 24 per cent report their origin as being from outside the region, with Sumbawanga in particular attracting entrepreneurs from elsewhere.

5.5.3 Self-generation of electricity

Although the study of the electricity consumption in commerce and industry focused on those connected to the TANESCO service, some efforts were made to identify institutions, businesses and industries located in the areas and using electricity produced by themselves (either permanently, or as a stand-by). Regular self-generation was observed in three of the four areas, i.e. Babati, Njombe/Makambako and Same, and was probably also present in Sumbawanga. The reason for not using the TANESCO service was stated to be that the reliability is not considered acceptable.

Self-generation is used, either to provide a back-up power supply, or to provide a power supply which is completely independent of TANESCO (TANWAT, in Njombe and the Kiru Valley schemes in Babati, may be seen as examples of this.) While the second category is more common near those areas supplied with power by TANESCO diesel power stations, or in the more remote and isolated areas, it is nevertheless surprising that even in grid-connected areas businesses found it necessary to invest in a stand-by generator.

5.5.4 Energy use in commerce and industry

Few of the consumers belonging to the "light commercial" and "light industrial" tariff groups rely entirely on electricity for their energy supply. Other forms of energy used are charcoal, wood, kerosene and diesel. Tables

5-13 and 5-14 summarize the findings on electricity use in the "light commercial" and "light industrial" tariff classes.

The "light commercial", tariff 2, consumers generally use electricity in a similar manner to the high income "residential consumers" in tariff group 1. As can be seen from Table 5-13, the average consumption per month is low, between 100 and 200 kWh/month. A radio is the most commonly found appliance. Non-electric stoves are used by most of the consumers in this group, sometimes in parallel with an electric cooking appliance. Refrigerators are found among 20 – 25 per cent of the shops, restaurants and guesthouses. Most of the consumers in this group do not really depend on electricity for their operation although electric lighting is certainly an important competitive factor for attraction of customers.

Table 5-13 Fraction of light commercial consumers, (tariff 2) using certain electrical equipment and appliances

Equipment or appliance	Shops	Restaurants and guest houses
Radio, casette recorder	81%	77%
Electric stove*	19%	15%
Kettle, iron	43%	33%
Refrigerator	21%	23%
Calculator	24%	8%
Average monthly electricity use kWh	104	188

*It was also found that 52% of the shops and 67% of the restaurants among the tariff 2 consumers used non-electric stoves. The structure of energy use for cooking is, therefore, similar to that found for households.

In addition to lighting, the "light industrial", tariff 3, consumers use electricity for welding and running electric motors, see Table 5-14. The variation in monthly consumption within this group is large, see also section 5.5.5. The average consumption is higher than for the "residential" and "light commercial" consumers. Some of the "light industrial" consumers depend on electricity for their operations and the alternative to the TANESCO service would be self-generation of electricity. Several have installed stand-by generators to ensure operation when the TANESCO supply fails. Enterprises in the agro-processing sector could use diesel engines for the grain mills. Carpentry and wood working enterprises could manage with handtools only as, in fact, many do.

Table 5-14 Fraction of light industrial consumers (tariff 3) using certain electrical equipment and appliances

Equipment or appliance	Garages and mechanical workshops	Agro-processing	Carpentry and wood working
Radio	45%	29%	0%
Electric stove*	11%	0%	0%
Small power tools	89%	0%	33%
Large power tools	78%	0%	100%
Grain milling machine	0%	94%	0%
Pump	11%	0%	0%
Stand-by generator	22%	6%	0%
Average monthly electricity use kWh	394	924	257

*It was also found that non-electric stoves were used by 45% of the garages (incl. mechanical workshops) and by 29% of the enterprises in the agro-processing category.

5.5.5 Monthly energy expenses

An overview of monthly expenditure on energy among "light commercial" and "light industrial" consumers is shown in Figure 5-2. For the purpose of analysis the tariff 2 consumers have been split up in two groups, i.e. "institutions" and "businesses". Electricity costs include payments to TANESCO as well as fuel costs for stand-by generators. Costs for other forms of energy include mainly charcoal, fuelwood and kerosene.

Electricity was found to be responsible for the largest part of the energy cost among institutions and light industry. A substantial part of the electricity costs for some consumers are, however, attributable to fuel costs for stand-by generators. Approximately 25 per cent of institutions (especially banks and post offices) and 16 per cent of light industrial consumers have additional

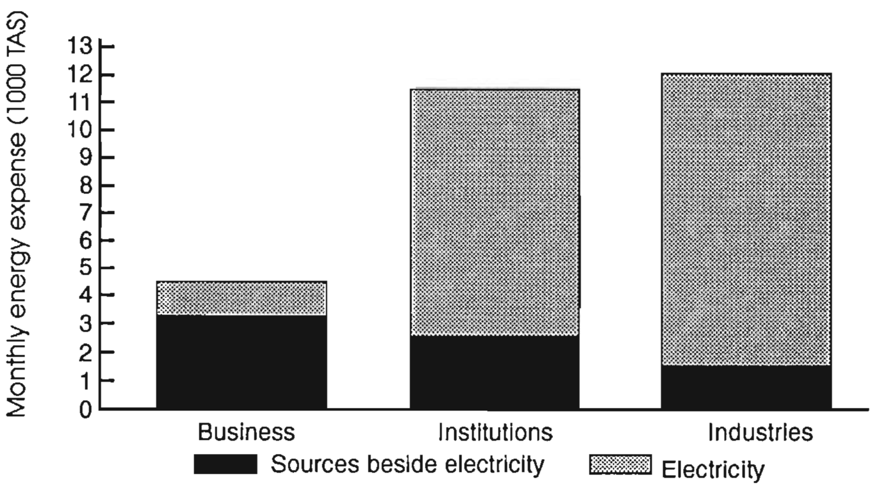

Figure 5-2 Monthly energy expense for light commercial and light industrial consumers

expenses as a result of self-generation. This would appear to be the main reason for their high expenditures on electricity.

On average, institutions were found to spend 8 950 TAS per month on electricity or electricity generation and 2 380 TAS on other forms of energy. Consumers in the "light industrial" category spend, 10 550 TAS per month on electricity and 1 300 TAS on other forms of energy.

For business consumers in the "light commercial" tariff group, electricity costs represent only 25 per cent of the energy cost. The average monthly electricity cost in this group was 1 170 TAS and the costs for other energy forms was 3 290 TAS.

5.5.6 *Electricity and employment*

Table 5-15 shows the average employment and average monthly electricity consumption among the "light commercial" and "light industrial" consumers. Again, for the purpose of analysis the tariff 2 consumers have been split into two groups, i.e. "institutions" and "businesses".

Table 5-15 Relation between employment and electricity use

Category	Employment[1] persons/consumer	Average electricity consumption kWh/month	Employed persons/kWh
Tariff 2			
Light commercial			
Businesses	5.8	78.5	0.07
Institutions	33.7	406	0.08
Tariff 3			
Light industrial	4.0[2]	511	0.008

[1]Close relatives not included.
[2]Two large employers are pulling up the tariff 3 average

As indicated in Table 5-15, government and non-government institutions are the major employers. Businesses and light industries usually employ few people outside of the direct family. Not surprising, the electricity consumption per employee is low in institutions and businesses and much higher in light industry.

As mentioned in section 5.3.3 the major industry in Njombe, TANWAT, which employs a large number of people, was not connected to the TANESCO supply. Similar signs that some larger enterprises prefer to rely on self-generation was found in Same, see section 5.3.4. This is not surprising considering the problems with supply reliability. It is not possible to generalise from so few observations, but the findings indicate that this is a problem which should be investigated further.

It is difficult to quantify new employment resulting from the TANESCO electrification. Most of the larger industrial activities were in operation using their own supply before electrification. Some, as mentioned above, still rely on self-generation. It appears that most of the new employment resulting from electrification can be found in the entertainment sector and possibly among small workshops. However, the employment that is generated is likely to be a function of an overall development of the town rather than a result of electrification per se. Thus, the creation of the regional capital at Sumbawanga has created a number of jobs in the service sector; and the locations of Babati and Same on major roads has enabled them to expand and improve their services to travellers.

5.6 Perceived Benefits of Electrification

At the end of each interview session, an open question was asked about the interviewee's opinion of the use of electricity in rural towns and villages. The responses vary somewhat between the areas studied, as documented in *(8)*, depending on local conditions but there are also considerable similarities. Many of those interviewed considered electricity as bringing important benefits to the rural communities. This response is not really surprising, considering the nature of the interview and the fact that the interviewee probably expected that the interviewers would be pleased with such a response.

One of the outstanding features of the responses, common for Njombe, Same, Sumbawanga and for Babati, was that electrification lead to provision of services which are accessible even to those people who do not have a domestic connection. The importance of grain milling and street lighting was particularly emphasized, while water pumping and provision of electricity to health services was also frequently mentioned. The role of electricity in supporting small industries and hence creating employment, is also regarded by many as a positive effect.

Unfortunately, the indirect benefits to households without electricity (i.e. provision of services such as street lighting, water pumping and health services) are often influenced by the fact that the payment of the electricity bills is a (local) government responsibility. Bills are often left unpaid or paid only when long overdue. In addition, when load shedding is practised, street lights – especially in the poorer sections of towns – are often the first to be affected.

With respect to electricity in the home environment, it is widely regarded as being a cheaper alternative to fuelwood, charcoal and kerosene[11]. It is questionable whether this would still be the case if the subsidies on electricity were lifted. Nonetheless, households and businesses recognize the discrepancy between the low recurrent costs for electricity (due to the subsidies) and the high investment costs (in service lines and wiring, and for appliances). A number of suggestions were offered as to how these costs might be evened out.

11 This opinion is correct, see discussion in section 5.4

Finally, there were complaints about the unreliability of the power supply even, surprisingly, from households and businesses in Same where power is tapped from the national grid. Unreliability of the power supply, and the costs of installation and of electrical appliances are regarded as major barriers to an expansion in the number of households and businesses connected to the power supply.

It is clear that non-connected households do share many of the indirect benefits of electrification. Electricity brings "modernisation" (a positive feeling of well-being which, unfortunately, cannot be measured) to the town; there are street lights and improved security at night, shops and bars remain open at night, services improve (water, health, etc.) and grain mills work for as long as the power supply does. These indirect benefits are shared by connected and non-connected households. However, poorer households tend to be located further away from the street lights and from the hospitals, the poorer households tend to collect water from stand pipes while richer households have domestic connections, and richer households are more likely to be customers in the shops and restaurants, etc. As usual, those who benefit most from electrification, are those who actually have the use of electricity in their homes. This does not include low income households in the rural towns, neither does it include the rural poor.

5.7 Problems Experienced with the Service

5.7.1 Installation cost

From the household interviews it is apparent that the high cost for installation and connection is a major obstacle to the electrification of homes, see Table 5-6. The cost can be estimated as between 20 000 and 100 000 TAS, depending on the size of the house and the distance from the distribution lines.

From the responses to the open question in the household questionnaire it is clear that the high initial investment prevents many from using electricity. A number of those interviewed actually suggested that the connection fee should be reduced and the tariffs increased to compensate for this.

5.7.2 Supply reliability and quality

As found from the technical evaluation, see section 3.10, both the reliability of the power supply, and the quality in terms of constant voltage, can be considered as below international standards in many rural areas. These issues were brought up in the interviews to find out whether this is regarded as a real problem among the users of electricity. The responses clearly showed that it is.

All categories of electricity consumers supplied by TANESCO identified poor reliability of the electricity supply as a major problem with the present service. During the interviews, households were asked how often they experienced power cuts. As many as 95 per cent reported supply interruptions and those households were then asked how often the interruptions occurred. The results, summarized in Figure 5-3, show that the TANESCO customers in diesel supplied Njombe and Sumbawanga are those perceiving supply interruptions as occurring most frequently. TANESCO customers in grid supplied Same report less frequent interruptions, whereas the privately supplied households in Uwemba reported the best supply reliability. Results from Babati are similar to those from Njombe and Sumbawanga.

The majority of those interviewed in these areas reported power cuts a few times a week and many reported power cuts every day. These experiences agree with the observations for these areas made by the technical team, see section 3.10.4. The primary reason is that the peak demand exceeds the available generating capacity, which makes load shedding necessary. Even in Same, which is grid supplied and does not suffer from capacity problems, 19 per cent of users report power cuts a few times a week, although the majority reports that this happens a few times a month.

It is interesting that the consumers connected to the independent mission-operated grid in Uwemba generally report power cuts less frequently than once a month, and then only as planned and announced power cuts to allow for maintenance activities to take place. This indicates that the problem is primarily a matter of management and resources.

Irregular power supply was identified by about 70 per cent of the "light commercial" and "light industrial" consumers as the major problem with the TANESCO service. As far as the quality of the supply is concerned, 25 per cent of the "light industrial" consumers and 15 per cent of the "light com-

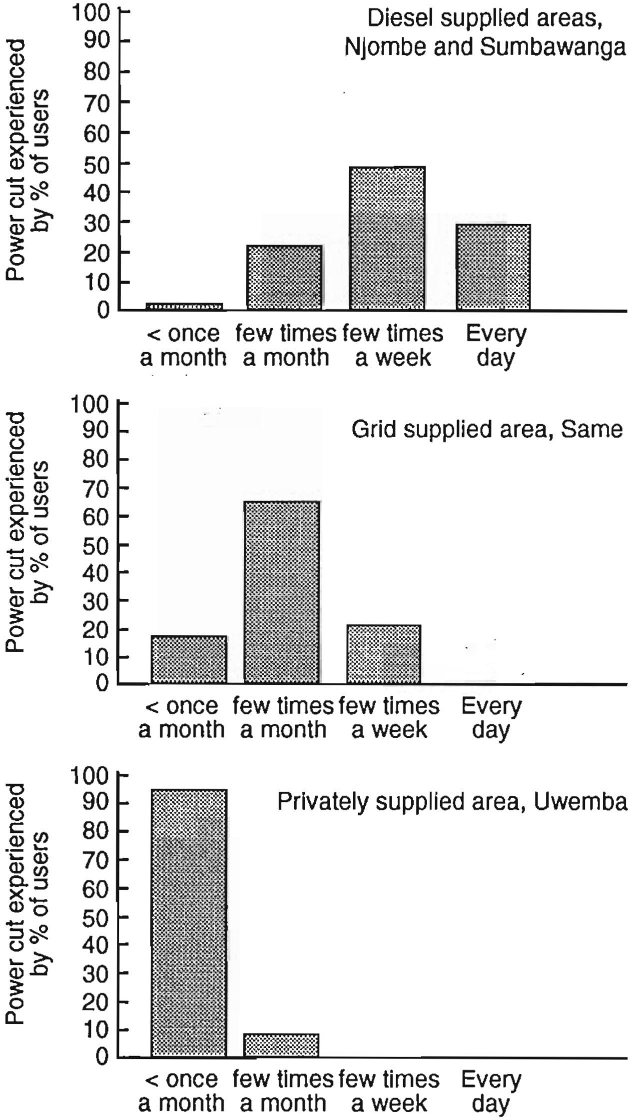

Figure 5-3 Households perception of frequency of power supply interruptions

mercial" consumers identified this as the main problem. A number of households reported that appliances had been damaged as a result of fluctuations in the power supply.[12]

5.7.3 Delays in connection

As can be seen from Table 5-6, long delays before connection was mentioned as the major reason for not using electricity by about 15 per cent of the non-connected households. However, the overwhelming majority of these were found in the three diesel supplied areas, where additional connection of customers is pointless due to the existing problems of meeting the peak demand.

5.7.4 Administrative difficulties

Complaints about administrative difficulties in dealing with TANESCO were found particularly in the more remote villages served through Same, where customers had to travel by bus to Same, (at a cost of several hundred shillings), in order to pay an electricity bill of approximately 100 TAS. If the bill was not paid, TANESCO would send out a team in a TANESCO vehicle to disconnect the supply. Sending out a vehicle each month to collect payments could lead to a considerable improvement in the service.

5.8 Generalization of the Findings from the Socio-economic Evaluation

For reasons of time and economy, the socio-economic studies had to be limited to a few selected areas. This poses the question of whether the findings are valid only for these four areas or whether they can be considered as generally representative of rural electrified areas in Tanzania. There are good reasons to believe that the latter is true to a large extent. First of all, the main findings are similar for all the four sites studied in detail. Secondly, the findings from the technical evaluations, which have covered most of the

12 There seem to be no record of damaged equipment at the TANESCO offices. The explanation could be that the equipment had not been properly registered with TANESCO, who cannot then be held responsible for damage. It does seem that there is under-reporting to TANESCO of electrical appliances installed.

rural areas served by TANESCO, indicate that the financial, technical and management problems are similar all over the country. Since all the problems experienced by the consumers have their roots in these financial, technical and management problems, it is most likely that the findings would have been similar if other areas had been selected for the socio-economic evaluations.

6
Evaluation of Rural Electrification Experiences in Tanzania

6.1 Issues Covered in the Evaluation

There are several ways in which experiences from a rural electrification project can be evaluated. One possibility is to compare what actually happened, or was actually achieved, with the expectations of those who were involved in the decision making process, or were affected by the decisions. Another possibility is to evaluate the experiences of the decision-makers and those affected with respect to the present attitudes towards the project. A combination of these two approaches has been used here.

For the evaluation of the socio-economic impacts, the recent "Rural electrification policy document" *(13)* has been used as the most recent documentation of the objectives and priorities of TANESCO and the Government of Tanzania with respect to rural electrification.

The formulations in the "Work plan" for this evaluation project highlight some special aspects of rural electrification which were also included in the evaluation. The explicit and implicit goals of various Donor Agencies which have been supporting rural electrification projects in Tanzania, are generally the same as those presented in the "Rural electrification policy document" and the "Work plan". A special evaluation with respect to Donors' objectives was, therefore, not considered necessary.

As far as technical performance is concerned, guidelines formulated by the International Electrotechnical Commission (IEC) as well as the assessment of the electricity users were used as a basis for the evaluation.

The following issues were covered in the evaluation:

— Provision of electric power to isolated areas.
— Electrification as a means to avoid deforestation.
— Electrification as a means to promote industry for a higher degree of processing of agricultural products.
— Electrification as a base for small scale industry.

— Electrification as a means for improvement of the standard of living for the rural population.
— Electrification as a means for improvement of the situation of women.
— Financial performance.
— Technical performance
— Use of appropriate technologies.

In the following sections of this chapter, the experiences from the rural electrification projects in Tanzania – as they appear from the information collected in this study – will be evaluated with respect to all these issues. It will be shown that many of the objectives of rural electrification as they have been formulated in the "Rural Electrification Policy Document" and other documents referenced below, have not been achieved or only partly achieved. The reasons for these shortcomings are discussed in this chapter. Possible ways to improve the situation are discussed in the following chapter.

6.2 Provision of Electric Power to Isolated Areas

6.2.1 Performance criteria

One of the main objectives of rural electrification according to the "Rural Electrification Policy Document" *(13)* is:

> *"To send power to the country's isolated areas, which otherwise do not have access to power from the National Grid; thus improving rural energy supply"*

The purposes for which the rural energy supply is to be improved are not specified in this general objective, but are highlighted in other, more specific objectives, which are discussed below. One aspect of rural electrification, which is not mentioned in the "Rural Electrification Policy Document" *(13)* is the sense of modernization, technical progress and optimism about future development brought to the population of the electrified areas. This is possibly a very important positive social effect of the electrification programmes. Electrification may thus facilitate recruiting of qualified professionals to positions in rural areas and possibly reduce slightly the migration of young people to the large cities.

No quantitative goals for the extent of rural electrification, are given in *(13)*. According to a paper presented by the Managing Director of TANES-

CO at the National Energy Policy Seminar in Arusha *(26)*, the ultimate goal is to provide access to electricity in all towns and villages of Tanzania. The fraction of the rural towns and villages actually electrified is, therefore, used as a performance criteria here.

6.2.2 Assessment

As can be seen from section 3.1 of this report, the TANESCO rural electrification programme has so far provided access to electricity in 37 rural towns (30 being district towns) and more than 14 rural villages. Rural electrification through non-TANESCO projects has covered at least another 22 rural villages. Therefore, out of the total number of 66 rural towns 44 per cent have to date been electrified. Of the 8 600 rural villages, probably less than 1 per cent have been electrified.

It should be noted that only a small fraction of the households in the electrified towns and villages are actually connected. As can be seen from Table 5-2 , the percentage varies between the towns, with 12 per cent connected households as a reasonable average.

For most of the towns visited, there is a substantial backlog of outstanding applications for connection, which indicates that TANESCO has difficulties providing services to all those who wish to use electricity. As an overall assessment, the progress can be characterized as modest.

6.2.3 Reasons for shortcomings

Several reasons why rural electrification has not progressed further in Tanzania can be identified. Lack of capital for investment in production units as well as transmission and distribution systems, and particularly a lack of foreign currency for purchase of hardware that must be imported, are certainly major constraints on expansion of rural electrification. According to the general manager of TANESCO, see *(26)*, the annual requirement of foreign currency to meet modest operating and development requirements can be estimated to 20 to 25 MUSD. The actual annual allocation by the Central Bank to TANESCO does not exceed some 7 MUSD. Even the Open General Licence (OGL) scheme does not satisfy the requirement of the electricity sub-sector. A significant proportion of the materials and equipment required for the development needs are not even included in the OGL list.

The poor financial viability of the rural electrification projects completed so far, which is documented in section 3.12 and discussed in more detail below in section 6.11, is probably a major reason for the modest progress of rural electrification. It is evident that TANESCO cannot afford to operate many more loss-making rural branches.

Possible solutions to these problems are discussed in chapter 7 of this report.

6.3 Electrification as a Means to Avoid Deforestation

6.3.1 Performance criteria

One of the main objectives of rural electrification according to the "Rural Electrification Policy Document" *(13)* is:

> *"To protect Tanzania's natural resources and environment by avoiding deforestation, desertification and denudation of soils; thus minimizing /avoiding the potential firewood crisis – the energy problem for the country's millions of poor and marginal in the rural areas"*

A reasonable criteria for assessment of the performance of rural electrification programmes with respect to this objective is the number of households in the electrified areas which have switched to electricity for cooking from the use of biomass fuels, i.e. firewood or charcoal. This criteria will be used here.

6.3.2 Assessment

The results of the socio-economic field work in four of the electrified areas, i.e. Babati, Njombe, Sumbawanga and Same, clearly show that electrification has resulted in only a marginal switch from biomass fuels to electricity for cooking. First of all, most of the households are not connected. Of those connected, only a small percentage use electricity for any cooking and all use biomass fuels for some cooking.

It is, therefore, clear that rural electrification has had virtually no impact on deforestation, desertification and denudation.

6.3.3 Reasons for shortcomings

The small fraction of the households that is actually connected to electricity is of course a major obstacle to substitution of biomass fuels by electricity. Lack of capital for bringing the house to a standard where connection is allowed by TANESCO as well as lack of capital to pay the connection fee, are important reasons for the small number of households connected, see Table 5-6.

The backlog of outstanding applications for connection, however, also indicates that there are reasons within TANESCO for this shortcoming. Shortage of line material, meters, equipment for construction and problems with transport is one such reason. At some sites, such as Babati and Njombe, the connected demand already exceeds the generating capacity and it is, therefore, pointless to connect additional residential consumers until the generating capacity has been increased.

The results from the socio-economic field work show, however, that connection of the house will not automatically lead to a shift from biomass cooking fuels to electricity. There are many reasons why biomass fuels are still being used by connected households and businesses. The investment required for an electric cooker and cooking utensils is certainly one obstacle to biomass fuel substitution. Cooking traditions, such as roasting of meat over charcoal, is another. Most important is probably that fuelwood can be collected for free or bought and paid for in small units in most rural towns and villages, whereas cooking with electricity means a considerable initial investment.

6.4 Electrification as a Means to Promote Industry for a Higher Degree of Processing of Agricultural Products

6.4.1 Performance criteria

One of the main objectives of rural electrification according to the "Rural Electrification Policy Document" *(13)* is:

> *"To use power to process agricultural products for export and/or use as finished goods (e.g khanga) or semi processed (e.g cotton lint) to get better prices, on the basis of "value added"; thus contributing to National Development and particularly the on going National Economic Recovery Programme"*

A reasonable criteria for assessment of the performance of rural electrification programmes with respect to this objective is the expansion of agro-based industries producing finished goods or semi-manufacture of goods in the electrified areas. This criteria will be used here.

6.4.2 *Assessment*

Table 6-1 lists the agro-based industries producing finished goods or semi-manufactured goods which were found to be located in or near-by those electrified areas that were studied in more detail. It appears that the impact of electrification on the development of agro-based industries has been insignificant. Several of the industries do in fact rely on their own power supplies rather than the service offered by TANESCO.

6.4.3 *Reasons for shortcomings*

There are several reasons why the rural electrification programme of TANESCO has not resulted in any significant expansion of agro-based industry producing finished goods or semi-manufactured goods. One obvious reason is that the TANESCO rural electrification programme appears to have given priority to district towns rather than to industry sites. In addition the Ministry of Industry and Trade in Tanzania is emphasizing location of industrial enterprises to large towns rather than to the towns and villages included in the rural electrification programme.

The main reason for the lack of success in this respect is certainly that access to electricity is not the main factor determining whether new agro-based industries will be created. A reliable supply of raw materials, good communications and an established market for the products are much more important factors. In comparison with all the other problems that must be solved before creation of such enterprises, the electricity supply is a minor one. This implies that the poor supply quality and reliability in some of the electrified rural areas[13] is probably not of major importance for the lack of industrialization in the rural areas. This conclusion is supported by the fact that industries in towns with poor supply relability use their own generators, e.g TANWATT and NJODECO in Njombe.

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13 See section 3.9, 3.10 and 6.11 for more details.

Table 6-1 Development of agro-based industry in the rural areas surveyed in detail

Site	Year of electrification	Agro-based industries	Operation started	Present electricity supply
Babati	1981	Several estates in near-by Kiru valley producing crude brown sugar "jaggery"	Before 1981	Own diesel generator sets
Njombe	1981	Tanganyika Wattle Company		Own biomass fuelled steam power plant with stand-by diesels
		NJODECO		Own diesel generator set
Same	1976	PADECO cotton ginnery	Before 1976	TANESCO
Sumbawanga	1980	None		

6.5 Electrification as a Base for Small Scale Industry

6.5.1 Performance criteria

One of the main objectives of rural electrification according to the "Rural Electrification Policy Document" *(13)* is:

> *"To establish a base for small scale industries as an alternative to the basic occupation of the rural population; to support agricultural development, the construction industry and others thus starting/initiating the industrial revolution in Tanzania"*

This objective appears as primarily focussed on productive uses of electricity within small or moderately sized enterprises. A reasonable criteria for assessment of the performance of rural electrification programmes with respect to this objective is the expansion of small industries and the utilization of electricity for agriculture and the construction industry in the electrified areas. This criteria will be used here.

6.5.2 Assessment

Examination of the data for electricity use in different tariff groups, see Tables 3-3 and 3-4, shows that productive uses of electricity (tariff groups 3 – 5) represent only a moderate fraction of the total electricity use in the rural areas.

Based on the observations made in the areas visited it must be concluded that electrification has resulted only in a modest expansion of small scale industry. In Sumbawanga, a small SIDO factory, making nuts, screws and bolts had been established after electrification as part of an integrated donor-supported development plan. In Same, six industrial projects had been started, again as part of an integrated donor-supported development programme. Nevertheless, as can be seen from Table 3-4, the electricity consumption in tariff classes 3 – 5 is significantly below the national average of 50 per cent. It is interesting that one of the new enterprises in Same, a construction company, is registered as a tariff 2 consumer and uses its own diesel generator to provide power to its three-phase tools.

Grain milling, which is commonly taking place using electricity in the electrified areas is not an activity brought about by electrification, but was already occurring before electrification using diesel engines as the power source. Electrification has provided support to agriculture through irrigation schemes at some sites, for example in Same.

It can be concluded that rural electrification has had only a modest impact on creation of small industries and is used only to a minor extent to support agriculture.

6.5.3 Reasons for shortcomings

The reasons why rural electrification has had modest success in the creation of small industries, and is only used to a small extent for support to agriculture are similar to those given under 6.4.3 concerning agro-based industries.

It also appears as if the TANESCO programme, in effect, has given lower priority to such uses for electricity. The emphasis of TANESCO on electrification of population centres has not, for example, always facilitated use of electricity in agriculture[14]. An example from one of the sites reviewed in detail, i.e. Babati, where the industrial area has not yet been electrified, also indicates that residential use has been given priority.

For small industry, the dis-incentives to electricity use created by the progressive tariff and the problems with reliability and quality of the electricity supply, are probably more important than for the larger industries discussed in section 6.4. Difficulties in financing the necessary building improvements, the connection fee and electrical appliances and tools can also be an important obstacle. It is an interesting observation that foot-powered sewing machines are still the most common among tailors and seamstresses in the electrified rural towns.

6.6 Electrification as a Means for Improvement of the Standard of Living for the Rural Population

6.6.1 Performance criteria

One of the main objectives of rural electrification according to the "Rural Electrification Policy Document" *(13)* is:

"To generally raise the standard of life for the rural poulation through improvement of
— *basic health services*
— *education and information systems*
— *water supply and irrigation*
— *food production, storing and processing*
— *security by lighting of homes and private and public installations"*

The success of rural electrification with respect to this objective can be assessed by examination of the extent to which electricity is actually used for the purposes specified above.

14 Kiru valley, an agricultural area close to Babati, where sugar cane is grown and processed, is one example of an area which has not been electrified as a result of the focus on electrification of population centres.

6.6.2 Assessment

Electrification has certainly improved the situation for basic health services, in the towns which have been electrified. Electrification has also improved the situation with respect to education and information, primarily through radios. Electric lights in schools are seldom found at the primary school level but are often found in secondary schools and colleges. According to information collected in the socio-economic field studies, children in the few houses that have been electrified do their homework after dark using electric light.

Electrification appears to have had a modest impact on water supplies and irrigation.

With regard to food production, storage and processing, electrified grain mills discussed above in section 6.5.2 and refrigerators represent the major users of electricity. The main use of refrigerators is apparently to improve business in bars and restaurants, i.e. for provision of cold drinks, and that use for food preservation is marginal. Cooking with electricity, which involves considerable advantages with respect to womens health (see section 6.7.1 below), is not practised to any significant extent, see section 6.3.2.

The impact of electrification on security is substantial and this is reflected in the information collected during the socio-economic field work. This, is to a large extent, a result of the TANESCO policy to install at least 300 street light bulbs in each electrified town or village. This advantage, is however, undermined by the low supply reliability in many of the rural areas.

In summary, electrification has resulted in significant improvements as regards security, basic health services and education and information through the radio. The impact is less significant with respect to other types of education, water supply and irrigation and marginal with regard to food production, processing and storage.

6.6.3 Reasons for shortcomings

The reasons for the limited use of electricity for cooking are discussed under section 6.3.3. The main reason for the limited use of electricity for purposes like water supply, irrigation and schools, is primarily that these uses have been given lower priority.

6.7 Electrification as a Means for the Improvement of the Situation of Women

6.7.1 Performance criteria

Improvement of the situation of women is not identified as a specific objective of rural electrification in the "Rural Electrification Policy Document" *(13)*. It is not uncommon, however, that this objective is emphasized in feasibility studies for rural electrification projects, see for example a recent study for FINNIDA (Finnish International DevelopmentAgency) *(17)*. The anticipated positive impact of rural electrification on the situation of women is also highlighted in the "Work Plan" for this study *(1)*:

> *"As a result of rural electrification, rural life can become not only attractive, but also more habitable. Even further, electric supply help to liberate the rural women (and children) not only from the yoke of carrying heavy loads of firewood and water but also increase their working hours making it easier to schedule their work loads and/or apportion some time for leisure."*

The impact of rural electrification on the situation of women, was not specifically covered by the questionnaires used in the socio-economic field studies. It is possible, however, to base the assessment upon an indirect evaluation, using available information about impacts of rural electrification on those aspects of rural life which are known to be of importance for the situation of women. Collection of fuelwood and water, cooking, land cultivation and small business are typical occupations for women. The effects of rural electrification on the situation of women will, therefore, be based on an assessment of the impact on such activities.

6.7.2 Assessment

It has already been concluded that the impacts of rural electrification on the use of fuelwood and cooking habits is negligible. Consequently, virtually no improvement of the situation of women with respect to collection and carrying of fuelwood, nor exposure to smoke and heat from cooking fires, has been achieved through the present rural electrification projects. Modest improvement may have been achieved through water supply systems. The employment situation for women in the electrified towns, where bars and restaurants flourish, can be assumed to have improved.

One possible aspect of the security improvement, which is particularly important for the situation of women, is the reduced risk of witch-craft allegations following the improved lighting of streets and houses.

6.7.3 Reasons for shortcomings

These have been discussed above under 6.3.3 and 6.6.3

6.8 Financial Performance

6.8.1 Performance criteria

Although it is not obvious that every rural electrification project must be financially self-supporting, it is also clear that there are limitations on the amounts by which rural electrification can be subsidized by electricity consumers in more densely populated areas.

A positive internal rate of return appears, therefore, as a reasonable financial performance criterion for rural electrification projects also.

This criterion appears to have been applied when decisions were taken at least for some of the projects included in this review. The feasibility study for 19 townships carried out by a consultant company from Germany in 1975 *(14)*, predicted a positive rate of return, which appears to be an important reason for recommending the project. Similar thoughts are presented in studies prepared for DANIDA (Danish International Development Agency) in 1977 *(15)* and for JICA (Japan Internatinal Co-operation Agency) in 1981 *(16)*.

A different approach has been taken in the very recent study made for FINNIDA in 1989 *(17)*. This appears to accept the fact that the proposed rehabilitation of diesel power plants by installation of new engines will lead to substantial financial losses but justifies the project on the basis of anticipated socio-economic benefits.

6.8.2 Assessment

This study has had great difficulties establishing the total cost for power generation at all the sites that were visited. It has, for example, not been possible to establish the capital costs to be allocated to each rural electrification project. It has also not been possible to determine part of the operating costs. This is mainly a result of the way in which the book-keeping in TANESCO is organized, since some of the operating costs for the rural areas are combined on a regional level. Nevertheless, it is quite clear that all the projects supplied by diesel generators are run at substantial financial loss.

This is a consequence of fuel costs being about three times higher than the average sale price for one kWh.

For the grid supplied projects, the relationship between revenues and operating costs is more favourable. The check on the financial results of the Same branch indicates that grid supplied projects may generate a small surplus, provided that the capital cost for transmission lines is not too high and that the consumption structure is favourable for a high average revenue on units sold.

6.8.3 Reasons for shortcomings

The main reason for the financial losses caused by the rural electrification projects is obviously that the tariffs do not reflect the marginal cost for the supply. The situation is aggravated by the combined effects of the tariff structure and the demand pattern. The tariff offers a large subsidy for small domestic consumers which dominate the consumption in rural areas. It is also clear that higher than necessary operating costs are caused at some sites by the high electrical losses, and by higher than normal fuel and lubricant consumption.

6.9 Technical Performance

6.9.1 Performance criteria

From the viewpoint of the consumers and the local population, the technical performance parameters of primary interest are:
— supply reliability,
— voltage and frequency stability, and
— environmental pollution.

The supply reliability is best assessed against the requirements of the users. This aspect was, therefore, covered in the questionnaires used for the socio-economic field studies. Supplementary data on recorded outages were also collected by the technical team.

Voltage and frequency stability can best be assessed against the IEC standards which define the following variations as acceptable:

Voltage	-5% to +5%
Frequency	-1% to +1%

The effects of oil spills, and to some extent noise from diesel power plants, are the main environmental problems associated with the present rural electrification programme. A reasonable requirement is that such oil spills should not cause pollution of wells, or of lakes or streams used for fishing or irrigation.

6.9.2 *Assessment*

With respect to supply reliability, the responses to the questionnaires used in the socio-economic field study indicate that power interruptions are frequent in the TANESCO supplied areas studied in detail. Most consumers report daily or weekly power cuts, see Figure 5-3. Unreliability of the supply was also mentioned as a major problem with the service provided by TANESCO by several of those interviewed. Commercial and industrial consumers, tariff classes 2 and 3, identified irregular power supply as the main problem. For such consumers, the unreliability has obvious financial implications. Some enterprises and institutions in the areas served by TANESCO prefer to use their own power plants[15], others have invested in stand-by units, see Table 5-14. This problem was not, however, identified as a major reason for non-connected households to delay their connection, probably because other obstacles like the expenses involved appeared as prohibitive.

The information on recorded outages collected by the technical team, see sections 3.9 and 3.10, confirms low reliability in many of the areas but also indicates large variations in the supply reliability. Several of the areas show reliabilities below 90 per cent which by any standard must be considered as low. The problem was found to affect both grid connected and diesel supplied areas.

Voltage fluctuations appear to be a problem at all the sites, including those which are grid supplied. Many of the consumers interviewed reported that appliances had been damaged by voltage fluctuations.

No quantitative data on emissions from the diesel power plants were collected in this study. A follow-up study on this was carried out in July – August 1990. This study *(31)* shows that there are potential water pollution problems from oil spills at several of the sites since interceptors in the drainage systems are either not functioning or have not been installed.

6.9.3 *Reasons for shortcomings*

The supply reliability problems in some of the grid supplied systems are a

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15 Examaples of this are the post office in Babati, TANWATT in Njombe and a RIDEP construction company in Same.

result of inherent problems with the existing systems. In the case of Tanga and Morogoro regions, the transmission and distribution systems are very old with a lot of rotten wooden poles. This frequently results in loose connections which are responsible for many of the supply interruptions.

For the diesel supplied systems, the reasons for the supply reliability problems differ between the sites. At some sites, like Babati, the peak load has outgrown the installed capacity, which results in a need for daily load-shedding. At other sites, like Njombe, the problem is primarily the long repair times caused by lack of spare parts, lack of tools, lack of manuals, lack of transportation means and/or inadequate training of the station crew. Problems with fuel and lubricant supplies appear to be less important now than they were a few years ago.

In the case of diesel gensets, the reasons for the voltage fluctuations are primarily the breakdown of the automatic voltage regulators; Babati and Njombe are examples. In such situations, voltage regulation and control must be undertaken manually. At neither of these sites was there an electronic technicians to take care of this problem. In the case of grid connected systems, the voltage fluctuations occur due to voltage variations in the transmission grid which are too large to be contained by the local tap changer. As for Kilimanjaro and Arusha regions, both located at the far end of the 132 kV line, the lack of the necessary compensating reactive power is responsible for large voltage fluctuations in these two regions.

The potential environmental pollution problem is primarily a consequence of inadequate specifications, i.e. that installation of interceptors was not required. Oil leakage could be observed at several of the plants, see section 3.9 for details.

6.10 Use of Appropriate Technology

6.10.1 Performance criteria

The last of the main objectives of the rural electrification programme identified in the "Rural Electrification Policy Document" *(13)* is:

> *"To determine appropriate technologies and local production capabilities which would reduce costs for rural electrification"*

An assessment of the success of rural electrification with respect to this objective is not possible unless "appropriate technologies" are defined. Here we will use this term for technologies which perform to the expectations of the users and can be operated, serviced and maintained using the locally available skills and infra-structure.

6.10.2 Assessment

The technologies used for rural electrification within the TANESCO programme are either grid connection (which utilizes a mixture of imported and locally manufactured equipment) or diesel power generation which utilizes imported equipment.

In the mixture of equipment for grid extension, the locally manufactured equipment includes: conductors – (AA) all aluminum of sizes 25, 50 and 100 mm^2 as well as lead-in wire (PVC) of sizes 10 and 16 mm^2, cross arms, tie strips, D – irons and bolts; impregnated wooden poles; and distribution transformers 11/.23 or 33/.23 kV single phase – capacity 15 and 25 kVA, 11/.4 or 33/.4 kV three phase – capacity 50, 100, 200, 315, 500 and 800 kVA.

Diesel generator sets are imported. However, a limited number of spare parts for these like rubber bushings are available locally. Servicing of alternators, e.g. rewinding is also done locally. It is quite clear that local production has only been used to a marginal extent.

There is no reason to doubt the appropriateness of the technology used for transmission/distribution.

The appropriateness of the diesel generator sets is more questionable. The information collected during the technical fact finding trips clearly shows that there are serious problems with service, maintenance and spare parts supply for the diesel generator sets on many sites.

It has also been established that the potential for small hydro-electric power plants, which require less maintenance and service, has only been utilized to a limited extent. None of the 17 isolated rural branches run by TANESCO is equipped with an operational mini-hydro power plant[16], even though a mini-hydro potential exists on many sites. In fact, there are more than 75 identified mini-hydro sites of capacity less than 2 MW with a com-

16 There are, however, three mini-hydro plants operated by TANESCO that supply towns connected to the national grid, namely in Balisi, Kikuletwa and Tosamanganga.

bined installation potential capacity of about 35 MW in Tanzania. At two of the diesel supplied rural electrification projects reviewed in detail, namely Njombe[17] and Sumbawanga an under-utilized mini-hydro potential was available.

In contrast, mini-hydro power plants are being used in several electricity generation projects outside of the TANESCO programme, see section 4.5.

6.10.3 Reasons for shortcomings

The primary reason for the limited use of locally produced equipment is apparently that most of the equipment needed is not presently manufactured in Tanzania. Other reasons are that the equipment being locally manufactured is not produced in sufficient quantity to meet the local demand, or that the locally produced equipment does not meet with quality standards. Further, contract conditions for certain equipment have requirements for exports which have to be met. Impregnated poles, transformers and conductors are examples of equipment being imported because of occasional shortages. Insulators are an example of components being imported because local products do not meet the requirements of the standards.

The reasons for the emphasis on diesel generator sets are more complex. Historic reasons are probably important. TANESCO was initially based on diesel power generation. Diesel power plants were also, before the oil price increases during the 1970s, without competition the cheapest solution in the capacity range of interest for rural electrification. Political pressure for rapid implementation of rural electrification projects, in combination with limited personal resources at TANESCO for conduction of the site specific studies needed for hydropower plants, is probably another important reason.

Preferences of Donors who prefer installation of equipment from their own country or use of certain "favoured technologies" also appears as an important reason. The present situation in Njombe, where additional diesel generators are installed rather than a step-down transformer for grid connection via Makambako or completion of the mini-hydro power plant under construction, is one example of this.

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17 The mini-hydro installation of TANESCO in Njombe had been completed but could not be commissioned after a head race channel collapse in 1988. The plant was repaired and commissioned in November 1991.

7
Discussion of Possible Solutions to the Main Problems

7.1 Major Reasons for Shortcomings of the Present Programme

The evaluation presented in chapter 6, of the experiences from the rural electrification programme in Tanzania, identifies a number of areas where the present programme has not yet succeeded in meeting the objectives formulated in the "Rural electrification policy document" and mentioned in the "Work plan" for this study. It should also be clear from chapter 6 that reasonable requirements of the consumers regarding reliability and quality of the supply have not always been fulfilled. Reasons for these shortcomings are also discussed in chapter 6. Although it is evident that the difficulties are a result of complex circumstances, it appears that the major reasons are as follows:

— The present organization of rural electrification does not adequately reflect the special organizational requirements of rural electricity supply.

— The criteria used for selection of the areas to be electrified have not been compatible with the objectives of rural electrification.

— Sufficient support for establishment of productive uses of energy has not always accompanied the electrification projects.

— The financial resources available to TANESCO for investment in rural electrification, and for covering the operating costs for the electricity supply to the rural areas, have been insufficient.

— The resources for management support and technical support allocated by TANESCO to the rural areas have been insufficient.

— Donor projects have not always considered the availability of cheaper or more effective alternatives.

— Conservation of natural resources through fuelwood substitution with electricity is unrealistic under present economic conditions.

Possible ways to improve the situation are discussed below. Since the possible solutions are somewhat dependent on how rural electricity supply is organized in the future, this issue is discussed first.

7.2 Adaptation of the Organization of Rural Electrification to Meet the Requirements of the 1990s

7.2.1 Special organizational aspects of rural electricity supply

Rural electricity supply in a country like Tanzania puts some special demands on the organization which is implementing and running the service. Since such a large portion of the population is yet to be supplied with this service, it is important to consider these special requirements carefully in order to arrive to an organization which is the most suited to handle these requirements.

During the planning and implementation phases for a new rural electrification project, the organization is faced with a number of problems related to the large step-wise change from no supply, to supply on a comparatively large scale. Sales promotion, load projections, technical specifications, equipment selection, choice of contractors, project supervision, staff training etc. are all demanding tasks, which require competent and experienced staff with sufficient insight into the local conditions to adapt the project to these, wherever required.

Afterwards, during regular operation, the size of the organization must be minimized in order to avoid excessive personnel costs. At the same time, however, a number of technical and administrative specialist functions must be maintained. As a result of budget constraints, and because of the limited time some of the specialist services are needed, many of the specialist functions must be obtained from outside the permanent staff on the site. Since the sites are often remotely located, assistance from outside can be difficult to obtain at short notice, particularly during rainy seasons. Remote locations can also lead to difficulties in attracting competent persons to the permanent staff.

At remote locations, difficulties with supplies of fuel, lubricants and spare parts should be expected due to transportation problems unless efforts are made to plan the supplies far ahead of the actual need.

In order to limit costs, the number of service vehicles must also be kept to a minimum despite the fact that the geographical distances within the areas served can be considerable, and that the roads are often in bad condition. Transportation problems for the consumers may create special problems for the communication between the consumers and the utility.

As a consequence of all this, it must be accepted that either the cost per unit delivered is higher in rural areas or the quality of the service lower than in areas with a larger demand.

7.2.2 Shortcomings of the present organization

The present organization consists of a comparatively strong (technically and administratively) headquarters in Dar es Salaam, which is supporting and supervising the individual areas through the hierarchy of zonal and regional headquarters. Although there is a special Manager for Rural Electrification under the Directorate of Corporate Services and also a Directorate of Diesel Plants (which in reality will be primarily concerned with rural areas), it appears that from most respects, the rural areas are treated like any other area, although with more limited resources allocated to them because of their small supply capacities.

There is no reason why this type of organization could not be able to give the additional support needed by the rural areas as a result of their more difficult situation, but there is also no particular reason why it could. If there is no person at a high level in the organization who considers rural electricity supply as his main responsibility, there is a large risk that it will often be given a lower priority.

During the field visits, many observations were made indicating that the problems with supply reliability, and to some extent also the cost of the service, are the result of inadequate technical and administrative support from the Zonal office, the Regional office or the Headquarters. Such issues are discussed in more detail in sections 7.4 and 7.5. A lower priority given at the Zonal and Regional offices, and the Headquarters, to the problems of the rural areas is one possible explanation for this lack of support.

The presently hopeless financial conditions available for operation of the rural services could explain at least an implicit lower priority status for the rural service areas supplied by diesel gensets. Every kWh sold in these rural areas contributes to the company deficit. It is, therefore, not in TANESCO's best financial interest to maintain these services at a high reliability or to expand the service.

The two main shortcomings of the present organization of TANESCO, therefore, appear to be:

— nobody in particular is primarily responsible for rural electrification and has the main task of providing acceptable services to the rural areas; and

— the lack of financial incentives for TANESCO to maintain and expand the service to the rural areas.

7.2.3 Advantages and disadvantages of other possible ways to organize rural electrification

Foley *(28)* discusses three other possible organizational structures for rural electrification, which have been practised in other countries.

Creation of a separate organization for rural electrification is one possibility. This approach has been applied, for example, in Bangladesh where a separate Rural Electrification Board was set up. Its only relationship with the national utility is that it buys power from the national grid. In Jamaica, the Rural Electrification Programme has a more limited role. It has been set up as a technical implementing agency, which is responsible for design and construction of rural electrification projects. Once construction has been completed and the project has passed its final inspection, the operation is taken over by the national utility.

Establishing separate local distribution and generation companies, which may buy power from the national utility at the 33 kV or 132 kV levels, but otherwise operate independently is another possibility. This type of organization is used in many industrialized countries. It has also been introduced in developing countries, often on a co-operative basis. In Bangladesh for instance, the administration, maintenance and financial management is handled by local rural electrification co-operatives, which are supervised and monitored by the Rural Electrification Board. A similar approach has been used in Fiji, India and the Philippines. In some countries such as India, this approach has been combined with substantial government subsidies. Problems have often been experienced with the system becoming overloaded and maintenance being neglected, primarily as a result of unwillingness by the local users to allocate sufficient funds for capacity expansion and maintenance.

A third possibility, which is reasonably simple to implement, is to establish a separate rural electrification division or department within the national utility. This approach was used in the very successful rural electrification programme in Algeria. There, the rural electrification division has developed into an organization with a staff of 4 500 and has six departments, covering different parts of the country. In Ireland, rural electrification was carried out by a Rural Electrification Office with a high degree of administrative autonomy, within the Electricity Supply Board.

Each of these approaches have advantages and disadvantages. A truly separate agency would take time to establish and staff. Legislation would almost certainly be required in most cases. Some duplication of functions which are already established within the national utility are difficult to avoid. This would lead to additional costs and possibly also to difficulties in finding competent staff. Uniform tariffs over the country cannot be maintained. Independent local agencies are associated with similar problems. The difficulties in finding competent staff can be expected to be significant.[18] Variations in local tariffs can be expected to cover a wide range and, in general, be much higher than for consumers supplied by the national utility, unless some kind of government cross subsidy is introduced. Many of these disadvantages can be avoided with a separate division within the national utility, but difficulties can then be expected with establishing and maintaining administrative and financial autonomy.

Creation of a separate agency for rural electrification has actually been tried in Tanzania. In 1984, the Parliament instituted a subsidiary of TANESCO, the Tanzania Rural Electrification Company, TARECO. Due to lack of funds, this agency has not yet been operational. Even though this separate agency might be the best solution once sufficient resources are available for a massive rural electrification programme, it seems more reasonable, at least as an interim solution, to try amendments within the present organization.

7.2.4 Possible amendments to the present TANESCO organization

It should be possible to create, without much delay and at marginal additional cost, a new Directorate of Rural Electrification with a separate budget and a separate allocation of foreign exchange. This Directorate should have a small staff at the headquarters in Dar es Salaam for administration of services to the rural areas and monitoring of their performance. The Director of Rural Electrification would execute his powers primarily through the other Directorates.

The present Manager for Rural Electrification should move to the new

18 The reason why this does not appear to be a problem for private schemes like those of mission stations or industries, is that these organizations have aquired a competent staff for other reasons and that this staff can be used for the operation of the electricity supply on marginal time.

Directorate and take the responsibility for planning of rural electrification projects. Managers may also be needed for finance, diesel generation, mini-hydro generation, biomass and solar based generation, transmission/distribution and customer services.

All revenue from rural areas should be credited to the accounts of this Directorate and all costs for purchases and services provided from other parts of the organization, allocated to these accounts.

When the time is appropriate for reviving TARECO, the new Directorate of Rural Electrification could form the nucleus of this new agency.

7.2.5 Electrification co-operatives

Although this solution might not be realistic for the majority of the non-electrified communities in Tanzania, creation of local distribution and generation co-operatives could result in quicker electrification of some communities where the conditions are favourable. The tariffs within these local distribution areas would be set locally on the basis of actual costs. Communities located reasonably close to the TANESCO grid could buy power from TANESCO at the high voltage supply tariff. More remotely located communities would buy power from a private supplier or run their own power plant. TANESCO might provide technical and management support to such co-operatives on a consultancy basis. This could be done through a special department under the new Directorate of Rural Electrification.

7.3 New Criteria for Project Selection

7.3.1 The present strategy and its effects

The present TANESCO strategy for rural electrification is based on the following order of priorities for electrification:

— district towns;
— agro-based industries;
— small towns;
— small industries; and
— villages.

Although a few small towns and villages have already been electrified, primarily as marginal projects where transmission lines happen to pass a village, the programme has not yet been extended below the district town level. Out of the 66 district towns that are considered as rural, 37 still remain to be electrified. Most of the district town electrification projects carried out so far have been focussed on electrification only and have not been part of an integrated development plan.

An examination of this strategy with respect to achieving the main objectives for rural electrification is given in the "Rural electrification policy document" *(13)*:

— protection of natural resources by substitution of biomass fuels with electricity;
— provision of electric power to isolated areas;
— promotion of industrial development for a higher degree of processing of agricultural products;
— establishment of a base for development of small scale industry;
— support to agricultural development, construction industry and others starting/initiating the industrial revolution in Tanzania; and
— improvement of the standard of living for the rural population.

The policy is, in principle, compatible with the first objective (conservation of natural resources). The fraction of the population in the towns which can realistically switch from biomass fuels to electricity for cooking is, however, so small that the objective cannot be expected to be achieved in the next decade.

The present strategy is also clearly compatible with the second objective (provision of power to isolated areas). If maximization of the number of people living in areas served by an electric utility is the objective, the strategy is correct. However, the strategy is not necessarily compatible with the third objective (promotion of industry for processing of agricultural products). The district towns are administrative and commercial centers rather than industrial centers. Agro-based industries which happen to be located in district towns or close to the transmission lines will of course benefit. Creation of new agro-based industries in electrified towns as a result of electrification alone is unlikely.

The strategy is compatible with the fourth objective (base for development of small scale industry). The limited progress achieved in this respect is due to other shortcomings of the present programme.

The present strategy is only partly compatible with the fifth objective (support to agricultural development, construction industry and those starting/initiating the industrial revolution in Tanzania). As regards the construction industry, the situation is similar to that for small scale industry. For agriculture, substantial additional investments in transmission/distribution systems are generally necessary in order to make the electricity supply systems for district towns useful to agriculture. The same generally applies for other activities like mining, cement production, brick making and saw-milling which depend on a localized resource base.

The strategy is compatible with the sixth objective (improvement of the standard of living for the rural population), particularly if maximization of the number of people living in areas served by an electric utility is the objective. The limited progress achieved with some aspects of improving the standard of living through electrification, is due to other shortcomings of the present programme.

It can be concluded that the present strategy is partly compatible, partly insufficient and partly incompatible with the main objectives of rural electrification defined in the "Rural electrification policy document" *(13)*

7.3.2 Criteria proposed in the "Rural electrification policy document"

The following is proposed in *(13)*: To electrify all district headquarters and agro industries followed by other townships and villages on the basis of:

1. Least cost power supply for the project.
2. The economic and social benefits to be accrued from the electrification (e.g contribution to National GDP).
3. The total cost of implementing the project.
4. Availability of funds (foreign and local) and materials for the project works.

Other possible criteria mentioned in *(13)* are:

5. Electrification of the much older district Centres before the newer ones.
6. Electrification of other townships, agro-industries and villages before District Centres on basis of:
   — being along 33 kV line routes,
   — being part of an integrated regional development plan,
   — being a National Strategic Installation,
   — political decision to foster development in selected, areas (e.g. Chamwino, Kigwe, Ndugurumi, Liwale), and
   — being a border post (e.g Tunduma).

These proposed criteria imply essentially the same strategy as the present one. They are therefore, inadequate and incompatible with the objectives in the same respects as have been identified in section 7.3.2.

7.3.3 A possible alternative strategy

A possible alternative strategy could be based on the following criteria:

1. Public support shall only be given to these rural electrification projects which are projected to show a economic net present positive value for the first ten years of operation.
2. Ranking of projects shall be based on the projected economic rate of return.
3. When projects show moderate differences in projected economic rate of return, they shall be given priority where projected revenues are to be collected from existing industries and institutions, or where a substantial part of the initial investment is financed by the would-be consumers.
4. Public utilities shall only engage in projects which show a projected financial internal rate of return above a level defined by company policy.
5. Projects qualifying under criterion 1 for public support, but not under criterion 4 as a public utility project, must either be implemented by a private utility or by an electrification co-operative or directly by the government (through the Ministry of Works).

7.3.4 Discussion

The criteria proposed here, differ from those proposed in *(13)* and discussed in section 7.3.2, in two important ways. First of all there is no automatic preference to administrative centers like the District towns, and secondly it is required that a quantitative estimate of the net present economic value is carried out and that this is positive.

Ranking based primarily on the projected economic rate of return is a logical consequence of the requirement for a positive net present economic value. The deviation from a strict implementation of this ranking method is justified on the basis of the lower risks involved when revenues are to be collected from already established enterprises or when the would-be consumers are prepared to contribute to the financing.

It should be understood that the proposed criteria do not ignore the various social benefits possibly brought by electrification. These benefits are to be accounted for by suitable adjustments of actual financial costs and revenues in the economic evaluation. The theoretical framework for such an analysis is given by Hansen *(18)*. Its application to rural electrification projects has been discussed by Sumari *(19)*. A PC-based computer programme for evaluation of different supply alternatives has been developed by Borg *(20)* as a part of this study.

The choices of quantitative values for the economic costs and revenues must be a result of a political decision, since these choices to some extent must be based on subjective judgement. It is suggested, however, that the economic value of electrical energy – regardless of its use – is put equal to the economic cost for the cheapest alternative method to meet the same needs, plus a portion of the profit the consumer is expecting to earn from the activity consuming the electricity. In general, this would mean that the economic value would be based on the generation cost from a small diesel generator set, i.e. at least 20 TAS/kWh[19]. For productive uses, a profit allowance should be added to the economic value of diesel generation substitution. This method would make it possible to account for the benefits of electricity for health care, schools, water systems and street lights in a simple way. It would also automatically give productive uses of electricity a higher ranking than residential uses.

The effect of this method will be that public support is only provided when the costs for common electricity generation, for transmission and distribution lines, metering and utility administration, are less than the cost for power supply with individual generator sets. It will also tend to promote solutions based on indigenous energy sources and penalize solutions relying on imported equipment and fuels.

The fourth proposed criteria must be considered in combination with the discussion of the financial situation of TANESCO, see section 7.5. It should be understood that the consequences of this criterion are dependent very much on the tariff policy.

One implication of the proposed criteria is that a project may qualify for public support, i.e. have a positive economic net present value, but not qualify as a public utility project, i.e. not showing adequate financial internal

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19 Cost level 1989. Based on fuel and lubricant costs only, at a diesel price of 34 TAS/kg, a diesel consumption of 0.3 kg/kWh and a lubricant consumption of 0.002 kg/kWh. The installed cost of the small diesel generator set is estimated to 500 USD/kW, the lifetime to 10 years and the real interest rate to 2 per cent. Maintenance and service costs are estimated to 2.5 per cent of the investment per 1000 operating hours. The annual operating time is assumed to be 2 000 hours at a load factor of 0.7. This estimate does not take into account the shadow factor on imported fuel and equipment.

rate of return. In such a case public support should still be possible, for example by the granting of loans or allocation of foreign aid funds. The responsibility for implementation and operation of the project must, however, be left with an organization which is prepared to cover the financial losses. Co-operation with a public utility, such as TANESCO is still possible, for instance through power exchange on terms which are financially acceptable to the utility. Such separate electrification projects are, in the long term, obvious candidates for connection to the public utility. They will promote electric load growth in the area served and they will assist in infra-structural improvement. This will gradually make connection more attractive to the public utility.

7.4 Improved Support for Establishment of Productive Uses of Electricity

7.4.1 Needs for improved support

Utilization of the electricity for productive purposes is necessary if electrification is to bring economic development. The present portion of the electricity supplied in rural areas that is used for productive purposes is not satisfactory, as discussed earlier in sections 6.4 and 6.5 which conclude that there are many possible explanations for this. The problems with supply reliability and supply quality, as well as the present tariff policy, probably contribute to slow development in the productive uses for electricity. Other factors related to shortage of capital, transport problems and lack of skilled labour are likely to be more important. Unless the present obstacles to expansion of productive uses of electricity in the rural areas are removed, the situation should not be expected to improve.

7.4.2 Integrated development plans

Apart from improving the utility service and modifying the tariff structure, as will be discussed below, the only possibility of bringing about more productive uses of electricity in rural areas is to integrate electrification planning with infrastructural, agricultural and industrial development planning.

Same is an example of an area where an integrated development plan is being implemented. Although the portion of electricity that is used for productive purposes is still modest, it is significantly higher than in Babati and Sumbawanga, for example, see Table 3-4.

7.5 Improving the Financial Situation of TANESCO

7.5.1 Shortcomings caused by lack of capital and resources for covering operating costs

It is quite clear that the weak financial situation of TANESCO is one of the fundamental reasons why many of the objectives of rural electrification have not been achieved. A general lack of capital, and in particular a lack of foreign exchange, is the major reason for the limited coverage of rural Tanzania by the electricity supply system.

Limited resources for purchase of fuel and lubricants, spare parts, tools and service vehicles, as well as provision of technical and managerial support to the rural areas is the major reason for the low supply reliability. The poor reliability undermines the main social benefit of rural electrification, i.e. improved security, and can be an important factor for lack of industrial expansion in the rural areas.

7.5.2 Reasons for the poor financial results of the rural areas

As shown in section 3.12, all the diesel supplied, and probably some of the grid supplied, rural areas are loss-makers in TANESCO. These losses are covered by revenues from some of the urban load centers. There are several reasons why many of the rural areas show poor performance from a financial point of view.

The isolated diesel supplied systems have considerably higher generation costs than the national grid. Fuel and lubricant costs amount to about 10 to 14 TAS/kWh which can be compared to the estimated supply cost from the national grid of a few TAS/kWh.

Many rural areas contribute a lower average revenue per unit sold than the national average. This is a consequence of the tariff system, in combination with the consumer structure in those areas. The tariff favours small domestic use and compensates for this by higher tariffs for large industrial use. In many rural areas small domestic use dominates the consumption, whereas productive uses account for about 50 per cent of the consumption on a national level. As a result the average revenue per unit sold can be below

3 TAS/kWh in the rural areas, as compared with the national average of 4.15 TAS/kWh.

Finally, electrical losses are comparatively high, both on the national level where 19 per cent transmission and distribution losses are reported for 1988 and for many of the rural areas, although few data are available which allow an accurate estimate.

Straightforward comparisons between costs for administration, customer services, transmission and distribution in rural areas and the urban load centres are not easily carried out. Some of the rural areas that are separate branches within TANESCO and for which complete cost data are available, show substantially higher administration costs than the national average. Relatively higher administration costs per unit sold should be expected for areas with a small supply.

7.5.3 Possibilities for reducing costs

Some improvement in the financial results by cost reductions appear possible, but must be further investigated before action is taken.

Reduction in the electrical losses by ten percentage units would be possible if in fact the technical losses are as high as 20 per cent. Whether the investments in the transmission/distribution system which may be necessary to achieve this reduction of the losses are financially justified needs to be studied.

There might also be a possibility to reduce fuel costs by more efficient operation of the generator sets. On some sites a reduction of the costs for lubricating oil appears as an obvious possibility. In Babati, for instance, the consumption during the last six months before the visit was about twice as high as the earlier average, probably as a result of leakage through old gaskets. However, these savings, if achieved, will not change the financial situation for the diesel supplied areas dramatically. The operation will still run at a high loss.

Another possibility that should be investigated for the diesel supplied systems is the installation of baseload production units of suitable capacity, which use either the mini-hydro potential which exists at many sites, or uses locally produced plantation wood or agricultural residue as fuel. Options that can be considered for the latter type of power plant are a steam engine or a "woodgas" engine. Use of such biomass power plants for co-generation of electricity and process heat can lead to very attractive solutions. At least one possible site for such a plant was identified during the review at a planned sugar mill in Kiru valley (close to Babati).

7.5.4 Possibilities for increasing revenues

There are three possibilities to increase the average revenue per unit sold in the rural areas:

a. to increase the average consumption in those tariff classes which have a progressive tariff, which also is highly subsidized at low consumption rates (i.e. for residential, light commercial and light industrial use);
b. to restrict additional connections to consumers paying a higher than average price per unit; and
c. to increase the tariffs for all or some tariff classes.

The present tendency in the areas reviewed in more detail is for expansion of use primarily among residential and light commercial consumers, where most of the electricity is used for lighting. Simply adding more consumers of this type will make the financial results worse, since the tariffs are so highly subsidized.

Of the alternatives for increased average revenue outlined above only the last one, i.e. increased tariffs, appears as realistic. Even if there might be ways in which TANESCO could stimulate more electricity use, for instance by the financing of appliances, an increase of the average consumption of residential and light commercial consumers, to the level where the tariff approaches the marginal generation cost in diesel supplied areas, is hardly possible. This will mean an increase to a level now reached by none of the residential and less than 1 per cent of the light commercial consumers. For residential consumers a monthly consumption of more than 2 500 kWh would be needed. A Swedish household (with electric cooker, refrigerator, deep-freezer, lighting and TV) uses less than 500 kWh/month. Even most houses with electric heating in Sweden use less than 2 500 kWh/month. An increase in consumption for the average residential consumer in Tanzania to such a level is not realistic in this century. It is also doubtful if such increases in consumption are desirable for TANESCO. The capacity expansion requirements which would follow are dramatic.

7.5.5 Weaknesses of the present tariff policy

The present tariff policy is based on the following principles:

— A uniform tariff is applied all over the country, regardless of the local costs for the service.

— Small residential, light commercial and light industrial consumers pay a lower price per unit than large consumers in the same category.
— Some consumer groups are subsidized and some are charged at a rate which is much higher than the actual cost of the service.

Since the cost for the service varies between the areas, in particular depending on whether they are supplied by the grid or by diesel generator sets, although the tariffs are uniform, the degree of subsidy varies between the areas. In principle, however, the subsidy flows from the large consumers in the grid supplied areas to the small consumers in the same areas and to most of the consumers in the diesel supplied areas.

This tariff policy apparently aims at stimulating development outside of the main population centers and making the benefits of electricity affordable for other than high income people. Possibly, the progressivity has also been introduced as a means to stimulate efficient use of electricity. This last objective may have been achieved to some extent but, as should be apparent from the discussion in chapter 6, it is questionable whether the other objectives have been achieved. The industrial development in the electrified rural areas is marginal and so is use of electricity outside of the high income group.

There are several negative effects of the tariff policy. An obvious implication of the subsidies is that some consumers must pay a tariff which exceeds the cost of the supply. In some tariff classes this has led to tariffs which approach the cost of self-supply with a diesel generator set. In a situation where the reliability and quality of the utility supply is questionable, this will stimulate a situation where TANESCO supply is limited to small subsidized users, with the larger consumers preferring to generate their own power. The financial implications for TANESCO are obvious and will result in difficulties in maintaining a supply reliability which is acceptable to the commercial and industrial consumers. A poor supply reliability will further stimulate self-supply among the commercial consumers. As mentioned in section 6.9, some examples of such consumer reactions have been observed during the field visits.

An unwanted effect of the present subsidy to residential and light commercial consumers is that the energy costs paid by the more wealthy people that are connected to electricity will actually be lower than those paid by the less wealthy which are not connected. Another unwanted effect is that there is no incentive for TANESCO, as a utility, to maintain the service in diesel supplied areas. The revenues will certainly be less than the costs, and the losses will increase with increased sales.

7.5.6 Possible amendments of the tariff policy

It appears possible to maintain the most important features of the present tariff policy, whilst at the same time eliminating the reasons for the present problems, by some simple adjustment of the tariff levels. An amended tariff could be based on the following principles:

— A uniform tariff is applied all over the country, regardless of the local costs for the service.

— The connection fee should be replaced for residential, light commercial and light industrial consumers by a fixed monthly fee based on main fuse size.

— For such consumers, consumption up to a certain minimum level (defined for each tariff class) shall be charged according to the estimated cost for bulk supply and transmission in the national grid (i.e. about 8 TAS/kWh at the 1989 cost level[20]). Consumption above this level shall be charged according to a progressive scale, up to the maximum tariff defined below.

— The average tariff charged to any customer shall be below the fuel and lubricant costs of a diesel generator set with the same capacity as the maximum demand of the consumer, i.e. between 16 and 22 TAS/kWh at the 1989 cost level[21].

— For low voltage and high voltage supply the tariff should be based on the long term marginal cost for grid supplied electricity.

With these tariff principles, those living in rural areas and the enterprises located there are still not disadvantaged by higher electricity bills. Small consumers in diesel-supplied areas are still being subsidized through the larger consumers in the grid supplied areas. The financial obstacle to electrification caused by the connection fee is removed and the possibility that use of an own diesel generator set will be cheaper than use of the TANESCO service is eliminated.

Details of an amended tariff have to be worked out. It must then be en-

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20 Estimated from data for 1988 presented in *(26)* using an inflation correction estimated from the change in exchange rate with USD.

21 This should be introduced to discourage use of own diesel generators rather than the TANESCO service.

sured that the total revenues will be sufficient to allow the sustainable development of TANESCO.

7.5.7 Possible negative impacts of increased tariffs

Comparison between the present average tariffs, illustrated in Figure 3-3, and the proposed increased tariffs, shows that the residential consumers are those that will experience the most drastic cost increases with the revised tariff system.

The average consumption of residential consumers is, however, quite low, i.e. generally below 200 kWh/month. At this consumption level an increase of the average tariff from 1 to 8 TAS/kWh would increase the monthly expenditure on energy by 1 400 TAS. It is not expected that this will lead to major difficulties for the present residential users, which appear to belong entirely to the high and middle income groups, see chapter 5.

7.5.8 Creation of incentives for TANESCO

It is quite clear that the lack of corporate incentive to operate the diesel power plants remains with the proposed tariff system. The proposed organizational changes make no difference in this respect.

An incentive for TANESCO to provide a good service also in the diesel supplied areas could be created by introduction of a government tax on assets in hydro-electric power plants and transmission lines. The funds so generated could be given back to TANESCO as a tax rebate based on the number of units sold in rural diesel supplied areas. The tax rebate should cover the cost difference between bulk power from the national grid and the fuel and lubricant costs for diesel power plants.

This approach can be considered as a method of formalizing the present cross-subsidy between consumers that are supplied from the national grid and those who are supplied from isolated diesel plants. The advantage is that it creates an incentive for TANESCO to run the diesel supplied systems efficiently.

The "added cost" on hydroelectric power that would be caused by this approach would be small since diesel generation now only amounts to about 3 per cent of the total generation in Tanzania. At the 1989 cost level, the required adjustment of the cost for grid supplied electricity would amount to less than 0.8 TAS/kWh.

Such an incentive scheme would, however, not encourage a desirable shift from diesel generation to other options based on local resources like mini-hydro, biomass and solar energy. An alternative could be to introduce a scheme based on the Productivity Improvement Programme (PIP) within TANESCO. If all employees within the Rural Electrification Directorate were to be given a cash bonus based on the number of units sold, there would at least be personal incentives to keep high sales in both grid supplied and diesel supplied rural areas. If this idea is accepted, details will have to be worked out.

7.5.9 Discussion

It is understood that the philosophy behind the present tariff system is to make it possible for people with low or moderate income to use the benefits of electricity. It is possible, however, that the effect of the progressive tariff is also to discourage use of larger amounts of electricity for productive purposes. The consequences are then a large number of small consumers using electricity mainly for lighting, a low average revenue on sold kWh and a low capacity use.

The majority of the population will benefit from increased tariffs, for two reasons:

1. Financial means to improve supply reliability will lead to large improvements security (street lights will work).
2. Financial resources will also be created for further expansion of rural electrification, thus providing access to an increasing share of the population.

It is evident that the reasons for maintaining the present subsidized tariffs are very weak.

7.6 Technical and Management Support to the Rural Electrification Projects

7.6.1 Needs for improved support

Most of the area managers that the survey teams met during the survey were found to be competent and keen to provide a good service to the electricity consumers. For economic reasons, their technical and administrative staffs were, however, small. Also many had experienced difficulties in hiring trained staff members. As a consequence, record keeping and evaluation of records was not carried out to the extent required for running the operation efficiently. In addition, service, maintenance and repairs, particularly of diesel generator sets, could not be carried out or was done so only after long delays with assistance from the regional headquarters or the main office in Dar es Salaam.

7.6.2 Possible improvements

The organizational change proposed in section 7.2.4, can be expected to lead to more rapid responses to requests for support from the rural areas. It will also be necessary, however, to improve on the record keeping and performance reporting from the rural areas to the headquarters. Installation of meters at the substation level to keep track of the amount and quality of energy actually delivered, will be necessary for many grid supplied rural areas. In addition it will be necessary to separate the accounts from those at regional level.

Strengthening of the local organizations for operation of the service in the rural areas will also be required. Such requirements will differ depending on local conditions and must be defined more accurately in a separate study.

7.7 Co-ordination of Donor Programmes

7.7.1 Nature of the problem

During the review of experiences from the rural electrification projects in Tanzania, several examples of donor financed projects have been identified where it appears that greater benefits for the rural population and TANESCO could have been achieved at lower cost if other technical solutions, better adapted to the local conditions or to TANESCO's overall programme, had been chosen. The lack of standardization of diesel generator sets is one example. This has without doubt aggravated the problems with service, maintenance and supply of spare parts for the diesel generator sets.

The recent programme, financed by FINNIDA, for rehabilitation of diesel power plants by installation of Wärtsilä diesel generator sets is another example. On some of the sites the capacity of the engines selected is very large for the actual load conditions. This can be expected to lead to unnecessarily high specific fuel and lubricant consumption. At two sites, it is questionable if new diesel generator sets is the optimum solution. In Njombe, a step-down transformer at Makambako, for supply to the area from the national grid would be a much cheaper solution for TANESCO. In Babati, where the present capacity limitations are caused by spare parts supply problems and the limited capacity of the main transformer, it appears that the cheapest solution would be a re-habilitation of the existing generator sets, expansion of the control board and connection of the existing stand-by transformer, at least until connection to the national grid which is scheduled for 1993.

7.7.2 Reason for the problems

There are several possible reasons for lack of co-ordination between donor programmes and the TANESCO overall programme. Information to the donor agencies or their consultants may have been incomplete. Reviews made by TANESCO of proposed solutions against other plans may have been inadequate. Donor agencies may have been restricted to certain solutions by their own policies or by instructions from their authorities, leaving other options for solving acute problems unavailable to TANESCO.

No attempt has been made in this study to investigate the reasons for each case, since this was not believed to facilitate constructive solutions to the problem.

7.7.3 Possible solutions

Co-ordination between donor financed projects and the overall plans of TANESCO can only be ensured if project documents are reviewed at TANESCO by the Directorate of Corporate Services.

Lack of coordination caused by incompleteness of information available to foreign consultants can be avoided by a closer involvement of TANESCO staff in the planning stage of rural electrification projects. This can be achieved either by transfer of the entire planning work to TANESCO staff or by using consultants stationed at the TANESCO office. Both options will require a strengthening of the TANESCO staff which will increase overhead costs. Donor funding of these costs can be difficult to obtain, as a result of donor policy, even though the planning costs with these options can be expected to be much less than if foreign consultants are used. A possible solution could be to set up a consulting company as a subsidiary to TANESCO which could bid for planning and project design contracts.

Problems caused by limited options owing to constraints imposed by the donor agencies can only be resolved by educating the donor agencies. Since this may be a slow process, requiring policy modifications at the government level of the donor country, TANESCO must introduce the policy of turning down projects which are not reasonably in line with TANESCO's overall plans. Whenever deviations from what appears as the optimum solution for

TANESCO are necessary in order to meet with constraints imposed by the donor agency, the issue should be brought up for discussion and decision on a higher level.

7.8 Conservation of Natural Resources

It should be apparent from the discussion in section 6.3 that rural electrification cannot realistically be expected to have a significant impact on the rate of deforestation in those areas where the natural forests are presently overused.

This means that deforestation must be abated by other means, such as improved forest management, introduction of more efficient charcoal production and introduction of more efficient stoves.

8
Recommendations

8.1 Purpose of the Recommendations

The recommendations given below are focussed on three objectives namely:

— Promotion of economic development by rural electrification.
— Improvement of the financial viability of rural electrification in Tanzania.
— Improvement of customer service in rural electrified areas.

The recommendations are of a general nature, implying that solutions which only apply to problems identified in one or a few rural electrification areas, are not discussed. Such issues are treated in the topical reports for each site.

The general recommendations have been grouped into three categories:

1. Recommendations which can be implemented within a short time frame (1 year) and which do not imply substantial investments.
2. Recommendations which may require longer time for implementation (2-5 years) but do not imply substantial investments.
3. Recommendations which may require longer time for implementation (2-5 years) and imply substantial investments.

8.2 Recommendations for the Near Future

1. Re-structure the electricity supply sector by creation of a separate division within TANESCO with rural electrification as its only responsibility. This division should have a separate budget and a separate allocation of foreign exchange.
   Details must be worked out, particularly in respect of the budget, allocation of foreign exchange and internal billing when services of other divisions are used.
2. Introduce an incentive system as a part of the "Productivity Improvement Programme" whereby those employed within the new Rural

Electrification Division would get a cash incentive based on the number of units sold.

Details must be worked out and the cost accounted for in the TANESCO budget.

3. The general tariff level of TANESCO should be raised in order to make sustainable development of the company possible. Also, the tariff structure should be revised according to the following principles:
   - A uniform tariff should be used all over the country, regardless of the local costs for the service.
   - The connection fee should be replaced for residential, light commercial and light industrial consumers by a fixed monthly fee based on main fuse size.
   - For such consumers, consumption up to a certain minimum level (defined for each tariff class) should be charged according to the estimated cost for bulk supply and transmission in the national grid (i.e. about 8 TAS/kWh at the 1989 cost level). Consumption above this level shall be charged according to a progressive scale, up to the maximum tariff defined below.
   - The average tariff charged to any customer should be below the fuel and lubricant costs of a diesel generator set with the same capacity as the maximum demand of the consumer, i.e. between 16 and 22 TAS/kWh
   - For low voltage and high voltage supplies i.e. tariffs 4 and 5, the tariff should be based on the long term marginal cost principle.

   Details must be worked out. It will be necessary, for example, to define the current cost levels for grid supplied and diesel supplied electricity. It will also be necessary to define the consumption levels in tariff groups 1 – 3 at which increased tariffs should be applied.
4. Revise the TANESCO criteria for project selection as follows:
   - Only those rural electrification schemes which are projected to show a positive economic net present value for the first ten years of operation, should be considered.
   - Ranking of projects should be based on the projected economic rate of return.
   - When projects show moderate difference in projected economic rate of return, they should be given priority where projected revenues are to be collected from existing industries and institu-

tions, or where a substantial part of the initial investment is financed by the would-be consumers.

— TANESCO should only engage in projects which show a projected financial internal rate of return above a level defined by company policy.

Details must be worked out. It will be necessary, for example, to specify the procedure for economic evaluations and also to specify quantitative values for the various shadow factors used in the evaluation. In addition, it will be necessary to define the minimum acceptable financial rate of return for rural projects (which may very well be negative for rural projects, provided that the tariff level is set so that sufficient profits are generated from the supply to urban areas).

5. Schemes which are projected to give a positive economic net present value for the first 10 years, but do not meet the minimum financial rate of return criterion defined by TANESCO, must be implemented and operated either by a private utility or directly by the government (through the Ministry of Works).

   Measures should be taken to promote private or co-operative solutions for such projects. This can be done by allowing donor financing for non-government electrification projects and by guaranteeing technical support from TANESCO (at market consultancy rates).

6. Improve the monthly reporting system within TANESCO and include comparisons for key performance parameters with acceptance standards.

7. Improve the follow-up of the monthly reports at the head office and formulate routines for reporting and action when monthly reports indicate problems that can not be handled at the local level.

8. Incorporate spare parts supply agreements in all donor financed equipment investment projects.

9. Improve co-ordination of Donor financed projects and ensure that TANESCO is given the final say in selection of projects and vendors for equipment.

8.3 Implementation within Five Years – Moderate Investment

10. Formulate individual rehabilitation and development plans for the electricity supply for each of the presently electrified rural areas and include electricity supply in all regional development plans (RIDEPs).
11. Formulate, for all isolated diesel supplied areas, a plan for reduction of operating costs, either by grid connection or switch to other cheaper generation alternatives, such as mini-hydro.
12. Install meters for monitoring the supply and the supply quality at substation level for all grid supplied rural areas.
13. Initiate recurrent training programs for:
    — area managers,
    — all types of operators.
14. Develop and implement better forecasting methods based on data collected from the monthly reports.
15. Standardize diesel power plants on the basis of the minimum number of genset sizes that will efficiently cover the demand range of interest. Details must be worked out, but it appears reasonable to base the standardization on engine types which are already frequently used in the country and can be purchased for the foreseeable future.
16. Follow the international development of generation technologies based on solar energy (photovoltaic and thermal) and on biomass as alternatives to diesel generator sets for sites without mini-hydropower potential.

8.4 Implementation within Five Years – Substantial Investments

17. Implement rehabilitation programmes for the presently electrified rural areas (See recommendation no. 10).
18. Formulate and implement integrated development plans for all areas affected by new rural electrification projects.
19. Develop the capability in Tanzania for local manufacturing of equipment needed for electricity transmission and distribution.
20. Develop the capability in Tanzania for licenced manufacture of equipment for mini-hydro power plants.

21. Develop capability in Tanzania for licenced manufacture of medium capacity diesel engines.
22. Select and introduce biomass based power generation technologies covering the capacity range 100 kW to 5 MW (to be used on isolated sites without mini-hydro potential).
23. When the time is right, consider activation of the Tanzania Rural Electrification Company, using the proposed new Directorate for Rural Electrification as the nucleus.

9
Final Remarks

There is no doubt that a reliable and affordable supply of electricity is an important factor for promotion of industrial development. There is also no doubt that access to electricity in homes can relieve women from many time-consuming chores, increase possibilities for studies and handicraft and generally make life more pleasant.

Even though this study has shown that many of the expected benefits of rural electrification have not yet been achieved, and that the reliability and the quality of the present service to the electrified rural areas is far from satisfactory, there should be no doubt that electrification of the entire country remains a sound development objective.

The issue is, therefore, not *if* but *how* this will be accomplished. The findings in this study indicate that the resources required, the difficulties involved and the complexity of the issues have so far generally been underestimated, whereas the importance of electricity as a promotor of economic development has generally been overestimated.

What is needed now is a modified approach to rural electrification where repetition of past mistakes is avoided and the major part of the limited resources is concentrated on supplying the service where the maximum impact on economic development in the rural areas can be expected. Only then can additional economic resources be generated for expansion of the service to the whole of the country.

Electrification of rural Sweden, which started about 1915, was about 99 per cent complete by the late 1950s, i.e. over a period of 35 years. Tanzania started in 1975 and still has a good chance of completing rural electrification quicker...

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Appendix I

TANESCO Tariff from June 1, 1989

Electricity Tariffs with Effects from June 1, 1989 Billings

Tariff No. 1 Residential

Applicable to premises used exclusively for domestic and private residential purposes:

0 – 100 kWh	TAS	0.75 per kWh
101 – 1 000 kWh	TAS	1.00 per kWh
1 001 – 2 500 kWh	TAS	4.00 per kWh
2 501 – 7 500 kWh	TAS	8.00 per kWh
Over 7 500	TAS	17.00 per kWh
Customer services charge up to 1 000 kW	TAS	25.00 per meter reading period
Customer services charge over 1 000 kW	TAS	100.00 per meter reading period

Tariff No. 2 Light Commercial

Applicable to shops, restaurants, theatres, hotels, clubs, harbours, schools, hospitals, airports, lodging houses, groups of residential premises with one meter and on premises where similar business or trade is conducted and where consumption is less than 10 000 kWh per meter reading period.

0 – 200 kWh	TAS	1.00 per kWh
201 – 1 000 kWh	TAS	9.50 per kWh
1 001 – 10 000 kWh	TAS	17.75 per kWh
Over 10 000 kWh	TAS	30.00 per kWh
Customer services charge up to 200 kW	TAS	100.00 per meter reading period
Customer services charge over 200 kW	TAS	300.00 per meter reading period

Temporary Supplies
Temporary supplies will be given on this tariff

Tariff No. 3 Light Industrial
Applicable to premises engaged in production of any article/commodity or in an industrial process where the main use of electricity is for motive power, or an electrochemical or electrothermal process and where the consumption is less than 10 000 kWh per meter reading period:

0 – 1 500 kWh	TAS	4.00 per kWh
1 501 – 3 000 kWh	TAS	8.50 per kWh
3 001 – 10 000 kWh	TAS	16.50 per kWh
Over 10 000 kWh	TAS	30.00 per kWh
Customer service charges	TAS	300.00 per meter reading period

Tariff No. 4 Low Voltage Supply
Applicable for general use where the consumption is more than 10 000 kWh per meter reading period:

a. Demand charge TAS 745.00 per kVA of billing demand (B.D) per meter reading period.
   The kVA maximum demand (M.D.) indicator shall be reset every meter reading period.

b. Unit charges:

First 150 times B.D. (kVA) units,	TAS 8.75 per kWh
Next 150 times B.D. (KVA) units,	TAS 8.00 per kWh
Remainder of units	TAS 7.50 per kWh

c. Customer service charge TAS 10 000.00 per meter reading period

Tariff No. 4A Agricultural Premises
Applicable to agricultural consumers whose consumption is more than 5 000 units per meter reading period, and engaged in direct raw farm produce production and/or processing

a. Demand charge TAS 180.00 per kVA of billing demand (B.D.) per meter reading period.
The kVA maximum demand (M.D.) indicator shall be reset every meter reading period.

b. Unit charges: TAS 2.10 per kWh

c. Customer service charge TAS 10 000.00 per meter reading period

Tariff No. 5 High Voltage Supply

Applicable for general use where power is metered at 11 kV and above.

a. Demand charge TAS 670.00 per kVA of Billing Demand (B.D.) per meter reading period.
The kVA maximum demand (M.D.) indicator shall be reset every meter reading period.

b. Unit charges:

First 150 times B.D. (kVA) units	TAS 8.25 per kWh
Next 150 times B.D. (kVA) units	TAS 7.55 per kWh
Next 150 times B.D. (kVA) units	6.90 per kWh
Remainder of units	TAS 6.00 per kWh

c. Customer service charge: TAS 15 000.00 per meter reading period.

Tariff No. 5A High Voltage Supply Energy Intensive Customers

Applicable to high tension consumers whose demand is above 5000 kVA and consumption above 800 000 kWh per meter reading period.

a. Demand charge TAS 475.00 per kVA of billing demand (B.D.) per meter reading period.
The kVA maximum demand (M.D.) indicator shall be reset every meter reading period.

b. Unit charges: TAS 2.10 per kWh

c. Customer service charge TAS 10,000.00 per meter reading period.

Tariff No. 6: Public Lighting

Applicable to public lighting and places of worship.

All units	TAS 1.80 per kWh

Tariff No. 8: NUWA Accounts

Applicable to all installations of National Urban Authority Water pumping installations with consumption above 10 000 units per meter reading period.

a.	Maximum demand charge	TAS 300.00 per kVA of billing demand (B.D.) per meter reading period.

The kVA maximum demand (M.D.) indicator shall be reset every meter reading period.

b.	Unit charges:	TAS 2.50 per kWh
c.	Customer service charge	TAS 10 000.00 per meter reading period

Tariff No. 9: Zanzibar Supply

Maximum demand	TAS 83.33 per kVA of maximum demand during each meter reading period.

The kVA maximum demand indicator shall be reset every meter reading period.

Units charge:	TAS 0.20 per kWh

Maximum demand readings are taken at Mtoni substation while the unit readings are taken at Ubungo substation.

Comments

1. Billing Demand (B.D.) is the higher of the kVA maximum demand (M.D.) during the month and 60 per cent of the highest kVA maximum demand for the preceding 11 months; provided that during the first year of operation the billing demand shall be the higher of the kVA maximum demand during the month.

Appendix 2

Licensed Electric Generators Outside TANESCO

2–1
Electric Generators Installed by Ministry of Works

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When installed	Good Condition	Out of Order	Remarks
1.	MOROGORO REGION								
	Lister Engine	–	–	32.25	Mahenge Hospital	–	Good	–	
2.	SHINYANGA REGION								
	1. Raston Engine (2pcs)				Kahama	–	–	Out	
	2. Lister Engine	–	–	–	Maswa Comworks	–	Good	–	
	3. Lister Engine (2pcs)	–	–	–	Bariadi Hospital	–	Good	–	
	4. Lister Engine (1pc)	–	–	–	Area Com. Office	–	–	Out	
	5. Lister Engine (1pc)	–	–	–	Shinyanga township	–	–	Out	
	6. Lister Engine (1pc)	–	–	–	–ditto–	–	Good	–	
3.	LINDI REGION								
	1. Yamman Diesel Engine	440/230	3	5 kVA	Chilala Chuo cha Wananchi	–	Good	–	
	2. Yatalanta Generator	(1) 230	1	7.5 kW	Ngongo Feed Mill	–	Good	–	
	3. Lister Engine (Peter Gen.) (1)	400/230	3	20 kVA	Home Affa–irs	–	Good	–	

Table continued

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When Installed	Good Condition	Out of Order	Remarks
	4. Yamaha	440/230	3	5 kW	Kinyonga Hosp., Kilwa	–	Fair	–	
	5. Lister Engine	230 V	1	6 HP	–ditto–	–	Fair	–	
	6. Yamaha	440/230	3	5 kW	Pande Medical Centre, Kilwa	–	Fair	–	
	7. Yamaha	440/230	3	5 kW	Liwale Hosp.	–	Fair	Out	
4.	MARA REGION								
	1. Ruston Generator	230	1	8 kVA	Serengeti Comworks	1977	Good	–	
	2. Lister Generator	230	1	16 kVA	–ditto–	1977	–	Out	Engine Problem
	3. Ruston Generator	400/230	3	25 kW	Mugume Police	1965	Good	–	
	4. Lister Engine	400/230	3	125 kVA	Tabora Serengeti	1978	Good	–	
	5. Lister Engine	400/230	3	90 kVA	Bunda	1984	Good	–	
	6. Lister Engine	400/230	3	90 kVA	Bunda	1984	Good	–	
	7. Lister Engine (1)	415/230	3	16.25 kVA	Tarime Hosp.	1975	Good	–	

Table continued

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When Installed	Good Condition	Out of Order	Remarks
	8. Empire Genset	600/75A	3	600	Tarime Hosp.	1973	–	Out	
	9. Siamens/Volk.gen	7.6 kVA	1	220U/34A	Tarime Hosp.	1973	–	Out	
	10. Lister Eng. (1)	415	3	16.25 kVA	Elimu Tarime	1979	Good	–	
	11. Lister Eng. (1)	400	3	52.75	Tarime Elimu	1973	–	Out	
	12. Stamford Gen.	415	3	48.75	Tarime Sec.School	1973	–	Out	Engine Problem
5.	RUKWA REGION								
	1. Peter gen (1)	230	1	7.2	Comworks	–	–	Out	
	2. Liga gener (1)	440/230	3	24 kW	Comworks	–	–	Out	
	3. Hamburg Gen	380/230	3	15 kVA	Prison	1989	Good	–	–
	4. Lister Eng. Gen	380/230	3	8.6 kW	Mpanda Gvt. Hosp.	–	–	Out	
	5. Honda Eng. Gen	130	1	3.5 kW	–ditto–	–	Good	–	
	6. Peter Gen	230	3	16 kW	Mali Asili Mpanda	–	Good	–	–
	7. Uston gen.set	415/230	3	30 kW	S'Wanga Gvt.	–	Good	–	–
	8. Fiat Gen.set	380/220	3	30 kW	TRM S'Wanga	1983	Good	–	–
6.	MBEYA REGION								

Table continued

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When installed	Good Condition	Out of Order	Remarks
	1. Petter	230V	–	3.5 kVA	Ileje (D.C)	–	–	Out	
	2. Lister Engine	415/230	3	29.2 kVA	Kyela (D.C)	–	Good	–	
	3. –	415/230	3	34.37	Kawetele (DCA)	–	–	Out	
10.	TABORA REGION								
	1. Lister Engine (2pcs)	–	3	–	TTC Elimu Tabora	–	Good		
	2. Lister Engine (1 pc)	–	3	–	–ditto–	–	–	Out	
	3. Lister Engine (2pcs)	–	3	–	Tabora TTC	–	Good	–	–
	4. (1 Pc)	–	3	–	Tabora TTC	–	–	Out	–
	5. Lister Engine (3pcs)	–	3	–	Comworks Tabora	–	Good	–	–
	6. (1 pc)	–	3	–	Tabora Magereza	–	–	Out	–
	7. (1 pc)	–	3	–	Ndala TTC	–	Good	–	–
	8. (1 pc)	–	3	–	Kitete Hosp.	–	Good	–	–
	9. (1 pc)	–	3	–	Iguna Hosp.	–	Good	–	–
	10. (1 pc)	–	3	–	Igunga Umwagili–aji	–	Good	–	–
	11. (1 pc)	–	3	–	Nzega Hosp.	–	–	Out	–

Table continued

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When installed	Good Condition	Out of Order	Remarks
11.	D'SALAAM REGION				Area 3, 3 pcs	–	Good	–	
	1. (5 pcs)	–	3	–	Area 4 ,2 pcs	–	Good	–	
12.	DODOMA REGION								
	1. Lister Engine (10 pcs)	–	3	–	–	–	7	3	
13.	KIGOMA REGION								
	1. Lister Engine (6 pcs)	–	3	–	–	–	6	–	
	2. (10 pcs)	–	–	–	–	–	8	2	–
14.	MWANZA REGION								
	1. Lister Engine (7 pcs)	–	–	–	–	–	4	3	–
	2. (21 pcs)	–	–	–	–	–	6	15	–
15.	IRINGA REGION								
	1. Lister Engine (5 pcs)	–	–	–	–	–	2	3	–
	2. (4 pcs)	–	–	–	–	–	1	3	–
16.	1. Legg	–	1	200–250	T.T.C. Kinampa–nda	–	Good	–	
	2. Legg	–	1	200–250	T.T.C. Kinampa–nda	–	Good	–	
	3. Caterpilar SRCR	–	3	400–	Power House	–	–	–	
	4. Caterpilar SRCR	–	3	400–	Tumaini Secondary School	–	Good	–	

Table continued

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When installed	Good Condition	Out of Order	Remarks
	5. Ruston Engineer	–	3	–	Tumaini Secondary School	–	–	–	
	6. LDC Altenatol	–	3	400–	Chuo cha Maendeleo ya Wana–nchi (FDC)	–	–	–	
	7. Ruston Engine	–	3	98–4	Kiomboi Hospital	–	Good	–	
	8. –	–	3	410–	Kiomboi Hospital	–	Good	–	
	9. Lister	–	3	–	Kiomboi Hospital	–	–	–	
	MANYONI								
	1. Petters	–	3	20	Ujenzi	–	Good		
	2. MFD–19785	–	3	12	Hospital	–	Good	–	
	3. LC31A	–	S–231V	10	ditto	–	Good	–	
	4. HR2	–	3	HP21	Jumbe Road.	–	Good	–	
	5. HR6	–	4 wire	HP64	ditto	–	Good	–	
17.	RUVUMA REGION								
	1. Lister Engine	415–250	3	–	Mbinga Kigonsera	–	good	–	

Table continued

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When installed	Good Condition	Out of Order	Remarks
	2. Ruston Engine	415–250	3	–	Mbinga–Mbamba Bay	–	Good	–	
	3. Ruston Engine	415–250	3	–	Liuli–Mbinga	–	Good	–	
	4. Ruston Engine	415–250	3	–	Mbinga–Mbamba Bay	–	Good	–	
	5. Yanima Engine	415–250	3	–	Mbinga–Ndumbi	–	Good	–	
	6. Yanima Engine	415–250	3	–	Mbinga–Mbamba Bay	–	Good	–	
	7. Lister Engine	V. 250	1	–	Mbinga Ujenzi	–	Good	–	
	8. Lister Engine	V. 250	1	–	Mbinga–Bomani	–	Good	–	
	9. Ruston Engine	415–250	3	–	Tunduru Ujenzi	–	Good	–	
	10. Scania Engine Brasiria	415–250	3	–	ditto		Good	–	
	11. Lister Engine	250	1	–	Tunduru Hosp.	–	Good	–	
	12. Peter Engine	415–250	3	–	ditto	–	Good	–	
	13. Yanima Engine	415–250	3	–	Songea Mifugo	–	Good	–	
	14. Volvo Penta Diesel	415–250	3	–	Tunduru Sec.	–	Good	–	

Table continued

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When installed	Good Condition	Out of Order	Remarks
	15. Volvo Penta Diesel	415–250	3	–	ditto	–	Good	–	
	16. John Dier	415–250	3	–		–	Good	–	
	17. Lister Machine	415–250	3	–	Tunduru M.C.H.A.	–	Good	–	
	18. Generator–Electric Set.	230	3	–	Cguo	–	Good	–	
18.	KAGERA REGION								
	1. AC Generator	415/249	3	27.5 kW	Muleba	–	Good	–	–
	2. AC Generator	380/415	3	42. kW	OMW Gera	–	Good	–	–
	3. AC Generator	400/230	3		Ngara	–	Good	–	–
	4. AGF Generator	220	1		Maruku	–	Good	–	–
	5. AC Generator	220/240	1		Police Station Bukoba	–	Good	–	–
	6. Generator	220/380 132/76	3		Govt. Hosp.	–	Good	–	–
	7. Generator	220/380,38	3		ditto	–	Good	–	–
19.	REGION KILIMANJARO								
	1. Dale DWG DLX	230	1	1	Tarakea Police	–	Good	–	–
	2. Benz DGA–57–14B	380	3	0.8	Miwarler Kilimo	–	Good	–	–

Table continued

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When installed	Good Condition	Out of Order	Remarks
	3. Stanford AC								
	Generator	380/44099/55	3	0.8	ditto	–	Good	–	–
	4. Brush AC.	415/240797/93	3	0.8	ditto	–	Good	–	–
Alternator									
	5.	400/440/20.5			Taveta	–	Good	–	–
	6. Brush	–	–	0.8	ditto	–	Good	–	–
	7. Brush	415/240/23.4	3	0.8	ditto	–	Good	–	–
	8. AC. CTRY Generator	240	1	1	ditto	–	Good	–	–
	9. Nale-Electrc F.	380/220.80	3	0.8	F.D.C.	–	Good	–	–
	Greatbratian								
20.	MTWARA REGION								
	1. Lister	415/240kVA	3		Ujenzi	–	Good	–	–
					Newala				
	2. Petter PJ4	400/280kVA	3		Chidya	–	Good	–	–
					Sec. School				
	3. Lister	75kVA	1		Ujenzi	–	Good	–	–
					Masasi				
	4. Petter PJ 2	kVA 12.5	3		Kitangali	–	Good	–	–
	5. Lister	415/240 V.	3		M.A.T.I.	–	Good	–	–
	6. Bedford Markow	kW 40	3		Airport	–	Good	–	–
					Mtwara				
	7. Petter PJ 2	kVA 27	3		Mkomainde	–	Good	–	–
					Hosp.				
	8. Petter AUT.	kVA 68.75	3		"	–	Good	–	–

Table continued

Generator Sets

S.N.	Model/Type	Voltage	No. of phases	Power (HP)	Location	When installed	Good Condition	Out of Order	Remarks
9.	Petter	27 kW 2.6	3		Newala Hosp.	–	Good	–	–
10.	Lister HP 32.25		3		ditto				
11.	Petter AUT	kW 55	3		Ligula	–	Good	–	–
12.	Lister 67139 NA	kW 10	1		Ndwika T.T.C.	–	Good	–	–
13.	Lombardin	kVA 6	1		Chuo cha Mgambo				

2–2

Private Generators Installed by Ministry of Works

List of private licenced electricity generators

Arusha

	Name	Address	Capacity	Area
(a)	*Standby generators in areas not supplied by Tanesco:-*			
1	Kongozi Estate Ltd	Box 1	25 kVA	Oldeani District
2	Karimu Coffee Estate	Box 159	6 kVA	Arusha District
3	Milimani Coffee Estate	Box 848	6 kVA	Arusha District
4	Shah Plantation Ltd	Box 848	16 kVA	Oldeani District
5	Monduli Coffee Estate	Box 667	14 kVA	Arusha District
6	Nitini Coffee Plant	Box 20	27.5 kVA	Oldeani District
b)	*Standby generators in areas supplied by Tanesco:-*			
1	Mrs. V. Leva	Box	3 kVA	Arusha District

Dar es Salaam

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
	NIL			
(b)	*Standby generators in areas supplied with Tanesco:-*			
1	Directors Of Metoordo	Box 543	18 kVA	Dar Es Salaam
2	Bahari Ya Tanzania	Box 585	3.5 kVA	Dar Es Salaam
3	Tanzania Film Co. Ltd	Box 9341	112 kVA	Dar Es Salaam
4	Embassy of U.S.A	Box 9123	11 kVA	Dar Es Salaam
			25 kVA	Dar Es Salaam
5	Canadian High Commission	Box 1022	30 kVA	Dar Es Salaam
6	Mohamed I. Balcal	Box 3660	12.50 kVA	Dar Es Salaam
7	Co-operative of T/nyika	Box 2567	35 kVA	Dar Es Salaam
8	Kibaha Education Centre	Box 35054	70 kVA	Kibaha
9	Mahenge Line Oysterbay	Box 519	12 kVA	Dar Es Salaam
10	Kioo Limited	Box 9275	385 kVA	Dar Es Salaam
11	Tanzania Wood Industry	Box 9160	5.5 kVA	Dar Es Salaam
12	Canron Intepace	Box 9384	250 kVA	Dar Es Salaam

Dodoma

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
	NIL			
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Regional Water Engineer	Box 930	3 kVA	Dodoma
2	Regional Water Engineer	Box 930	213.5 kVA	Dodoma
3	Msikiti	-	1.5 kVA	Kondoa
4	River Bar	Box 84	2 kVA	Kondoa
5	Dodoma Paradise Cinema Ltd	Box 76	25 kVA	Dodoma
6	Katoke Seminary	Box 31	31.1 kVA	Bihawana
7	United Construction Camp	Box 1000	115 kVA	Dodoma

Iringa

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied with Tanesco:-*			
1	Rugemba Lead School	-	27 kVA	Iringa
2	Mgagao T.P.D.F	-	25 kVA	Iringa
3	Ifunda Secondary School	Box 35	106 kVA	Iringa
4	National Small Industry	Box 158	22.5 kVA	Njombe
5	Mr A.A. Sachel	Box 60	8 kVA	Njombe
6	B.A. Jiuray	Box 18	1.5 kVA	Njombe
7	Hassanal Juma	Box 10	3 kVA	Njombe
8	Jiwa Stores	Box 12	6 kVA	Njombe
9	Government Hospital	-	52.5 kVA	Mufindi
10	Mafinga National Service	Box 10	52.5 kVA	Mufindi
11	Tanzania Diamond Cutting	Box 97	250 kVA	Iringa
12	Ifunda Technical School	Box 97	106 kVA	Iringa
13	Sao Hill	-		Mufindi
14	Cotex Textile Spinning Mill	Box 97	22.5 kVA	Iringa
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Evangelical Church	Box 97	20 kVA	Njombe
2	Evangelical Church	Box 97	7 kVA	Njombe
3	Evangelical Church	Box 97	20 kVA	Njombe
4	Lugala L. Church	Box 97	9 kVA	Njombe
5	Government Sec. School	Box 4	52.5 kVA	Iringa
6	Marjid Tagwa	Box 266	3 kVA	Iringa
7	Njombe Government Store	Box 15	1 kVA	Njombe
8	Evangelical Church	Box 97	13.1 kVA	Njombe

Kagera

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Bukoba Diocese	Box -	50 kVA	Bukoba
2	Rwamdaizi Hospital	-	7.5 kVA	Bukoba
3	Murgwanza Hospital	-	64.25 kVA	Bukoba
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	The District Medical	Box -	25.5 kVA	Karagwe
2	The District Medical	Box 20	47 kVA	Biharamulo
3	D.D.D.	Box -	6 kVA	Karagwe
4	D.D.D.	Box 9	6 kVA	Bukoba

Kigoma

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Police Signal	Box 70	1.75 kVA	Kigoma
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Madini Private-Mpanda	Box -	44 kVA	Mpanda
2	Comworks	Box -	7.06 kVA	Mpanda
3	D.D.D.	Box 34	55 kVA	Mpanda
4	White Fathers	Box 13	3 kVA	Kasulu
5	Nyanza Salt Mines	Box 3042	350 kVA	Uvinza
6	E.A. Community	Box 84	6 kVA	Kasulu
7	Kasaga Garage	Box 42	5 kVA	Kasulu
8	Kabaga Hospital	Box 42	10 kVA	Kigoma
9	Heri Mission Hospital	-	20 kVA	Kigoma
10	D.F. Manager	Box 14	13.1 kVA	Kasulu
11	E.A.C.	Box 14	6 kVA	Kibondo
12	R.C. Training Centre	Box 47	1.25 kVA	Kibondo
13	Kibondo Government Hospital	Box 6	7.5 kVA	Kibondo
14	Mahemba Parish	Box 1	12.5 kVA	Kibondo
15	Heri Mission	Private Bag	20 kVA	Kigoma

Kilimanjaro

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied with Tanesco:-*			
1	Pangani Forest	Box 1024	162.5 kVA	Moshi
(b)	*Standby generators in areas supplied with Tanesco:-*			
1	Kalembelilian (1964) Ltd	Box -	10 kVA	Kilimanjaro
2	Sanya Juu Moshi	-	13 kVA	Kilimanjaro
3	Miwaleni Moshi	Box 3042	52.5 kVA	Moshi
4	Same Secondary School	-	13.1 kVA	Same
5	Government Hospital	Box 10	4 kVA	Moshi
6	Moshi Airport	Box 3051	5 kVA	Moshi
7	Kilimo Moshi	Box 99	35 kVA	Moshi
8	Forest	-	12.5 kVA	Moshi
9	Veterinary Division	-	3.25 kVA	Moshi

Lindi

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Frelimo Farm	Box 28	50 kVA	Nachingwea
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	E.C.P. Marambo	Box 22	1 kVA	Nachingwea
2	T.P.D.F.	Box 15	25 kVA	Nachingwea
3	R.C.M. Mnero	Box 24	12 kVA	Nachingwea
4	Nachingwea	Box 40	1500 kVA	Nachingwea
5	Murumba Centre School	Box 24	6 kVA	Nachingwea
6	Nafco Seed Farm	Box 50	35 kVA	Nachingwea
7	Uriero Hospital	Box 24	6 kVA	Nachingwea
8	T.P.D.F	Box 15	12.5 kVA	Nachingwea
9	Ndugu Sisal Estate	Box -	22.5 kVA	Nachingwea
10	Larry S. Thomas	Box 1032	3.5 kVA	Lindi
11	Khoja Shia I. Thnaasheri Jamat	Box 130	25 kVA	Lindi
12	National Bank of Commerce	Box 1083	12 kVA	Lindi

Kagera

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Bukoba Diocese	Box -	50 kVA	Bukoba
2	Rwamdaizi Hospital	-	7.5 kVA	Bukoba
3	Murgwanza Hospital	-	64.25 kVA	Bukoba
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	The District Medical	Box -	25.5 kVA	Karagwe
2	The District Medical	Box 20	47 kVA	Biharamulo
3	D.D.D.	Box -	6 kVA	Karagwe
4	D.D.D.	Box 9	6 kVA	Bukoba

Kigoma

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Police Signal	Box 70	1.75 kVA	Kigoma
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Madini Private-mpanda	Box -	44 kVA	Mpanda
2	Comworks	Box -	7.06 kVA	Mpanda
3	D.D.D.	Box 34	55 kVA	Mpanda
4	White Fathers	Box 13	3 kVA	Kasulu
5	Nyanza Salt Mines	Box 3042	350 kVA	Uvinza
6	E.A. Community	Box 84	6 kVA	Kasulu
7	Kasaga Garage	Box 42	5 kVA	Kasulu
8	Kabaga Hospital	Box 42	10 kVA	Kigoma
9	Heri Mission Hospital	-	20 kVA	Kigoma
10	D.F. Manager	Box 14	13.1 kVA	Kasulu
11	E.A.C.	Box 14	6 kVA	Kibondo
12	R.C. Training Centre	Box 47	1.25 kVA	Kibondo
13	Kibondo Government Hospital	Box 6	7.5 kVA	Kibondo
14	Mahemba Parish	Box 1	12.5 kVA	Kibondo
15	Heri Mission	Private Bag	20 kVA	Kigoma

Mbeya

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Kilimo Mbimba	Box Upoloto	6.25 kVA	Mbeya
2	Rungwe Tea Estate	Box –	106 kVA	Rungwe
3	Igogwe	Box 100	22 kVA	Tukuyu
4	Tazama Pipelines Ltd	Box 497	80 kVA	Mbeya
5	Mwambani RC.. Hospital	Box -	7.5 kVA	Chunya
6	Ipinda Rice Mill	Box 57	7.5 kVA	Mbeya
7	Isoko Mission	Box 57	12 kVA	Tukuyu
8	Kaha Stores	Box 21	600 kVA	Kyela
9	The Unitabe Fradwa	Box -	3 kVA	Chunya
10	Mbarali Irrig. Scheme	Box -	7.5 kVA	Mbeya
11	Utengule Tea Coffee	Box 139	1500 kVA	Mbeya
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Ujenzi Tunduma	Box -	30 kVA	Mbozi
2	Government House	Box -	7.1 kVA	Kyela
3	Tukuyu Tea	Box 25	3 kVA	Tukuyu
4	Tukuyu Tea	Box 35	1.5 kVA	Tukuyu
5	Chivanjee Estate	Box 39	1.5 kVA	Tukuyu
6	Utengule Tea Coffee	Box 139	1.7 kVA	Mbeya

Morogoro

	Name	Address	Capacity	Area
	(a) Generators in areas not supplied by Tanesco:-			
1	Mikumi W. Lodge	Box 14	67.5 kVA	Morogoro
2	Kilimanjaro Sisal Estate	Box -	10 kVA	Morogoro
3	Mbaraka Salum	Box 77	6.5 kVA	Kidodi
4	Jumba La Elimu	Box 31	2 kVA	Ifakara
5	Ulanga Cotton & Rice Farm	Box 1	7.5 kVA	Ifakara
6	Shengena Bar	Box -	100 kVA	Ifakara
7	Shule Ya Ufundi	Box 14	7.5 kVA	Ifakara
8	Wami Prisons Farm	Box -	13.1 kVA	Morogoro
9	Dirung Farms	Box -	3 kVA	Morogoro
10	Ulanga Cotton & Rice Farm	Box -	17 kVA	Ifakara
11	Kanisa Katoliki Ngela	Box 640	3.5 kVA	Morogoro
12	Kidodi Sugar Estate	Box 640	3 kVA	Kidatu
(b)	*Standby generators in areas supplied with Tanesco:-*			
1	Vitonga S. Estate	Box 657	2.5 kVA	Morogoro
2	R. C.	Box 91	7.5 kVA	Kidatu
3	Ulanga Bar	Box 31	7.7 kVA	Kidatu
4	City Bar Kidatu	Box 126	100 kVA	Kidatu
5	Kilombero Sugar Ltd	Box 50	11.50 kVA	Kidatu
6	Ulanga Saw Mills	Box 7	7.5 kVA	Kidatu
7	Co-operative	Box 310	7 kVA	Morogoro
8	Kisuro Studio	Box 8	40 kVA	Kidatu
9	Mbotwa Estate	Box 5	2.5 kVA	Kidatu
10	Ilonga Saw Mills	Box 7	2.5 kVA	Kidatu
11	Mtibwa Sugar Estate	Box -	428 kVA	Morogoro
12	Mulonda R.C. Mission	Box -	25 kVA	Morogoro
13	Nural Kassam	Box -	21.7 kVA	Mikumi
14	Asenga Store	Box 35	1.6 kVA	Kidatu
15	Kimamba S.estate	Box 9	245 kVA	Kimamba
16	H.H.A. Jamachama	Box 40	3 kVA	Ifakara

Mtwara

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Chidya Gov. Secondary School	Box -	33.5 kVA	Masasi
2	Government Hospital	Box 151	20 kVA	Masasi
3	E.L.M. Division	Box 56	34.4 kVA	Masasi
4	N.B.C.	Box 105	12.5 kVA	Masasi
5	Ujenzi	Box 43	34.4 kVA	Newala
6	Migogo Mission	Box 43	6 kVA	Masasi
7	Masasi Hotel	Box 57	12.5 kVA	Masasi
8	Manganga Trade School	Box -	1500 kVA	Ndanda
9	Mkowe Parish	Box -	6 kVA	Ndanda
10	R.C.M. Migongo	Box 43	12 kVA	Masasi
11	Likuledi Parish	Box 43	29.9 kVA	Masasi
(b)	*Standby generators in areas supplied by Tanesco:-*			
	NIL			

Musoma

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Ikizu Seminary School	Box -	50 kVA	Musoma
2	Bwei Chuo Cha Mafunzo	Box -	6.0 kVA	Musoma
3	Buhemba J.K.T.	Box 36	18.75 kVA	Musoma
4	Ikizu Siminary	Box -	35 kVA	Musoma
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Ikizu Seminary	Box -	50 kVA	Musoma
2	Mara Cotton Industry	Box 60	62 kVA	Musoma
3	Headmaster Tarime Secondary	Box 183	3 kVA	Tarime

Mwanza

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Biharamulo Cotton Farm	Box 699	256 kVA	Mwanza
2	Nyasamo Ginnery	Box 728	321 kVA	Mwanza
3	Nasa Ginneries	Box 728	135 kVA	Mwanza
4	Ukerewe	Nansio	20 kVA	Mwanza
5	Forest Project	Geita	11.5 kVA	Mwanza
6	Sengerema Secondary School	Geita	52.5 kVA	Mwanza
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Kilimo	Box 961	18.5 kVA	Mwanza
2	Ujenzi	Box 961	32 kVA	Mwanza
3	Ujenzi	Box 961	35 kVA	Geita
4	Nyanza Industrial Co.	Box 728	400 kVA	Mwanza
5	Nyanza Industrial Co.	Box 728	42 kVA	Mwanza
6	Nyanza Industrial Co.	Box 728	150 kVA	Mwanza
7	Nyanza Industrial Co.	Box 728	272.5 kVA	Mwanza
8	Nyanza Industrial Co.	Box 728	218 kVA	Mwanza
9	Nyanza Industrial Co.	Box 728	150 kVA	Mwanza
10	Nyanza Industrial Co.	Box 728	120 kVA	Mwanza

Pwani

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Opel Estate	Box 10038	38 kVA	Bagamoyo
2	A. S. Abood	Box 4	6 kVA	Bagamoyo
3	R.C.M	Box 16	7.5 kVA	Bagamoyo
4	Bagamoyo Secondary School	Box 42	42 kVA	Bagamoyo
5	Champsi Mulji	Box 10020	7.5 kVA	Bagamoyo
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Salum Salum	Box 25	7.1 kVA	Bagamoyo
2	J. M. Co.	Box 3	7.05 kVA	Bagamoyo

Shinyanga

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Mhunze Ginnery	Box 240	218 kVA	Shinyanga
2	Ujenzi	Box 240	27.5 kVA	Shinyanga
3	Luguru Ginnery	Box 240	415 kVA	Shinyanga
4	Shinyanga	Box 240	172 kVA	Shinyanga
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Shinyanga Region	Box 240	272.5 kVA	Shinyanga
2	Shinyanga	Box 240	30 kVA	Shinyanga
3	Kolandoto	Box 46	51 kVA	Shinyanga

Sumbawanga

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
	NIL			
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Sumbawanga Govt. Hospital	Box -	7 kVA	Sumbawanga
2	Works Sumbawanga	Box -	7.1 kVA	Sumbawanga
3	N.B.C.	Box -	6 kVA	Sumbawanga
4	R.C.M.	Box 24	34.4 kVA	Sumbawanga
5	Government Hospital	Box 44	7.4 kVA	Sumbawanga
6	R.D.D.	Box 123	23 kVA	Sumbawanga
7	Naco	Box 106	106 kVA	Sumbawanga

Tabora

	Name	Address	Capacity	Area
(a)	*Generators in areas not supplied by Tanesco:-*			
1	Farmers Centre	Box -	13.1 kVA	Urambo
(b)	*Standby generators in areas supplied by Tanesco:-*			
1	Dia and Takies	Box 205	125 kVA	Tabora
2	District Council	Box 4	22.5 kVA	Nzega
3	Nzega Workers Co-op	Box 154	7.5 kVA	Nzega
4	Shell Company Ltd	Box 85	5 kVA	Nzega
5	Workers	Box -	2.6 kVA	Nzega
6	Nzega Hospital	Box 8	10 kVA	Nzega

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