



**Local Management of Rural Power Supply**  
A new approach in Tanzania

**Monica Gullberg, Maneno Katyega and  
Björn Kjellström**



*Monica Gullberg*

**Local Management of Rural Power Supply  
A New Approach in Tanzania**

**Monica Gullberg, Maneno Katyega and  
Björn Kjellström**

Stockholm Environment Institute  
Box 2142  
S-103 14 Stockholm  
Sweden  
Tel: +46 8 412 1400  
Fax: +46 723 03 48  
E-mail: [postmaster@sei.se](mailto:postmaster@sei.se)  
<http://www.sei.se>

Responsible Editor: Karin Hultcrantz  
Cover: Karin Hultcrantz  
Copy and Layout: Solveig Nilsson  
Stockholm Environment Institute

© Copyright 1999 by the Stockholm Environment Institute.

*This publication may be reproduced in whole or in part and in any form for educational or non-profit purposes, without special permission from the copyright holder(s) provided acknowledgement of the source is made. No use of this publication may be made for resale or other commercial purpose, without the written permission of the copyright holder(s).*

**ISBN: 91 88714 68 3**

## ACKNOWLEDGEMENTS

The work presented in this report is carried out jointly by the Stockholm Environment Institute (SEI) and the Tanzania Electric Supply Company (TANESCO). Substantial contributions are also made by the University of Dar es Salaam, and especially the Department of Sociology and the Department of Electric Engineering. The Royal Institute of Technology, Stockholm, has as well contributed through the Department of Electric Power Engineering.

Special thanks are addressed to the staff at the TANESCO-Tabora Zonal and Regional offices who have carried out much of the direct support to the Urambo Electric Consumers Co-operative. Further, we are grateful to the co-operative development committee and all the members of the co-operative that have provided us with ample information on their activities.

The SEI would like to thank the Swedish International Development Co-operation Agency (Sida) for kindly providing the support that made this report possible.

Monica Gullberg, Maneno Katyega and Björn Kjellström

## NOTATIONS

### Abbreviations and acronyms

ACAP	Annapurna Conservation Area project (Nepal)
ADB	Asian Development Bank
Ah	Ampere hours
BPC	Butwal Power Company Limited (Nepal)
CEA	Central Electricity Authority (India)
CFE	Comision Federal de Electricidad (Mexico)
CFL	Compact Fluorescent Lamp
COBEE	Compania Boliviana Energia Eléctrica
CRE	Cooperativa Rural de Electrificación (Bolivia)
EE&D	Energy, Environment & Development (programme at SEI)
ELFEC	Empresa de Fuerza Eléctrica de Cochabamba (Bolivia)
ENDE	Empresa Nacional de Electricidad (Bolivia)
ESP	Economic Survival Plan
ERP	Economic Recovery Programme
FINNIDA	Finnish International Development Agency
GASCO	Gas Supply Company (Tanzania)
GDP	Gross Domestic Product
GEF	Global Environment Facility
GJ	Gigajoule
GTZ	German Agency for Technical Cooperation
GW	Gigawatt
GWh	Gigawatthours
Hydel	Shortname for Hydro-electric used in Asia
IMF	International Monetary Fund
IREDA	Indian Renewable Energy Development Agency Ltd.
ITDG	Intermediate Technology Development Group (UK)
km <sup>2</sup>	square kilometers
kV	kilovolt
kVA	kilovoltampere
kW	kilowatt
kWh	kilowatthours
Ltd	Limited
lm	lumen
lmh	lumenhours
m.a.s.l.	meters above sea level
m <sup>2</sup>	square meters
MECOS	Mbinga Electricity Consumers Cooperative Society (Tanzania)
MCCCO	Mbinga Coffee Curing Company Limited (Tanzania)
MWEM	Ministry of Water, Energy and Minerals (Tanzania)
NBC	National Bank of Commerce (Tanzania)
NEA	Nepal Electricity Authority
NEEPCO	North-Eastern Electric Power Corporation (India)
NGO	Non-Governmental Organisation
NHPC	National Hydro-Electric Power Corporation (India)
NOK	Norwegian Crowns
NORAD	Norwegian Agency for Development Cooperation
NRECA	National Rural Electric Cooperative Association (US)
NTPC	National Thermal Power Corporation (India)
°C	Degrees Celsius
REC	Rural Electrification Corporation (India)
SAP	Structural Adjustment Plan (Tanzania)
SASDA	Secretariat for Analysis of Swedish Development Assistance

SATA	Swiss Association for Technical Assistance
SCECO	Salleri Chialsa Electricity Company (Nepal)
SEB	State Electricity Board (India)
SEI	Stockholm Environment Institute
SHDB	Small Hydel Development Board (Nepal)
SHPD	Small Hydel Power Department (Nepal)
SIDA	Swedish International Development Authority
TANESCO	Tanzania Electric Supply Company Limited
TARECO	Tanzania Rural Electrification Company
TJ	Terajoule
TAS	Tanzanian Shilling
UDC	Urambo District Council (Tanzania)
UECC	Urambo Electric Consumers Committee (Tanzania)
UECCO	Urambo Electric Consumers Co-operative Limited (Tanzania)
UK	United Kingdom
UMN	United Mission to Nepal
UN	United Nations
US	United States
USAID	United States Agency for International Development
USD	United States Dollar
W	Watt
Wh	Watthours
W <sub>p</sub>	Watt peak (as opposed to watt nominal)

### Exchange rates applied

Approximate date	TAS equivalent to 1 USdollar
December, 1992	330
May, 1993	360
July, 1993	400
December, 1993	447
January, 1994	490
December, 1994	530
February, 1994	550
May, 1995	570
February, 1996	500
January, 1997*	598
July, 1997*	625
January, 1998*	640
July, 1998*	670
January, 1999*	684

\* Source: Bank of Tanzania. "Economic Bulletin for the Quarter ended 31<sup>st</sup> December 1998".

## TABLE OF CONTENTS

<b>Acknowledgements</b>		<b>iii</b>
<b>Abbreviations and Acronyms</b>		<b>iv</b>
<b>Table of Contents</b>		<b>vi</b>
<b>Executive Summary</b>		<b>ix</b>
<b>Figures 1-4 and Photographs</b>		<b>xxxiii</b>
<b>1.</b>	<b>INTRODUCTION</b>	<b>1</b>
1.1	Background	1
1.2	Energy use and supply in Tanzania	2
1.3	The electricity policy in Tanzania	3
1.4	Organisation of the project	6
<b>2.</b>	<b>THE CONCEPT OF LOCALLY MANAGED ELECTRICITY SUPPLY</b>	<b>9</b>
2.1	Historical and international perspectives	9
2.2	Introduction of locally managed electricity supply in Tanzania	14
2.3	History of cooperatives in Tanzania	15
2.4	Tariff considerations for rural electrification cooperatives	16
2.5	Important policy and research issues	21
<b>3.</b>	<b>PILOT SITES INVESTIGATED IN TANZANIA</b>	<b>25</b>
3.1	Overview	25
3.2	Method and data used by TANESCO for the feasibility and tariff studies	25
3.3	Summary of results for Shimbi	26
3.4	Summary of results for Sikonge	29
3.5	Summary of results for Urambo	30
3.6	Summary of results for Mbinga	34
3.7	Evaluation of the feasibility studies	36
<b>4.</b>	<b>IMPLEMENTATION OF THE FIRST PILOT PROJECT IN URAMBO</b>	<b>37</b>
4.1	Presentation of Urambo	37
4.2	Formation of the Urambo Electric Consumers Co-operative Society	40
4.3	Rehabilitation of the power plant	43
4.4	Rehabilitation and extension of the distribution grid	44
4.5	Training of personnel	45
4.6	Service agreement	45
4.7	Metering of consumption	45
4.8	Tariffs	47
4.9	Installation of energy efficient lights	47
<b>5.</b>	<b>EVALUATION OF EXPERIENCES FROM THE FIRST PILOT</b>	<b>49</b>
5.1	Monitoring activities	49
5.2	Management and organisation of the Cooperative	50
5.3	Rehabilitation and operation of the power plant	51
5.4	Rehabilitation, extension and operation of the distribution network	56
5.5	Personnel	57
5.6	Electricity consumers and demand development	59
5.7	Metering of consumption	70
5.8	Tariffs charged	71
5.9	Financial performance	76
5.10	Demand side management	84

5.11	Sociological observations	87
5.12	Unresolved issues	89
<b>6.</b>	<b>DISSEMINATION OF EXPERIENCES</b>	<b>91</b>
<b>7.</b>	<b>EVALUATION OF ENERGY EFFICIENT LAMPS AND PHOTOVOLTAIC SYSTEMS FOR VILLAGES OF URAMBO'S SIZE</b>	<b>93</b>
7.1	Need for new technologies in rural electrification	93
7.2	Energy efficient lamps	93
7.3	Photovoltaics	101
7.4	Overall assessment	112
<b>8.</b>	<b>FUTURE PLANS OF URAMBO ELECTRIC CONSUMERS CO-OPERATIVE SOCIETY</b>	<b>115</b>
8.1	Planning objectives	115
8.2	Short term plans (within 2 years)	115
<b>9.</b>	<b>CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE ACTIVITIES</b>	<b>117</b>
9.1	Lessons learned and main conclusions	117
9.2	Unresolved issues	119
9.3	Recommendations for future activities	120
<b>APPENDICES:</b>		
<b>A</b>	<b>Tanzania, its people and their energy use</b>	<b>127</b>
<b>B</b>	<b>Electricity tariffs of TANESCO</b>	<b>153</b>
<b>C</b>	<b>By-Laws of Urambo Power Co-operative Society</b>	<b>173</b>
<b>D</b>	<b>Contract for service between TANESCO and UECCO</b>	<b>183</b>
<b>E</b>	<b>Training programme for UECCO-OPERATORS</b>	<b>187</b>
<b>F</b>	<b>Urambo Electric Consumers Co-operative Society (UECCO)</b>	<b>193</b>
<b>G</b>	<b>Resolutions from the Rural Electrification Seminar in Tabora, June 7-9, 1996</b>	<b>195</b>
<b>H</b>	<b>PV-dimensioning</b>	<b>199</b>
<b>I</b>	<b>Agreement between the Urambo District Council (UDC) and the Urambo Electric Consumers Co-operative Society</b>	<b>201</b>
<b>References</b>		<b>203</b>



## **EXECUTIVE SUMMARY**

### **1. Introduction**

The rural electrification program in Tanzania has been on going since independence in 1961, with the national utility, Tanzania Electric Supply Company Ltd. (TANESCO) being responsible for its implementation. By 1992, 14 townships and 37 villages had been electrified as a result of this program. This covers only a small fraction of rural Tanzania. It is estimated that in 1998, less than 1% of the rural households in Tanzania had access to electricity. Refer to Figures 2 and 3.

Electricity constitutes only 1% of Tanzania's final energy consumption. Except for the few latest years, electricity generation and distribution in Tanzania has been the full responsibility of TANESCO. The national electricity grid is mainly supplied by large-scale hydro power plants (391 MW), and thermal power plants (148 MW). Rural areas are supplied either by a transmission line from the national grid or by diesel generator sets. The isolated branches run by TANESCO have an installed capacity amounting to a total of 23 MW.

Electric lighting is the dominating use of electricity in rural areas. Industrial use in these areas is marginal. Very few rural households use electricity for cooking. Cooking is made with fuelwood and to some extent charcoal and kerosene. Where electricity is not available, kerosene in simple wick lamps is used for lighting.

As part of the research co-operation between TANESCO and the Stockholm Environment Institute, SEI, an extensive evaluation of the experiences from the rural electrification program in Tanzania was carried out in 1989 - 1991<sup>1</sup>. The four main conclusions from this evaluation were in summary:

- The rural people appreciate electrification.
- Rural electrification is a large financial burden on TANESCO.
- The quality of the service, in particular the supply reliability, is low in rural areas.
- Many of the perceived benefits of rural electrification, like the creation of small scale industries or reduced use of fuel wood for cooking, have not materialised to a significant degree.

As a result of this evaluation it was recommended to try a new approach to rural electrification in Tanzania, based on local management of supply and distribution and with TANESCO's role limited to bulk supply of electricity and technical support. TANESCO agreed to carry out a few pilot projects to collect experiences from this approach as part of the research co-operation between TANESCO and SEI.

The present energy policy of Tanzania includes statements that encourage a departure from the earlier course of action and that have direct implications for local initiatives to

---

<sup>1</sup> Kjellström B., Katyega M., Kadete H., Noppen D. and Mvungi A., *Rural Electrification in Tanzania: Past Experiences – New Approaches*, SEI, 1992.

rural electrification. In particular, the encouragement of private initiatives and the possibility for these to apply tariffs differing from TANESCO's, facilitates for local initiatives.

This project is a co-operation between the SEI, the University of Dar es Salaam and TANESCO, involving the head quarters in Dar es Salaam and the regional offices. The Swedish International Development Authority, SIDA, has mainly provided funding.

## **2. Approach to Locally Managed Electricity Supply**

Local management of electricity supply was very important in the early days of rural electrification in many industrialised countries, and is still important for instance in USA and Sweden. In developing countries, locally managed electricity supply is prevalent in both Asia and Latin America but to a much lesser degree in Africa. Locally managed power supply systems in these parts of the world are mostly complementary to existing national grids.

A study<sup>2</sup> conducted jointly by TANESCO and SEI, which included visits to Bolivia, India and Nepal, confirmed that rural electrification with local management can be successful in developing countries, provided that the activities are properly organised and given sufficient initial support. The visited organisations included cooperatives as well as shareholder companies. An analysis of their conditions as formulated by national policies for rural electrification, and donors' involvement, was made.

Historical and international experiences are useful for the pilot projects in Tanzania, but should not be applied unreflected. In Tanzania, the weak infrastructure, the lack of technically educated people in rural areas and the low paying ability of the majority of the rural population are factors which can be expected to lead to difficulties.

It was believed that successful implementation in Tanzania of a rural electrification programme based on local management would require strong local commitment and leadership, careful adaptation to local conditions and strong initial technical and management support from a central organisation.

TANESCO appeared as the most suitable organisation to provide the technical and management support. Such support would include a pre-feasibility study with a tariff estimate, assistance in organising the local body to manage the electricity supply, technical support during design, installation and commissioning of equipment, training of local technical and administrative personnel and continued technical and management support upon request. TANESCO's involvement would also ensure that installations comply with the TANESCO standard. This was seen as an important factor since it is expected that the local distribution networks will eventually be connected to the national grid.

---

<sup>2</sup> Gerger Å. and Gullberg M., *Rural Power Supply with Local Management: Examples from Bolivia, India and Nepal*, SEI 1997. ISBN 91 88714 31 4

Depending on the location of the area to be electrified, the estimated demand and the local energy resources available, the supply can come from the national grid or from an isolated power plant. Isolated power plants may use diesel generator sets, a mini-hydro power plant, a biomass fuelled power plant or solar electricity. It can be expected that in many cases a diesel power plant will be the least cost short-term solution, to be followed by grid connection or an isolated plant using a renewable energy source when the demand has reached a certain level.

The role of the local management will be to organise the consumers, set the tariffs, collect payment for the service, take responsibility for the daily operation and call upon TANESCO when technical and management support is needed. The full responsibility for the financial sustainability of the service rests with the local organisation.

Different organisational set-ups are possible. A private organisation or company may be the best choice in some cases, a cooperative solution in others. Combinations can of course also be considered where for instance a private company manages the supply, whereas distribution is managed by a cooperative that buys power from the supplier. Cooperatives, mainly for agriculture, have existed in Tanzania for many decades, while private companies were only recently welcomed into the national economy.

### 3. Pilot Sites Investigated in Tanzania

Up to 1996, four sites for possible pilot projects have been studied by TANESCO. Key data are given in table 1.

The sites studied are Shimbi in Kilimanjaro region, Sikonge and Urambo in Tabora region and Mbinga in Ruvuma region. In Shimbi, grid connection was the obvious supply solution. An isolated diesel power plant was found to be the least cost solution for Sikonge in the short time perspective. In Urambo an existing isolated network supplied by a diesel power plant could become the base for further activities. Supply from an existing diesel power plant at a coffee curing plant appeared as a possibility in Mbinga.

**Table 1. Key data for sites investigated as candidates for pilot project**

Site	Population	Estimated demand after 4 years (MWh/year)
Mbinga	14 970*	2 225
Shimbi	21 050**	8 770
Sikonge	8 874**	1 150
Urambo	11 830**	387

\* (1993)

\*\* (1988)

Shimbi was found to be less suitable as a pilot case, because part of the village was already serviced by TANESCO. Organisation of a locally managed supply would lead to either that the present consumers were taken over by the new organisation, with tariff increases as a result, or that two suppliers with different tariffs would be

servicing the area. Neither seemed as a good solution. Sikonge was given lower priority because of the high investment required, about 1.5 MUSD. Urambo was selected as the first pilot case, because the investment required was modest and because there had already been local initiatives to solving the electricity supply problem.

Mbinga was selected as the second pilot case, because a distribution network, although not quite complete, was already available. This was a result of a TANESCO investment program, which has not yet been completed.

The tariff studies that were made by TANESCO for these sites are not entirely comparable because fuel prices and exchange rates have been changing. The estimated tariffs required for sustainability range however from about 0.11 USD/kWh in a grid connected Shimbi to about 0.22 USD/kWh in diesel supplied areas. These tariffs are significantly higher than the tariff charged by TANESCO for small domestic and commercial consumers, i.e. between 0.015 and 0.05 USD/kWh.

#### **4. Implementation of the First Pilot Project in Urambo**

##### ***4.1 Presentation of Urambo***

Urambo village is located 80 km west of Tabora in Tabora region. The Urambo urban ward inhabits close to 12,000 persons, but only a small fraction of these live in the area that is presently reached by the electricity distribution grid. Agriculture is the dominating activity in the district, and tobacco an important crop. Urambo district alone contributed 26% of the total Tanzania Mainland purchases of flue cured tobacco in 1990.

In July 1994, a sociological baseline study<sup>3</sup> was carried out in Urambo urban ward. Interviewees were mainly those who were at the time connected to the electricity distribution system in Urambo. The study covers only about 0.5% of the households in Urambo ward. Results reveal that this group of people tend to be relatively less dependent on agricultural activities alone than what is shown by national aggregated data. Rather, they make their living from commercial activities.

In Urambo there are more than 100 shops, one bank, one post office and twelve restaurants. Eight guesthouses exist, some of which have a bar connected. Urambo has also a hospital, two dispensaries, a teachers' training collage and a police station with a prison belonging to it. There are various small-scale industrial activities in Urambo such as grain milling and aluminium works (1994).

Energy needs in Urambo are to a large extent met by fuel wood for cooking and kerosene for lighting. Some small-scale industries as well as bigger institutions have invested in small diesel generator sets to meet their electricity needs.

In 1985, three diesel generation sets were installed in Urambo on the Urambo District Commissioner's (UDC's) initiative. They were meant to provide street lighting and

---

<sup>3</sup> Mvungi A. and Sanga A., *A Base Line Study of Urambo*, Dar es Salaam University, 1995.

meet selected electricity requirements in the town centre. A distribution grid was erected with support from TANESCO. Electricity services were on the UDC's expense. These are the generation and distribution facilities inherited by the Cooperative.

#### ***4.2 Formation of the Urambo Electric Consumers Co-operative Society***

In 1992 the UDC had decided to cease electricity services due to lack of funds. Instead an informal arrangement was made whereby a committee of five electricity consumers, Urambo Electricity Consumers Committee (UECC), was organised that collected funds for the diesel purchases. The District Engineer continued to be in charge of running the engines.

Discussions between the UDC, representatives from SEI, TANESCO and the committee held in June 1993 identified the following problems with the informal arrangements as preventing sustainable development of the electricity supply in Urambo:

- The poor status of the power plant with only one set operational;
- Ambiguities as regards the sharing of responsibilities for maintenance between the District Engineer, UDC and TANESCO;
- Unclear responsibilities of the committee with respect to the electricity consumers;
- Lack of competence in Urambo for service and maintenance of the system;
- Uncertainties about the consumers' obligations.

The proposed new approach presented by SEI and TANESCO was to form an electricity consumer cooperative that would own and maintain the system. This would be the first pilot project for local management of electric power supply in Tanzania. The suggested approach was accepted in Urambo and led to the formation of the Urambo Electric Consumers Co-operative Society, UECCO, which was officially registered in September 1993. The Cooperative as well acquired licence to generate and distribute electricity from MWEM by that time. Shortly after its formation, the Cooperative inherited the entire power generation and distribution system from the UDC under conditions as specified in appendix E.

With financial support from SIDA, SEI offered assistance to the Cooperative. This included support for rehabilitation of the power plant, some extension of the distribution network to make connection of the hospital and the industrial area possible, training of operators, costs for initial TANESCO support to UECCO and monitoring of the performance of the new organisation.

TANESCO headquarters in Dar es Salaam offered to assist in the organisation of the Cooperative by carrying out a tariff study and by drafting by-laws for the Cooperative and a service contract between TANESCO and UECCO.

The by-laws for UECCO, and the contract between UECCO and TANESCO were formulated with reference to guidelines from NRECA as well as the Swedish Electricity Association and with influential inputs from the Legal Secretary of TANESCO. Following recommendations from the Legal Secretary of TANESCO,

and with the approval of the provisional committee, three trustees<sup>4</sup> were engaged to support the Cooperative in legal matters, etc.

#### ***4.3 Rehabilitation of the power plant***

The Urambo power plant, commissioned in 1985, consists of three identical generator sets of Caterpillar diesel engines rated at 85 kW and connected to a 500 kVA step up transformer 0.4/11 kV. The diesel engines were in poor condition in 1993. When UECCO was formed only one generator set was operational and it was in need of a major overhaul. SEI has assisted in delivering spare-parts from Europe. The status in August 1997 was that only one set was operational, one was in need of service, and a third was completely torn apart. It was decided that rehabilitation of the third generator set would not be carried out and that instead a new 108 kW generator set would be purchased by SEI and with SIDA funds. The purchase of the new generator set was delayed by formalities regarding exemption from import duties by Treasury in Tanzania. The generator set was eventually ordered in December 1997 and was installed during 1998.

#### ***4.4 Rehabilitation of the distribution network***

The status of the distribution network when the Co-operative took over responsibilities could generally be described as satisfactory according to TANESCO standards. In 1993, there were three transformers in the system, of which the Town transformer carried 87% of the load. Rehabilitation and extension of the network included erecting an additional 0.2 km of 11 kV line, mounting three new transformers, and reshuffling load. Figure 4 shows the present distribution network (11 kV) and the six transformers. Table 2 (section 5.4) lists the capacities of the transformers and their connected load in August 1997.

#### ***4.5 Training of personnel***

Training of personnel was initially arranged for two operators and one accountant. TANESCO designed special training programmes. Unfortunately, for different reasons, the personnel that attended the initial training left the Co-operative. Since then new training sessions have been held for one operator and one accountant, while one operator has on the job training only.

#### ***4.6 Service agreement***

TANESCO-Tabora regional office provides technical and administrative support to the Co-operative on request and at cost, according to a service agreement.

#### ***4.7 Metering the consumption***

Metering only existed at the powerhouse in the inherited system, and electricity consumers were paying a monthly fixed rate for the services. UECCO continued applying the fixed rates system during its initial years. During 1995, however, meters were installed with the financial help from SIDA through SEI.

---

<sup>4</sup> Mr. Samuel Sitta, Member of Parliament, Urambo, Mrs Esther Masunzu, Assistant Commissioner for Energy and Electricity at the Ministry of Water, Energy and Minerals, and Mr. Masanja, Regional Development Director at Tabora.

The fixed rates system had then proved to induce too much conflict between consumers and the Co-operative Development Committee decided to arrange for meters to be installed at consumer premises of those who wished. With a meter installed, a monthly fixed rate of 4.25 USD is to be added to the electricity bill, covering the amortisation payment for the meter and the cost for meter reading. Load limiting circuit breakers in combination with a modified fixed rate were also discussed. Although the option would result in a lower monthly fixed cost, consumers were not interested in load limiting circuit breakers.

#### **4.8 Tariffs**

During the period with un-metered fixed rates, four rates existed:

**Residential**, limited to houses and only for residential purposes;

**Commercial**, including shops, bars, restaurants and small workshops;

**Guest houses**, and;

**Institutions**, including the District Commissioners office, National Bank of Commerce and FDC.

The fixed rates were adjusted several times during the period, but were eventually found inappropriate as they neither did meet the actual cost for delivering electricity, nor reflected differences in consumption between consumers. After installations of meters, the consumers have been charged per energy unit consumed.

#### **4.9 Installation of energy efficient lights**

Electric lighting is by far the dominating load in the Urambo power system. Given the limited generation capacity and the high tariffs, energy efficient lamps was regarded an option worth evaluating. Compact Fluorescent Lamps consume only about 25% of the energy for the same light output as an incandescent lamp. 85 CFLs were installed in Urambo in 1994.

### **5. Evaluation of operational experiences from the first pilot project**

#### **5.1 Monitoring activities**

TANESCO, SEI and the Sociology Department at the University of Dar es Salaam have monitored the Cooperative in Urambo through a series of visits to the village and by correspondence with the Co-operative Development Committee. A total of fourteen visits have been made to Urambo over the years 1992-1997, of which nine have involved SEI staff.

#### **5.2 Management and organisation of the Cooperative**

Following Tanzanian praxis, a development committee has managed the Cooperative. The fact that the number of members has grown over the past five years indicates that the committee has been managing the Cooperative well. However, there are a few issues that have not been adequately handled if referring to the by-laws of the organisation. There have been fewer members meetings than stipulated in the by-laws. The first annual general meeting of the Cooperative was in February 1995, i.e. one and a half years after the Cooperative's official registration. An underlying reason mentioned is the lack of audited annual accounts for the years 1995 and 1996, which in it self is a shortcoming.

It may very well be that the committee has acted in the best of the Cooperative and its members when concentrating on the electricity services rather than the meetings and auditing. Still, by neglecting the obligations that should ensure the members full insight in the Cooperative's activities and finances, the committee puts the Cooperative's survival at risk. Poor management, resulting in among other things the consumers' unwillingness to pay bills is a common reason for local organisations for electricity supply ceasing in other developing countries.

### ***5.3 Rehabilitation and operation of the power plant***

The rehabilitation of the power plant is still not finalised and the delay has been a major source of trouble for the Cooperative. The rehabilitation was supposed to be a direct and initial support to the pilot project from SEI and SIDA. In retrospect it is clear that the approach to rehabilitate the three existing sets was not the most cost efficient. Rehabilitation has been costly, and it has been a very time consuming activity. A contributing factor is that the type of generator set is no longer manufactured. By the end of 1995 spare parts totalling USD 55 935 had been supplied, Two sets had then been successfully rehabilitated. A new generator set of 108 kW, costing USD 21 400, was installed during 1998.

### ***5.4 Rehabilitation, extension and operation of the distribution network***

The rehabilitation and extension of the distribution network was carried out by personnel from TANESCO Tabora. Technically, there have been no problems with this part of the project.

Studies of the load distribution in the system have been carried out on two occasions, in July 1994 by Andersson<sup>5</sup> and August 1997 by Daati<sup>6</sup>. In 1994 only two transformers were connected. The average measured load was then about 71 kW, with the town transformer carrying the major part or 62 kW. The balance between the phases was found to be reasonably even. In August 1997, the total average load on the transformers was determined to be 33 kW. The load distribution determined in August 1997 is shown in table 2.

**Table 2. Load distribution in Urambo August 1997**

<b>Transformer location</b>	<b>Rated capacity (kVA)</b>	<b>Average load (kW)</b>
Town	100	22.21
Tobacco godown	50	1.82
Industry area	50	0.27
Boma village	100	6.17
Bomani	50	2.62
Police	50	disconnected
Hospital	50	disconnected
		<b>(Total: 33.09)</b>

<sup>5</sup> Andersson, E.C., 1995, *Electric Energy Efficiency in Urambo Power Supply System, Part One*. A SIDA Minor Field Study in Tanzania, 1995.

<sup>6</sup> Daati, S., *Technical Report from Urambo Power System*, TANESCO, 1997.

Measurements of the power supply quality in September 1997 showed voltage values between 236 and 212 V which is 2 to 12% below rated voltage of 240 V. The lower values are just outside the TANESCO standard of  $\pm 10\%$ . The frequencies ranged between 47.3 and 44.1 Hz, i.e 5 to 12% below rated frequency. An inspection of the transformers in August 1997 indicated neglected maintenance.

### **5.5 Personnel**

The Cooperative has had difficulties recruiting qualified and reliable personnel for operation of the power plant, minor lines work and administrative tasks. The two initial operators, coming from Tabora, which were trained by TANESCO, see section 4.5, left in late 1994 after conflicts with the provisional Development Committee.

Three young men from Urambo were then selected by the provisional Development Committee to succeed the initial operators. While they were initially getting on the job training, they eventually received further training at Tabora and Kigoma by TANESCO that was financed by SEI. One of the two operators quit in February 1996, because his family moved from Urambo. He had been replaced by another young man. The fairly good operating records of the plant indicate that the training of the operators has been adequate.

For almost a year after registration, the Cooperative had no accountant. The Secretary of the provisional Development Committee was then responsible for collection of revenues and payment of bills. There appears to have been no regular book keeping during this period. After recommendations from SEI and TANESCO, an accountant was employed in August 1994. Training, funded by SEI, was carried out by TANESCO-Tabora during two weeks. This accountant was fired in mid 1995 after misuse of funds. One of the operators was then assigned with the task to work both as accountant and operator. This situation still prevailed in August 1997.

An anticipated benefit with local management is that management costs should be lower. One possible measure is the number of employees per monthly MWh generated. Comparisons with TANESCO's isolated branches indicate that the number of operators at UECCO is normal. It is not really possible to manage with less than three for a system of that capacity.

A more detailed comparison between Urambo and one particular TANESCO system, Mafia, however shows the interesting result that the specific personnel cost is twice as high at Mafia despite a smaller number of employees per monthly MWh<sup>7</sup>. The explanation is obviously the lack of overhead costs at UECCO and the lower qualifications of the UECCO staff.

### **5.6 Electricity consumers and demand development**

The number of connected consumers has increased from 67 in December 1994 to 101 in June 1997. In the same time the average load supplied during the 4 to 5 evening

---

<sup>7</sup> Gwang'ombe, F., *Technical comparative study on rural public power supply versus community managed power supply: Urambo/Mafia, TANESCO, 1995.*

hours of operation has dropped from about 77 kW to 41 kW. The average power per consumer has thus dropped even more, from 1149 W in December 1994 to about 406 W in June 1997. This is obviously an effect of the switch from un-metered flat rate to a tariff based on metering and a charge per unit consumed.

During the time a flat rate tariff was used, it was impossible to know the individual consumption at the different consumers. The average monthly energy consumption per consumer can however be estimated and has dropped from about 100 kWh in the end of 1994 to about 45 kWh in June 1997.

Several efforts have been made to gain information about the structure of the electric load. Prior to the installation of meters however, this was largely speaking not successful. In July 1994, it was determined that the average load per consumer was around 845 Watt, but there was no detailed information about the actual structure.

After the installation of meters it has been possible to obtain a clearer view of the consumption structure. Table 3 shows the situation during the first half of 1997.

Residential consumers dominate in number and consumption. The average monthly consumption is between 30 and 40 kWh. This can be compared to the domestic consumption in the Bolivian and Nepalese organisations visited during the international survey, see Chapter 2. The consumption in Bolivia ranged between 8.5 kWh/month and 78 kWh/month and in Nepal between 27 kWh/month and 127 kWh/month. On the average, the consumption in Urambo is similar to that in rural areas of these countries. Commercial consumers in Urambo show a slightly higher average consumption. Of the metered consumers 63% used less than the overall average. Only 14% used more than 100 kWh/month.

There has been an interesting shift in load structure from lighting load dominating in 1994 to a situation in August 1997 when lights account for only 30% of the connected load and various appliances for the other 70%. Among appliances, household appliances like electric irons and cookers, kettles and deep freezers account for about 30% of the connected load in August 1997. This has obvious implications for the gender aspects of the project, although it has not been established to what extent these appliances contribute to the electric energy consumption. The high tariff can be expected to act as an obstacle to extensive use of electricity for ironing and cooking. Among entertainment appliances, both radios and videos have increased in number since 1994. The increase is dramatic for videos that have increased in number from 15 to 47. In August 1997, commercial video shows were offered at several locations in Urambo.

**Table 3. Consumption of different consumer categories in 1997**

	Jan	Feb	Mar	Apr	May	Jun
<b>Residential</b>						
Metered consumers (no.)	66	66	66	66	65	65
Metered consumption (kWh)	2370	2198	2613	2268	2170	2032
Average consumption (kWh)	35.9	33.3	39.6	34.4	33.4	31.3
Flat rate consumers (no.)	0	0	0	0	0	1
<b>Commercial</b>						
Metered consumers (no.)	28	28	27	27	28	28
Metered consumption (kWh)	1372	1476	1438	1594	2027	1948
Average consumption (kWh)	49.0	52.7	53.2	59.0	72.4	69.5
Flat rate consumers (no.)	0	0	0	0	0	0
<b>Institutions</b>						
Metered consumers (no.)	1	2	2	2	2	2
Metered consumption (kWh)	27	58	114	40	59	67
Average consumption (kWh)	27.0	29.0	57.0	20.0	29.5	33.5
Flat rate consumers (no.)	0	0	0	0	1	1
<b>Public</b>						
Flat rate consumers	3	3	4	4	4	4
<b>Street lights</b>						
Working street lights	6	6	6	6	6	8
Estimated consumption <sup>1)</sup>	127	125	142	134	140	157

<sup>1)</sup>Calculated from operating time and power 150 W for each

For correct setting of the tariff it is important that the distribution losses in the system are known. The un-paid electricity for the period Jan-May 1997 was found to be close to 20% of the generated electricity.

Part of the un-paid electricity may be consumed in the churches and mosques. The consumer survey made in August 1997 shows however that the total connected load in this consumer category is only 680 W. Even with a load factor of 100%, the un-paid monthly consumption in this group can not be more than about 50 kWh. The conclusion is that technical and other losses, like unauthorised consumption, may amount to close to 20% in the UECCO system.

### ***5.7 Metering of the consumption***

Use of a flat rate, based on installed load, requires the least investment and eliminates the need for periodic meter reading. The experiences from Urambo from un-metered supply of electricity are however un-favourable. The system caused large losses for the Cooperative and was considered un-fair by many of the consumers.<sup>8</sup> It is possible that a more sophisticated approach to flat rate estimation, based on actual connected load rather than consumer category would have been more successful but this approach was never tried in Urambo.

When in May 1995 the consumers were asked about their preferences between meter (4.25 USD/month for five years) and a cheaper load limiting circuit breaker, (0.75 USD/month for five years) 16 opted for circuit breakers and 68 for meters. Those who chose circuit breakers however changed their mind when the installation was due. The reason has not been established but in many cases the cause seems to be that the circuit breaker makes it impossible to use most of the appliances other than a radio.

### ***5.8 Tariffs charged***

Flat rates with different rates for the four main consumer categories were used in Urambo when the electricity was supplied by the District Council. Since the users were not equipped with meters, the use of flat rates continued when the Cooperative took over the responsibility. From October 1995, the consumers with meters have paid an energy charge, whereas those without meters have remained on flat rate. Table 4 summarises the electricity tariffs charged in Urambo during almost five years, 1992-1997. For comparison, TANESCO's tariffs are given as well.

It is interesting to compare the flat rates established by the provisional Cooperative Development Committee in 1994 with the cost paid for electricity by the average consumer in the period January to June 1997, when the consumer loads have been adjusted to the higher tariffs. The comparison is made in table 5. The table shows that despite the significant reduction of the average load, from about 1150 W in December 1994 to about 400 W in June 1997, the cost to the consumers has increased significantly.

As can be seen from table 4, the tariffs in Urambo are dramatically higher than the tariffs in the national grid served by TANESCO. The experience from Urambo

---

<sup>8</sup> Mvungi, A. and Sanga, A., 1995.

appears to indicate that people in Tanzania, even in rural areas, are prepared to pay a lot more for electricity than perhaps assumed when the TANESCO tariffs are decided upon. An effect of a higher tariff is that the consumption is reduced until a bare minimum is reached. A further increase in the tariff, when consumers have adjusted the consumption to a minimum level, can be expected to lead to dropout of consumers. It is not possible to tell from the Urambo experience where this limit can be found. The fact that some consumers have been unable or unwilling to pay the electricity bills may indicate that the Cooperative is now operating close to this limit and that the average household is not prepared to pay more than about 15 USD per month for five hours per day of light consuming about 230W, which is approximately equivalent to 4 incandescent bulbs of 60W.

**Table 4. Electricity tariffs charged in Urambo**

Date	1992 December	1994 December	1995 October	1996 February	September	1997 March	July
<b>Urambo tariffs:</b>							
Flat rates USD/month							
Residential	6.1	10.4	14.7			41.6	
Commercial	10.6	16.0	21.2			83.2	
Guest house	15.1	18.9	21.2			83.2	
Institution	19.7	47					
Place of worship					6.7	6.7	9.6
<b>Energy charge</b>							
USD/kWh	0.28*	0.33	0.44	0.44	0.50	0.56	
TAS/kWh	150*	200	240	260	300	350	
<b>TANESCO tariffs:</b>							
Residential USD/kWh		0.02	0.031	0.036	0.034	0.033	0.037
Bulk energy USD/kWh		0.11	0.13	0.16	0.15	0.15	0.16
<b>Economic data:</b>							
Exchange rate TAS/USD	330	530	613	550	596	601	625
Fuel price							
USD/litre	0.42	0.45	0.49	0.56	0.55	0.67	0.68
TAS/litre	139	240	300	310	325	400	425

\*Recommendation in TANESCO/SEI tariff study, December 1994. All consumers still on flat rate

**Table 5. Monthly costs for electricity in different consumer categories (USD)**

	Flat rate	Cost for average consumer	
	Dec 1994	Jan-Feb 1997	Mar-Jun 1997
<b>Residential</b>	10.4	15.2	17.3
<b>Commercial<sup>a)</sup></b>	16.0-18.9	22.3	31.7
<b>Institutions</b>	47.2	12.3	17.5

a) Shops and guest houses

### **5.9 Financial performance**

For any electricity supplier, it is obvious that the revenues need to cover the costs if the activity shall sustain. UECCO has two types of incomes. On the one hand shares, membership fees, and connection fees, and on the other hand the charges for delivered electricity. Although the shares and fees contribute to cover some initial costs when new consumers join the Cooperative, the resulting cashflow is small in comparison to the operating costs and the revenues from electricity sales. Table 6 is based on UECCO's own bookkeeping and shows how collected revenue and outstanding claims have developed since June 1994.

**Table 6. Collected revenue and outstanding claims (TAS)**

Period	Collected revenue	Outstanding claims accumulated
<b>1994</b>		
June-Dec	3,244 281	
<b>1995</b>		
Jan-June	2, 865,523	25,500
July-Dec	1, 813,300	31,000
<b>1996</b>		
Jan-June	4, 472,350	106,690
July-Dec	6, 689,850	183,500
<b>1997</b>		
Jan-June	6,381,336	382,420

According to the UECCO bookkeeping the dominating operating expenses are fuel, lubricants and salaries. The specific generation cost has increased from about 0.24 to about 0.33 USD/kWh. Increasing costs for fuel explains the increase in specific generation cost.

Operating expenses have exceeded operating revenue during each period of the three years except the latest period reported Jan-Jun 1997. The main reason for this is that consumers on flat rate have consumed more energy than they have been paying for. The monthly operating loss for each of the first two periods shown in table 6, when all consumers were on flat rate, was about 330 000 TAS (530 USD, July 1997). After most consumers were equipped with meters, the monthly loss dropped to about 50 000 TAS in 1996 and turned into a monthly profit of about 90 000 TAS in 1997. The actual profit is less however since the costs shown in UECCO's bookkeeping do not include an adequate allocation for maintenance costs and capital accumulation. In order for UECCO to accumulate 30% of monthly capital costs, their costs must be reduced or their revenues increased by about 360 USD per month. Full recovery of the

capital costs with the present cost level and tariff requires that the consumption be increased by a factor of four.

It was evident already during the SEI/TANESCO mission in December 1994 that UECCO was fighting serious liquidity problems. It was therefore agreed between SEI, TANESCO and UECCO that meters should be installed and the consumers charged per consumed energy unit. The tariff would be designed as to cover the operating cost plus a reasonable share of the capital costs. In order for UECCO to maintain sufficient liquidity, UECCO was given a loan of 8500 USD by SEI to be disbursed in instalments.

It would be interesting to compare UECCO's finances with TANESCO's, and also to some extent with local organisations for rural power supply in other countries. Unfortunately however, there are obvious difficulties to determine the total cost for power generation and distribution in the TANESCO isolated diesel branches. One difficulty is that costs are not always recorded separately for the respective stations but are often combined on a regional level. It was nevertheless concluded in the recent evaluation of rural electrification in Tanzania that all the diesel supplied branches were deficit making. This is a consequence of fuel costs being about three times higher than the average sale price for one kWh.<sup>9</sup>

If TANESCO's isolated branches cover less than 30% of its costs with revenues, UECCO's financial performance is better than TANESCO's. UECCO in 1997 covers close to 75% of its costs, inclusive of maintenance and full capital costs, with revenues.

Compared to UECCO, local organisations for management of power supply in Bolivia, India and Nepal use significantly lower tariffs. For domestic consumers, the price per kWh ranges between USD 0.03 and 0.26 in these organisations, whereas UECCO's tariff is USD 0.56/kWh presently and for all consumer categories. The reason for the difference is mainly the high cost for maintaining and running diesel-generating sets. In Bolivia, India and Nepal, the tariffs in the lower end of the interval apply to systems where tariffs are either subsidised by urban consumers or where low cost mini- or micro hydro power plants with low operating costs have been implemented<sup>10</sup>.

Regarding costs for operation, management and administration (OMA), a comparison with organisations in Bolivia and Nepal is possible. It appears that UECCO's OMA-costs are within the range of the other organisations'. Comparisons of OMA-costs are however obviously difficult, first because different technologies are used for supply and secondly because maintenance may be more or less adequate. It is for example clear that the maintenance level in Urambo has been too low and the same accounts for some of the international examples.

---

<sup>9</sup> Kjellström, B., et al, 1992.

<sup>10</sup> SCECO appears an exception with high capital costs and yet low tariffs. See table 2-1.

### ***5.10 Demand side management***

Demand side management in Urambo has been of interest for financial reasons and technical reasons. Reduction of the consumer loads was obviously important when it became apparent that with the flat rate, the consumers were using more electricity than they were paying for. The technical reasons for demand side management are, first to avoid overloading and tripping because the connected consumers consume more than one generator set can cope with, secondly because reducing the load of the present consumers would make it possible to connect additional consumers without expansion of the generating capacity. Measures to manage the demand for electricity have included:

- An information campaign requesting the consumers to restrict their electricity use during the time fixed monthly rates were still applied.
- The installation and evaluation of compact fluorescent lights (CFLs) in Urambo.

Impacts from the information campaign were negligible, a factor contributing to opting for meters instead of fixed monthly rates.

Conclusions regarding CFLs include that despite a number of antagonising factors, they last sufficiently long to become a cheaper alternative than incandescent bulbs. However, fluorescent tubes are even cheaper. See further section 7.

### ***5.11 Sociological observations***

Electrification of Urambo was done in 1985. The impacts of electrification as such can therefore not be established from the observations in Urambo during the period 1994-1997. The change of organisation from a community service to a cooperative may still have had some social implications because this leads to a change of quality in the service, higher costs for the electricity and required more participation from electricity consumers.

The baseline study made in June 1994<sup>11</sup> indicated in summary that the people interviewed were positive to electrification and optimistic about the ability of the village to operate and manage an electrification cooperative. At that time there was however disappointment regarding the quality of services and a general feeling that although being an electricity consumer and likewise a member of the cooperative one did not have good insight in the Cooperative's activities.

Since then, the service has improved as well as the interaction between the Cooperative management committee and the members. The sociological follow-up study made in August 1997<sup>12</sup> was therefore focussed on issues that had been identified as particularly interesting from a general point of view namely:

- Benefits for women;
- Creation of new industrial activities and the benefits from electrification;

---

<sup>11</sup> Mvungi, A. and Sanga, A., 1995.

<sup>12</sup> Sanga, A., *New approaches to rural electrification in Tanzania: A Follow up Study of Urambo Electricity Consumers Co-operative*, University of Dar es Salaam, 1998.

- The high tariff as an obstacle to expanded use of electricity;
- Management problems in a rural electrification cooperative and possibilities to deal with these.

The main conclusions were:

A majority of the women interviewed brought up improved lighting during the evening hours as a benefit from access to electricity. In their view electric lighting renders cooking easier; enables school children to read; enhances security; and enables the performance of different household activities at night.

As regards use of electricity for industrial activities, the number of small industries was found to be increasing but none was found to use electricity for industrial activities. Therefore, no industrial activities can be claimed to be a result of the UECCO services.

Industrialists' main reasons for not opting for an UECCO membership were:

- Electricity is only available during evening time but the industrial activities take place in day-time;
- The electricity is "too weak" for industrial loads;
- Use of own generator sets is cheaper if the generator set has already been purchased.

Small industries using their own generator sets were garages (using electricity for instance for welding), sawmills and grain mills.

The follow-up study as well as other observations made in Urambo during visits made during 1997, clearly show that the high tariff (350 TAS/kWh) is significantly limiting the electricity use.

Still in 1997, some members brought up the issue of not being properly involved in the decision-making processes of the Cooperative. This again underlines the importance of arranging members meetings and ensuring information dissemination in general.

## **6. Dissemination of experiences**

Information regarding progress of the project has subsequently been given to SIDA. In addition, articles have on a few occasions been published in the SEI EE&D newsletter. The most important dissemination activity in Tanzania has been the seminar held in Tabora in June 1996. There were 25 participants. A representative from MWEM was present, as well as representatives from Kasulu and Kibondo villages in Kigoma region. Recently, TANESCO and SEI have also published a simple newsletter. The newsletter is meant to be a forum for electrification cooperatives to discuss their activities and experiences.

## **7. Alternative technologies**

### ***7.1 Need for new technologies in rural electrification***

Rural electrification in Tanzania has traditionally almost exclusively been in the form of grid extension or commissioning of off-grid diesel power plants. In a few cases a local mini-hydro power plant has been the most feasible option. For any energy supply system, it is of course desirable that costs for generating and delivering energy are kept at a minimum. It is quite likely that for many of the present energy requirements in Tanzania, new technologies could help decrease the energy services cost. Also, new technologies and especially technologies harnessing renewable energy resources are potentially better options from the national point of view because they lessen the Tanzanian dependence on imported fossil fuels. Further, seen in a global perspective, if the expanding energy demand in developing countries can be met without equally much increasing fossil fuel consumption it helps mitigate the green house gas effect. For Urambo, two new technologies have been evaluated, energy efficient lamps and solar panels.

### ***7.2 Energy efficient lamps***

Energy efficient lamps, Compact Fluorescent Lamps, CFLs, consume less energy per lumen output than incandescent bulbs do. On average, about 25% of the energy are required for the same lumen output. On the other hand, CFLs are more expensive than incandescent bulbs.

In Urambo, and with the present tariff, if a CFL lasts for more than 673 hours it becomes a cheaper option for the consumer than the incandescent bulb. However, some types of CFLs give rise to more distribution losses in the system. Therefore, extensive use of CFLs in the Urambo distribution system may require the tariff to be increased with up to 30%. With this higher tariff, the CFL must last for at least 720 hours to become a cheaper option for the consumer. Experience from Urambo shows that only 4% of 86 installed CFLs had failed before 750 hours. It can be concluded therefore that CFLs are cheaper to use than incandescent bulbs.

Fluorescent tubes have likewise lower energy requirement per lumen output than incandescent bulbs. Fluorescent tubes as well give rise to more losses than incandescent bulbs. In much, the fluorescent tube and the CFL have common load features. It is speculated that the CFL is more convenient to use than the fluorescent tube because it requires only one lamp holder, but there are no studies carried out in Urambo to confirm it. What is clear though, is that from a financial point of view, the fluorescent tube needs only to last for 153 hours or, with a 30% increased tariff, for 235 hours to be cheaper than the incandescent bulb. Producers estimate the lifetime of a fluorescent tube to be 6000 hours.

From the comparison between different lamps to be used in Urambo it can therefore be concluded that unless there are convenience arguments speaking for the CFL, the fluorescent tube is preferable over the CFL. Both CFLs and fluorescent tubes are however preferable over the incandescent bulb.

### *7.3 Individual PV-sets as an option to traditional electricity supply*

Because lighting is clearly the dominating load at present in Urambo, it is justified to evaluate the option of each and every consumer having its own photovoltaic power supply system. It is important in this comparison to remember that only the lighting load is considered. While it is truly a large part of the present load, many electricity consumers in Urambo today have also invested in equipment that require 220 V AC supply. Further there are potential consumers in the village with appliances requiring three-phase 380 V AC supply. The individual PV-set option therefore limits the possibilities for expanded electricity uses in Urambo much more than the traditional option does.

From a financial point of view, and if considering the light requirements only, the only case in which the individual PV-system is more attractive than fluorescent tubes in a diesel supplied system is when less than half the capacity is utilised in the traditional system. The same accounts for CFLs in a traditional system.

With a tax-exemption for PV-sets, and assuming that the installed capacity is fully utilised in the traditional system, the PV lighting option becomes cheaper than incandescent bulbs in a traditional diesel supplied system, but not than fluorescent tubes or CFLs powered by a diesel genset.

It happens that PV-equipment retailers add up to 40% to net-import prices<sup>13</sup>. In such cases, even incandescent bulbs in traditional diesel supplied systems are financially more beneficial than individual PV-sets for lighting consumers in villages like Urambo.

Most consumers living within reach of the present distribution net work in Urambo are therefore not recommended to opt for individual PV-sets. Exceptions from the rule may be if there are loads that require exceptionally high reliability in power supply, like vaccine storages or similar. For consumers living beyond reach of the present distribution net work, individual PV-sets or PV-lanterns are likely to provide cheaper, cleaner, and brighter lighting than their present luminaries, which are often kerosene lamps or other flame-based equipment.

For electricity consumers for which the PV option is the presently most beneficial for financial reasons, it remains a fact that individual PV-sets are often better replaced with a traditional system at some point. This is true for example for those living in a village where industrial activities are developing. The point in time at which the PV-option becomes more expensive may occur before the full lifetime of the PV-equipment is utilised, and the PV-system then becomes a financial burden to these consumers. A mechanism that facilitates the introduction of the environmentally less hazardous PV-option, is therefore an established second hand market.

---

<sup>13</sup> SADCC Energy sector, *Study on NRSE Pricing in the SADCC Region*, May 1992. Annex 2.

## **8. Future plans**

At a rural electrification seminar held in Tabora in 1996 the chairman of UECCO presented the future plans of UECCO's. They are anticipatory in nature until UECCO operates well and is profit making.

Overall planning objectives are based on the local consumer preferences and the wellbeing of the local community. The broad objectives of the electrification plans are therefore:

- ◆ to meet future community needs, including to address the financial and economic viability of the community;
- ◆ to enable UECCO to operate on a financially sound basis, and;
- ◆ to meet the welfare needs of the society by enabling the provision of basic needs, e.g. water pumping, medical care, education etc.

### Short term plans (within two years):

- ◆ to liaise with TANESCO-Tabora to acquire a plot for future main substation for a high tension line from Tabora (80 km);
- ◆ to complete the ongoing distribution line extension work;
- ◆ to connect the Teachers Training College;
- ◆ to rehabilitate and strengthen the network;
- ◆ to carry out strategic connection of new consumers including proper meters. (The aim for January 2000 is to have 200 consumers connected.)
- ◆ to train plant operators and network crew as well as recruit an accounts clerk;
- ◆ to acquire more office furniture;
- ◆ to review the tariff regularly so that the true cost of providing the services is reflected.

### Medium term plans (2-5 years):

- ◆ to connect to the national grid;
- ◆ to maintain the generating sets as standby capacity and/or for expansion into Urambo's satellite villages;
- ◆ to erect high tension lines to four more areas;
- ◆ to erect distribution transformers in the new areas.

## **9. Conclusions and recommendations for future activities**

### ***9.1 Lessons learned and main conclusions***

The attempts to introduce locally managed power supply in Tanzania have generally been received very well, among decision makers, villagers in Urambo's surroundings, as well as in other regions in the country.

In essence, the by-laws formulated for Urambo seem to have been adequate.

The contribution and support from the TANESCO-regional office in Tabora (closest regional office) have been instrumental in the success.

Rehabilitating old generator sets has been a mistake. It has been both costly and time consuming. The initial estimates of rehabilitation costs made by TANESCO were grossly optimistic. During the process of rehabilitation, additional needs for spare parts arose that almost doubled the rehabilitation cost

Training provided to the Cooperative through TANESCO head quarters and TANESCO-Tabora in cooperation has been essential for the activities in UECCO. An experience is though that there is a tendency that trained people get employed elsewhere in the country, and therefore budgets for training must cover some 'losses'.

Metering seems to be necessary for a cooperative of UECCOs size and consumer category mix. Flat rate tariffs without actually having cut-out fuses installed did definitely not work. By far revenues did not cover the actual costs for delivering the services.

Bookkeeping has not been adequate. No annual reports including balance sheets have been prepared, but the entering has been done chronologically only. By-laws state that balance sheets shall be presented to the members annually - this has not been the case.

Members meetings in general, and annual meetings in particular have been neglected by the cooperative development committee for long periods. This also shows that the by-laws have not been followed.

UECCO charges 0.56 USD per kWh (March 1997). When all consumers would be metered, and if the amount of electricity sold increases from the present 5000 kWh/month to about 9000 kWh/month, UECCO will most certainly be covering its running costs plus recovering 30% of the capital costs. (UECCO has no real capital costs since the equipment has been paid by TANESCO and SIDA, but the 30% recovery is estimated to be appropriate as a fund for future reinvestments).

The present load is dominated by lighting. Enhanced lighting has provided different members of the households the possibility to use the night hours more efficiently.

No industrialisation can be attributed to the cooperatives electricity services. Electricity is provided during five hours per night at date. There may be potential users (handicraft and mechanical shops, etc.) during daytime, but that is only speculation.

### ***9.2 Recommendations for future activities***

The UECCO shall preferably be closely monitored for another two years (1998 and 1999). There is however no reason to wait longer with the initiation of additional pilot projects.

Parallel to launching and monitoring other pilot projects, we see it as crucial to establish a national organisation that can provide support to these and following local management initiatives. We call it ABRECO, Advisory Board for Rural Electrification Cooperatives. It could be a group of people from TANESCO rural

electrification department, representatives from the university and from some domestic bank. ABRECO shall have sufficient authority to plan, channel funds to and implement rural electrification projects with local management structures.

We recommend that ABRECO formulate conditions for initiatives to be supported. The conditions shall serve to ensure that projects become sustainable in general and financially viable in particular. ABRECO should also guide that projects develop along the lines of national plans for development. There could for example be requirements that a certain degree of social responsibility is taken by the local management organisation.

A gradual shift of responsibilities from TANESCO/SEI to ABRECO during the pilot projects would allow for a natural growth of ABRECO from two or three people to perhaps ten to fifteen.

ABRECO is then the key organisation to which capacity building activities shall be addressed in Tanzania and regarding rural electrification. They need for example have insight in experiences from abroad regarding policies and financial schemes, and knowledge regarding technical options such as new and renewable energy technologies.



FIGURES AND PHOTOGRAPHS

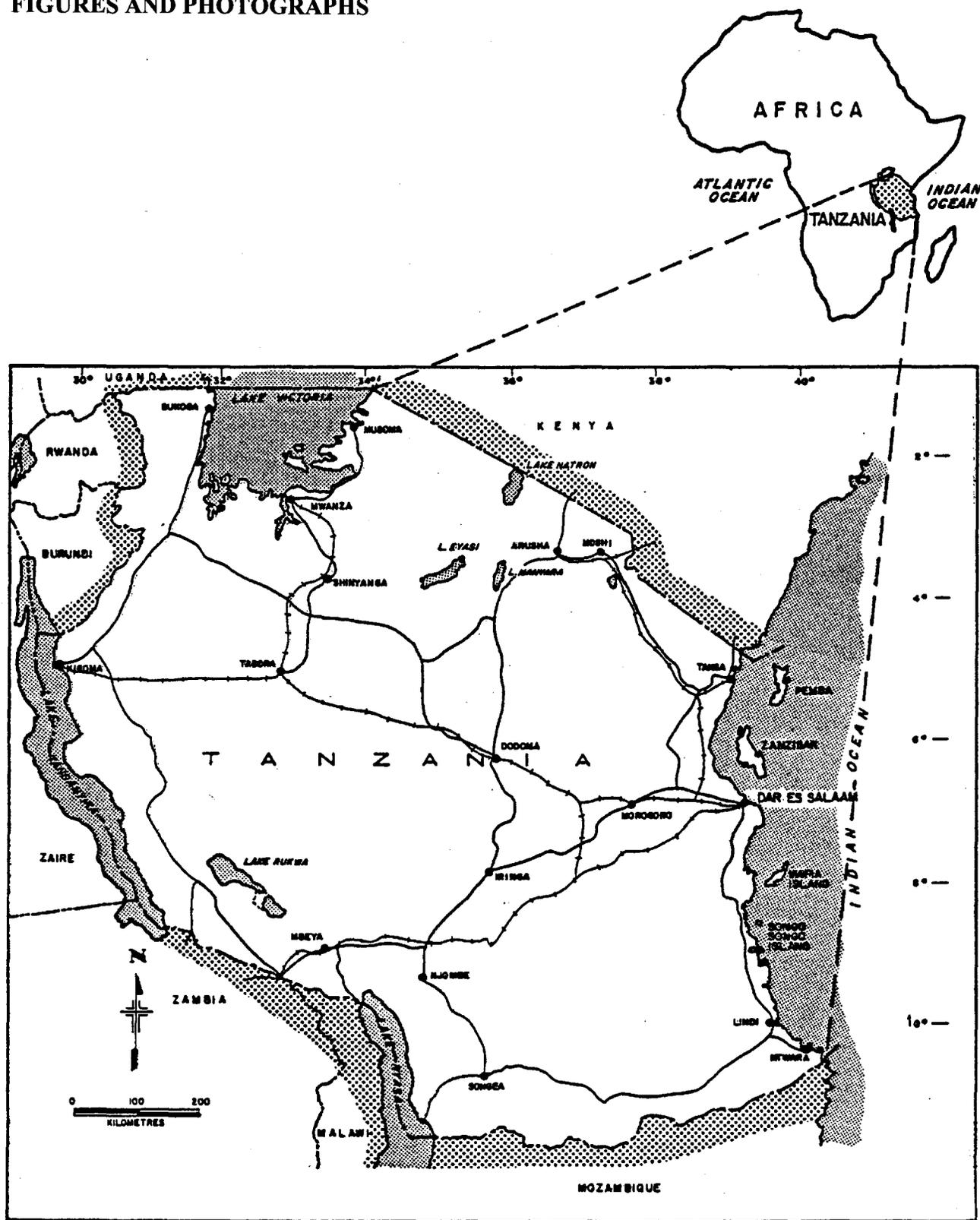
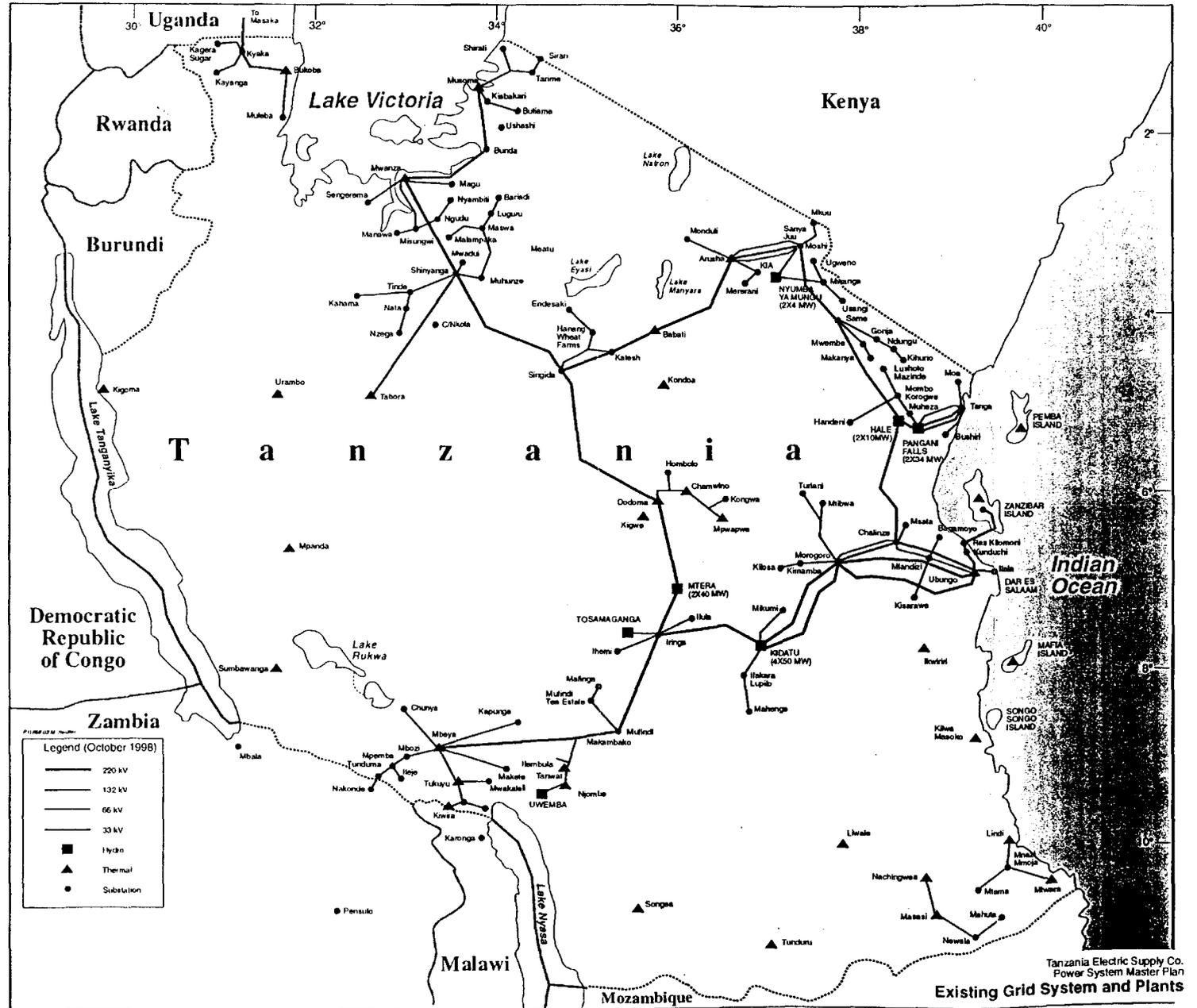


Figure 1. Map of Tanzania.

Figure 2. National Electricity grid and Tanesco's isolated branches.



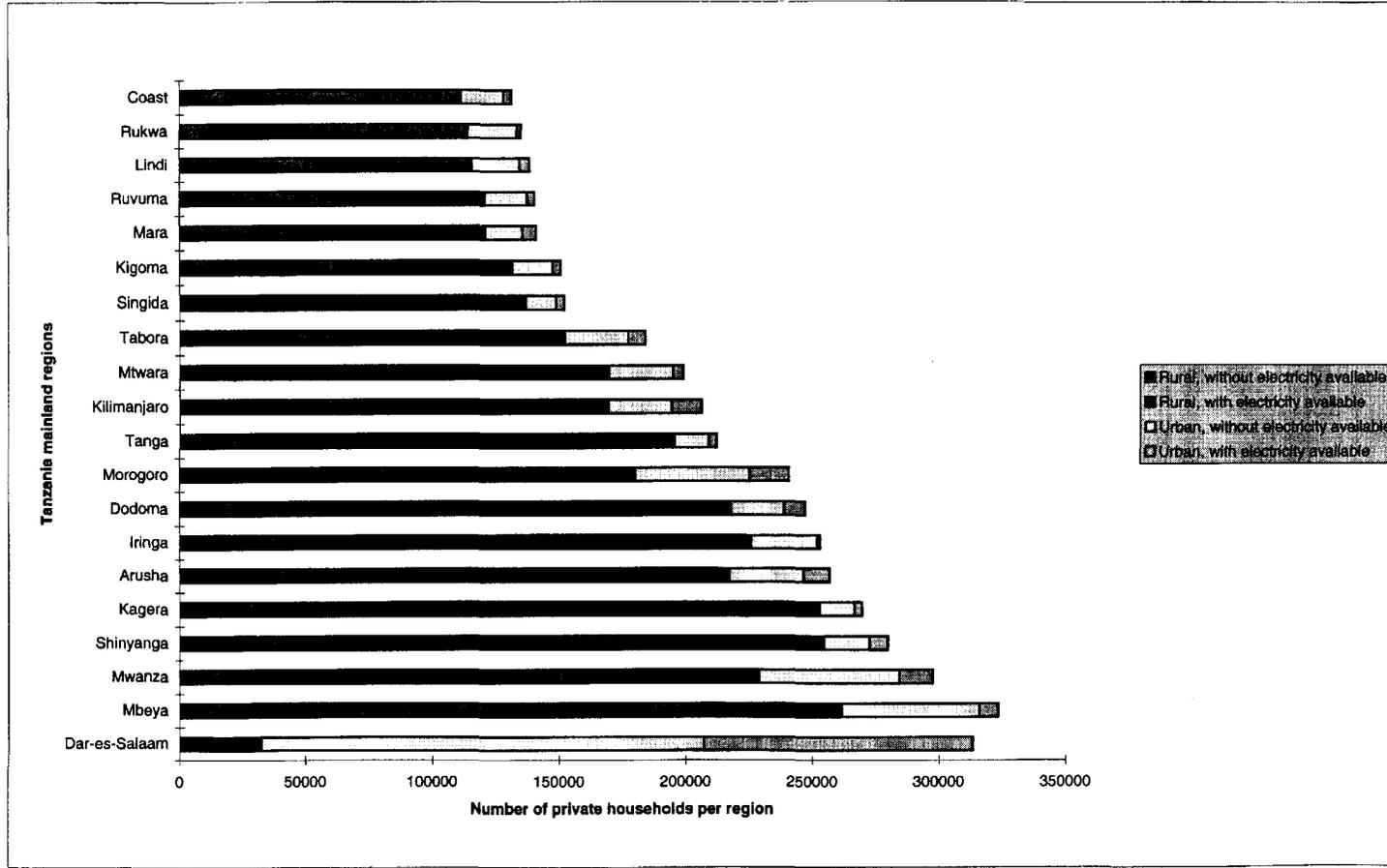


Figure 3. Households availability of electricity on regional basis.

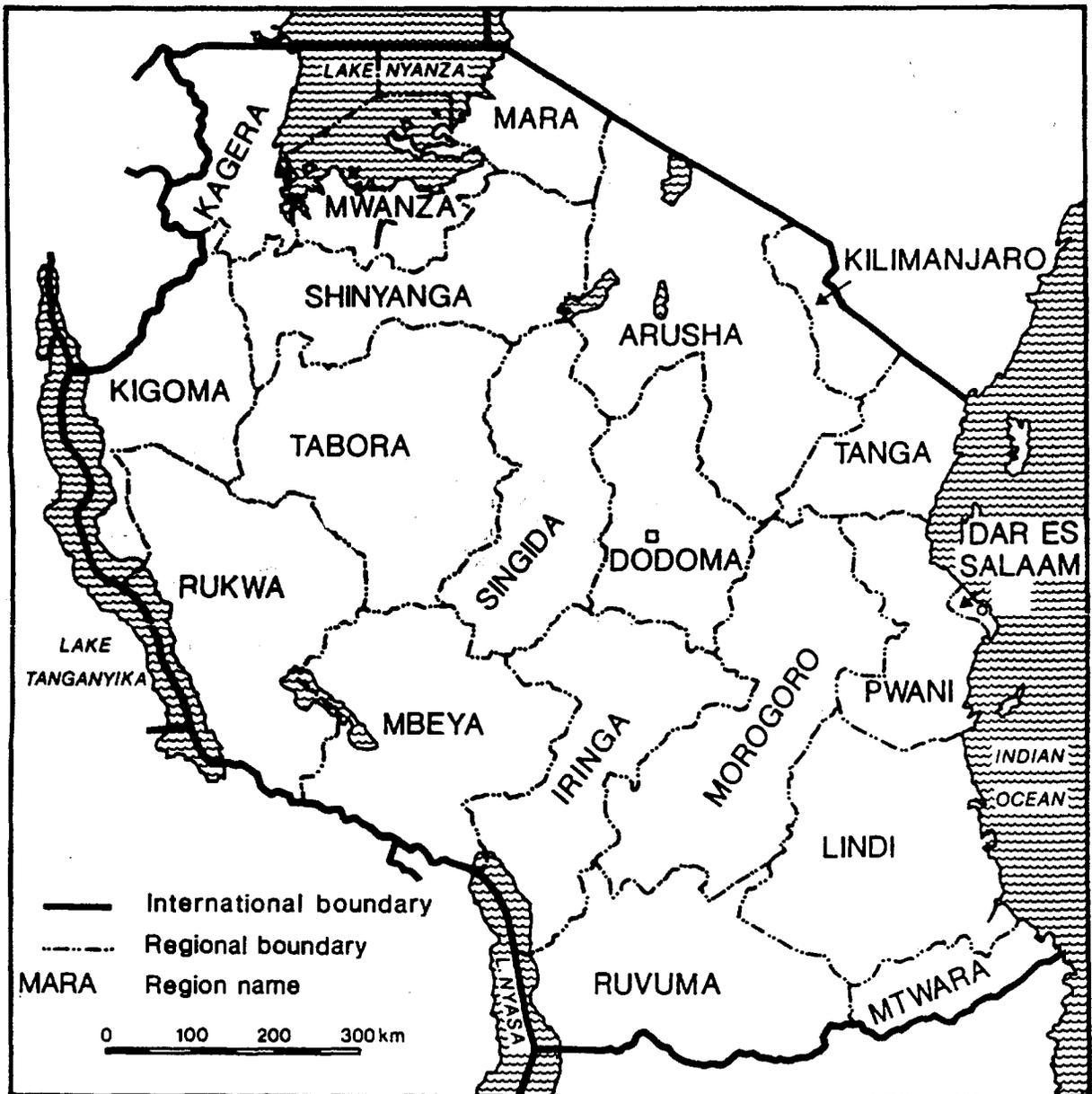


Figure 3b. Tanzania mainland regions.

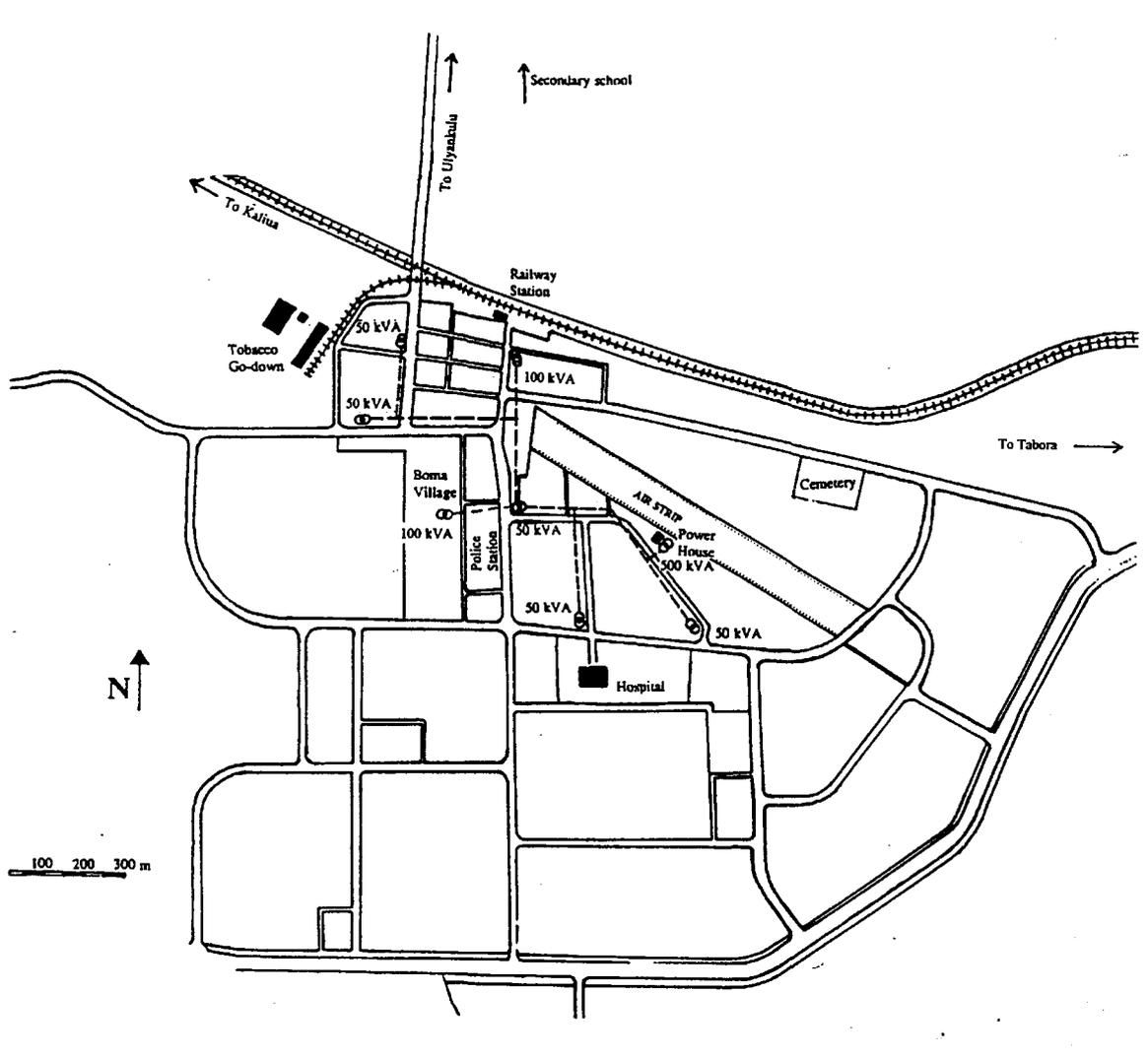


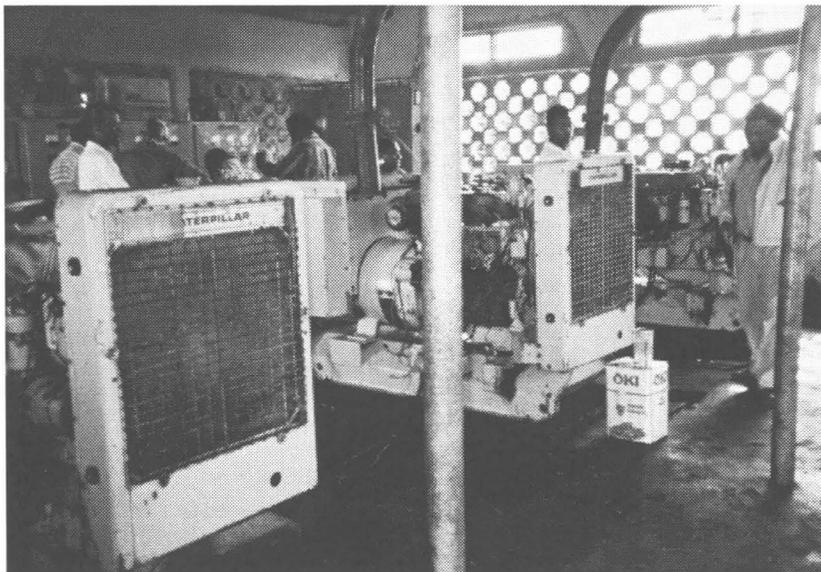
Figure 4. Map of Urambo village with 11kV distribution system.



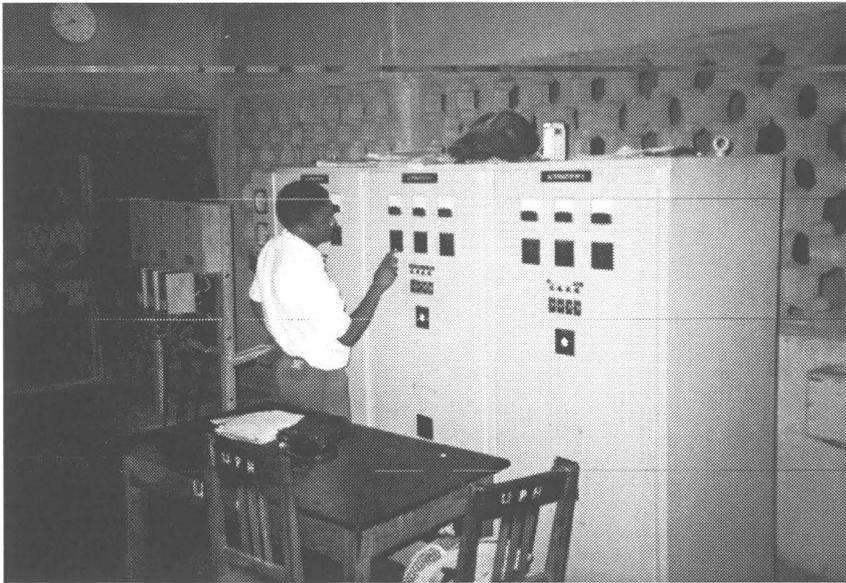
The co-operative development committee gathered outside UECCO's office.



The power house in Urambo.



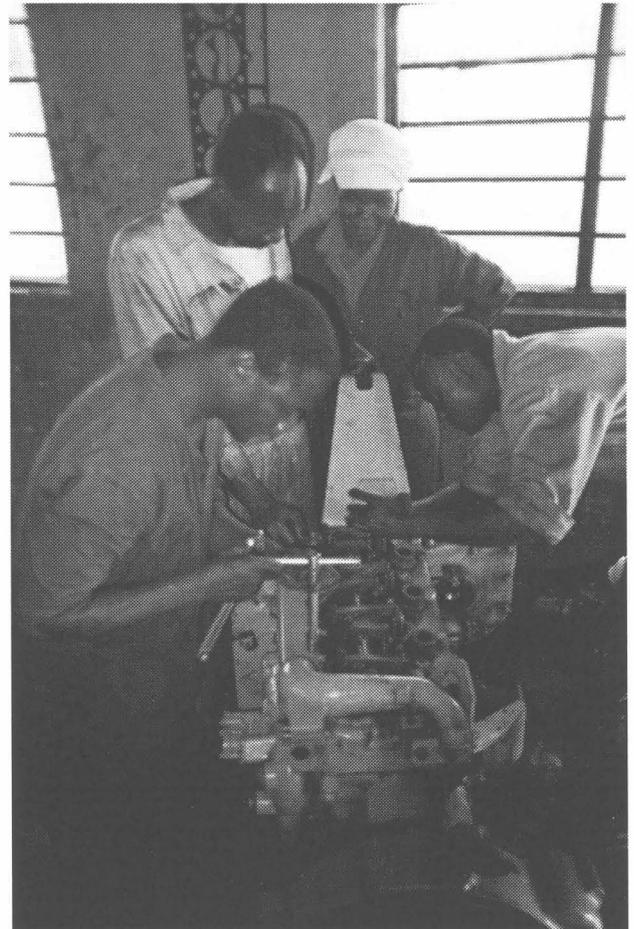
Interior of the power house showing the three generator sets.



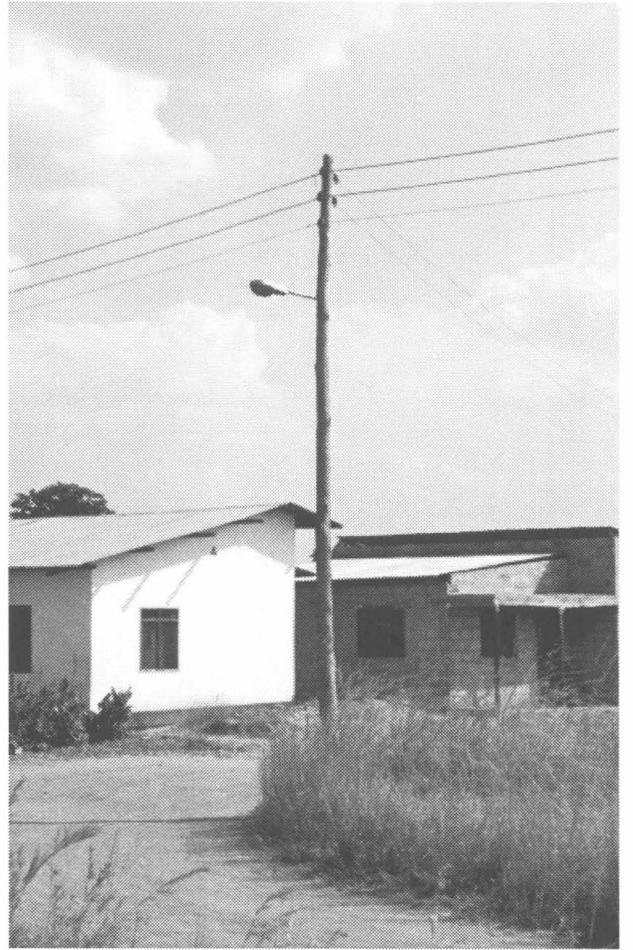
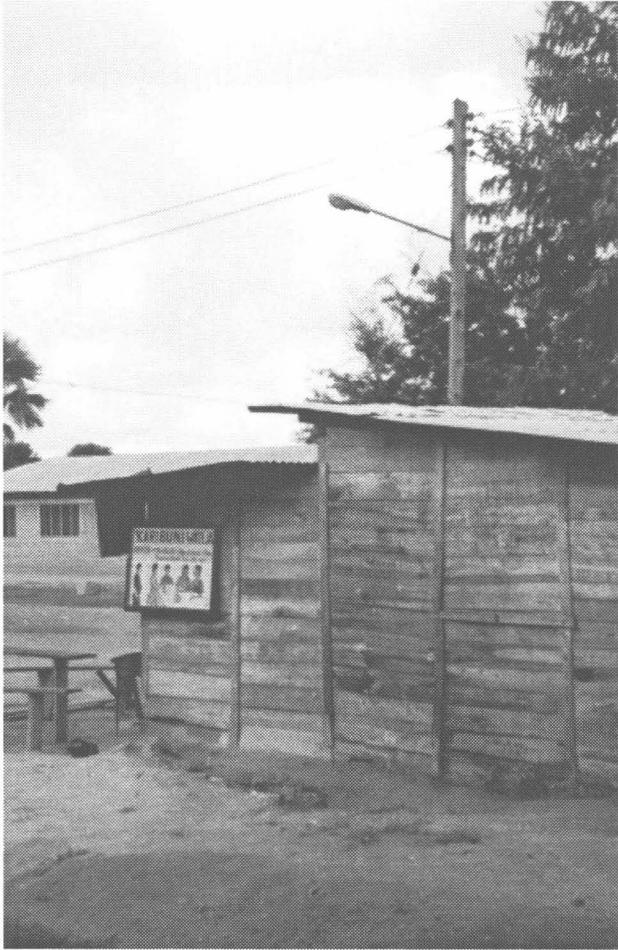
**Controlpanel in the power house.**



**Extension of the distribution system in Urambo.**



**Rehabilitation work on the engine of one of the generators.**



Typical street lights and buildings in Urambo.

# 1. INTRODUCTION

## 1.1 Background

Since independence, rural electrification has been an important part of the national development program in Tanzania. The parastatal utility, Tanzania Electric Supply Company Ltd., TANESCO, has been responsible for the entire electrification program, including rural electrification. Funding has been channelled through the Government of Tanzania. International donors have covered the major part of the investments.

The rural electrification program has so far resulted in electrification of 37 rural towns and 14 villages. Along with the economic problems in Tanzania in the 1980s the rural electrification program stagnated however. About 30 rural townships and a large number of villages remain to be electrified. It has been estimated that less than 1% of the rural households in Tanzania have access to electricity.

Fig. 3 illustrates the availability of electricity in Tanzanian households on a regional basis.

As part of the research cooperation between TANESCO and the Stockholm Environment Institute, SEI, an extensive evaluation of the experiences from the rural electrification program in Tanzania was carried out in 1989 - 1991<sup>1</sup>. The four main conclusions from this evaluation were:

- The rural people, including those who are not yet connected to the service appreciate electrification.
- Rural electrification is a large financial burden on TANESCO. This is particularly pronounced for the isolated diesel supplied areas. In view of this situation, TANESCO will not be able to pursue the rural electrification program sustainably unless either the tariffs are dramatically increased or financial support is provided from the government.
- The quality of the service, in particular the supply reliability, is low in rural areas. This can be explained partly by difficulties with spare parts supply and weaknesses in TANESCO's organisation. The main reason is probably that TANESCO cannot afford to maintain a reliable service.
- Many of the perceived benefits of rural electrification which have been used to justify a high economic value, like promotion of small industries and reduced demand for woodfuel as a cooking fuel have not materialised to a significant degree.

As a result of this evaluation it was recommended to try a new approach to rural electrification in Tanzania, based on local management of supply and distribution and with TANESCO's role limited to bulk supply of electricity and technical support.

---

<sup>1</sup> Kjellström B. et al., 1992.

Since this is a new concept in Tanzania, TANESCO agreed to carry out a few pilot projects to collect experiences from this approach as part of the research co-operation between TANESCO and SEI. This report summarises the progress of these activities until mid 1997, which include a number of feasibility studies and implementation of the first pilot project in Urambo village, Tabora region.

## **1.2 Energy use and supply in Tanzania**

General information about Tanzania as regards demography, economics and energy can be found in appendix A.

Tanzania, with a GNP per capita in 1997 of 210 USD, is considered among the poorest countries in the world. Close to 85% of the population live in rural areas and agriculture is the main economic activity.<sup>2</sup> The infrastructure in terms of transport capacity, energy supply, water supply, sanitation and telecommunication is weak in many rural areas which is a serious obstacle for development.

The country's 1996 total primary energy consumption was 12.5 million tons of oil equivalents (toe) which translate into about 0.4 toe per capita. Of the energy consumed, 95% was combustible renewables and waste, 4% petroleum products and 1% electricity. The contribution from coal was negligible. The final energy consumption by sector was distributed as 79% in households, 12% in industry and 2% for transportation. Other end user categories include the agriculture and service sectors.<sup>3</sup>

In 1996, a total of 477,000 tons of oil and 4,000 tons of coal were consumed. Tanzania's per capita commercial energy consumption was 0.02 toe which is below average for Sub-Saharan Africa. Of the commercial energy consumption in 1996 77% was petroleum products, 22% electricity and 1% coal. Of the commercial energy 45% was used for transportation, 25% for the industry and 14% in the households.

Woodfuel is the dominating energy source, used primarily as cooking fuel but also to some extent as a fuel for industrial activities. All petroleum fuels are imported which is a heavy burden on the national economy. However, fuel oil imports as a percentage of export earnings drastically declined to about 26% in 1997 (from 50% in the seventies to eighties).<sup>4</sup> Availability of petroleum fuels in the rural areas was at times unreliable before 1990. In the recent years, it appears that this has not been a problem.

The national electric grid system connects the main urban areas and is supplied mainly by hydropower (391 MW) with thermal power supplements (148 MW). There are 22 isolated systems operated by TANESCO. Together they have a generating capacity of 23 MW. Most of these are supplied with diesel power plants with capacities from 100 kW to 4.5 MW. Fig. 2 shows a map of Tanzania with its national grid and TANESCO's isolated systems. See also appendix A, table A-2.

In some of the areas that have not been electrified by TANESCO, private electricity generation is practised by industries, by institutions like hospitals, schools, and mission stations and by the most affluent individuals. Some agro-based industries like

<sup>2</sup> UNDP 1999, *Human Development Report 1999*.

<sup>3</sup> OECD 1998, *Energy Statistics & Balances of Non-OECD Countries 1995 - 1996*.

<sup>4</sup> Bank of Tanzania, *Economic Bulletin for the Quarter Ended 31st December 1998*.

sugar mills use biomass residues as fuel for power generation and some mission stations use mini-hydro power plants. Photovoltaic power generation is utilised for electric lighting to some extent, but small diesel gen-sets appear to dominate for small-scale electricity generation.

### 1.3 The electricity policy of Tanzania<sup>5</sup>

The energy policy of Tanzania is briefly summarised in appendix A. The general objectives as expressed there apply also for the electricity sector. Thus, priority is given to developing and utilising the indigenous energy resources, to arrest woodfuel depletion and to conduct sound and stable energy pricing. A continued human resource development is also aimed for.

More precisely, in the electricity sector, *'the policy with regard to electricity generation is to continue putting emphasis on the exploitation of the ample hydropower resources. In addition, extension of the transmission lines and the expansion of the distribution network will be undertaken in order to bring more load centres into the interconnected largely, hydro-based grid'* (clause 61). An objective is *'...to bring hydroelectricity to large load centres formerly supplied with thermal electricity such as Iringa, Mbeya, Dodoma, Shinyanga, Mwanza, Tabora and Musoma'* (clause 62).

Apart from hydroelectric power, utilisation of natural gas has been seriously considered<sup>6</sup>.

In the policy, it is clearly stated that TANESCO will have a central role in planning the activities in the national grid (clause 65). However, although TANESCO has for a long time in principle been the sole actor, also the power sector is influenced by the market economy oriented policies developing in the country: *'Electricity development embraces the development of production, transmission, distribution, and end-use infrastructure. The development of institutions to perform this task requires an assessment of how effectively these institutions can perform the various tasks in the system from production to end-use'* (clause 169).

*'...In respect of power production, therefore, the question is not whether or not TANESCO has a statutory monopoly to develop major hydropower or thermal based schemes, but whether or not the goals of the energy policy on electricity development can be achieved by the virtual monopoly of TANESCO or through the separation of the generation function from the transmission and distribution of electricity. There will be an electricity board for power policy and planning and below it there will be two separate organisations, one responsible for generation and transmission and the other responsible for distribution and customer services'* (clause 170).

On July the 16th in 1992, the Minister of Energy officially announced the intended privatisation of production and distribution of electricity<sup>7</sup>. This is also reflected in the

---

<sup>5</sup> This chapter is based on: Ministry of Water, Energy and Minerals (MWEM), 1992. *The Energy Policy of Tanzania*.

<sup>6</sup> (Please see appendix A for an overview of existing resources.) *'...Construction of a pipeline from Songo Songo to Dar es Salaam, the distribution network, conversion of industries to gas and development of gas power station will be implemented as soon as possible. In addition, the utilisation of the Mnazi Bay gas for onsite electricity generation should be expedited'* (clause 64).

policy document (clause 170), where it is stated that '*...the Government has given a mandate to other organisations to exploit the hydropower resources and to install thermal-based generation....*' This change in policy is important and a prerequisite for any local organisation for power supply to exist and be autonomous. TANESCO will remain the main actor for development of the transmission system.

TANESCO is also requested to improve its relationship with the consumers:

*'Expansion of the transmission network will be TANESCO's focus in the near and medium term. However, the costly investment in the grid system can only be beneficial if a larger percentage of the population has access to electricity. Expansion of the distribution networks will be an important aspect of institutional reorganisation of the company. Furthermore, in order to reach a larger part of the population, TANESCO will be required to develop stronger supplier-customer relationships than is existing now. TANESCO will be required to develop customer advisory services to reach out to the consumer and follow on the customer end-use patterns including appliances and their development and offer expanded end-use advisory services'* (clause 172).

*'... Where electricity is available in the rural areas, deliberate efforts will be made to disseminate and popularise simple electric stoves and other electric appliances for income generation and social welfare improvement'* (clause 156).

Regarding rural electrification, the policy in much remains consistent with that of recent years. In line with former objectives: *'Since all regional headquarters have been electrified, efforts will be focused on the electrification of all district headquarters by the year 2005. In this regard, first priority will be given to districts and areas with agro-based industries and other community productive power needs, which are within an economic break-even distance from the interconnected grid in order to use relatively cheaper hydropower. Second priority will be given to districts and areas with agro-based industries and other community productive power needs but which are outside the economic break-even distance from the grid'* (clause 67). *'For districts where it is uneconomic to obtain electricity from the grid, alternative electric power sources will be sought. In considering the alternative sources preference will be given to the exploitation of micro- and mini-hydro sites'* (clause 68).

In order to finance rural electrification where it is not financially viable the Government will create a fund: *'...A surcharge on tariffs will be used to raise revenue from electricity consumers for this fund. Furthermore, considering the linkage between the petroleum sector and woodfuel use, TPDC (Tanzania Petroleum Development Corporation) will contribute a certain percentage of its gross profit to the Rural Electrification Fund. Duties and taxes add to the cost of rural electrification. The Government will waive these duties and taxes for furtherance of rural electrification programmes'* (clause 69).

The rural electrification policy further includes statements that encourage a departure from the earlier course of action and have direct implications for local initiatives to rural electrification. *'For forests and agro-processing industries considered*

---

<sup>7</sup> African Research Bulletin, July 16th-August 15th 1992, pg.10933.

*uneconomic to be supplied with electricity from the grid, alternative power sources will be sought. Among the alternative options to be given priority is the production of electricity by these industries through combustion or gasification of their own wastes. Possibilities of synchronising such power plants to the national power grid will be looked into' (clause 70).*

Concerning village electrification, the ministry is even more direct in its intended involvement of local capacities: *'In order to accelerate the pace of rural electrification and reducing the costs of implementing the schemes, self-reliance will play a key role. In this context communities will be requested to contribute by way of waiving compensation due to farmers and property owners along the transmission line routes and substation plants; and whenever possible providing labour in assisting the implementation. The resulting savings from this waiver that can be as high as 30% of the total local cost component will reduce the implementation costs for the projects. Furthermore communities will be mobilised to organise themselves into construction brigades and assist in trace clearing and digging of holes at nominal fees. In addition, communities will be required to provide partial finances towards meeting financial costs of these projects. Significant savings in costs will be realised compared to conventional ways of electricity supply' (clause 71).*

Energy pricing policies is brought up in a special chapter, where some general objectives about electricity tariffs are given. TANESCO uses a pan-territorial tariff, which means that local generation and distribution costs have no impact on the tariff paid by the consumers. The tariff is set by TANESCO and has to be approved by the Government. It is stated in the policy that electricity tariffs will continue to be pan-territorial (clause 126). Historically, the policy has been to keep the tariff as low as possible, unfortunately to the extent that this has made it impossible for TANESCO to recover capital costs and even caused difficulties for TANESCO to meet the costs of maintaining the power plants and transmission/distribution system. In the recent years the tariffs have been allowed to increase. In the present policy document, it is especially stated that *'...Pricing will reflect the need for the sector to contribute significantly to its own future development, including a contribution to rural electrification, development of its own internal capacity for research, development and production of essential requirements' (clause 127).* The tariffs valid in July 1993 and November 1997 are shown in appendix B.

Continued cross subsidising of electricity tariffs is further an aim (clause 128). For small domestic, commercial and industrial consumers, the tariff is progressive, so that those who have a small consumption pay less per electric energy unit (kWh) than those using more electricity do. In particular small domestic and commercial consumers are being subsidised by the larger industrial consumers. One consequence of the tariff structure is that rural electrification projects whereby both capital costs and operating costs are high per unit delivered and at the same time the consumption is dominated by small domestic and commercial consumers, with a low tariff, cannot be expected to be financially viable for TANESCO.

However, in the section on "Electricity development", in the policy document a policy statement that correlates more directly to tariff setting in self-reliant systems is made: *'Where TANESCO has not established a public power supply system private electricity generation and distribution will be encouraged. The tariffs applicable to*

*such schemes will be reviewed by the government. TANESCO will be required to purchase excess electricity from private power supplies and co-generation at mutually agreed prices' (clause 171). It is herewith implied that exceptions from the rule can be made and tariffs can be set as to cover actual costs in self-reliant systems.*

Tanzania's current energy policy thus includes two new fundamental principles supporting the self-management approach to rural electrification:

- 1) Private electricity generation and distribution will be encouraged where TANESCO has not established a public power supply system.
- 2) Tariffs can be set locally and differ from the pan-territorial tariff if justified.

Further, there are several statements that facilitate the development of such an approach:

- A fund will be created for financing of rural electrification.
- Private investors are allowed to operate in the power sector.
- TANESCO, still being the major actor, will co-operate with private schemes connected to the grid and purchase electricity at mutually agreed prices.
- The Government aims at supporting TANESCO's contact with the existing and potential end-users. This may be interpreted as a resource for technical and managerial support to local organisations.
- Duties and taxes, which add to the cost of rural electrification, will be waived.

Even though all the statements in the Energy Policy Document have not yet been implemented, there is no doubt that the Government of Tanzania encourages new approaches to organisation of rural electricity supply.

#### **1.4 Organisation of the project**

The project "New approaches to organisation and management of rural power supply" has been part of the "Energy, Environment and Development Program". This program has been financed by the Swedish International Development Cooperation Agency (Sida) and carried out by the Stockholm Environment Institute (SEI).

This particular project has been executed in cooperation between SEI and Tanzania Electric Supply Company (TANESCO) with Ms Monica Gullberg, M.Sc., SEI, Professor Björn Kjellström (consultant to SEI) as project co-ordinator and Mr Maneno Katyega, Chief Technical Engineer for Research and Development of TANESCO as project leader in Tanzania.

The Research Department of TANESCO carried out feasibility studies and tariff studies for the pilot sites. The studies were reviewed by SEI.

Historic information about organisation of rural electrification cooperatives in industrialised countries and more recent information from developing countries were

collected by SEI and TANESCO. On basis of this information the Legal Department of TANESCO prepared the draft by-laws for the first cooperative in Urambo.

Rehabilitation of the power plant in Urambo, improvement of the distribution system in Urambo as well as training of the power plant operators in Urambo has been the responsibility of the Regional Office of TANESCO in Tabora, which also has provided technical assistance for maintenance of the power plant and the distribution system. Assistance with spare parts supply was provided by SEI.

The Department of Sociology of the University of Dar es Salaam has been responsible for a sociological evaluation of the effects of establishing the rural electrification cooperative in Urambo.



## 2. THE CONCEPT OF LOCALLY MANAGED ELECTRICITY SUPPLY

### 2.1 Historical and international perspectives

Local management of electricity supply is nothing new. In fact local systems have in most industrialised countries existed before a nation-wide grid was established. Typically, industries pioneered using electricity for their production and loads like streetlights and domestic lights in the surroundings were subsequently added to the system. In many cases it has taken more than half a century to reach the point of an interconnected grid and a few more decades before electricity has become available to everyone. Despite the interconnection of the local supply networks to a national grid, many industrialised countries are still relying to some extent on locally managed electric utilities. Motives for such organisations to exist can for example be economic or environmental. The legal form for a local utility may be a private or public company, a cooperative, or an association.

Worldwide, the cooperative organisation is perhaps the most frequently used form for the local management of decentralised electricity systems in developing countries. Internationally, a major actor in the development of rural electric cooperatives is the *National Rural Electrification Co-operative Association* (NRECA), a US organisation funded through the *US Agency for International Aid* (USAID). In 1964, USAID approved to the world's first international loan for cooperative rural electrification (Colombia), soon to be followed by similar programmes in Nicaragua, Ecuador and Costa Rica<sup>1</sup>. Since then, NRECA has launched comparable programmes in many other countries, especially in South America and Asia.

Even if cooperatives have dominated the recent history of locally managed electrification, liberalisation trends result in private firms and shareholder companies becoming increasingly common.

Traditionally, rural electrification in developing countries has relied on grid extension or, for remote communities either on diesel generator sets or mini-hydro power, depending on the proximity to a suitable site for a hydro power plant.

The policy of many donors to promote use of renewable energy sources has resulted in a few projects where generator sets are driven by biomass gasifiers and also in several projects where electricity for lighting and operation of water pumps is provided with individual solar panels. Tied to the latter projects is often a scheme with loans to be paid to a revolving fund, which can be used for providing solar panels to additional households. Often, applying renewable energy technologies in itself brings about local management to some extent.

Local initiatives to electricity supply are prevalent in all the major third world regions of today, although in Africa the experiences are scarce. These initiatives are often a consequence of the national rural electrification programmes progressing slowly. Commonly, the local systems have direct support from foreign donors, implying that these have found local initiatives worthy to support besides the national rural electrification programme. The ample international experiences with local initiatives to rural power supply made it important to carry out an international survey early in

---

<sup>1</sup> Ross J. E., *Co-operative Rural Electrification: Case Studies of Pilot Projects in Latin America*, Praeger Publishers, 1972.

the process of initiating similar projects in Tanzania. The experiences from other countries were expected to be of direct practical use for the ongoing work in Tanzania. Also, studies of individual cases could help to highlight some policy factors that are of key importance for the organisations' wellbeing in different political environments. This aspect seems particularly important now that the Tanzanian society is transforming from socialistic to more open market oriented, where TANESCO and rural electrification will be included in the process.

Such a survey was conducted jointly by TANESCO and SEI and included visits to Bolivia, India and Nepal. The study confirmed that rural electrification with local management could be successful in developing countries, provided that the activities are properly organised and given sufficient initial support<sup>2</sup>. Four cooperatives in Bolivia, one in India and three in Nepal were visited for fact collection. Grid supply was used in five of the cooperatives. One cooperative used diesel generators and the other two small hydro power plants of 50 and 400 kW respectively. Table 2-1 gives a summary of key data for these cooperatives.

The three countries visited have different political systems and different kinds of relations to multi- and bilateral donors. Despite the diversity in conditions under which the visited utilities operate, several generic observations were made.

Local initiatives to electrification need for their success be assisted by an experienced and fairly impartial organisation. It is crucial for the sustainability of a small power-supplier that it is able to do careful and proper technical planning with respect to the specific preferences expressed by the local consumers. The assisting organisation shall thus not only be technically skilled but also concerned about the welfare of the consumers. Further, it is advisable that the assisting organisation works along the directives of the national development plan.

Financial support for implementation must be provided. This can be done either as favourable loans or as grants justified by the general rural development programme of the country. The scope in terms of funding and time frame of the external assistance may vary between different projects. A common observation from the international survey is that most locally managed power schemes require several years of external assistance.

Crucial for the smooth handling of assistance to local organisations, let it be technical, financial or managerial, is the existence of an indigenous organisation with sufficient autonomy and a mandate to implement rural electrification. It should ensure that rural electrification programmes are well designed and properly targeted. It should also assist the local enthusiasts in seeking for funds from the government or from donors, and work out training programmes for the local staff.

Appropriate training programmes are another instrumental factor highlighted in the international survey. While it is easy to see that the systems design needs to be directed by an experienced organisation, day-to-day activities appear easier for amateurs to handle. However, common for all the visited organisations is that they underline the importance of training at multiple levels during the period of

---

<sup>2</sup> Gerger Å. and Gullberg M., 1997, *Rural Power Supply with Local Management: Examples from Bolivia, India and Nepal*, SEI 1997. ISBN 91 88714 31 4

commissioning, implementation and during the first years of operation. In fact, poor management and inadequate maintenance constitute one of the two most prevalent problems identified in the survey.

The other main problem is tariff setting. A frequent governmental ambition is pan-territorial tariff. Aims in the national development plan to maintain equal tariffs counteract many local and economically self-reliant power systems.

Last but not least, it became clear from the survey that the sincere interest from the local people to help electrify their neighbourhood is crucial. There may be different approaches to mobilise the people in different societies, but there must be a tangible interest that can be captured in an official organisation with legal status. Further, there need also be a few persons gifted with leadership talents so to overcome possible internal disputes and to represent the local people in their contacts with donors, banks etc. Although this is not a surprising finding, the need for local support and serious commitment is sometimes overlooked once a help-to-self-help-programme has been launched.

Table 2-1 Key data for locally managed rural electrification organisations visited in Bolivia, India and Nepal

	BOLIVIA				INDIA	NEPAL		
GNP per capita (USD)	670				310	170		
Organisation	CEY	CEM	CSEC	CRE	CESS	AUO	GVEC	SCECO
Type of organisation	Co-operative	Co-operative	Co-operative	Co-operative	Co-operative	Co-operative	Co-operative	Shareholder company
No. of consumers	5,600 <sup>I</sup>	262 <sup>II</sup>	1,600	161,000 (4,500) <sup>III</sup>	50,000	158	253	4,000
Power from	Grid	Diesel sets	Grid	Grid (+gas)	Grid	Grid	Micro Hydro	Micro Hydro
Installed generating capacity (kW)	-	182	-	(6,140) <sup>IV</sup>	-	-	50	400
Contracted bulk power (kVA)	on request (max 2,500)	-	500	on request	on request	-	-	-
Total investment (USD)	2,011,000 <sup>V</sup>	400,000 <sup>VI</sup>	300,000 <sup>VII</sup>	83,400,000 <sup>VIII</sup> (3,450,000) <sup>IX</sup>	*	31,000 <sup>X</sup>	70,000	2,500,000- 4,150,000 <sup>XI</sup>
Total investment (USD/consumer)	360	1.111 <sup>XII</sup>	650 <sup>XIII</sup>	518 (765) <sup>XIV</sup>	*	207	277	625 <sup>XV</sup>
Total investment USD /kW <sub>installed cap</sub>	-	2.198	-	(562)	-	-	1,400	6,250
Household tariff (USD/kWh)	0.08	0.26	0.26	urban=0.05 rural =0.15	0.15 <sup>XVI</sup>	0.03 <sup>XVII</sup>	0.03 <sup>XVIII</sup>	0.06 <sup>XIX</sup>
Power supply (hrs/day)	24	4	4	24	24	24	24	24
Peak demand (kW)	1,400 kVA (Dec-93)	65 (Nov. -93)	120	146,000 (5,300) <sup>XX</sup>	120	28	50	250 (Jan.-94)
Average load factor (%)	37 % (May -95)	40%	40%	urban=60% rural=50%	*	82%	50 %	43 %
Average household consumption (kWh/month)	44.5	8.5 (Mid-93)	18	urban=212 rural=78 <sup>XXI</sup>	*	45	(63) lodges included	Level 1= 27 Level 2=123 Level 3= 127

- I 4,800 active and 800 passive (May 1995).
- II Data from November 1993, three months before the rural electrification cooperative ceased to exist.
- III Number of consumers in the Valles Cruceños system.
- IV Gas power plants, 4,400 kW in Camiri, 1,740 kW in Mataral.
- V Costs for transmission and distribution network.
- VI The estimated initial investment was USD 400,000. When including recent investments under ELFEC's responsibility the figure is USD 1,300,000. (Interview with Mr. F.G. Chopitea, ELFEC).
- VII The estimated initial investment was USD 300,000. When including recent investments under ELFEC's responsibility the figure is USD 1,200,000. (Interview with Mr. F.G. Chopitea, ELFEC).
- VIII Investments in Santa Cruz integrated system, and for distribution only since generation is provided by the state utility. (12/31/1994).
- IX Investments in the Valles Cruceños system: 2,081,000 for generation and 1,398,000 for distribution. (12/31/1994).
- X Investment for distribution network to Asedri (Phoksingkot excluded).
- XI 2,500,000 is a rough calculation on previous investment. 4,150,000 USD includes recent investments for future extension, resulting in a present investment per consumer at approximately 1,000 USD.
- XII Based on the 360 consumers that the cooperative had in mid 1993.
- XIII Based on the app. 460 consumers the cooperative had 5 years after its start (Interview with Mr. F.G. Chopitea, ELFEC).
- XIV Investment cost per consumer in the isolated systems.
- XV Based on USD 2,500,000 investment.
- XVI For consumers with a maximum peak load of 2 kW.
- XVII Subscribed power (W)/ cost per month (USD)/fraction of consumers in category: 25/0.40/13.5%; 50/0.80/73%; 250/2.20/13.5%. Average system load factor: 82%. Result in average cost per kWh: 0.027 USD.
- XVIII Cost per installed Watt/month: 0.01 USD, average system load factor: 50%. Results in an average energy unit cost of 0.027 USD/kWh.
- XIX Subscribed power (W)/ cost per month (USD)/average consumption in category (kWh/month)/ fraction of consumers in category: 100/1.4/27/56%; 500/5/123/30%; 2,000/6/127/14%. Result in average cost per kWh: 0.060 USD.
- XX Peak load in the Valles Cruceños system.
- XXI The average consumption in Valles Cruceños is 39kWh/month, improving from 34 kWh/month in 1994.
- \* Data missing.

## **2.2 Introduction of locally managed electricity supply in Tanzania**

It is not obvious how the historic experiences from electrification of industrialised countries and the more recent experiences with local management of electricity supply in other developing countries can be adapted to suit the conditions in Tanzania. The weak infrastructure, the lack of technically educated people in rural areas and the low paying ability of the majority of the rural population are factors which can be expected to cause special difficulties in Tanzania.

It appeared obvious however that successful implementation in Tanzania of a rural electrification programme based on local management would require strong local commitment and leadership, careful adaptation to local conditions and strong initial technical and management support from a central organisation.

TANESCO appeared as the most suitable organisation to provide the technical and management support. Such support would include a pre-feasibility study with a tariff estimate, assistance in setting up the local organisation to manage the electricity supply, technical support during design, installation and commissioning of equipment, training of local technical and administrative personnel and continued technical and management support upon request.

In order to facilitate later integration with the national grid, it appeared as reasonable to require that all installations shall comply with the TANESCO standard.

The source of electricity supply should be selected depending on the location of the area to be electrified, the estimated demand and the local energy resources available. The supply can come from the national grid or from an isolated power plant. Isolated power plants may use diesel gen-sets, mini-hydro power plants, a biomass fuelled power plant or solar electricity. It can be expected that a diesel power plant will be the least cost short-term solution in many cases, to be followed by grid connection or an isolated plant using a renewable energy source when the demand has reached a certain level.

The role of the local management would be to organise the consumers, set the tariffs, collect payment for the service, take responsibility for the daily operation and call upon TANESCO when technical and management support is needed. The full responsibility for the financial sustainability of the service would rest with the local organisation.

Different organisational set-ups are possible. A private organisation or company may be the best choice in some cases, a cooperative solution in others. Combinations can of course also be considered, where for instance the supply is managed by a private company, whereas distribution is managed by a cooperative which buys power from the supplier.

## **2.3 History of cooperatives in Tanzania**

Since the cooperative is one of the organisation forms to be tried for locally managed rural electrification in Tanzania, the historic experiences from cooperative organisations in Tanzania are worth reviewing.

Marketing cooperatives in Tanzania date back to the 1920's.<sup>3</sup> The early development of cooperative unions served at breaking the Asian monopoly for purchasing of coffee. After the enactment of the Arusha Declaration in 1967, Ujamaa<sup>4</sup> cooperative societies mushroomed after direct government encouragement. For some years to come, cooperatives would be an instrument to achieve an efficient domestic agriculture that secured the welfare of the ordinary farmers as well as the export of crops. During the 1970's though, it became more and more evident that many grass-root farmers were not content with the centrally steered crop handling and many refused delivering their yields to the government. In May 1976, the government disbanded the cooperative unions with the official argument that their contribution to national development had become most questionable.<sup>5</sup>

Since then, although cooperatives have not been promoted as much as during the Ujamaa period of the 60's, the Tanzanian marketing cooperatives have been reintroduced. This happened in 1982 when a pressing national economy made the government desperately look for ways of controlling the economy. The re-introduction may also have reflected the failure of other, new institutions to handle the agriculture business in Tanzania in a satisfactory way.<sup>6</sup> A few years later, cooperatives were again caring for the bulk of agricultural trade in the country.

Unfortunately though, it should soon become clear that the government's reluctance to control, and act for, the financial soundness of the cooperatives resulted in cooperative debts growing tremendously. The government drove reintroduction of cooperatives ad absurdum. Banks were more or less forced to give new loans to cooperatives, although they had failed to get paid for the previous loans. By 1991, cooperatives had a debt amounting to the equivalence of their three years' turnover.<sup>7 8</sup>

Despite the seemingly poor performance of cooperative movements in Tanzania, they have in fact showed quite an ability of surviving. Reasons for their poor financial performance may be both external and internal. The external factors would typically be draught, international oil-crises etc., but also the fact that the national policies have been changing so frequently. Poor management is the most likely internal reason.

Seen from an infrastructure and regional planning point of view, the villages formed during Ujamaa remain and constitute an important institution in the Tanzanian society

---

<sup>3</sup> Dr. Festus L., *Rural development under the changing development paradigm: the case of co-operatives*, University of Dar es Salaam, Economics Department, paper presented at 2nd State of Politics Conference, Dar es Salaam from July 4th to July 6th 1994.

<sup>4</sup> Ujamaa means 'family/relative/socialism' in Kiswahili and was used by Julius Nyerere to illustrate how the Tanzanian socialism should be interpreted as an extension of the traditional African social pattern of caring for your family/neighbours. In the early phases of the Ujamaa villagisation programme, co-operatives were registered on a voluntary basis, and mostly in places where villages were already mature. Later, the agricultural co-operative model was more heavily promoted and according to the Ujamaa Villagisation Act, enacted 1975; all registered villages should be interpreted as multi-purpose co-operatives. During the period 1969-1974 more than 23,000 Ujamaa villages had been registered.

<sup>5</sup> Bryceson D., 1984, *Second Thoughts on Marketing Co-operatives in Tanzania: Background to their Reinstatement* (Development series 5) Plunkett Foundation for Co-operative Studies, 1994. ISBN 0 85042 056 3.

<sup>6</sup> Dr. Festus L., 1994.

<sup>7</sup> Ibid.

<sup>8</sup> Dr. Amos M., 1994, *Rural development under the changing development paradigm: the case of co-operatives*, University of Dar es Salaam, Department of political science and public administration, paper presented at 2nd State of Politics Conference, Dar es Salaam from July 4th to July 6th 1994.

through which in principle the entire rural population can be reached. The cooperatives have contributed to some of the human resource and infrastructure up-building in the country. Also, with its history of cooperatives, Tanzania has a relatively well-developed legal framework for cooperatives as well as an established experience among common people on advantages and disadvantages with cooperatives. This experience may help in balancing between development projects operated as private enterprises or by the community in an era of liberalisation.

At the 2nd State of Politics Conference in Dar es Salaam, 1994, the role of cooperatives was brought up as one of many issues in changing the development paradigm. The latest Co-operative Act (1991) was referred to, and a few changes relative to earlier acts highlighted. One important change is that cooperatives are now to be considered to be private institutions and not agencies of the state. As such government control can only be achieved through fiscal and monetary policies just as in the case with ordinary private organisations.<sup>9</sup> Further, it was argued that the cooperatives could be a very appropriate instrument for continued rural development, especially if considering their large installed capacity in terms of transport, crop processing facilities, storage, office and other premises<sup>10</sup>. It was also clarified that although Tanzanian cooperatives have traditionally dealt with agriculture, other activities such as education, manufacturing etc. may also be appropriate.

## **2.4 Tariff considerations for rural electrification cooperatives**

### **2.4.1 General considerations**

Electricity tariffs are usually designed to fulfil one or all of the following requirements:

- The costs incurred for providing the service shall be recovered;
- The cost structure of power generation and supply shall be reflected in order to promote a consumer's behaviour that is in line with an overall optimisation of the energy system;
- Certain forms of electricity use shall be promoted or discouraged;
- The tariff shall be relatively easy to use;
- The tariff shall be understood and accepted by the users.

It is obvious that no supplier of electricity can ignore the first of these requirements for an extended period if the enterprise has to be financially sustainable. This is true also for locally managed suppliers, like rural electrification cooperatives.

Whether or not the tariff shall be designed to fulfil the second and third requirements is to some extent a political question. Unless "external costs", reflecting for instance environmental impacts, are included in the cost structure used for design of a tariff meeting the second requirement, the second and third requirement will usually be conflicting.

---

<sup>9</sup> Dr. Amos M., 1994.

<sup>10</sup> Dr. Festus L., 1994

The last two requirements are particularly important for small electrification cooperatives.

#### ***2.4.2 Tariff structure***

An electricity tariff may be designed as fixed charge, a charge based entirely on consumption of electric energy or a combination of a fixed charge and an energy fee.

Only the third of these options can fulfil all the three first requirements listed above. Such a tariff will however require some extra effort for calculation of electricity bills and may also be more difficult to explain to the consumers.

A tariff based on an energy charge requires metering of the electricity, which involves an investment of about 165 US dollars for each single-phase consumer.

A flat rate can be used without metering. It will then be based on the installed load or the capacity of the main fuse. Such tariffs were used with some success when electricity was introduced for instance in Sweden and have been suggested as a method to minimise investments since no meter is required. As will be shown in section 4.7, the flat rate tariff will only be attractive for the consumers if the consumption is very low.

#### ***2.4.3 Recovery of capital costs***

One of the key issues in determination of a tariff for a newly started electrification cooperative is the recovery of capital costs. If the full capital cost shall be reflected in the tariff from the first day of operation, when the load is low, the tariff will be so high that use of the service will be discouraged. The few consumers that might afford the service at a high tariff will find it more attractive to use individual diesel gen-sets.

The problem might be solved by postponing inclusion of capital costs until the load has grown to a level when the tariff including capital cost is competitive with the cost of operating private gen-sets.

The problem of how capital costs shall be recovered will also depend on how the initial investment was financed. If the cooperative has borrowed all the capital required for the initial investment, repayment must eventually be made. In such case, the full capital cost must be recovered sooner or later, depending on the loan agreement.

If, on the other hand, a gift or a government grant has financed the initial investment, recovery of the capital costs is more a matter of collecting a sufficient capital for re-investments when the equipment must be replaced. In such case, recovery of about 30% of the capital might be sufficient to raise funds for re-investment.

It will in general be an advantage for a newly started electrification project if the capital costs can be shifted into the later part of the economic lifetime of the equipment invested in. This will make it possible to keep the tariffs at an attractive level also in the first years when the number of consumers and the consumption is low.

The effect of loan conditions on the required tariff for break-even is illustrated in tables 2-2 and 2-3 below, which show the development of the tariff for a hypothetical cooperative supplied by diesel gen-sets. The investment required has been estimated from standard values. A distribution network similar to that used in Urambo has been assumed. Deviations from this investment estimate, depending on local conditions must be expected.

Both tables are based on the assumption that 30% of the initial investment shall be accumulated during the lifetime of the equipment for re-investment when the equipment must be replaced. Different assumptions have been made about the interest rate and the part of the initial investment that must be repaid.

Table 2-2 shows the break-even tariff for constant monthly generation at different levels. It could roughly illustrate the variation of the tariff that would be obtained if the tariff each year shall reflect the actual cost including the need for capital accumulation with straight depreciation.

Table 2-3 shows the tariff that would be required if a constant tariff is applied during the first ten years under different assumptions about the load growth. Linear load growth from 5000 kWh/month has been assumed.

The calculated tariffs can be compared with the cost of using a new small diesel gen-set of 2 kW for supply of electricity to a residential house or small business. With the fuel costs and real interest rates assumed for the calculations in tables 2-2 and 2-3, this cost will be about 0,58 USD/kWh<sup>11</sup>. The marginal cost for operating an existing small gen-set of this capacity will be about 0,44 USD/kWh.

The tables illustrate that 100% recovery of the initial investment can lead to tariffs that are not competitive with new small individual diesel gen-sets if the cooperative generation is limited to evening time (4-5 hours per day) with a load that is less than 40% of the firm capacity. For such operation, the load factor must increase from the initially assumed 20% to about 80% during the assumed 10 year lifetime of the gen-sets, to make it possible to keep a tariff that is competitive with new small individual gen-sets. With the assumed data and 100% recovery of the initial investment, it will be impossible for the cooperative to keep a tariff that makes it financially attractive to switch from an existing individual gen-set to the cooperative supply.

With 100% recovery of the initial investment, 30% capital accumulation and 2% real interest, the monthly generation must reach at least 38000 kWh during the first 10 years for a plant with a firm capacity of 170 kW, if a constant tariff below 0,40 USD/kWh shall be possible. This cannot be done with 5 hours daily operation (evenings only). In order to reach such a low tariff, sufficient industrial loads requiring daytime operation must also be connected. Assuming a lighting load of about 25000 kWh in the evening and night, the average daytime load would have to be about 54 kW.

---

<sup>11</sup> A 2 kW diesel generator set costs about 1400 USD/kW and has a specific fuel consumption at full load of about 0,45 litre/kWh. 5 hours daily operation at a load factor of 60% and 10 years lifetime was assumed for the estimate. The specific fuel consumption at 60% average load was assumed to be 0,55 litre/kWh.

**Table 2-2 Break-even tariff for different assumptions on initial investment recovery and annual generation**

<u>Investment assumptions:</u>					
	<b>Capacity kW</b>	<b>Investment USD</b>	<b>Economic life years</b>		
Diesel gensets	3*85	45 000	10		
Distribution system	400	280 000	25		
<u>Operating cost basis:</u>					
Fuel price, USD/litre		0,65			
Fuel consumption, litre/kWh		0,30 <sup>*)</sup>			
Maintenance cost, gensets		20% of fuel cost			
Annual maintenance cost network,		2% of investment			
Service agreement USD/year		2200			
Annual salaries USD		1500			
Other annual costs, USD		115			
Distribution losses		10%			
<u>Break-even tariff, USD/kWh:</u>					
		Monthly generation kWh			
		5000	10000	20000	30000
Load factor <sup>**)</sup>					
5 hours daily operation		0,20	0,40	0,78	
24 hours daily operation		0,04	0,08	0,16	0,25
Interest 5%					
Investment recovery 100%		0,89	0,58	0,43	0,38
Capital accumulation 30%					
Investment recovery 0%		0,42	0,34	0,31	0,30
Capital accumulation 30%					
Interest 2%					
Investment recovery 100%		0,80	0,53	0,40	0,36
Capital accumulation 30%					
Investment recovery 0%		0,44	0,35	0,31	0,30
Capital accumulation 30%					

<sup>\*)</sup> Modern diesel gensets have specific fuel consumption at full load of about 0,26 litre/kWh.

<sup>\*\*)</sup> Based on 170 kW firm power

**Table 2-3 Break-even tariff for constant tariff during first 10 years with 30% capital accumulation and different assumptions on recovery of initial investment**

Financial assumptions same as in table 2-2

Initial monthly generation 5000 kWh

Break-even tariff, USD/kWh:

	Generation, 10000	kWh/month, 20000	year 10 30000
Load factor <sup>*)</sup>			
5 hours daily operation	0,40	0,78	
24 hours daily operation	0,08	0,16	0,25
Interest 5%			
Investment recovery 100%	0,71	0,54	0,47
Capital accumulation 30%			
Investment recovery 0%	0,38	0,34	0,32
Capital accumulation 30%			
Interest 2%			
Investment recovery 100%	0,63	0,49	0,43
Capital accumulation 30%			
Investment recovery 0%	0,39	0,34	0,32
Capital accumulation 30%			

\*) Based on 170 kW firm power

In chapter 7 the option of individual PV-sets is as well evaluated and compared to the diesel option outlined here.

## **2.5 Important policy and research issues**

### **2.5.1 Overview**

The proposed basic strategy for introduction of locally managed electricity supply in Tanzania is outlined in section 2.2.

Before nation-wide implementation of this strategy can be carried out, a number of important issues need to be resolved. Some of the issues are policy issues, which can only be resolved politically, other are primarily of socio-techno-economic nature and require some research for resolution. The distinction between the two types of issues is not clear-cut, since the implications of decisions on some of the policy issues can not easily be foreseen because there is incomplete knowledge about socio-techno-economic issues. This is the reason why several pilot projects are desirable before the concept is promoted nation-wide.

The fundamental socio-techno-economic issue is how much financial, technical and administrative support an electrification cooperative will require in order to survive and develop in a sound way. The answer will obviously depend on the local conditions and this leads to the question how the sites which have the best potential for successful development can be identified so that limited resources available for support to cooperatives can be allocated in the best way.

Related to this issue is the actual cost of providing electricity through a centralised system in small rural communities, possibilities to cut-down on operating costs and necessary investment, possibilities to use part time managers and the need for training of local technical personnel. Also important is of course the ability and willingness of the people in the community to pay the actual cost and the possibilities to use the electricity for income generating activities, which can improve the future paying ability.

The fundamental policy issue is how much initial subsidy to new rural electrification projects can be justified on the basis of equity considerations and the expected social and economic benefits. It is obvious that previous rural electrification projects have been heavily subsidised and are still being subsidised through the pan-territorial tariff. Equity would require subsidies on a similar level to new projects, but it is clear that such subsidies are not possible if the number of rural projects would increase significantly. Consequently it will be necessary to establish what actual social and economic benefits can be expected and how much these benefits are worth to the nation.

### ***2.5.2 Studies of socio-techno-economic issues in the pilot projects***

Studies of possibilities to minimise the cost of the electricity are obviously of large importance and must therefore be included in the pilot projects.

Not very much can be done to reduce the investment required for the transmission and distribution network if the network shall comply with TANESCO standards. Optimised stepwise capacity expansion can theoretically be used to avoid over-investment in stand-alone power plants. This however requires some relevant experience as regards the load development in rural communities. The experiences from previous projects in Tanzania are unfortunately not useful since these are valid for considerably lower tariffs. An important objective of the pilot projects will therefore be to generate a database that can be used for future planning. Some reduction in the initial investment would be possible if kWh-meters could be avoided. This would require a flat rate that could be based either on the connected load or load limiting circuit breakers. If this method for reduction of the investment works in practise can only be found out from pilot projects.

For cooperatives supplied from diesel gen-sets, the fuel cost is a major part of the total cost. Keeping a low specific fuel consumption by continuing service and maintenance to the generator sets is therefore important. The review of experiences from the rural projects operated by TANESCO<sup>12</sup> showed large variations between the different sites in this respect. The performance of cooperatives regarding fuel efficiency and the technical support required to keep it high are other aspects that need to be studied.

Use of energy efficient appliances and in particular energy efficient lamps is one possibility to reduce the cost for the consumers without sacrificing benefits brought by electricity. The energy efficient lights are however more expensive to buy and their economy depends on a longer lifetime compared to conventional incandescent lamps. The lifetime under conditions representative of rural electrification cooperatives in Tanzania is largely unknown. (See Chapter 7). Testing of energy efficient lamps and

---

<sup>12</sup> Kjellström B. et al. , 1992.

hopefully demonstration of a cost saving is probably required before people in rural villages are prepared to invest in these devices.

The ability to pay for electricity may be estimated from the available socio-economic statistical data. The willingness to pay is another matter. It might be assumed that this would depend mainly on the relative costs of the available options for the energy service. A comparison with the amount a family will spend on kerosene for lights and dry cells for radios<sup>13</sup> indicates that electricity is only financially attractive if the tariff is below about 0,15 USD/kWh. Such a comparison however ignores the improvement in the quality of lighting that will be achieved with electricity. A more relevant comparison would be individual generation, either with small gen-sets or photovoltaic cells. From estimates presented in section 2.4.4 it appears that the tariff would have to be below 0,4 USD/kWh to stimulate switch from an existing individual gen-set to cooperative supply and below about 0,58 USD/kWh to be more attractive than purchase of a new small gen-set. These estimates are however theoretical. In reality, the specific fuel consumption of existing individual gen-sets will depend on their condition, and can very well be much higher than the 0,55 litre/kWh assumed for a new gen-set operated at a load factor of 0,6. This would tend to stimulate a shift from individual gen-sets at higher tariffs than 0,40 USD/kWh. On the other hand, if the reliability of the cooperative service is found to be inadequate, an individual gen-set may still be preferred even if the tariff for cooperative electricity is low. Likewise can an individual PV-system be preferable in some cases, although as presented in Chapter 7 the equivalent energy price is estimated to at least 1.6 USD/kWh. Experience from pilot projects appears as the only possibility to find out how much the people in rural communities are able and willing to pay for centrally produced and supplied electricity.

### ***2.5.3 Studies of benefits justifying subsidies to rural electrification projects***

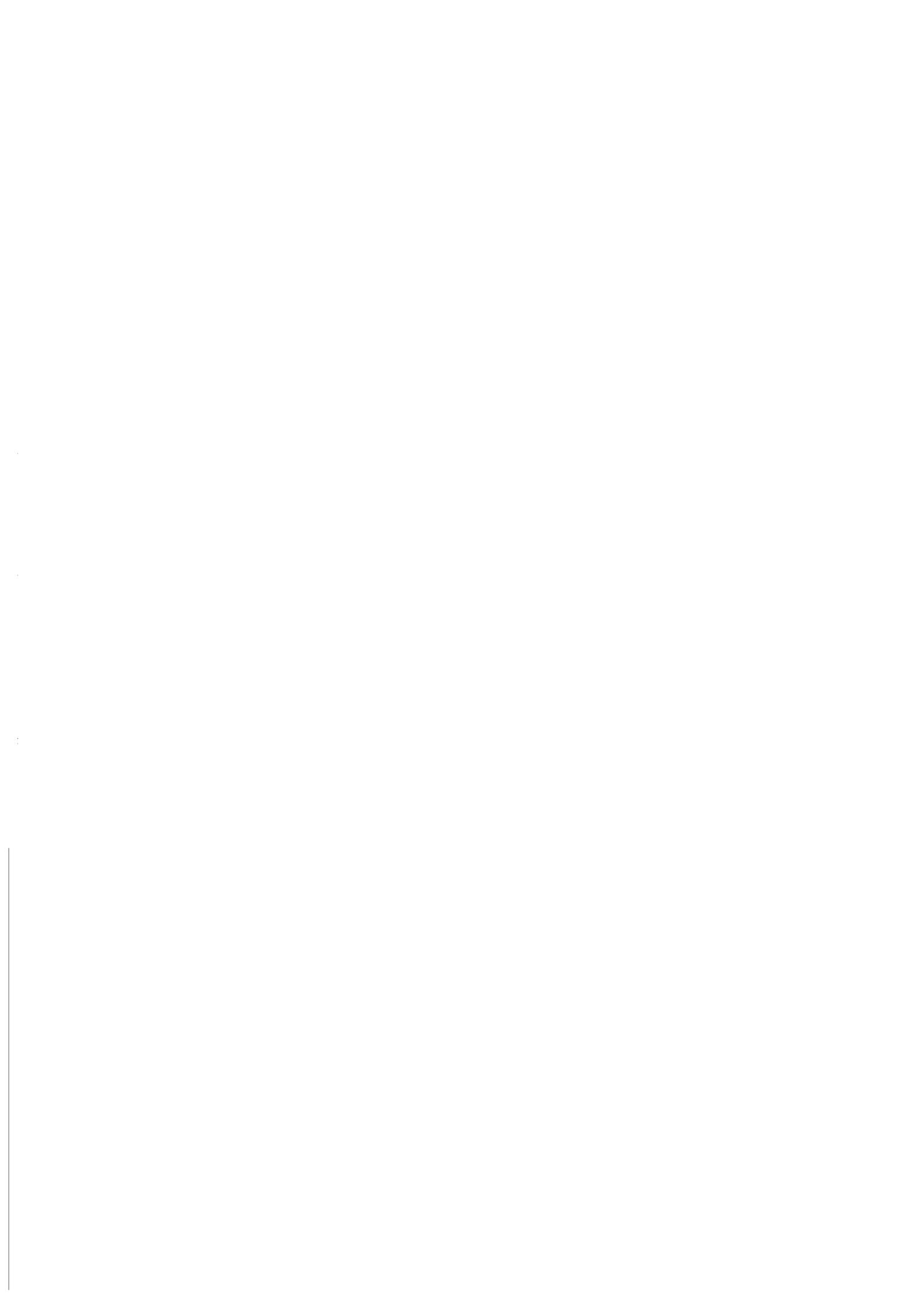
Feasibility studies for rural electrification projects in Tanzania have generally shown that the projects are not financially feasible with the pan-territorial tariff used by TANESCO. The projects that have been carried out despite this have been justified on other grounds. A detailed review of such motives and an evaluation of the performance of the projects implemented by TANESCO with respect to such motives are provided by Kjellström, Katyega et al. (1992). Typically, subsidies to rural electrification projects have been justified by expectations about reduced deforestation, promotion of industrial activities, improvement of the living standard of the rural population and benefits for women. The study of the TANESCO-projects found little evidence that these wider social and economic benefits had materialised. To a large extent, the reason for failure to achieve the objectives that had justified the subsidies could be traced back to the difficulties of TANESCO to expand the supply to meet demand and to provide a reliable service in the rural areas.

The surveys done within that study did nevertheless indicate that electrification was considered to bring benefits also to those who were not directly using electricity. Street lights improved security, and the availability of electric light in shops and bars made the town more attractive to travellers and visitors, which increased business activities and promoted local economic development.

---

<sup>13</sup> Katyega M.J.J. et al. *Feasibility Study on Electrification of Shimbi and Sikonge villages*, SEI, Dar es Salaam University and TANESCO, 1994.

With locally managed electricity supply, the priority problems that TANESCO encounters when allocating resources for investment and maintenance in urban or rural areas, will be significantly reduced and in essence only include costs for supportive service. At least one important reason for the failure to reach the objectives that justified subsidies will therefore be eliminated with local management. To what extent this will lead to better performance as regards reduced deforestation, promotion of industrial activities, improvement of the living standard of the rural population and benefits for women remains to be established and this can only be done by evaluation of the experiences from pilot projects.



### 3. PILOT SITES INVESTIGATED IN TANZANIA

#### 3.1 Overview

Up to 1996, four sites for possible pilot projects have been studied by TANESCO. Key data are given in table 3-1.

The sites studied are Shimbi in Kilimanjaro region, where grid connection was the obvious supply solution, Sikonge in Tabora region, where an isolated diesel power plant was found to be the least cost solution in the short time perspective, Urambo in Tabora region, with an existing isolated network supplied by a diesel power plant and finally Mbinga in Ruvuma region, where supply from an existing diesel power plant at a coffee curing plant appeared as a possibility.

**Table 3-1 Key data for sites investigated as candidates for pilot project**

	Population	Estimated demand after 5 years MWh
<b>Mbinga</b>	14 970 (1993)	2225
<b>Shimbi</b>	21 050 (1988)	8 770
<b>Sikonge</b>	8 874 (1988)	1 150
<b>Urambo</b>	11 830 (1988)	406

#### 3.2 Method and data used by TANESCO for the feasibility and tariff studies

All the feasibility studies were based on site specific information collected during site visits which was combined with generic data used by TANESCO for planning purposes.

In the studies for Shimbi and Sikonge<sup>1</sup>, the electric energy consumption and the peak load during the 15 years following electrification were estimated on the basis of assessments of the number of consumers of different categories that will be using electricity. Based on the location of the potential consumers, a distribution network was outlined. The supply options were identified and the rated capacity of the supply determined. The required investments in foreign and local currency were then estimated as well as the operating cost for each year. Calculations of the financial rate of return were then made for different assumed tariff levels.

In the case of Shimbi and Sikonge calculations were also made to compare the present cost of using kerosene for lighting and batteries for the radio with the cost of using electricity.

Standard electricity consumption assumed for different types of consumers are shown in table 3-2. A load factor of 0,5 was used to estimate the peak demand from the estimated consumption.

<sup>1</sup> Katyega M.J.J. et al., 1994.

**Table 3-2 Standard electricity consumptions assumed by TANESCO**

<b>Consumer category</b>	<b>Monthly consumption kWh</b>
<b>Residential house</b>	168
<b>Commercial</b>	338
<b>Small industry</b>	337
<b>Street light</b>	91.25
<b>Churches</b>	91.25

For calculations of the annual costs, the data in table 3-3 were used.

**Table 3-3 Data for financial cost calculations**

<b>Project life</b>	30 years
<b>Loan conditions</b>	
<b>Foreign</b>	2% interest, 25 years
<b>Local</b>	20% interest, 15 years
<b>Annual operation and maintenance cost, fraction of investment</b>	2%
<b>Distribution losses</b>	10%
<b>Tariff for bulk supply</b>	Tariff 5 (about USD/kWh in 1996)
<b>Specific diesel consumption</b>	0,34 litre/kWh
<b>Lubricant oil consumption</b>	0,0033 litre/kWh

### **3.3 Summary of results for Shimbi**

A feasibility study to electrify Shimbi as a pilot village for electrification through establishment of a rural power cooperative was undertaken in 1992 by TANESCO and University of Dar es Salaam. Shimbi was considered to be a high-income village. The village is located on the eastern slopes of Mt. Kilimanjaro. In 1988, the population was 21,000. Agriculture is the main occupation of the people with coffee and banana as major crops. The villagers own cattle, goats, sheep and fowl.

The villagers are facing an energy situation whereby most of the woodfuel supply is illegally obtained from Mount Kilimanjaro Forest Reserve. Owing to the land shortage, possibilities to establish large wood lots to meet household energy needs is not possible. Hence, firewood for cooking and other end uses, if obtained legally, tend to be quite expensive. Energy for lighting which tends to depend much on kerosene is also expensive as there is no nearby kerosene depot.

Therefore, the main aim of the study was to investigate the feasibility of electrifying all the households in Shimbi village under the cooperative arrangements. This included implementation of house wiring, service lines, streetlights and distribution network for the entire village.

Field surveys of the entire village consisting of Shimbi Kati, Mashariki, Mashami, Masho, Makiidi and Maharo were done during the first two weeks of 1992. The village was revisited during portions of months of July, August and September 1992 to augment information on household energy consumption characteristics and costs.

The existing Moshi to Mkuu Rombo TANESCO medium voltage transmission line crosses the village. By 1994, about 300 out of 3,500 households had been connected to TANESCO line network commissioned in 1985. The high costs of house wiring and connection and general shortage of connection material explain the slow electrification of many households.

Also, in 1992 a household energy survey was conducted to investigate the current expenditures on energy for lighting, cooking, and powering of radios. The major aim was to find out whether the households would be better off by switching to electricity at higher tariffs expected to be charged by the cooperative (relative to TANESCO subsidised tariff) or status quo (going without electricity).

A questionnaire was distributed in each of the six small Shimbi villages. Three non-electrified households in each village were selected to fill in the questionnaires. The local government leaders in each ward made the selection. People were selected mostly on ability to fill in the questionnaire accurately without supervision.

The majority of the respondents consisted of educated people – primary school teachers, ward secretaries, primary cooperative officers, elected political leaders, and retired government officers. There was at least one farmer involved as well. A total of 18 households responded. Data collection was done for two months whereby one questionnaire each month was filled in.

Questionnaire analysis revealed that open wick lamps (koroboi) were mostly used in the kitchen, toilets and animal huts/sheds. Some used them in the bedrooms. Glass covered wick lamps are commonly used in the sitting rooms and bed rooms. On the average 4 lamps are used during 6 - 10 PM and occasionally by very few during 6 – 6.30 AM. Since kerosene costing 110-150 TAS/litre is found to be expensive, the average 8 litres/month consumption was considered absolute necessary usage. Extinguishing unnecessary light sources when not needed was a widely practised energy conservation measure.

Firewood was the main fuel for cooking for the majority. Few used kerosene stoves to prepare fast snacks and tea. Main meals were therefore prepared by firewood. Very few people used kerosene for starting fire. To avoid such expenses, most of the villagers used dry wood sticks and grass to start the fire. Wood from the farms supplemented wood purchases. On the average TAS 3600 was used for buying wood every month.

On the average 7 batteries costing about 140 TAS were used every month for powering radios. There were a few electric torches used as outdoor lights. These were not included in the questionnaire analysis.

Ember from the fireplace was utilised for ironing. Maize cobs were popular energy sources for ironing. Very few villagers used charcoal for ironing. Still people did not put proper records for charcoal expenditures for ironing.

With these data, the monthly energy costs for a household can be estimated as follows (1994 cost level):

4 light sources consuming 8-9 litre kerosene	1100 TAS
1 radio consuming 7 batteries	1000
cooking, firewood	<u>3600</u>
	5700 <sup>2</sup>

The kerosene and the batteries can be replaced with electricity with an estimated consumption of 42 kWh/month (assuming that conventional incandescent lamps of 60 W are used for lighting). The break-even cost for electricity would be 50 TAS/kWh or 0.15 USD/kWh at the exchange rate in 1992.

The above findings formed the basis for evaluation of the financial implications of different electricity tariffs for the households.

The feasibility study established a 15 years electricity demand forecast for the village. During the forecasted period, the load was expected to grow from 0.5 MW in year 1 to 2.6 MW in year 15. Options investigated included sub-transmission from the grid or diesel generation in the village.

An investment comparison showed that grid extension to the village was a superior alternative to diesel generation in the village. The grid supply option was strongly economic, financially sound to TANESCO, the proposed cooperative and marginally to the individual household customers. The high financial gains to TANESCO from the proposed project could be negotiated for lower tariff to the proposed cooperative. Moreover, the project was as well socially and environmentally sound and hence was recommended for implementation.

Project implementation to commissioning of the main 33 kV distribution network could be realised in a year. Completion of all village households' house wiring and construction of service lines would take another one to two years. Furthermore, the people were willing to cooperate with TANESCO in any way to make the project a success. The estimated investment amounted to the equivalent of 3.8 M USD, including housewiring 0.8 M USD.

The estimated tariff required to recover costs including bulk power supplied at 0.08 USD/kWh was estimated to 0.11 USD/kWh, i.e. below the break-even tariff estimated from costs for kerosene and batteries.

As the project was of a pilot nature, it was recommended that TANESCO go ahead with implementation if funding could be secured. The report suggested some ways be sought to reduce the capital costs and thereby improve the project economics within the ability of the consumers to pay. It was obvious from the study that the cooperative tariff would be higher (USD 0.11 / kWh) than the TANESCO tariff enjoyed by existing consumers in the Shimbi village (USD 0.025/kWh). Since it was considered necessary to apply a uniform tariff in the village, TANESCO demanded a written commitment from the 300 households that were already electrified to switch from the subsidised TANESCO tariffs to a true cost tariff to be charged by the cooperative. This issue has not been resolved to date.

---

<sup>2</sup> This is equivalent to USD 17.2 with the exchange rate of 330 TAS/USD, September 1992.

### 3.4 Summary of results for Sikonge

A feasibility study to electrify Sikonge as a pilot village for electrification through the establishment of a rural power cooperative was undertaken in 1992 by TANESCO and the University of Dar es Salaam.<sup>3</sup>

Sikonge was selected as a representative low-income area in the country. This is relative to Shimbi village in the north of the country.

Sikonge village is located 72 km south of Tabora. The 1992 population was estimated at 8,800,000. Like Shimbi, agriculture is the main occupation of the people. Tobacco, sunflower and groundnut are major crops. The area is endowed with more natural resources than Shimbi. The resources are timber, honey and bees' wax, fishing and small-scale gold mining. Hence Sikonge has a high potential to grow fast. Land availability is not a problem. Sikonge villagers also own cattle, goats, sheep and fowl.

The village situation in terms of energy resources appears not to be a problem. Fuelwood supply comes from nearby natural forests. Some of the households collect fuelwood there. Those who cannot, buy it. Energy for lighting is a major energy cost and much depends on kerosene. There are a number of privately owned diesel generator sets in the village. Public power supply has not been established. Therefore, only a few villagers have access to electricity.

Like Shimbi, a limited household energy survey was undertaken to determine the prevailing energy consumption characteristics in the village for lighting, cooking, powering radios and ironing. The data formed the basis for the economic and financial evaluation in the feasibility study. The monthly consumption of kerosene was found to be about 50% of that in Shimbi, i.e. 4-5 litres/month. The price of kerosene was higher, 475 TAS/litre and the monthly expenditure for lighting therefore about 2100 TAS. If the lower lighting demand would prevail after electrification, the monthly electricity consumption can be estimated to about 15 kWh and the break-even tariff to about 140 TAS/kWh or 0.42 USD/kWh.

The feasibility study established a 15 years electricity demand forecast for the village. During the forecasted period, the load was expected to grow from 77 kW in year 1 to 0.42 MW in year 15. Options investigated included sub-transmission from the grid and generation in the village, using diesel generator sets.

An investment comparison showed that diesel generation in the village was a superior alternative to grid extension to the village. The estimated investment for the diesel option would be 0.6 M USD million, which can be compared to 1.5 M USD for the grid connection. The diesel option was found to be socially and environmentally sound. Financially it was positive to the proposed cooperative provided the consumers could pay the proposed high tariff estimated to 0.22 USD/kWh. As it was a pilot project, it was recommended to implement the project with a precaution that cost saving efforts are made to improve its economics, and more importantly, the transmission option was suggested given special consideration for implementation over the diesel plant. The villagers could easily sustain the lower O&M costs if the project is negotiated to become a grant from the donors, central or local government.

---

<sup>3</sup> Katyega M.J.J. et al., 1994. *Feasibility Study on Electrification of Shimbi and Sikonge villages*, SEI, Dar es Salaam University and TANESCO.

Given the same incentives, the diesel plant would not offer similar financial gains to the villagers. Hence, it was suggested that the transmission line option be given an upper hand for implementation.

Project implementation to commissioning of main transmission and distribution line network could be realised in about a year. Moreover, the people were willing to cooperate with TANESCO in any way to make a project a success.

It can be concluded that despite the high tariff required electric lighting would still be cheaper than the use of kerosene because of the high price paid for kerosene in Sikonge.

As the project was of a pilot nature, it was recommended that TANESCO go ahead with implementation if funding could be secured. It was emphasised that cost cutting strategies be sought to reduce capital costs of the project so that cost of delivered energy would be affordable.

### **3.5 Summary of results for Urambo**

Urambo Township is located in Tabora region. Urambo district in 1988 possessed 188,081 residents, of which 11,830 lived in Urambo urban ward. The urban population had increased to 12,984 in 1994. Agriculture is the most prevalent income-bringing activity in the Urambo district.

According to national statistics, the district is neither very strong in large-scale farming nor industrial activity. A conclusion could be that the Urambo district is not among the richest districts in the country. National statistics however do not include the informal economic activities that have developed significantly in Tanzania lately. It appears as if the local market in Urambo is relatively flourishing, and there are certainly inhabitants with better resources than those indicated by national statistics. (See also 4.1 and appendix A).

In 1985, the District Council of Urambo made an effort to provide electricity as a public service. A power plant was commissioned with the help from the Ministry of Works and TANESCO. Up to early nineties, a limited number of offices, commercial buildings and richer households in the township were connected to Urambo's public grid. Street lighting was an important issue to the Urambo District Council (UDC), and as far as the distribution system allowed, out door lighting was installed. The UDC bore the diesel expenditures for some years and also contributed spare-parts to the plant. In 1992, however, the UDC ceased being responsible for supplying electricity, since there was no more money.

At that time, since the electricity demand was still prevalent, a voluntary committee, the Urambo Electricity Consumers Committee (UECC), was formed to keep the services alive. The committee consisted of a handful of relatively wealthy and prominent persons in the Urambo urban ward. The committee collected funds among themselves and from other interested persons, enough to buy diesel for running the generating sets at the powerhouse. UECC also delivered the diesel to the power plant, but from that point they had no further involvement in the electricity services. The UDC still owned the power plant and had the District Engineer (DE) operating the

machines. Then as earlier, electricity was generated for some few hours per day only, or when funds ceased, not at all.

Urambo was regarded as a suitable place for conducting a pilot project since there was a proved interest from the local people to manage their own power supply. There were also functioning power lines and a local power plant, although the equipment was in poor condition. It was envisaged that the consumer group should grow as soon as the power generating capacity allowed, and thus constitute a large enough load to enable financial viability in the system.

A TANESCO team carried out a tariff study for Urambo in early 1993<sup>4</sup>. The load forecast was based on the demand data for different types of consumers summarised in table 3-4. The power plant was assumed to operate for 4 hours in the morning and 4 hours in the evening.

Table 3-5 shows the estimated initial load and the predicted load development. The tariff calculations assumed that additional investments of 13 000 USD would be necessary for rehabilitation of the power plant and that 126 000 USD would be required for extension and rehabilitation of the distribution network. Only the marginal capital investment was included when the capital cost was computed for tariff purposes. There were no meters at the consumers at this stage, and the first tariff estimation was based on flat rates. Table 3-6 shows the other assumptions for the tariff calculation and the recommended flat rate tariffs.

---

<sup>4</sup> Katyega M. and Sumari C., *Establishment of Urambo Rural Power Co-operative: Tariff Study*, TANESCO 1994.

**Table 3-4 Assumed consumption patterns in Urambo**

	Quantity	Capacity Watts	Total (Watts)
<b>Residential Category</b>			
Lighting	5	60	300
Kitchen, light	1	60	60
Radio	1	60	60
Refrigerator	0	100	0
Fan	1	75	75
Total			495
Coincident factor		1.3	<b>381</b>
Milling Machine		10,000	10,000
Coincident factor		1	<b>10,000</b>
<b>Commercial (Shops)</b>			
Fans	1	75	75
Lighting	3	60	180
Radion	1	100	100
Refrigerator	1		1,000
Total		1,000	1,355
Coincident factor		1.3	<b>1,042</b>
<b>Commercial (guest houses, Bar etc.)</b>			
Fans	2	100	200
Lighting	18	60	1,080
Refrigerator	1	1,000	1,000
Total			2,280
Coincident factor		1.3	<b>1,754</b>
<b>Institutions (offices)</b>			
Fans	6	100	600
Lighting	24	10	240
Equipment	1	2,000	2,000
Total			2,840
Coincident factor		1.1	<b>2,582</b>
<b>Hospital</b>			
Lighting	35	10	350
Laboratory	1	4,000	4,000
Total			4,350
Coincident factor		1.3	<b>3,346</b>
<b>Oil pressing</b>			
Coincident factor	1	5,000	5,000
		1	<b>5,000</b>
<b>Tobacco w/shop</b>			
Coincident factor	1	10,000	10,000
		1	<b>10,000</b>

**Table 3-5 Load forecast for Urambo**

<b>Tariff group</b>	<b>MD kW</b>	<b>Monthly (kWh)</b>	<b>Total energy kWh</b>	<b>Maximum Demand (kW)</b>	<b>Diversified Demand</b>
Residential	0.38	45.69	5,712	48	37
Milling machine	10.00	1200.00	2,400	20	20
Commercial (shops)	1.04	125.08	5,003	42	32
Commercial G/houses	1.75	210.46	1,473	12	9
Offices (Bank etc)	2.58	309.82	1,859	15	12
Hospital	3.35	401.54	402	3	3
Oil pressing	5.00	600.00	600	5	4
Tobacco w/shop	10.00	1,200	1,200	10	8
<b>Total</b>		<b>4,093</b>	<b>18,648</b>		
Daily running hours	4				
Morning peak (kW)				108	88
Evening peak (kW)				105	81
<b>Load development</b>					
<b>Year</b>		<b>Energy (kWh)</b>		<b>Peak Demand (kW)</b>	
1		223,780		85	
2		268,535		102	
3		322,243		123	
4		386,691		147	
5		406,026		154	
6		426,327		162	
7		447,643		170	

**Table 3-6 Tariff estimation for Urambo (TANESCO 1993)**  
**Exchange rate 1 USD = 360 TAS**

**Cost and performance data:**

<b>Additional investment</b>	
Diesel generator set rehabilitation	13 000 USD
Rehabilitation/extension of network	126 000 USD
<b>Operating cost data:</b>	
Specific fuel consumption	0,34 litre/kWh
Fuel price	0,42 USD/litre
Lubricant price	2,22 USD/litre
Distribution losses	10%
<b>Annual maintenance costs:</b>	
Diesel generator sets	2% of investment
Network	1% of investment
<b>Monthly generation</b>	<b>37 300 kWh</b>
<b>Generation cost components:</b>	
Fuel cost	0,143 USD/kWh
Lubricant cost	0,007
Maintenance	<u>0,003</u>
	0,152
<b>Generation cost</b>	<b>55 TAS/kWh</b>

**Tariff**

Consumer group	Flat rate (TAS)	Allowed monthly use
Residential	3 000	50
Commercial	7 000	116
Guest houses	11 500	190
Institutions	16 000	264
Hospital	22 000	364
Oil mill	32 000	529
Milling machine	65 000	1074
Tobacco godown	65 000	1074

**3.6 Summary of results for Mbinga**

Mbinga has been a candidate for a rural electrification pilot project since 1994. As part of the SEI/TANESCO research project, Mbinga has been visited on four occasions for preparation of a pilot project<sup>5</sup>:

1994

January 18 -21	TANESCO team for fact collection
June 3 - 7	SEI/TANESCO team for discussions with district officials, the missionaries and the Mbinga Coffee Curing Company
September	TANESCO team for fact collection on private generator sets

<sup>5</sup>The electrification co-operative in Mbinga, Mbinga Electric Co-operative Society, MECOS, was registered in August 1996. Distribution of electricity started on April 15, 1997 with power delivered from the coffee curing company MCCCCO. There were 93 members of MECOS. The experiences will be reported separately.

1996  
October

TANESCO team for evaluation of repair needs of a Scania gen-set of 175 kVA

Mbinga was selected for study as a representative high-income area in the country. Mbinga village is located 100 km west of Songea. 1993 population was estimated at 15,000 people. Agriculture is the main occupation of the people, coffee, maize and groundnut are major crops. The resources are timber, honey and bees' wax, fishing and small-scale gold mining. Hence it has a high potential to grow fast. Land availability is a problem. Mbinga villagers also own cattle, goats, sheep and fowls.

The village situation in terms of energy resources appears to be a problem. Fuel-wood supply comes from distant natural forests. Energy for lighting is a major energy cost and much depends on kerosene. The study in September 1994 showed that there are a number of privately owned diesel generator sets in the village. The number of operational generator sets in addition to those owned by Mbinga Coffee Curing Company (MCCCO) was established as 31, with a total installed capacity of about 250 kW. Most of these gen-sets used diesel engines, a few very small ones used petrol and one used kerosene. Interviews with the owners indicated that the generator sets were operated between 3 and 15 hours each day. Measurements carried out by a TANESCO team indicated that the sum of the average loads of the generator sets not owned by MCCCO would be about 108 kW and the average weighted specific fuel consumption of these generator sets about 0.44 litre/kWh. The variations in specific fuel consumption are large. The smallest generator sets (capacity below 3 kW) were generally found to have very high specific consumption, generally above 1 litre/kWh. For the larger generator sets the specific consumption ranged from about 1 to about 0.25 litre/kWh with a tendency that low load factor gave a high specific fuel consumption.

The coffee curing company MCCCO, operates a generator set rated at 570 kVA supplying the coffee curing plant and some residential houses used by the company staff. In 1993 TANESCO started construction of a distribution system. The original plans were to supply Mbinga by a mini-hydro plant but this scheme was never implemented due to shortage of funds.

During their visit in June 1994, SEI and TANESCO suggested that the electricity should initially be supplied by diesel generator sets at the coffee curing plant MCCCO, which has a demand not exceeding 200 kVA but a generator with a capacity of 570 kVA. The consumers should form a cooperative, which would be responsible for distribution of the power and would purchase power from the coffee curing plant. Later, the coffee curing plant and the distribution system should be supplied from a mini-hydro plant<sup>6</sup>. The general manager of MCCCO agreed in principle but underlined that a stand-by generator of 200-250 kVA must be made available, since MCCCO would otherwise be at too high risk for lack of power supply during the curing season.

---

<sup>6</sup> There are several possibilities in the vicinity of Mbinga. TANESCO has completed a study where a mini-hydro plant will be built in Nakatuta, located 70 km from Mbinga and 90 km from Songea. The plant would have a continuous firm capacity of 4.4 MW and would supply Mbinga, Songea and Peramiho. Possible start of operation not yet known subject to securing financing.

In addition to the stand-by generator, necessary investments would include a step-up transformer 0.4/11 kV of about 800 kVA, a control panel with voltmeter, amperemeters, kVAh meter and kWh meter at the coffee curing plant and connection of the transformer to the distribution network.

In 1994, the investment for transformer, control panel and distribution network was estimated to 200 MTAS (0.41 MUSD). The generation cost estimated by MCCCCO in January 1992 was 60 TAS/kWh (about 0.24 USD/kWh). The estimate was based on a measured specific fuel consumption of 0.38 litres/kWh and a specific lubricants consumption of 0.012 litres/kWh.

The study of rehabilitation needs for a Scania generator set of 175 kVA, which was in the possession of Mbinga District Council and had earlier belonged to a Brazilian construction company, concluded that it is difficult to establish the condition of the equipment and that the cost of rehabilitating could not be estimated accurately. It was therefore recommended not to attempt such a rehabilitation.

### **3.7 Evaluation of the feasibility studies**

Shimbi was found to be less suitable as a pilot case, because part of the village was already serviced by TANESCO. Organisation of a locally managed supply would lead to either that the present consumers were taken over by the new organisation, with tariff increases as a result, or that two suppliers with different tariffs would be servicing the area.

Sikonge was given lower priority because of the high investment required, about 1.5 MUSD.

Urambo was selected as the first pilot case because the investment required was modest and because there had already been a local initiative to solve the electricity supply problem.

Mbinga was selected as the second pilot case, because a distribution network is already available as a result of a TANESCO investment program, which has not yet been completed.

The tariff studies that have been made by TANESCO for these sites are not entirely comparable because fuel prices have been changing. The tariffs required for sustainability range however from about 0.11 USD/kWh in a grid connected Shimbi to about 0.22 USD/kWh in diesel supplied areas. These tariffs are significantly higher than the tariff charged by TANESCO for small domestic and commercial consumers, i.e. between 0.015 and 0.05 USD/kWh.

These TANESCO tariffs are apparently subsidised, and in particular in the isolated, diesel supplied networks, with equity consideration of making electricity affordable for these consumer groups.

The relatively much higher tariffs that will be necessary in the electrification cooperatives, inevitably leads to the question of affordability. Whether the consumers in the studied villages will really be prepared to pay the full cost for electricity supply can only be found out from actual experience.

## 4. IMPLEMENTATION OF THE FIRST PILOT PROJECT IN URAMBO

### 4.1 Presentation of Urambo

#### 4.1.1 Location and population

Urambo Township is located in Tabora region in western Tanzania, between Tabora and Kigoma, and along the German-built railway between Dar es Salaam and Lake Tanganyika. Dry 'Miombo' woodland surrounds the township. Tabora region covers 76,200 km<sup>2</sup> land. Urambo district accounts for 21,300 km<sup>2</sup>, i.e. more than a quarter of the region's area. Urambo district has 188,081 inhabitants.<sup>1</sup>

Urambo Urban ward hosts 11,830 persons<sup>2</sup>. Only a small fraction of the Urambo urban ward is presently within reach of the power distribution network, see section 4.3. The exact number of households existing in this particular part of the township is not specified, but it is evident that the majority of the inhabitants live south of the Urambo Hospital and are thus not in reach of the present grid. (See fig. 4).

A household in Urambo district typically consists of 6-8 persons, both in rural and urban areas. Most households have their drinking water coming from a well outside the house, and a pit latrine for sanitation.<sup>3</sup>

#### 4.1.2 Economic activities in Urambo

For Urambo district as a whole, agriculture is by far the main activity. Maize and paddy are the major food crops. Tobacco, groundnut and sunflower are the most common cash crops. According to annual reports from Urambo Agricultural Office, the production of maize 1991/1992 was 33,000 tonnes, paddy 12,000 tonnes, tobacco 6,000 tonnes and groundnut 6,000 tonnes in Urambo district. Apart from cultivating, hunting wild animals is common, and to some extent also fishing. Hard wood and timber, charcoal, honey and beeswax are available in the district and most of these resources are also commercialised.

Informal economic activities have generally grown in Tanzania during the latest years, and the true composition of economic activities in a township like Urambo is therefore difficult to distinguish. Nevertheless, to get a picture of the economic activities in Tabora region relative to other regions, data compiled in Statistical Abstract 1991 are useful:

- In terms of cotton production, which is the most important export commodity in Tanzania, Tabora region contributed 5% of total purchases during 1989/90, i.e. 5,260 tonnes. Hence, Tabora was the fourth largest retailer of seed cotton among the mainland regions, following Shinyanga with 41% of total purchases, Mwanza (31%) and Mara (10%).
- Tobacco, accounting for 3% of Tanzania's total export value in 1990, is the third most important export commodity. Urambo district alone did in 1989/90 contribute 2,167 tonnes to the total mainland purchases of flue cured tobacco, i.e.

<sup>1</sup> Bureau of Statistics Dar es Salaam, 1991: *Statistical abstract 1991*.

<sup>2</sup> Ibid.

<sup>3</sup> Bureau of Statistics Dar es Salaam, 1992: *Household Budget Survey 1991/92*.

26%. The same year, 55% of the country's flue cured tobacco purchases took place in Tabora region, inclusive of those in Urambo.

In July 1994, a sociological base line study was carried out in Urambo urban ward. Interviewees were mainly those who were at that time, or had recently been, connected to the electric distribution system in Urambo<sup>5</sup>. The study covered only about 0.5% of the households in Urambo urban ward. Results reveal that this group of people tends to be relatively less dependent on agricultural activities alone than what is shown by national, aggregated data. Rather, they make their living from commercial activities.

Amongst the interviewees, 37% were engaged in commercial activities alone and 26% in agricultural. 19% were engaged in both agriculture and commercial activities, 14% were workers who supplemented their income with agricultural or business related activities and only 4% were workers who depend on their employed income for their survival. The same study gives that, on the average, these households cultivates about 4.2 acres of maize, 3.1 acres of tobacco, and 3.0 acres of ground nut.<sup>6</sup>

Amongst the interviewed farmers, the best equipped possessed almost 50 acres, while the least equipped had 1 acre. Incomes from agricultural activities depend on type of crop, crop yield per acre, price per kg, and how much can be sold after having bunkered for own needs. Thus the highest incomes can exceed TAS 2,500,000 per season, which accounts for very few, while the smallest farmers do not sell at all<sup>7</sup>. The average household among those studied could earn TAS 862,000 (1,626 USD) per year from agriculture if yields are as expected and everything is sold.

For the different commercial activities, the base line study presented the expected gross incomes per year. Unfortunately, the expected expenses were not given, resulting in net incomes remaining unknown. Table 4-1 shows the expected gross incomes for a number of commercial activities in Urambo urban ward.

---

<sup>4</sup>Bureau of Statistics, Dar es Salaam, 1991.

<sup>5</sup>A sample of 37 households, 2 Institutions, 1 bar, 1 guesthouse with electricity, 8 households without electricity and 10 households plus 1 institution that for different reasons had been disconnected.

<sup>6</sup>Mvungi A. and Sanga A., 1995.

<sup>7</sup> For calculations the following data are used: (there are two crop seasons per year)

Max yield per acre:	Maize, 4 bags
	Tobacco, 3.2 bellos
	Groundnut 1.6 bags
Price per unit:	Maize, TAS 3,600/bag
	Tobacco, 40,000/bello(bello = 100 kg)
	Groundnut, TAS 3,600/bag

**Table 4-1 Expected annual gross income per commercial activity in Urambo urban ward**

Activity	Income per year (TAS)	(USD)
Petrol Station	54,000,000	102,000
Butcher	21,600,000	41,800
Welding workshop	5,400,000	10,200
Timber sale	4,704,000	8,900
Shop	2,700,000	5,100
Milling machine	1,800,000	3,400
Pombe shop (Bar)	1,260,000	2,400
Bakery	756,000	1,400
Guest house	240,000 - 2,400,000	450-4,500
Diary cows	228,000	430

The economic activities in Urambo are linked. During a dry period, yields are low and commercial activities in town automatically experience hard times<sup>8</sup>. Many also run parallel businesses, such as both diary cows and a guesthouse.

In Urambo Township, there is both a bank (Tanzanian National Bank of Commerce) and a post office. Eight guesthouses are running, some of which have a bar connected. There are 102 shops and 12 restaurants. Pharmacies and kiosks exist and the offering of assets is reasonably large.<sup>9</sup> Urambo also possesses a hospital, two dispensaries, a teachers' training college and a police station with the prison belonging to it. There are various small-scale industrial activities such as grain milling and aluminium works going on in Urambo. Some of the small enterprises have their own diesel generating set, and a number of diesel filling stations are established to meet this demand as well as supplying the vehicles in the area. The tobacco go down in the outskirts of Urambo town is a large building. There are also a number of official houses and offices for the local government.

Measuring how developed and wealthy Urambo is in relation to other villages in Tanzania is difficult. Statistics on household incomes are based on national samples, and statistics on regional agricultural and manufacturing production do not include the informal sector. (See Appendix A). A sociological study in 1993 could identify some factors that were frequently mentioned by the villagers as constraining development.<sup>10</sup> One of these factors was Urambo's isolated location. Except the train to Kigoma and Tabora/Dar es Salaam, no goods transports can be regarded as regular through out the year. Water shortage is also a serious problem in the eyes of most villagers. Many interviewees spontaneously brought up electricity. Lack of reliable electricity was often given first priority in the row of development constraints.

#### ***4.1.3 Energy in Urambo prior to the cooperative formation***

Availability of fuelwood in Urambo district is not a problem for the time being, and it is by a wide margin the most frequently used fuel for cooking. Government staff and

<sup>8</sup> Rains missed out in Urambo for 1992 and 1993.

<sup>9</sup> The authors' very subjective measure.

<sup>10</sup> Mwaipopo R., *Study on attitudes towards electrification: Urambo*, Dar es Salaam University, 1993.

businessmen sometimes use charcoal and kerosene to supplement their cooking energy needs. Both these fuels are easily available.<sup>11</sup>

Apart from being a supplementary fuel for cooking, kerosene is used for lighting and for running refrigerators. Refrigerators are rare. Only some bars, the hospital, and some of the richer households have them. Lighting though, is widely spread. Small-scale industrialists as well as bigger institutions have in some cases defrayed small diesel generator sets to meet their electricity needs. They are typically used for pumping water, pumping diesel, running milling machines, etc. Some of the larger institutions run their diesel generating sets also for lighting, fans or other electrical appliances. In 1993, a small consumer group enjoyed electricity supply from a common generator, see 3.5.

Most of the people of Urambo were well aware of electricity and its possibilities when this project started in 1993. A study on attitudes towards electricity was carried out in Urambo as part of the pilot site evaluation study. To those who had no personal experience of electricity, energy coming via the grid appeared clean and comfortable. From those who have some experience of electricity supply the comments were naturally much more varying.

Up to the date of the study on attitudes, no one in Urambo had been able to rely exclusively on electricity for any specific application, due to unreliable or insufficient supply. However, it was found that most people were positive to electricity bringing socio-economic benefits to Urambo. No one then explicitly expressed fear for physical danger related to electricity use being increased, or worried about access to electricity increasing social inequity in Urambo.

Compared to other sources of energy, most people regarded electricity as having higher ranking. Owners of shops and guesthouses were the most devoted users. Their interest can be explained by the fact that they benefit business-wise from having electricity. Other institutions prioritised electricity as a symbol of status rather than for direct profit.

Common for all electricity consumers in Urambo interviewed in 1993, was their disappointment with the low power supply quality. Many consumers suffered from voltage drops meaning their equipment did not function. Refrigerators, cookers, TVs and tape recorders became mere furniture. Not only was the tension too low in voltage when supplied, it was also irregularly supplied. Frequent breakdowns in the system and poorly scheduled load shedding in the distribution area, made power supply unreliable to its consumers.<sup>12</sup>

#### **4.2 Formation of the Urambo Electric Consumers Co-operative Society**

After an investigation of the situation in Urambo, summarised in section 3.5, TANESCO and SEI agreed to select Urambo as the first pilot project for local management of electric power supply.

As explained in section 3.5, Urambo was already electrified when the pilot project on local management was initiated. During the period 1985-1992 electricity was

---

<sup>11</sup> Katyega M. and Sumari C., 1994.

<sup>12</sup> Mwaipopo R., 1993.

provided by the Urambo District Council (UDC). When lack of funds made it necessary to terminate the operation of the power plant, an electric consumers committee (UECC) was formed which continued the operation. The arrangement was quite informal and there were several ambiguities as regards the rights and responsibilities of UDC and UECC. There is no doubt however that the existence of an organisation with some experience from at least partial local management of electricity supply facilitated the implementation of the pilot project.

Discussions between the district commissioner of Urambo and representatives from SEI, TANESCO and UECC held in June 1993, identified the following problems as preventing sustainable development of the electricity supply in Urambo:

- The status of the power plant, with only one gen-set operational;
- Unclear responsibilities as regards maintenance and service of the power plant;
- Unclear responsibilities of UECC with respect to the consumers of electricity;
- Unclear responsibilities of TANESCO for maintenance and service of the system;
- Lack of competence in Urambo for service and maintenance of the power plant and the transmission/distribution system;
- Uncertainties about the obligations of the consumers.

The representatives from SEI and TANESCO suggested that a more formalised management approach should be tried, where the full responsibilities for the service should be taken over by a cooperative and all the consumers would be members. The rights and obligations of the cooperative and the members/consumers should be stipulated in the by-laws for the cooperative. The ownership of the existing equipment should be taken over by the cooperative by an agreement with the District Council. By special agreement with TANESCO, the cooperative should be able to call upon TANESCO for technical and administrative support. If these conditions were fulfilled, SEI would be able to finance the rehabilitation of the power plant, some extension of the distribution network to make connection of the hospital and the industrial area possible, training of operators, costs for initial TANESCO support to the cooperative and monitoring of the performance of the new organisation, through funds made available by SIDA for initiation of pilot projects on new approaches to management of rural power supply.

The proposal was accepted in Urambo and following Tanzanian praxis, a provisional development committee was selected at a cooperative formation seminar in July 1993. This committee was to act until a Cooperative Development Committee could be elected at the first general meeting of the members. With inputs from the DC, the members of the former UECC and five others formed a committee. The hastily organised provisional development committee for Urambo Electric Consumers Co-operative became responsible for:

- The first contacts with TANESCO and SEI concerning development of conditions for the pilot project;

- Design of preliminary operation and accounting procedures for the activities;
- Fixing a preliminary tariff;
- Managing immediate services required by consumers, such as connections and disconnections;
- Drafting of by-laws and agreements with TANESCO;
- Arranging for registration of the cooperative;
- Arranging for the first regular members meeting.

The by-laws for UECCO and the contract between UECCO and TANESCO were formulated with reference to guidelines from NRECA as well as the Swedish Electricity Association and with influential inputs from the Legal Secretary of TANESCO. Simultaneously with the cooperative formation, it was expected that the District Commissioner would approve to an ownership transfer of the equipment at the powerhouse. This turned out to require comprehensive negotiations with the local government, a process in which the development committee played a central role.

Following recommendations from the Legal Secretary of TANESCO, and with the approval of the provisional committee, three trustees<sup>13</sup> were nominated to support the cooperative in legal matters, etc.

The Urambo Electric Consumers Co-operative Society, UECCO, was officially registered in September 1993. The by-laws are included as appendix C and the proposed cooperation agreement between UECCO and TANESCO as appendix D. It was decided to set the membership fee at 5000 TAS. Each member must also buy at least one share of 7000 TAS<sup>14</sup>

The ownership of the equipment was transferred to UECCO without any fee on Wednesday December 1, 1993 following signing of a hand-over contract between Urambo District Council and Urambo Electricity Consumers Co-operative. This arrangement was authorised by the Budget and Planning Committee of UDC meeting of July 30, 1993 (54/93), where Mr Robert Mgalula, Chairman of UDC and Mr Tessua, District Executive Director of UDC were present.

Since then, UECCO's Development Committee has been responsible for the maintenance, operation and development of the Urambo power system.

The provisional development committee performed well in most respects but appeared to have difficulties to mobilise the consumers as active members of the cooperative. The reasons for these difficulties are not clear but it is reasonable to

---

<sup>13</sup> Mr. Samuel Sitta, Member of Parliament, Urambo, Mrs Esther Masunzu, Assistant Commissioner for Energy - Electricity at the Ministry of Water, Energy and Minerals and Mr Masanja, Regional Development Director at Tabora.

<sup>14</sup> In 1994 the membership fee was equivalent to about 10 USD and one share to 14 USD.

assume that the consumers hesitated to commit themselves too much before it had been demonstrated that the service could be maintained with an acceptable quality.

The first annual general meeting of the cooperative was held on February 25, 1995, whereby a new Co-operative Development Committee with six members was elected. Five of the members had also been members of the provisional committee.

#### ***4.2.1 Transfer of responsibilities for the power plant and distribution network***

As discussed earlier in section 3.5 and 4.1 above, the power plant initially belonged to UDC and the distribution network was donated by TANESCO. The power plant is located in the District Engineer's yard. Following signing of the hand-over contract between UDC and UECCO, the conditions and responsibilities imposed on UECCO were the following:

- The generating sets and plant will be owned by UECCO within Urambo District only;
- At anytime, UECCO cannot sell the generating sets or plant without the written approval of UDC;
- UECCO will regularly provide to UDC the plant's technical status report using inputs made available by TANESCO via the established TANESCO service contract;
- UECCO can use the plant as collateral to solicit a loan from any reputable bank for development purposes provided UDC is fully involved in such moves.

(See also Agreement, Appendix I)

In view of the above, the transfer was free of charge, smooth and very generous. So far, there has been no major problems regarding ownership of the plant since the transfer was made, thanks to the wise leadership in Urambo local government and UECCO.

### **4.3 Rehabilitation of the power plant**

#### ***4.3.1 Status of the power plant in 1993***

The Urambo power plant, commissioned in 1985, consists of three identical gen-sets with Caterpillar diesel engines rated at 85 kW connected to a 500 kVA step up transformer 0.4/11 kV. The diesel engines were in poor condition in 1993. One had a cracked cylinder block, and only one out of three fuel injector pumps was functioning. Another problem was oil leakage. Voltage regulators and other electrical equipment in the generators were missing, thus making it impossible to synchronise two generator sets. Frequency regulation is manual. A control panel with instruments for determination of voltages and currents in the three phases is available. A kWh-meter measures the energy delivered to the grid. In 1993, the energy meter was not properly installed and did not measure accurately until in late 1995 when it was reinstalled.

#### ***EMBED 4.3.2 Rehabilitation of the generator sets***

After inspection of the power plant by engineers from TANESCO Tabora, a list of spare-parts needed for complete rehabilitation of the plant was prepared. After contacts with spare-parts suppliers in Europe, the costs for the spare-parts was estimated to 29 000 USD. Major costs were a new cylinder block, a new fuel injector pump and an alternator for battery charging.

SEI ordered the spare-parts and arranged for their delivery to Tabora. TANESCO, through the Tabora office, carried out the rehabilitation of the power plant. The rehabilitation was started in early 1994. At that time, the service was no longer functioning since all the gen-sets had been grounded.

The first gen-set that was completely renovated was used to start regular operation in June 1994. By the beginning of 1996, two gen-sets had become operational.

For the third unit, it had been found necessary to service the injector pump at an estimated cost of 2 500 USD. Also the alternator of the third unit was found to need servicing at a cost which is still unknown. It was decided that rehabilitation of the third gen-set would not be carried out and instead a new 108 kW gen-set would be purchased. The purchase of the new gen-set was initially delayed by formalities regarding exemption from import duties by Treasury in Tanzania. After finally having sorted out this problem, the new gen-set was ordered in October 1997 and was installed in February 1998.

#### **4.4 Rehabilitation and extension of the distribution grid**

##### ***4.4.1 Status of the distribution system in 1993***

The existing distribution network when UECCO took over responsibilities could generally be described as satisfactory according to TANESCO standards. There were some shortcomings in the low voltage parts of the network. Some single-phase lines were too long (sometimes up to 1 km) which caused unacceptably low voltage at the most far off consumers. Also, in some cases the pole spans exceeded recommended standards with risks that the ground clearance of the lines was too low.

The distribution system covered the residential areas along the road from the DC office to the police station and further to the railway station, see fig. 4 with a map of Urambo. There were three transformers, all rated at 50 kVA, namely at the DC office, at the police station and at the railway station (called town transformer). About 87% of the load had been connected to the Town transformer and the balance essentially to the police station transformer.

The system did not extend to the industrial area, the tobacco-go-down, the hospital or the teachers college. As a consequence, the possibilities for productive use of the electric power were very limited.

##### ***4.4.2 Extension of the distribution grid***

Upon request from UECCO, it was decided to extend the 11 kV network to include three new transformers:

- Hospital                      50 kVA
- Industrial area              100 kVA

- Tobacco-go-down 50 kVA

This work was completed in October 1994. Further, between October 1995 and July 1996, additional 0.2 km of medium voltage 11 kV line to Boma Village, one substation of 100 kVA and 0.9 km of low voltage line was erected.

TANESCO and SIDA have shared the costs as follows:

Tanesco	29 400 USD
SIDA	<u>22 000 USD</u>
	51 400 USD

At the end of 1996, the distribution network included about 4.2 km of medium voltage 11 kV lines, 6.2 km of low voltage 0.4 kV lines and 7 substations. The transformers at the railway station and the industrial area had then been switched. The 11 kV grid is shown in fig. 4.

#### **4.5 Training of personnel**

The provisional development committee estimated that it was necessary to employ two operators and one accountant.

The two operators were recruited in consultation with the TANESCO, Tabora Office. A three weeks course training was arranged for them at TANESCO, Kigoma on SEI's expense, see Appendix E. The training lasted from December 4 to 27, 1993.

For reasons discussed further in section 5.4, these two operators left UECCO, which had to employ 3 new ones. Two weeks training of one operator at a time was done at Tabora beginning the following dates: June 26, 1995, July 17, 1995 and July 13, 1997.

The first accountant employed by UECCO was trained at TANESCO, Tabora during November 1 to 14, 1994.

#### **4.6 Service agreement**

It was obvious to all parts involved that UECCO would not be able within a foreseeable future to build the capacity required for specialised service and maintenance work in the power plant or on the transmission and distribution system.

The staff at the TANESCO-Tabora regional office, located 83 km from Urambo have all the necessary qualifications and had been engaged in the rehabilitation of the power plant as well as rehabilitation and extension of the transmission/distribution system. It therefore appeared that the best solution for UECCO would be to make an agreement with TANESCO for continued technical and administrative support.

Such an agreement was prepared, see appendix D, but had not yet been signed by TANESCO in July 1997. In essence, TANESCO declares that the necessary technical and administrative support will be provided when requested by UECCO and that this service will be charged at actual cost.

#### 4.7 Metering of consumption

Before the management of the system was taken over by UECCO, individual metering of the consumption was not practised. Only the total supply could be metered at the powerhouse. Payment for the service was based on a flat rate, which was different for different categories of users.

Since meters were not available, UECCO had to continue with the same approach. The system was however considered unfair by many of the consumers. UECCO therefore requested assistance with installations of meters. SEI accepted to provide meters on the condition that the cost for the meters should be included in the tariff, to be paid within 5 years with an interest of 10%.

Two options were offered, namely regular single-phase meters or circuit breakers. Two ratings for the circuit breakers were offered, namely 1A (adequate for a nominal load of 220 W<sup>15</sup>) and 2A (adequate for a nominal load of 440 W).

The investment required for an installation with a single-phase meter, a fused cut-out, a meter board and meter box was found to be 166 USD (including installation), whereas for installation of a circuit breaker, a fused cut-out and a meter board was 34 USD. The monthly payments for the consumers would be equivalent to 3.67 USD/month for the meters and 0.75 USD/month for the circuit breaker.

Through the provisional cooperative development committee, the consumers in Urambo were informed in April 1995 about the implications of choosing a meter or circuit breaker. With a meter, a consumer would have to pay a higher fixed charge, which including a meter reading charge of 300 TAS would amount to 4.25 USD/month. On the other hand there would be no risk for overcharging if the actual load would be less than estimated. With a circuit breaker, the monthly fixed charge would be less, equal to 0.75 USD/month, but if the load would not be constant and equal to the nominal capacity of the circuit breaker, the flat rate would lead to some overcharging. For the flat rate tariff, SEI had recommended UECCO to charge 0.28 USD/kWh. It appeared that consumers that could not manage with a circuit breaker for 2 A, i.e. with a load exceeding 440 W, would probably benefit from a meter since the load factor had to be above 78% to make the circuit breaker more attractive. For a load of 220 W, the load factor had to be below 53% to make the meter the cheapest solution.

Before ordering the meters, the consumers were asked about their preferences. Meters were preferred by 68 consumers, 2A circuit breakers by 15 consumers and a 1A circuit breaker by one consumer. When the equipment was to be installed, it turned out that all the consumers wanted meters. Since only 75 meters had been ordered, some consumers were still being un-metered at the end of 1995.

The situation in July 1997 was that 95 consumers were metered, 6 were un-metered flat rate consumers and 23 consumers had been temporarily disconnected. Of the consumers on flat rate three were places of worship and two commercial consumers.

---

<sup>15</sup> Tests carried out with circuit breakers of the type purchased, manufactured by Legrand and marketed by ELFA AB in Sweden showed that the breakers could take a load of 360 W for more than 2 hours but were activated to disconnect the load within 10 - 50 seconds if the load exceeded 460 W.

Also the streetlights were on flat rate. There was no consumer premise with a circuit breaker.

#### **4.8 Tariffs**

Due to lack of meters UECCO was forced to continue to use the flat rate system when it commenced its services in 1993. Four tariff categories were used. The residential category was limited to houses used only for residential purposes. The commercial category included shops, bars, restaurants and small workshops. In most cases, part of the consumption is used in the private quarters of the owner. Guesthouses were a separate category. Institutions included the DC office, NBC and FDC.

The original tariff was computed on basis of the estimated number of light sources and ability to pay. The revenues were expected to cover costs for the fuel and lubricants only. The flat rate tariffs have been adjusted on several occasions, see section 5.8, as a consequence of increasing fuel prices and the obvious need to cover other operating costs of the cooperative. As discussed further in section 5.6, it is obvious that most consumers consumed more electricity than assumed when the flat rates were determined. The flat rates therefore resulted in large operational deficits. This was the reason why UECCO asked for assistance with installation of meters.

After installation of meters, the consumers are charged per unit consumed. The development of the tariff is shown in table 5-15, which also allows a comparison with TANESCO tariffs.

#### **4.9 Installation of energy efficient lights**

Since most of the load in Urambo is for lighting and since the generation cost is relatively high, it was believed that energy efficient lamps in form of compact fluorescent lamps (CFLs) could be an attractive option to the conventional incandescent lamps. The CFLs consume about 25% of the electric energy for the same light output in lumen. Use of CFLs would therefore make it possible to increase the number of consumers by roughly a factor of four without increasing the generating capacity. Advantages and disadvantages of energy efficient lamps are more thoroughly discussed in chapter 7.

Despite the much higher price for CFLs, the consumers might also be able to reduce their cost for lighting. A crucial issue is then the lifetime of the CFLs in the environment of Urambo in comparison to the lifetime of the much cheaper incandescent lamps.

With the purpose of studying this, 84<sup>16</sup> CFLs were installed in Urambo between September 29 and October 2, 1994. The lamps were of four types, with pin type fittings and screw fittings and with external electromagnetic ballast and integrated electronic ballast. The power ranged from 9 to 25 W. Table 4-2 shows the number of lamps of each type that were installed. In total 13 consumers were selected by UECCO for trying the CFLs. These consumers were instructed not to remove the lamps as long as they performed satisfactorily and make a note of the date of failure.

---

<sup>16</sup> Philips in the Netherlands provided the CFL lamps free of charge.

**Table 4-2 Type and size of the CFLs installed in Urambo**

CFL installed (W)	Incandescent removed (W)	Type of holder	No of pieces	place installed
PL-EC (9)	40	B22	10	Sittingroom, bedroom and corridors
PL-EC (15)	75	B22	11	Sittingroom, bedroom and corridor
SL (18)	75	B22	10	Sittingroom, corridor and security
SL (25)	100	B22	9	Corridor, street-light and security
PL-EC (9)	40	E27	11	Sittingroom, bedroom and corridors
PL-EC (15)	75	E27	12	Sittingroom, bedroom and corridor
SL (18)	75	E27	10	Sittingroom, corridor and security
SL (25)	100	E27	11	Corridor, street-light and security

Source: Gwang`ombe F., 1995.

## 5. EVALUATION OF EXPERIENCES FROM THE FIRST PILOT PROJECT

### 5.1 Monitoring activities

SEI and TANESCO have followed the progress of UECCO through correspondence with the UECCO chairman. Teams from SEI and TANESCO have also visited Urambo on the following occasions to collect data and discuss the progress with representatives of UECCO:

1992	January	Visit by TANESCO team for fact collection
	December	Visit by TANESCO team for tariff study
1993	June	Visit by SEI/TANESCO team for discussion on formation of the cooperative
1994	June	Visit by SEI/TANESCO team for progress review
	July	Baseline sociological study by University of Dar es Salaam;
	September	Visit by SEI/TANESCO team for studies of load distribution;
	December	Visit by SEI/TANESCO team for progress review
1995	June	Visit by SEI/TANESCO team for progress review
1996	February	Visit by SEI/TANESCO team for progress review
	June	Visit by SEI/TANESCO team for progress review
1997	February	Visit by SEI/TANESCO team for progress review
	May	Visit by TANESCO team for progress review
	August	Visit by SEI/TANESCO team for progress review Sociological follow-up study by University of Dar es Salaam

## **5.2 Management and organisation of the Cooperative**

The history of the formation of UECCO is summarised in section 4.1.

It is clear that most of the electricity users were not much involved in the formation and initial operation of the Cooperative. In the sociological baseline study made in 1994<sup>1</sup>, it is speculated that the formation of the cooperative was imposed on the electricity users, who, even if they were not negative to the idea should have been given more time to consider the options.

The provisional Development Committee did not give high priority to make the consumers more engaged in the management of the cooperative. It was not until after SEI made it a condition for further financial support<sup>2</sup> that the first annual general meeting was called and all the consumers were made to become members and shareholders.

After the first annual general meeting of the Cooperative in February 1995, general meetings of the cooperative as stipulated in the by-laws have never been convened. One of the reasons is that there has been nobody to prepare audited annual accounts for the years 1995 and 1996. The District Cooperative Officer was supposed to do this but it had not yet been done in July 1997. Without audited accounts, the Cooperative Development Committee decided to postpone the general meetings for all members. However, the Cooperative Development Committee has been meeting several times each year to review tariffs, meet political and other officials as well as discuss how to run the Cooperative.

There should be no doubt that the Cooperative Development Committee has experienced greater difficulties than necessary because of delays in provision of assistance promised by SEI. The rehabilitation of the first two generator sets required much more time than anticipated. As a consequence, the service was interrupted during the first part of 1994. This obviously made it difficult for the Committee to make the consumers commit themselves by becoming members of the Cooperative. Uncertainty about the future of the cooperative is probably an important reason why the provisional Development Committee hesitated to call members to a general member meeting during 1994.

The delay in the installation of the meters has contributed to the financial difficulties of the cooperative, see section 5.9. The meters were expected to be installed in March 1995 but the installation was not completed until September 1995.

The complete rehabilitation of the power plant has still not been carried out, for reasons explained in section 5.3 but this does not seem to have caused any real problem since any of the two rehabilitated generator sets is able to take the full load after the drop in load following meter installation, see further section 5.6.

Managerial problems are common in local organisations for self-management of power-supply<sup>3</sup>, see also section 2.1. The electricity cooperative in Urambo with its

---

<sup>1</sup> Mvungi A. and Sanga A., 1995.

<sup>2</sup> See agreement between SEI and UECCO, December 13, 1994.

<sup>3</sup> Gerger Å. and Gullberg M., 1997.

nature of a pilot project has developed under influence and preconditions as set by TANESCO, SEI and general Tanzanian laws.

The management guidelines in the by-laws of UECCO may be reasonable and have formally been accepted by the members of the Cooperative. The obvious deviations from the rules regarding preparation of annual audited accounts and arrangement of annual members meetings can partly be explained by the initial difficulties the Cooperative Development Committee has faced. The deviations can also indicate that the members of the cooperative and in particular the Committee does not find these rules very important.

The Cooperative Development Committee may have acted in the best interest of the cooperative and its members when it has given higher priority to management of the daily operation and keeping up the supply of electricity. Still, the negligence to fulfil the obligations which shall ensure control of the finances and provide the members with possibilities to influence the development of the Cooperative puts the survival of the cooperative at risk.

It appears that efforts are required to inform the Cooperative Development Committee of UECCO and Development Committees of new electrification cooperatives about the importance of independent auditing and arrangement of members meetings.

### **5.3 Rehabilitation and operation of the power plant**

#### ***5.3.1 Rehabilitation of the generator sets***

The situation before rehabilitation is summarised in section 4.3.2 where also the procedure for rehabilitation is outlined. As mentioned there, the cost for the spare-parts that had been identified by TANESCO to be required for the rehabilitation was 29 000 USD.

However, as the rehabilitation progressed, further needs for spare-parts were identified in smaller portions. By the end of 1995, spare-parts totalling 55 935 USD had been supplied. Two of the gen-sets had then been successfully rehabilitated.

Besides being expensive, the rehabilitation also turned out to be very time consuming. Part of the problem was the difficulties with communication from TANESCO's Tabora office, via SEI to the supplier of the spare-parts, UNATRAC in Great Britain. What in particular made the rehabilitation difficult is the fact that the gen-sets in Urambo are of a type that is not any longer manufactured. On several occasions, the spare-parts, which were delivered after a long waiting time, turned out not to fit and had to be returned.

In retrospect it is obvious that rehabilitation of the existing gen-sets has not been cost effective. A new gen-set of 108 kW, with possibilities for parallel operation is available for 21 400 USD c.i.f. Dar es Salaam. Even if freight to Urambo and installation must be added, purchase of three new diesel gen-sets would certainly have given more value for the money.

### 5.3.2 Operation and maintenance of the generator sets

Electricity is generated for four to five hours per evening. The operators in Urambo keep logbooks where operating data are recorded every 30 minutes. The logbooks include notes about fuel filling and service made to the generator sets. The logbooks are in good order and give useful information about the operating experiences.

Table 5-1 shows the number of operating hours for the rehabilitated gen-sets n:o 1 and 2 during the period July 1994 - June 1997.

**Table 5-1 Operating hours for rehabilitated gensets**

Period	Genset 1	Genset 2
1994		
July-Dec	622	10
1995		
Jan-June	209	497
July-Dec	337	36
1996		
Jan-June	127	697
July-Dec	0	934
1997		
Jan-June	0	874
Total after rehabilitation	1 295	3 048

The plant operators have carried out minor service jobs like filling and the change of lubricating oil. For more demanding tasks, assistance has been called in from TANESCO Tabora. After completion of the rehabilitation, this has happened on the following occasions:

1995	Dec	Two fitters, one electrical technician;
1996	March	One diesel technician, one fitter, one electrical technician;
	Sept	- Two fitters, one electrical technician;
1997	July	- One mechanical technician, one fitter, one electrical technician.

Each visit has lasted for two-three days. There has been no documentation of work done, but routines have been amended meaning that these will be pursued henceforth, both at TANESCO Tabora and UECCO. In August 1997 it was agreed that UECCO should open a repair logbook in order to keep track of the repairs that are made.

The status of the generator sets in August 1997 was as follows:

Unit 1	-	The unit was rehabilitated. It was grounded since February 1996. It could run but could not take any load. Problem with injector pump suspected; <sup>4</sup>
Unit 2	-	Operational but with oil leakage;

<sup>4</sup> The injector pump was sent to Dar es Salaam twice for service. When first serviced TANESCO Tabora failed to install it properly (manuals were not available). When serviced again UAC installed the pump. It is now suspected to have failed once more.

Unit 3 - Cannibalised for spare-parts. Will be replaced by new unit.

It is obvious that the regular maintenance of the two rehabilitated generator sets is not carried out as planned. There is no reason that one generator set shall be kept grounded for more than a few months if the service agreement with TANESCO is functioning properly. The problem is however that the agreement has not yet been signed by TANESCO (see section 4.6). As a consequence there has been no formal basis for TANESCO Tabora to provide service to UECCO. The service that has been provided after completion of the rehabilitation has been limited to occasions when the generation has stopped in Urambo. When this was brought to attention in August 1997, steps were taken to make the service agreement operational.

### ***5.3.3 Specific fuel and lubricant consumption***

The costs for fuel and lubricants are a dominating part of the costs for electricity supply in Urambo. For this reason, the specific consumption of fuel and lubricants, i.e. the consumption per generated unit of electricity, is of large interest.

The specific fuel consumption of gen-set No. 1, the first gen-set to be rehabilitated was measured by a SEI/TANESCO team on December 6 1994. The electric energy generated was estimated by reading the kWh meter at the powerhouse. The fuel consumption was determined by topping up the fuel tank before the test and measuring the amount of fuel needed for topping up after the test. The gen-set was operated for four hours, between 7.15 and 11.15 p.m. During that time 282 kWh were generated and 109 litres of fuel consumed. For an average power output of 70.5 kWh, the specific fuel consumption was found to be 0.39 litres/kWh.

The operators of the plant keep daily records of the filling of fuel and lubrication oil as well as the generated kWh. Table 5-2, which has been generated from these data, shows the recorded consumption of fuel and lubricants and the calculated specific consumption for the period from July 1994 to June 1997.

**Table 5-2 Specific fuel and lubricant consumptions**

Period	Generation kWh	Average load kW	Fuel consumption		Lubricant consumption	
			liters	liters/kWh	liters	liters/kWh
1994						
July-Dec	39690	62.8	13550	0.34		
1995						
Jan-June	45450	64.4	17470	0.38	104	0.0023
July-Dec	17920	48.0	6725	0.38	47	0.0026
1996						
Jan-June	30300	36.8	11620	0.38	44	0.0015
July-Dec	32380	34.7	14580	0.45	136	0.0042
1997						
Jan-June	31620	36.2	14285	0.45	115	0.0036

The data show a stepwise increase in the specific fuel consumption by about 20% from the period July-December 1996. An increase of the specific fuel consumption by 5-10% is not unexpected when the average load drops from about 75% to about 40%. The recorded increase is somewhat more than would be expected for this reason and the time of the increase of fuel consumption is not coincident with the drop in average load.

Since the increased fuel consumption has a significant effect on the cost of generation and consequently on the tariff, it will be necessary for TANESCO Tabora to look into the problem as soon as the formalities regarding the service agreement have been sorted out.

It should be noticed, however, that a specific fuel consumption of 0.45 litre/kWh is comparable with data for TANESCO diesel plants collected during the survey in 1989-1990.<sup>5</sup> The specific fuel consumption in Ikwiriri, which then operated a generator set of 150 kW was 0.47 litres/kWh. For the six power plants operating 1500 rpm generator sets visited during that survey, the specific fuel consumption range between 0.43 litre/kWh (Babati) and 0.72 litre/kWh (Chamvino).

#### 5.3.4 Supply reliability

An important measure of the quality of electricity supply is the supply reliability. On basis of the operating records from 1991 to June 1997, the outage hours and the availability can be determined as shown in table 5-3.

**Table 5-3 Operating records for Urambo power plant**

Period	Scheduled hours*	Outage hours	Availability %
1991	1 646	234	85.8
1992	1 531	275	82.0
1994 Jul - Nov	612	118	79.9
1995 Jan - Dec	1 460	183	87.5
1996 Jan - Dec	1 830	70	96.5
1997 Jan - Jun	905	50	94.5

\* The plant is occasionally operated for more than the scheduled hours. This has not been credited here.

From January 1995, the availability has been 92.8%. This must be regarded as acceptable considering the circumstances. The performance is comparable to small isolated diesel plants of TANESCO, although it appears that Urambo presently have slightly better records than recently observed TANESCO-managed isolated diesel generation plants. In Babati, which is a TANESCO-managed isolated diesel generating plant with three operational units, power outages due to technical problems totalled 107 hours during 1988.<sup>6</sup> The three sets together thus supplied electricity at 82% availability.

<sup>5</sup> Kjellström B. et al., 1992.

<sup>6</sup> Kjellström B., Katyega M. and Kadete H., *Report on a technical fact collection visit to Babati, Arusha region 11 to 19 July 1989* (Table 5-1). SEI 1990 (EE&D series no.2).

At Urambo the availability has suffered from the fact that initially only one and later two generator sets have been made operational. It is also notable that the availability was improved in 1995 if compared to 1994, since many of the outages during the period July - November 1994 were direct consequences of ongoing repair work. Outages caused by system overload became increasingly frequent in the end of 1994. It is suspected that the overload was caused by some unauthorised industrial activities such as welding. The overload problem disappeared when meters were installed in the second half of 1995. In Urambo, the supply reliability will be considerably improved with three operational sets. Assuming 80% availability for all sets, the probability of a complete loss of capacity will be less than 1% with three sets operational, and 4% with two sets operational.

## 5.4 Rehabilitation, extension and operation of the distribution network

### 5.4.1 Rehabilitation and extension

Personnel from TANESCO Tabora carried out the rehabilitation and extension of the distribution network. Technically, there have been no problems with this part of the project.

### 5.4.2 Load distribution

Studies of the load distribution in the system have been carried out on two occasions, in July 1994 by Andersson<sup>7</sup> and August 1997 by Daati<sup>8</sup>. In 1994 only two transformers were connected. As shown in table 5-8 the average measured load was then about 71 kW, with the town transformer carrying the major part or 62 kW. The balance between the phases was found to be reasonably even, see table 5-8.

In August 1997, the total average load on the transformers was determined to 33 kW. The load distribution determined in August 1997 is shown in table 5-4.

**Table 5-4 Load distribution in Urambo August 1997**

Transformer location	Rated capacity (kVA)	Average load (kW)	Phase loads (kW)		
			R-Y	Y-B	R-B
Town	100	22.21	11.20	2.03	8.98
Tobacco godown	50	1.82	0.88	0.60	0.34
Industry area	50	0.27	0.19	0.04	0.04
Boma village	100	6.17	6.09	0.04	0.04
Bomani	50	2.62	0.02	0.70	1.90
Police	50	disconnected			
Hospital	50	disconnected			
		<b>(Total: 33.09)</b>			

The load is small in comparison to the connected load of about 172 kW, see further discussion in section 5.6.

<sup>7</sup> Andersson E.C., 1994.

<sup>8</sup> Daati, 1997.

The measurements showed that the load was not well balanced in most of the transformers. The loads are however generally much less than the rated capacity of the transformers. Balancing of the loads will not be an easy task since the connected loads are so much larger than the actual loads.

#### ***5.4.3 Power supply quality***

Measurements of the power supply quality were carried out in early September 1997. The measurements were done at nine consumers who participated in the field testing of compact fluorescent lights (see sections 4.9 and 5.10 for more details). The voltage measurements showed values between 236 and 212 V which is 2 to 12% below rated voltage of 240 V. The lower values are just outside the TANESCO standard of  $\pm 10\%$ . The frequencies ranged between 47.3 and 44.1 Hz, i.e. 5 to 12% below rated frequency.

#### ***5.4.5 Maintenance of transformers***

An inspection of the transformers in August 1997 indicated neglected maintenance. Some of the fuse houses were broken. In each of the Town and Bomani transformers one cartridge fuse was missing and the corresponding line was directly connected to the customers. This is a dangerous practise since any direct contact between the live line and the neutral/earth wire may lead to burning of consumer appliances and even damage to distribution lines and transformers.

### **5.5 Personnel**

The cooperative has had difficulties recruiting qualified and reliable personnel for operation of the power plant, minor lines work and administrative tasks.

The two initial operators, coming from Tabora, who were trained by TANESCO, see section 4.5, left in late 1994 after conflicts with the provisional Development Committee. One of the operators was fired after allegations for diverting fuel and the other left voluntarily because he feared a similar fate. It has not been possible to confirm that fuel was in fact diverted. It is therefore quite possible that there were other, perhaps personal reasons, for the conflict that led to the loss of the first two operators.<sup>9</sup>

Three young men from Urambo were then selected by the provisional Development Committee to succeed the initial operators. Initially these three received on the job training by TANESCO staff that were engaged in the rehabilitation of the generator sets at Urambo. They later received further training at Tabora and Kigoma by TANESCO that was financed by SEI. One of the two operators quit in February 1996, because his family moved from Urambo. Another young man had replaced him. The fairly good operating records of the plant indicate that the training of the operators has been adequate.

For almost a year after registration, the Cooperative had no accountant. The Secretary of the provisional Development Committee was then responsible for collection of revenues and payment of bills. There appears to have been no regular book keeping during this period. After recommendations from SEI and TANESCO,

---

<sup>9</sup> Both soon became employed by TANESCO.

an accountant was employed in August 1994. Training, funded by SEI, was carried out by TANESCO-Tabora during two weeks. This accountant was fired in mid 1995 after misuse of funds. One of the operators was then assigned with the task to work both as accountant and operator. This situation still prevailed in August 1997.

Salaries of personnel in February 1996 were as follows:

- Accountant/Operator (trained) 51 USD/month
- Operator (trained) 41
- Operator (untrained) 36

An anticipated benefit of introducing local management of rural power supply is that the cost for personnel can be reduced. Possible indicators for comparison could be persons employed per monthly generated MWh or average cost for personnel per generated kWh. For Urambo the number of persons employed has varied between 3 and 4 and the monthly generation between 5 and 8 MWh. Monthly salary costs have amounted to about 130 USD. Comparative data for TANESCO's isolated diesel supplied grids are difficult to find. Data presented in the evaluation of all rural diesel plants operated by TANESCO done in 1989-1990<sup>10</sup> indicate that the number of staff for operation of the system, ranges from 5 to 9 for the TANESCO plants in the capacity range up to 525 kW. The number of system operators per monthly MWh is compared in table 5-5.

**Table 5-5 Personnel for system operation in Urambo and small diesel plants operated by TANESCO**

Site	Urambo	Liwale	Ikwiriri	Babati
Monthly generation MWh	5-7.9	2.5	10	81.5
System operators	3	4	5	9
Operators/monthly MWh	0.38-0.6	1.6	0.5	0.11

A comparative study made for Mafia Island and Urambo in 1995 allows a comparison of the total number of employees and the total cost for personnel.<sup>11</sup> Table 5-6 shows a comparison of Mafia and Urambo as regards total personnel and personnel costs.

**Table 5-6 Comparison between Urambo and Mafia as regards total personnel and costs for personnel**

Site Date	Urambo late 1994	Mafia early 1995
Monthly generation MWh	7.9	120
Number of employees	4	40
Employees/monthly MWh	0.51	0.33
Personnel cost USD/kWh	0.017	0.038

<sup>10</sup> Kjellström B. et al., 1992.

<sup>11</sup> Gwangómbe F., 1995. *Technical Comparative ...*

When comparing the size of employed staff of UECCO and the costs for it with those of TANESCO's diesel plants it should be taken into consideration that:

- UECCO operates with less qualified personnel and shall buy more qualified service and maintenance from TANESCO.
- The plant operated by UECCO is located within the premises of the District Engineer, which means that no extra watchmen are necessary.

The comparison in table 5-5 indicates that the number of operators at UECCO is normal. It is not really possible to manage with less than three for a system of that capacity.

The comparison in table 5-6 shows the interesting result that the specific personnel cost is twice as high at Mafia despite a smaller number of employees per monthly MWh. The explanation is obviously the lack of overhead costs at UECCO and the lower qualifications of the UECCO staff.

## 5.6 Electricity consumers and demand development

### 5.6.1 Number of consumers and average load

Table 5-7 shows the development of the number of consumers and the total delivered average load from June 1994 to June 1997.

The number of connected consumers has increased from 67 in December 1994 to 101 in June 1997. In the same time the average load has dropped from about 77 kW to 41 kW. The average power per consumer has dropped even more from 1149 W in December 1994 to about 406 W in June 1997. This is obviously an effect of the switch from un-metered flat rate to a tariff based on metering and a charge per unit consumed.

**Table 5-7 Development of average load and number of electricity consumers in Urambo**

Time	Number of active consumers	Average system load (kW)	Average load per consumer (W)*
1994 Dec	67	77	919
1995 June	56	65	928
1995 Dec	66	43	521
1996 June	56	37	528
1996 Dec	99	34	274
1997 June	101	38	300

\* Estimated assuming technical losses in transmission and distribution of 20% and operation during scheduled hours.

During the time a flat rate tariff was used, it was impossible to know the individual consumption at the different consumers. The average monthly energy consumption per consumer can however be estimated and has dropped from about 100 kWh in the end of 1994 to about 50 kWh in June 1997.

### 5.6.2 Consumption of different consumers

Several efforts have been made to gain information about the structure of the electric load. A study made of the distribution network in July 1994<sup>12</sup> included measurements on the different phases of the two transformers that were connected at that time. The results are shown in table 5-8. Connected to the DC transformer were only 16 residential consumers with a total load of 9 kW. The average load on the town transformer was 62 kW of which two thirds was residential load.

**Table 5-8 Loads in the Urambo power system as measured in July 1994.**

Transformer-substation and phase	Town transformer				DC transformer				TOTAL
	red	yellow	blue	total	red	yellow	blue	total	
Measured average load at transformer (kW)	20.3	19.8	22.0	<b>62.0</b>	2.2	3.5	3.3	<b>9.0</b>	<b>71.0</b>
Connections:									
Institutions									
no.	-	-	1	<b>1</b>	-	-	-	-	<b>1</b>
%	-	-	4%	<b>1%</b>	-	-	-	-	<b>1%</b>
Guest houses									
no.	3	1	1	<b>5</b>	-	-	-	-	<b>5</b>
%	14%	5%	4%	<b>7%</b>	-	-	-	-	<b>6%</b>
Commercial									
no.	3	3	11	<b>17</b>	-	-	-	-	<b>17</b>
%	14%	14%	44%	<b>25%</b>	-	-	-	-	<b>20%</b>
Residential									
no.	16	17	12	<b>45</b>	6	6	4	<b>16</b>	<b>61</b>
%	73%	81%	48%	<b>66%</b>	100%	100%	100%	100%	<b>73%</b>
TOTAL									
no.	22	21	25	<b>68</b>	6	6	4	<b>16</b>	<b>84</b>
%	100%	100%	100%	<b>100%</b>	100%	100%	100%	100%	<b>100%</b>
Average load/consumer* (Watt)	923	943	880	912	367	583	825	562	845

\* Calculated average. Source of data: Emma Catrin Andersson.

In theory it should be possible to estimate the average demand for each of the four consumer categories from these data. However, the large variation of the average load for residential consumers that can be determined by the measurements at the DC transformer, to which only residential consumers are connected, shows that such an exercise would be fairly meaningless. The average load of 845 W is however significantly higher than the expected average load of 632 W that would result from the average load data assumed by TANESCO in the tariff study, see section 3.6.7.

After the installation of meters it has been possible to obtain a clearer view of the of the consumption structure. Table 5-9 shows the situation during the first half of 1997.

<sup>12</sup> Andersson E.C., 1995.

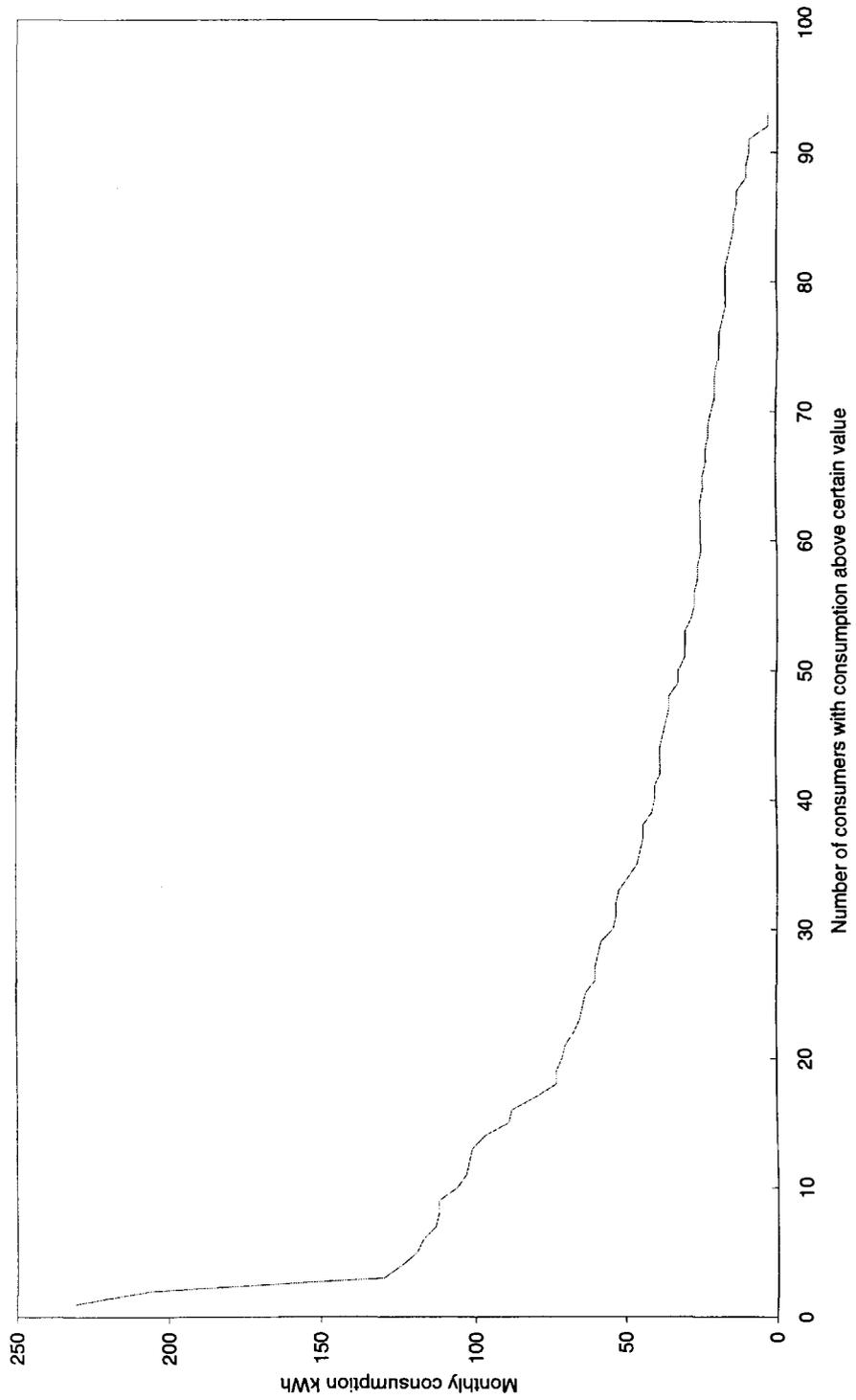
**Table 5-9 Consumption of different consumer categories in 1997**

	Jan	Feb	Mar	Apr	May	Jun
<b>Residential</b>						
Metered consumers (no.)	66.0	66.0	66.0	66.0	65.0	65.0
Metered consumption (kWh)	2370.0	2198.0	2613.0	2268.0	2170.0	2032.0
Average consumption (kWh)	35.9	33.3	39.6	34.4	33.4	31.3
Flat rate consumers (no.)	0	0	0	0	0	1.0
<b>Commercial</b>						
Metered consumers (no.)	28.0	28.0	27.0	27.0	28.0	28.0
Metered consumption (kWh)	1372.0	1476.0	1438.0	1594.0	2027.0	1948.0
Average consumption (kWh)	49.0	52.7	53.2	59.0	72.4	69.5
Flat rate consumers (no.)	0	0	0	0	0	0
<b>Institutions</b>						
Metered consumers (no.)	1.0	2.0	2.0	2.0	2.0	2.0
Metered consumption (kWh)	27.0	58.0	114.0	40.0	59.0	67.0
Average consumption (kWh)	27.0	29.0	57.0	20.0	29.5	33.5
Flat rate consumers (no.)	0	0	0	0	1.0	1.0
<b>Public</b>						
Flat rate consumers	3.0	3.0	4.0	4.0	4.0	4.0
<b>Street lights</b>						
Working street lights	6.0	6.0	6.0	6.0	6.0	8.0
Estimated consumption <sup>1)</sup>	127.0	125.0	142.0	134.0	140.0	157.0

<sup>1)</sup> Calculated from operating time and power 150 W for each lamp

Residential consumers dominate in number and consumption. The average monthly consumption is between 30 and 35 kWh. This can be compared to the domestic consumption in the Bolivian and Nepalese organisations visited. During the international survey, see chapter 2, the consumption in Bolivia ranged between 8.5 kWh/month and 78 kWh/month. In Nepal between 27 kWh/month and 127 kWh/month. On the average, the consumption in Urambo is similar to that in rural areas in these countries. Commercial consumers in Urambo show a slightly higher average consumption.

Most of the consumers consume less than the overall average monthly value, which is about 50 kWh. This is illustrated in fig. 5-1, which is valid for August 1997. Of the metered consumers 63% used less than the overall average. Only 14% used more than 100 kWh.



**Figure 5-1. Distribution of electricity consumption in Urambo August 1997**

### 5.6.3 Types of loads connected to the system

In December 1994, when the system frequently tripped because of overloads, TANESCO carried out a house-to-house survey to determine the connected loads. The number of consumers visited was 72. The total connected load was found to be 166.2 kW, with 98.5 kW as lighting load (59%) and 67.7 kW in form of various appliances. Fig. 5-2 shows how the total connected load was distributed between the 72 consumers and also how the load was divided between lighting load and other loads.

The lighting load dominated and in particular so for the consumers with a connected load below 1500 W. The shares of different appliances contributing to the connected non-lighting load are shown in table 5-10.

**Table 5-10 Load of electric appliances of different types installed in Urambo, December 1994**

Appliance	Estimated load (W)	Number	Fraction of connected non-lighting load (%)
Electric iron	1000	37	54.7
Cooker	1000 - 3200	9	20.3
Kettle	1500	5	11.1
Refridgerator/ Freezer	100 - 250	16	3.4
Fan	65 - 100	19	2.0
Radio	9 - 100	69	1.2
TV/video	100	15	2.2
Pump	2000	2	3.0

As shown in table 5-10, radios were the most commonly used appliance, owned by most of the consumers, and followed by electric irons. The contribution of radios to the connected load is however small, whereas the electric irons have a very large share of the connected non-lighting load. For peak load projections it would obviously be interesting to study the simultaneity factor for ironing.

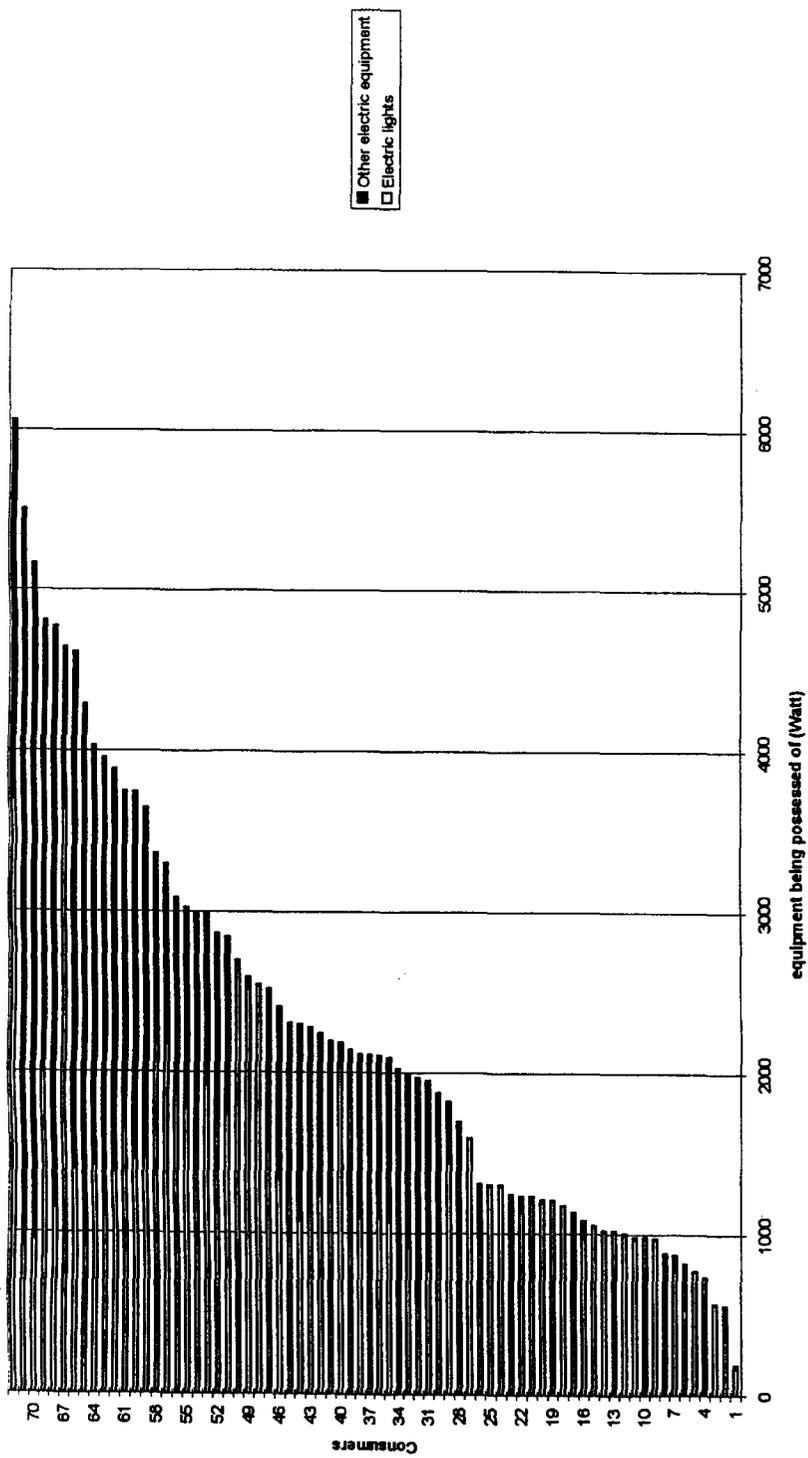


Figure 5-2. Inventory of appliances installed in Urambo, December 1994

As a preparation for the meter installation, a second house-to-house survey was carried out in May 1995<sup>13</sup>. The objective of the survey was to advise the consumers in the choice between a meter and a load limiting circuit breaker. A TANESCO representative visited all the consumers and potential consumers (not connected at the time of the survey) and discussed with them to what extent they would use their different devices when metered. On the basis of the results of the interviews, the likely future consumption could be estimated. This made it possible to assess if a meter or a circuit breaker would be the most economic choice. Also the total future load in Urambo could be estimated. The results are summarised in table 5-11.

**Table 5-11 Estimated electricity use in Urambo after the installation of meters and load limiting circuit breakers (1995)**

	Institutions	Guest houses	Commercial	Residential	All categories
<b>Number of consumers visited</b>	7	7	15	58	87
<b>Connected</b>	4	6	12	47	69
<b>Not connected</b>	3	1	3	11	18
<b>Estimated energy consumption</b>	<b>kWh/ month %</b>				
<b>Light</b>	772 91.0%	944 93.0%	828 83%	3,573 84%	6,117 86%
<b>Cooker</b>	- -	- -	- -	320 7.5%	320 4.5%
<b>Refrigerator/ Freezer</b>	24 2.8%	42 4.1%	90 9.0%	75 1.8%	231 3.2%
<b>TV</b>	10 1.2%	11 1.1%	22 0.2%	70 1.6%	113 1.6%
<b>Iron</b>	32 3.8%	2 0.2%	16 1.6%	67 1.6%	117 1.6%
<b>Radio/music</b>	6 0.7%	12 1.2%	26 2.6%	60 1.4%	104 1.5%
<b>Fan</b>	4 0.5%	4 0.4%	16 1.6%	72 1.7%	96 1.3%
<b>Kettle (heater)</b>	- -	- -	- -	24 0.6%	24 0.3%
<b>Total</b>	<b>848 100%</b>	<b>1,015 100%</b>	<b>998 100%</b>	<b>4,261 100%</b>	<b>7,122 100%</b>
<b>Average load (kW)</b>	7.1 11.9%	8.6 14.4%	8.3 14.0%	35.5 59.8%	59.4 100%

Source of data: Bosco Selemani

Lighting was going to be the dominating load, accounting for as much as 86% according to the consumers' own predictions in May 1995. The remaining 14% of the load would constitute of cookers, refrigerators or freezers, TVs, irons, radios and other music equipment, and heaters for kettles. For 80% of the consumers, a meter would be preferable over a load limiter.

The house-to-house survey in May 1995 resulted in an estimated average system load of about 60 kW divided between 87 consumers. In December the same year, when a majority of the consumers had been equipped with meters, the actual average system load was 43 kW,

<sup>13</sup> Selemani Bosco, 1995. *House to house survey: electrical load and consumption data: Urambo*, TANESCO 1995.

divided between 66 consumers see table 5-7. It has since then dropped slightly. In June 1997 the average system load was 41 kW, see table 5-7.

A third house-to-house survey was conducted in August 1997.<sup>14</sup> A total of 123 consumers were visited, out of which 23 were not connected at the time of the survey. Table 5-12 shows the distribution of the load between different appliances.

**Table 5-12 Structure of the connected load August 1997**

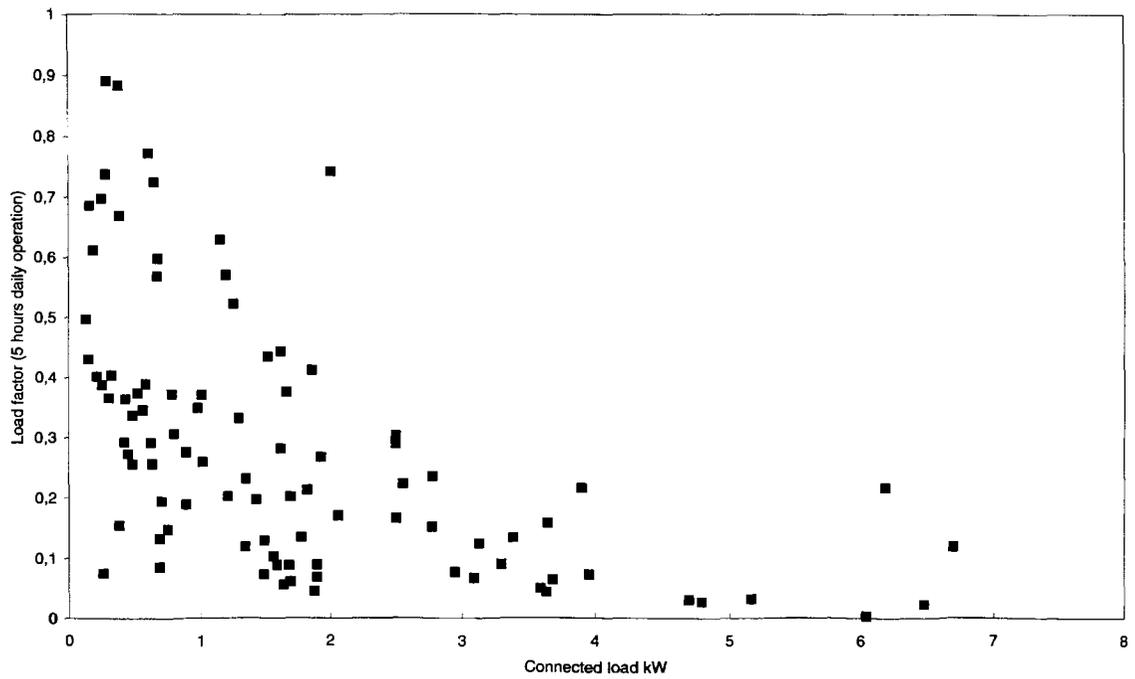
Load type	Range of load (W)	Number	Connected (kW)	Fraction of load (%)
<b>Lighting:</b>				
CFL:s	9-25	49	0.77	0.45
Light bulbs	5-100	850	37.81	22.03
Fluorescent light	20-60	308	11.64	6.78
<b>Total lighting</b>			<b>50.23</b>	<b>29.27</b>
<b>Appliances:</b>				
Electric iron	1000	40	40.00	23.30
Cooker	2000-4500	8	24.50	14.27
Kettle	2000	4	8.00	4.66
Fridge	150	25	3.75	2.19
Deep freezer	1000	23	23.00	13.40
Fan	100	45	4.50	2.62
Mixer	200	2	0.40	0.23
Shaver	10	6	0.06	0.04
Radio	40-100	75	2.95	1.72
TV/video	150	47	7.05	4.11
Pump	1400	3	4.20	2.45
Grain mill	3000	1	3.00	1.75
<b>Total appliances</b>			<b>121.41</b>	<b>70.74</b>
<b>Total connected load</b>			<b>171.64</b>	

A comparison with the results of the survey made in December 1994 shows some interesting shifts of the load structure. The total connected load has not increased much, from about 166 to 171 kW, despite the increase of the number of consumers surveyed (from 72 to 123). The connected lighting load, which dominated in 1994, has dropped from almost 100 kW to just above 50 kW. On the other hand the connected load of appliances has almost doubled from about 68 kW to about 121 kW. Radios and electric irons are still among the most common appliances, but TV/videos show a dramatic increase and are now more common than electric irons. Several appliances are found on the list for August 1997 which were not in Urambo in 1994. There was in August 1997 one small grain mill connected.

There is a large variation in the connected load between the consumers. The range is from 120 W to 6.7 kW. The survey in August 1997 revealed that most consumers did not use more than a fraction of their connected load. For some appliances, like cookers, the reason is the high cost of the electricity, for other, like refrigerators and deep freezers the reason is that the electricity is only available for about 5 hours each day. The load factor of the consumers tends to drop with increasing connected load, see fig. 5-3, which shows the load factor for 5 hours daily operation. However, in the range up to 2 kW connected load, where

<sup>14</sup> Daati, 1997.

most of the consumers are found, the load factor varies between 5% and about 80%. It therefore appears as impossible to find a useful relationship between the connected load and the actual consumption under the present circumstances.



**Figure 5-3. Load factor as function of connected load in Urambo August 1997**

#### **5.6.4 Street lights**

Streetlights were removed during 1995 because the cooperative was not prepared to cover the expense. In March 1996, after a donation from an individual at SEI, which also became a member of the cooperative, volunteering to pay for 10 streetlights, 10 streetlights of 100 W were installed.

By July 1996 all the donated lamps had been burnt out. Six were replaced and another two were installed in June 1997. The street lights were then located at the Police transformer, the Post Office, Milda guest house, Ulyankulu road, Tabora road, Majengo Kati, Urambo motel and Patel Road.

#### **5.6.5 Distribution losses and flat rate consumption**

For correct setting of the tariff it is important that the distribution losses in the system are known. Before meters were installed, it was assumed that losses are 10% but it was not possible to verify or adjust this estimate. After installation of meters, the possibilities for estimation of the distribution losses improved, but as long as there were still several consumers on flat rate (due to lack of meters) a direct determination of the losses was still not possible. During the period January to June 1997, the number of consumers on flat rate was few, and a reasonably accurate determination of the losses for this period can be made.

Table 5-13 shows a calculation of un-paid electricity. At least for budgeting purposes this must be considered as distribution losses. The data show that the un-paid electricity for the period Jan-May 1997 has been close to 20% of the generation. The drop to 16% in June is probably a result of overcharging the two new flat rate consumers.

Part of the un-paid electricity may be consumed in the churches and mosques. The consumer survey made in August 1997 shows however that the total connected load in this consumer category is only 680 W. Even with a load factor of 100%, the un-paid monthly consumption in this group can not be more than about 50 kWh. The conclusion is that technical and other losses may amount to close to 20% in the UECCO system.

**Table 5-13 Calculation of un-paid consumption in Urambo, Jan-Jun 1997**

Month	Jan	Feb	Mar	Apr	May	Jun
<b>Generation (kWh)</b>	5020	4970	5470	5140	5680	5340
<b>Paid consumption:</b>						
Metered consumption (kWh)	3769	3730	4165	3902	4256	4047
Paid flat rate consumption:*						
Churches and mosques (kWh)	46	46	53	53	53	53
Households (kWh)	0	0	0	0	0	8
Commercial (kWh)	0	0	0	0	0	0
Institutions (kWh)	0	0	0	0	0	167
Street lights: Estimated consumption (kWh)**	127	125	142	134	140	157
<b>Total paid consumption (kWh)</b>	3942	3901	4360	4089	4449	4507
<b>Unpaid consumption (kWh)</b>	1078	1069	1110	1051	1231	833
Fraction of generation %	22	22	20	20	22	16

\* Calculated with flat rates 4000 TAS for churches and mosques, 25000 TAS for households and 50000 TAS for institutions, energy tariffs 260 TAS/kWh Jan-Febr and 300 TAS/kWh March-June.

\*\* Calculated from operating time and power 150 W for each lamp

### 5.7 Metering of consumption

Use of a flat rate, based on installed load, requires the least investment and eliminates the need for periodic meter reading. The experiences from Urambo from un-metered supply of electricity are however un-favourable. The system caused large losses for the cooperative and was considered un-fair by many of the consumers.<sup>15</sup> It is possible that a more sophisticated approach to flat rate estimation, based on actual connected load rather than consumer category would have been more successful but this approach was never tried in Urambo.

A simple cost comparison was made by SEI and TANSECO to help sort out which would be the economically most beneficial solution for the individual consumers. The key in these calculations is the consumers load factor, i.e. the ratio between the average load and the maximum load. With a relatively stable load, this factor will be close to one, whereas if there are peaks in the power requirements, the load factor becomes lower. The cheaper load limiting circuit breaker is suitable when the load does not vary much with time.

<sup>15</sup> Mvungi A. and Sanga A., 1995.

When in May 1995 the consumers were asked about their preferences between meter and a cheaper load limiting circuit breaker, 16 opted for circuit breakers and 68 for meters. Those choosing circuit breakers however changed their mind when the installation was due. The reasons have not yet been established but most probably the cause is that the circuit breaker makes it impossible to use most of the appliances other than radio.

The shift during the second half of 1995 from un-metered flat rate to metering of the electric consumption and charge per unit consumed during the second half of 1995 resulted in a significant drop of the load at the power plant, from about 65 kW in June to about 43 kW in December 1995, see table 5-7.

### **5.8 Tariffs charged**

The District Council used flat rates with different rates for the four main consumer categories in Urambo when it was responsible for the electricity supply. Since the users were not equipped with meters, the use of flat rates continued when the Cooperative took over the responsibility. From October 1995, the consumers with meters have paid an energy charge, whereas those without meters have remained on flat rate.

When regular operation started in 1994, the tariffs were based on estimates made by TANESCO. Two tariff studies were carried out, one in May 1993<sup>16</sup>, the other in September 1994<sup>17</sup>. The results are summarised in table 5-14. Both estimates are based on the same assumed consumption data, the same fuel and lubricant prices and the same specific fuel and lubricant consumption. The estimate from September 1994 includes capital costs. It is also based on higher assumed maintenance costs for the diesel gen-sets, and lower assumed maintenance costs for the distribution network.

During the progress review visit made by a TANESCO/SEI team in December 1994, a revised tariff estimate was made and presented to the provisional Cooperative Development Committee. This tariff was calculated so that the revenues should cover operating expenses only until the time when meters had been installed. Capital costs were calculated but not included in this provisional tariff. Consumers were encouraged to adjust their consumption to a level where the flat rates covered the generation cost of 0.28 USD/kWh, see appendix F.

Later tariffs have been calculated using this calculation as a model.

Table 5-15 shows the development of the electricity tariff in Urambo since 1992, i.e. since before the Cooperative started. In order to facilitate the comparisons the tariffs are given in USD, although obviously the payments were made in TAS. The official exchange rate and the approximate fuel price are also shown in the table. For comparison the tariffs charged by TANESCO for residential consumers (households) and the energy charge for bulk power purchase are included in the table.

---

<sup>16</sup> Katyega M. and Sumari C., 1994.

<sup>17</sup> Ibid.

**Table 5-14 Results of initial tariff studies made by TANESCO**

<b>Study</b>	<b>1993 May</b>	<b>1994 Sept<sup>a)</sup></b>	<b>1994 Dec<sup>b)</sup></b>
<b>Assumed monthly consumption (kWh)</b>			
Household	46	46	36
Shops	125	125	56
Guesthouse	210	210	67
Offices	310	310	167
<b>Monthly generation (kWh)</b>	<b>37 300</b>	<b>32 250</b>	<b>8 100</b>
<b>Investment to recover, USD</b>			
Gensets	0	35 000	35 000
Distribution system	0	126 000	126 000
<b>Annuity factors</b>			
Gensets	0	0.081	0.091
Distribution system <sup>0</sup>	0.091	0.091	
<b>Specific consumptions (litre/kWh)</b>			
Fuel	0.34	0.34	0.4
Lubricants	0.003	0.0033	0.002
<b>Fuel and lubricant prices (USD/litre):</b>			
Fuel	0.42	0.42	0.46
Lubricants	2.22	2.22	2.66
<b>Distribution losses</b>	0%	0%	10%
<b>Other operation costs (USD/month)</b>			
Diesel maintenance	21.6	319	290 <sup>c)</sup>
Distribution maintenance	105	52.5	50
Operators	0	0	102
Miscellaneous	0	78	97
<b>Generation cost component (USD/kWh)</b>			
Capital costs	0	0.037	(0.151)
Fuel and lubricants	0.149	0.149	0.190
Maintenance	0.003	0.012	0.042
Operators	0	0	0.013
Miscellaneous	0	0.002	0.012
Distribution losses	0	0	0.026
<b>Total</b>	<b>0.152</b>	<b>0.200</b>	<b>0.283<sup>d)</sup></b>
<b>Recommended<sup>e)</sup> flat rate tariffs USD/month</b>			
Household	8.33	9.20	10.4
Shops	19.44	25.00	16.0
Guesthouse	31.90	42.00	18.9
Offices	44.44	62.00	47.2

<sup>a)</sup> The break-even tariff was calculated for years 1 - 15. Results given here are for year 4.

<sup>b)</sup> The generation cost to charge the consumers during the period January - July 1995 was calculated ignoring capital costs. The consumption was supposed to be adjusted by the consumers so that flat rate covered generation cost.

<sup>c)</sup> Costs for efforts made by TANESCO Tabora partly covered by SEI during this period.

<sup>d)</sup> The recommended flat rates in May 1993 agree well with the rounded off generation cost except for households, where the tariff is about 15% higher than the estimated generation cost. Flat rates recommended in December 1994 were those actually charged (see remark b).

<sup>e)</sup> If capital costs are included the break-even tariff will be 0.43 USD/kWh

**Table 5-15 Electricity tariffs charged in Urambo**

<b>Date</b>	<b>1992 December</b>	<b>1994 December</b>	<b>1995 October</b>	<b>1996 February</b>	<b>1996 September</b>	<b>1997 March</b>	<b>1997 July</b>
<b>Urambo tariffs:</b>							
Flat rates USD/month							
Residential	6.1	10.4	14.7			41.6	
Commercial	10.6	16.0	21.2			83.2	
Guest house	15.1	18.9	21.2			83.2	
Institution	19.7	47					
Place of worship					6.7	6.7	9.6
<b>Energy charge</b>							
USD/kWh		0.28*	0.33	0.44	0.44	0.50	0.56
TAS/kWh		150*	200	240	260	300	350
<b>TANESCO tariffs:</b>							
Residential USD/kWh		0.02	0.031	0.036	0.034	0.033	0.037
Bulk energy USD/kWh		0.11	0.13	0.16	0.15	0.15	0.16
<b>Economic data:</b>							
Exchange rate TAS/USD	330	530	613	550	596	601	625
Fuel price							
USD/litre	0.42	0.45	0.49	0.56	0.55	0.67	0.68
TAS/litre	139	240	300	310	325	400	425

\*Recommendation in TANESCO/SEI tariff study, December 1994. All consumers still on flat rate

Fig. 5-4 illustrates how the energy tariff has developed relative to the fuel price. The diagram shows that the tariff increases have been larger than justified by fuel price rises only. The Cooperative Development Committee has made the tariff adjustments on basis of the gradually increasing experiences about the real cost of the operation.

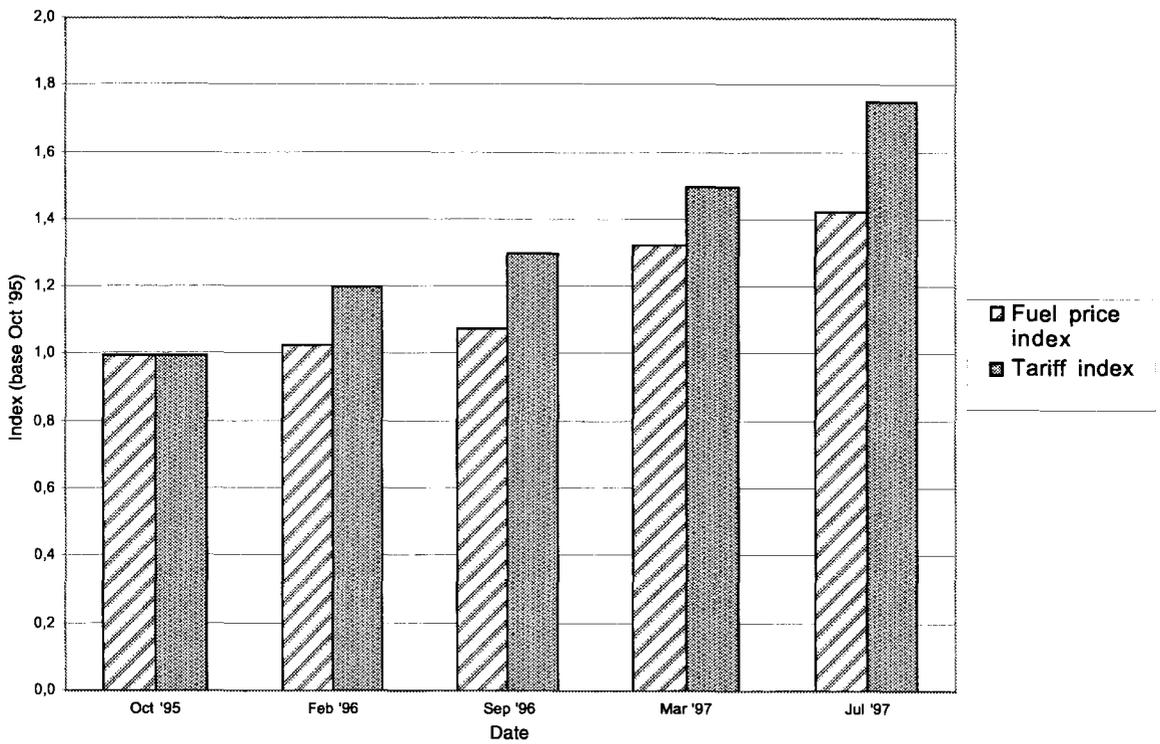


Figure 5-4. Comparison of tariff increases and fuel price increases in Urambo

It can be noticed that the first two tariff studies made by TANESCO ignored several important cost elements like operators and distribution losses. The tariff calculation in December 1994 was more realistic but the capital costs were not included in the provisional tariff. Later tariffs have been redesigned to recover part of the capital costs, see further section 5.9.4.

It is interesting to compare the flat rates established by the provisional Cooperative Development Committee in 1994 with the cost paid for electricity by the average consumer in the period January to June 1997, when the consumer loads have been adjusted to accommodate the higher tariffs. The comparison is made in table 5-16. The table shows that despite the significant reduction of the average load, from about 1150 W in December 1994 to about 400 W in June 1997, the cost to the consumers has increased significantly.

**Table 5-16 Monthly costs for electricity in different consumer categories (USD)**

	Flat rate Dec 1994	Cost for average consumer Jan-Feb 1997	Mar-Jun 1997
Residential	10.4	15.2	17.3
Commercial <sup>a)</sup>	16.0-18.9	22.3	31.7
Institutions	47.2	12.3	17.5

a) Shops and guest houses

As can be seen from table 5-15, the tariffs in Urambo are dramatically higher than the tariffs in the national grid served by TANESCO. The experience from Urambo appears to indicate that people in Tanzania, even in rural areas, are prepared to pay a lot more for electricity than perhaps assumed when the TANESCO tariffs are decided upon. An effect of a higher tariff is that the consumption is reduced until a bare minimum is reached. A further increase in the tariff, when consumers have adjusted the consumption to a minimum level can be expected to lead to dropout of consumers. It is not possible to tell from the Urambo experience where this limit can be found. The fact that some consumers have been unable or unwilling to pay the electricity bills may indicate that the Cooperative is now operating close to this limit and that the average household is not prepared to pay more than about 15 USD per month for five hours of light consuming about 230W, which is equivalent to 4 light bulbs of 60W.

## **5.9 Financial performance**

### **5.9.1 General considerations**

UECCO has two types of incomes. On the one hand shares, membership fees, and connection fees, and on the other hand the charges for delivered electricity. The share is a contribution to the working capital of UECCO (equivalent to about one months operating cost for servicing one consumer). The cost of the share has no relationship to the actual assets of UECCO.

The membership fee is supposed to cover administrative costs for registration of a new consumer. The connection fee is supposed to cover connection costs. Although these incomes contribute to cover some initial costs when new consumers join the Cooperative the resulting cash flow is small in comparison to the operating costs and the revenues from electricity sales.

It is obvious that the revenues from sales of electricity must at least cover the operating costs, if the cooperative shall have a chance to be financially sustainable. If the cooperative shall not depend on 100% grants for re-investments and expansion, it must also recover a sufficient part of the capital cost to qualify for loans for new investments. Ideally the full capital cost shall be recovered, but this leads to very high tariffs during the initial years.

### 5.9.2 Collection of membership fees and payment for shares

Table 5-17 shows the cost of one share and the different fees charged by UECCO. There have been minor changes since 1994. In July 1996 the re-connection fee was increased to TAS 1000 (about US dollar 1.67).

**Table 5-17 UECCO's fees**

Fee	Dec 1994		June 1997	
	TAS	USD	TAS	USD
Membership	5,000	9.4	5000	8.0
Share <sup>1)</sup>	7,000	13.2	7000	11.2
Connection/service line	3,000	5.7	3000	4.8
Re-connection	500	0.94	1000	1.7

1) One compulsory share follows on connection.

Membership fees, connection fees and shares were initially not paid as anticipated. During the first year of the Cooperative, only very few consumers paid their fees and the share. Lately, following pressures from the Cooperative Development Committee, the number of consumers having paid their fees has increased. Had the by-laws been properly enforced in terms of membership fees and compulsory shares, UECCO would have possessed an accumulated capital of at least 1,020,000 TAS<sup>21</sup>, i.e. close to 2,000 US dollars already by December 1995. At that time however only 206,500 TAS had been collected in membership fees and shares, as shown in table 5-18.

The situation regarding payment of membership fees and shares has improved considerably since then. In June 1997, there were 15 consumers out of 101 that had not paid either membership fee or share. The un-paid amount was 152 000 TAS or 243 USD.

**Table 5-18 Collected membership fees and shares**

Date	Accumulated membership fee and share payments	
	TAS	USD
October -93		
December -94	88,000	166
February -95	180,000	329
December -95	929,500	1668
December -96	1,321,500	2217
May -97	1,519,500	2483

Connection and service line fees are added in portions of 500 TAS on top of the monthly payment for the service during the six first months, and are not recorded separately in the book keeping.

<sup>21</sup> Membership fee and one share per consumer x 85 consumers.

### 5.9.3 Collection of revenues from electricity sales

The history of tariffs charged is summarised in section 5.8. Until August 1995 all the consumers paid a flat rate tariff which was different for different categories of users but did not depend on the connected load of the individual consumer. From October 1995 those consumers who had received a meter paid a sum per unit consumed. A few consumers who were without meter paid a flat rate, which was supposed to cover the actual cost for generating the electricity consumed.

Out-standing claims on consumers who pay their bill late is a problem for UECCO just as it is for TANESCO. Table 5-19 shows how consumer charges, collected revenue outstanding claims have developed since June 1994.

**Table 5-19 Collected revenue and outstanding claims (TAS)**

Period	Collected revenue	Outstanding claims accumulated
<b>1994</b>		
June-Dec	3,244 281	
<b>1995</b>		
Jan-June	2, 865,523	25,500
July-Dec	1 ,813,300	31,000
<b>1996</b>		
Jan-June	4 ,472,350	106,690
July-Dec	6 ,689,850	183,500
<b>1997</b>		
Jan-June	6,381,336	382,420

### 5.9.4 Cost for supplying the service

Table 5-20 shows the operating expenses and the operational result of UECCO during the first three years of operation. The data have been collected from UECCO's records during evaluation visits and have not been audited. The allocation of expenses between "Maintenance", "Stationary" and "Miscellaneous" has been made by estimates for some periods. This is of minor importance since the items "Fuel and lubricants" and "Salaries" dominate the operating expenses. As shown in table 5-20, the specific generation cost has increased from about 0.24 to about 0.33 USD/kWh. Increasing costs for fuel explains the increase in specific generation cost.

**Table 5-20 Operating expenses and operational result of UECCO, 1994 - 1997**

<b>Period</b>	<b>1994 Jul-Dec</b>	<b>1995 Jan-Jun</b>	<b>Jul-Dec</b>	<b>1996 Jan-Jun</b>	<b>Jul-Dec</b>	<b>1997 Jan-Jun</b>
<b>Expense items (1000 TAS)<sup>a)</sup>:</b>						
Fuel and lubricants	4 537	4 638	2 018	4 400	5 124	5 592
Fuel transport	74	54	18	54	54	90
Salaries	215	234	78	240	400	420
Maintenance	118	60	12	60	60	41
Stationary	46	48	16	60	60	28
Postage and miscellaneous	85	12	4	24	24	44
<b>Total</b>	<b>5 075</b>	<b>5 046</b>	<b>2 146</b>	<b>4 838</b>	<b>5 722</b>	<b>6 215</b>
<b>Generation kWh</b>	<b>39 690</b>	<b>45 450</b>	<b>17 920</b>	<b>30 300</b>	<b>32 380</b>	<b>31 620</b>
<b>Specific expense</b>						
TAS/kWh	128	111	119	160	177	197
USD/kWh	0.24	0.20	0.21	0.29	0.30	0.33
<b>Metered use kWh</b>				<b>17987</b>	<b>24623</b>	<b>23869</b>
<b>Revenues (1000 TAS):</b>	<b>3 244</b>	<b>2 865</b>	<b>1 813</b>	<b>4 472</b>	<b>6 689</b>	<b>6 381</b>
Period balance 1000 TAS	-1 831	-2 181	-333	-366	+967	+166
<b>Accumulated operational result:</b>						
1000 TAS	-1 831	-4 012	-4 345	-4 711	-3 744	-3 578
July 1997 USD	-2 930	-6 420	-6 953	-7 539	-5 990	-5 725

a) The expenses have been extracted from UECCO:s records during evaluation missions. Audited accounts are not yet available.

The records of UECCO do not include capital costs and only small amounts for maintenance and TANESCO's service. Examination of table 5-20, which also shows the total revenue (collected and outstanding) for each period, shows however that there has been no room for capital costs or higher maintenance costs, except during the latest period shown, Jan-Jun 1997 which shows a surplus of 548 000 TAS (877 USD July 1997).

For the financial sustainability of the Cooperative it is obviously important that the tariff includes sufficient margins for maintenance and some capital accumulation. Table 5-21 shows an estimation of these margins on basis of the tariff and cost data for July 1997. The monthly margin for maintenance and capital costs with the assumed data is about 483 USD.

The monthly maintenance costs estimated by TANESCO for keeping the generator sets and the distribution network functional amount to about 511 USD. The breakdown of the cost is shown in table 5-21. With such average maintenance costs, there will be no room for accumulation of capital - in fact there will be a small monthly loss of capital.

The required monthly capital accumulation if 30% of a 45 000 USD re-investment in generator sets shall be achieved in ten years and a 280 000 USD re-investment for a distribution system shall be achieved in 25 years is about 330 USD if accumulated capital is increasing with a real interest rate of 2% per annum. It appears that in order to achieve this, costs must be reduced or revenues increased by about 360 USD per month.

Possibilities to achieve this are discussed in section 5.9.7.

**Table 5-21 Margins for maintenance and capital costs, July 1997**

<b>Estimated monthly generation and consumption:</b>	
Generation, kWh	5 500
Unpaid energy 20%, kWh	1 100
Paid energy, kWh	4 400
<b>Basis for estimate of operating expenses:</b>	
Fuel cost USD/litre	0.68
Lubricant cost, USD/litre	1.7
Specific fuel consumption, litre/kWh	0.45
Specific lubricant consumption, litre/kWh	0.004
Fuel transport USD/month	25
Salaries USD/month	116
Stationary, postage and miscellaneous, USD/month	120
<b>Tariff (USD/kWh)</b>	<b>0.56</b>
<b>Estimated monthly costs and revenue USD:</b>	
Fuel	1 683
Lubricants	37
Fuel transport	25
Salaries	116
Stationary, postage and miscellaneous	120
<b>Sum of above costs</b>	<b>1 981</b>
<b>Revenue from sales</b>	<b>2 464</b>
<b>Margin for maintenance and capital costs</b>	<b>483</b>
<b>Estimated average monthly maintenance costs (USD)</b>	
Spare parts, 20% of fuel cost	336
TANESCO personnel (6 persondays/month)	100
Transport for TANESCO personnel	75
<b>Sum of estimated maintenance cost</b>	<b>511</b>
<b>Monthly accumulation of capital (USD)</b>	
<b>Possible from above revenues and costs</b>	<b>-28</b>
<b>Required for 30% accumulation (at 2% interest)</b>	<b>332</b>

### **5.9.5 Financial performance**

The financial performance of UECCO is summarised in table 5-19, which shows that operating expenses have exceeded operating revenue during each period of the three years except the last period Jan-Jun 1997. The main reason for this is that consumers on flat rate have consumed more energy than they have been paying for. The monthly operating loss for each of the first two periods shown in table 5-19, when all consumers were on flat rate, was about 330 000 TAS (530 USD, July 1997). After most consumers were equipped with meters, the monthly loss dropped to about 50 000 TAS in 1996 and turned into a monthly profit of about 90 000 TAS in 1997.

As discussed in section 5.9.4, the actual profit is less however since the costs shown in table 5-19 do not include an adequate allocation for maintenance costs and capital accumulation. If the average maintenance costs turn out to be as estimated by TANESCO, also the period Jan-Jun 1997 shows a small monthly loss of about 3 000 TAS (4.6 USD) and gives no room for accumulation of capital.

### 5.9.6 Liquidity problems

It was evident already during the SEI/TANESCO mission in December 1994 that UECCO was fighting serious liquidity problems. At that time, the reason for the problems was that the consumers used more electricity than they were paying for. It is interesting to compare the estimated average load, see table 5-7 and the connected loads, see fig. 5-3 to the loads that were compatible with the flat rates used in December 1994, see table 5-22.

**Table 5-22 Justified maximum average load for different consumer categories (December 1994)**

Category	Flat rate TAS/month	Justified load W at 150 TAS/kWh
Institutions	25 000	1 400
Guest houses	10 000	560
Commercial	8 500	475
Residential	5 500	310

It appears that very few, if any, of the consumers kept the load below the level justified by the flat rate paid.

The solution agreed between SEI, TANESCO and UECCO was to install meters and charge the consumers per consumed unit at a tariff that would cover the operating cost plus a reasonable share of the capital costs. In order for UECCO to maintain sufficient liquidity, UECCO was given a loan of 8500 USD by SEI to be disbursed in instalments. Based on the estimated time schedule for installation of the meters, re-payment of the loan in monthly instalments of 177 USD was scheduled to start in February 1996. The schedule for re-payment of the loan was later modified so that re-payment will start in February 1, 1998. The modification of the schedule was justified on basis of delays, outside of UECCO's control, in the installation of the meters and delays in the transfer of the agreed loan instalments to UECCO from SEI via TANESCO.

Comparison of the accumulated operational result of UECCO shown in table 5-19 with the loan from SEI is difficult because of the changing currency exchange rate. If the loss for each period is converted to USD with the exchange rate for that period, the accumulated loss by December 1996 will be 8900 USD, i.e. more than the loan given by SEI.

### 5.9.7 UECCO's finances in perspective

It would be interesting to compare UECCO's finances with TANESCO's, and also to some extent with local organisations for rural power supply in other countries. Unfortunately however, there are obvious difficulties to determine the total cost for power generation and distribution in the TANESCO isolated diesel branches. One difficulty is that costs are not always recorded separately for the respective stations but are often combined on a regional level. It was nevertheless concluded in the recent evaluation of rural electrification in Tanzania that all the diesel-supplied branches were deficits. This is clear since fuel costs were about three times higher than the average sale price for one kWh.<sup>22</sup>

<sup>22</sup> Kjellström B. et al., 1992.

If TANESCO's isolated branches cover less than 30% of their costs with revenues, UECCO's financial performance is better than TANESCO's. UECCO in 1997 covers close to 75% of their costs, inclusive of maintenance and full capital costs, with revenues.

Compared to UECCO, local organisations for management of power supply in Bolivia, India and Nepal use significantly lower tariffs<sup>23</sup>. For domestic consumers, the price per kWh ranges between USD 0.03 and 0.26 in these organisations, whereas UECCO's tariff is USD 0.56/kWh presently and for all consumer categories. The reason for the difference is mainly the high cost for maintaining and running diesel-generating sets. In Bolivia, India and Nepal, the tariffs in the lower end of the interval in general apply to systems where tariffs are either subsidised by urban consumers or where low cost mini- or micro hydro power plants with low operating costs have been implemented.<sup>24</sup>

Regarding costs for operation, management and administration (OMA), a comparison with organisations in Bolivia and Nepal is possible. Table 5-23 below lists these costs for six of the organisations and UECCO. The figures are obtained from the respective organisations own bookkeeping, and their way of entering costs may differ slightly. The values may however serve as a basis for discussion. Generally, consumed items, such as fuel and spare-parts are not included. The OMA-costs in Urambo include fuel transports, salaries, stationary and miscellaneous but not costs for TANESCO services. (See table 5-20). The dominating part is personnel costs. It appears from the comparison in table 5-23 that UECCO's recorded OMA-costs are within the range of the other organisations'.

**Table 5-23 Operation, Maintenance and Administration (OMA-) costs in some local organisations for rural power supply**

Organisation	Supplied by	OMA-cost	GDP
Urambo Electric Consumers Cooperative, Tanzania	Diesel	0.047 USD/kWh	120 <sup>2</sup>
Gandhruk Village Electrification Committee, Nepal	Micro-hydro	0.013 USD/kWh <sup>1</sup>	170 <sup>1</sup>
Aserdi Users' Organisation, Nepal	Grid	0.018 USD/kWh <sup>1</sup>	170 <sup>1</sup>
Salleri Chialsa Electricity Company, Nepal	Micro-hydro	0.027 USD/kWh <sup>1</sup>	170 <sup>1</sup>
Cooperativa Eléctrica de Mizque, Bolivia	Diesel	0.04 USD/kWh <sup>1</sup>	670 <sup>1</sup>
Cooperativa Eléctrica Yungas, Bolivia	Grid	0.052 USD/kWh <sup>1</sup>	670 <sup>1</sup>
Cooperativa Rural de Electrificación, Bolivia	Grid	0.11 USD/kWh <sup>1</sup>	670 <sup>1</sup>

Sources: 1) Gerger Åsa and Gullberg Monica, 1997. 2) 1997 World Development Indicators, World Bank.

Comparisons of OMA-costs are however obviously difficult, first because different technologies are used for supply and secondly because maintenance may be more or less adequate. It is clear that the maintenance level in Urambo has been too low. Table 5-21 is based on an estimated OMA-cost of about 0,08 USD/kWh exclusive of costs for spare-parts, but inclusive of costs for TANESCO services in terms of both personnel and transport. (0,14 if including estimated cost for spare-parts). The maintenance part in this estimate might be higher than necessary, but there is no experience from such maintenance level in Urambo to show that this is the case. Likewise, there is for most of the organisations in table 5-23 an uncertainty about to what extent the local organisation enjoys and/or pays for assistance from larger national or international organisations. An exception might be CRE where

<sup>23</sup> Gerger Å. and Gullberg M., 1997, *Rural Power Supply with Local Management: Examples from Bolivia, India and Nepal*.

<sup>24</sup> SCECO appears an exemption with high capital costs and yet a low tariff. See table 2-1.

supportive services are accounted for. Their recorded OMA costs are also higher than the others, in fact more alike the estimates made for UECCO in table 5-21.

As pointed out in section 5.9.5, the present revenue - even at the very high tariff - is not sufficient for recovery of the full capital cost. It is obviously interesting to investigate if expansion of the service would make it more profitable. The calculations shown in table 5-24 indicate that this is in fact possible. The basis for estimation of the operation expenses is the same as that used in table 5-21 and so is the tariff. The calculations show that an increasing fraction of the capital costs can be covered if the consumption increases. With about 400 consumers, having the same average consumption as those in July 1997, the full capital cost can be recovered, assuming that the expanded consumption can be achieved without additional investments in the distribution system. The resulting load will be about 160 kW which requires parallel operation of the gen-sets.

**Table 5-24 Required number of consumers for recovery of full cost in Urambo**

<b>Basis for estimation of operating expenses</b>			
Average consumption, kWh/month, consumer	45		
Average power demand, kW/consumer	0,33		
Unpaid energy, %	20		
Fuel cost, USD/litre	0,68		
Lubricant cost, USD/litre	1,7		
Specific fuel consumption, litre/kWh	0,45		
Specific lubricant consumption, litre/kWh	0,004		
Spare parts, % of fuel cost	20		
TANESCO support, USD/month	175		
Fuel transport, USD/litre	0,01		
Salaries, USD/month	116		
Miscellaneous costs, USD/month, consumer	1,2		
<b>Tariff, USD/kWh</b>	<b>0,56</b>		
<b>Consumption and generation data</b>			
Number of consumers	100	200	395
Electric energy generation, kWh/month	5400	10800	21330
Peak power demand, kW	40	79	156
<b>Monthly operating costs and revenues, USD</b>			
Fuel cost	1652	3305	6527
Lubricant cost	37	73	145
Spare parts	330	661	1305
TANESCO support	175	175	175
Fuel transport	24	49	96
Salaries	116	116	116
Miscellaneous	120	240	474
Revenues	2520	5040	9954
<b>Monthly accumulation of capital, USD</b>	<b>65</b>	<b>421</b>	<b>1116</b>
<b>Fraction of capital cost (1106 USD at 2% interest)</b>	<b>0,06</b>	<b>0,38</b>	<b>1,01</b>

## **5.10 Demand side management**

### ***5.10.1 Needs for demand side management***

Since parallel operation of the generator sets is not in reality possible in Urambo, the capacity of one generator set, rated at 85 kW at present, limits the possible consumer load to about 70 kW.

Demand side management in Urambo has been of interest for financial reasons and technical reasons. Reduction of the consumer loads was obviously important when it became apparent that with the flat rate, the consumers were using more electricity than they were paying for. The technical reasons for demand side management are, first to avoid overloading and tripping because the connected consumers consume more than one generator set can cope with, secondly because reducing the load of the present consumers would make it possible to connect additional consumers without expansion of the generating capacity.

### ***5.10.2 Awareness campaign***

In December 1994, the system suffered from overload problems and it was also apparent that many consumers used more electricity than they were paying for. An information campaign was then launched, a "Call for energy conservation" and distributed to all the consumers. A translation of the text to English is provided in appendix F. The impact of the campaign was hardly noticeable. If any, minor impact was noticed it lasted for only one month, hence rendering the exercise as useless.

### ***5.10.3 Experience from energy efficient lamps***

The installation of compact fluorescent lights in Urambo, described in section 4.9 represents a first step towards more effective use of electricity for lighting in Urambo. If the CFLs prove to be cheaper than incandescent lights, a significant impact is possible in Urambo. According to the house-to-house survey in August 1997, 38 kW was installed as incandescent bulbs. With CFLs this lighting load can be reduced to about 9 kW. There can however also be disadvantages with the CFLs. Some types of CFLs cause a reduction of the power factor,  $\cos \varphi$ , which leads to increased distribution losses, see further chapter 7.

The overall economy of CFLs is very much dependant on their actual lifetime, as further discussed in section 7.2. Table 5-25 summarises the experiences in Urambo regarding failures so far. This issue is further discussed in chapter 7.

**Table 5-25 Experience regarding lifetime of CFL:s**

Type of CFL Connection <sup>a)</sup> Load W	Magnetic ballast Type SL				Electronic ballast type PL-EC			
	B22 25	B22 18	E27 25	E27 18	B22 15	B22 9	E27 15	E27 9
<b>Location and experience:</b>								
Installed in Urambo (Oct 1994)	9	10	11	10	11	10	12	11
1994 Dec (120 h)								
Survivors	9	10	11	10	11	10	12	11
Failures	0%	0%	0%	0%	0%	0%	0%	0%
1995 Dec (1200 h)								
Survivors	9	10	10	10	11	9	11	11
Failures	0%	0%	9%	0%	0%	10%	8%	0%
1997 Apr (3400)								
Survivors	8	9	9	8	11	7	10	10
Failures	11%	10%	18%	20%	0%	30%	17%	9%
1997 Aug (4000 h)								
Survivors	5	9	3	5	9	4	7	10
Failures	44%	10%	73%	50%	18%	60%	42%	9%
Installed in Tabora (Oct 1994)	2	2	0	1	1	0	0	1
1997 Aug								
Survivors	2	2	0	1	1	0	0	1
Installed in Dar (Oct 1994)	1	0	1	1	0	2	0	0
1997 Aug								
Survivors	1	0	0	0	0	2	0	0
Total								
Installed	12	12	12	12	12	12	12	12

a) B22 pin connection, E27 screw connection

Accumulated operating times have been estimated from the operating time of the generator sets. Out of the 84 CFLs installed in Urambo 3 CFLs or about 4% failed within 1200 hours, 12 or about 14% within 3400 hours and 32 or 38% within 4000 hours. The failure rates appear to be different for the different types, as can be seen in table 5-25, but the samples are small and it is therefore questionable if the differences observed in the failure rates are statistically significant.

Comparisons with the experience from the few CFLs installed in Tabora and Dar es Salaam are difficult, partly because the operating time is more difficult to estimate and partly because the number of lamps installed in these places is very small. Of the 12 CFLs installed there, 2 or 17% had failed in August 1997, which appears to indicate a lower failure rate than in Urambo.

According to information from the manufacturer of the CFLs the rated voltage for CFLs is 220-230V and the rated frequency 50 - 60 Hz. The median life is claimed to be 10 000 hours for lamps mounted base down and free burning. Spot checks on several occasions show voltages in the range 198-238V and frequencies down to 45 Hz at the premises in Urambo where the CFLs were installed. It is quite possible that higher voltages have occurred. This and the fact that many lamps in Urambo are mounted with base up could explain a shorter lifetime.

One experience regarding CFLs in Urambo is that the CFLs with magnetic ballast (type SL) and pin connection (type B22) tended to be too heavy for some lamp holders, leading to loose connection and either flickering light or no light at all. Some of the CFLs had been removed for this reason already in December 1994. When installed in another place they were however working to satisfaction.

## **5.11 Sociological observations**

### ***5.11.1 General remarks***

Some social impacts can be expected if a village like Urambo experiences the transition from un-electrified to electrified. In the case of Urambo however, the electrification was done already in 1985. The impacts of electrification as such can therefore not be established from the experiences in this project. The change of organisation from a community service to a cooperative may still have had some social implications because this leads to a change of quality of the service, higher costs for the electricity and required more participation from electricity consumers.

### ***5.11.2 Issues identified in the baseline study***

The baseline study made in June 1994<sup>25</sup> indicated that the people interviewed were positive to electrification and optimistic about the ability of the village to operate and manage an electrification cooperative. At that time, immediately after service was resumed after a long period of irregular service, there was apparent disappointment with the quality of the service, see section 3.6.6. Very few of the consumers at that time considered themselves involved in the cooperative.

---

<sup>25</sup> Mvungi A. and Sanga A., 1995.

### *5.11.3 Follow-up study in 1997*

The development since 1994, summarised in the preceding sections shows objectively that the quality of the electric supply service has improved in Urambo after UECCO took over the responsibility for the supply and that the consumers have become more actively involved in the cooperative. The sociological follow-up study made in August 1997 was therefore focussed on issues that had been identified as particularly interesting from a general point of view namely:

- Benefits for women;
- Creation of new industrial activities and the benefits to these of electrification;
- The high tariff as an obstacle to expanded use of electricity;
- Management problems in a rural electrification cooperative and possibilities to deal with these.

Data collection was conducted mainly by formal interviews with 34 households. Of the persons interviewed 17 were men and 17 women. Business places were also visited for discussions. These visits included shops, restaurants, guesthouses, milling machines, garages, sawmills, one dispensary, one church and a mosque. Three focus group discussions for youths and one for women was arranged. Informal discussions also included visits to key persons to seek their opinion on the people's current and future demand for electricity, the sustainability of UECCO and the managerial capacity of UECCO, in particular regarding its ability to deal with the leadership challenges associated with the daily routines.

The findings reported by Sanga can be summarised as follows:<sup>26</sup>

Of the women interviewed, 88% indicated that the availability of electricity reduced time for meal preparation because the improved lighting made it easier to find the things needed. The better light also made it easier to identify foreign objects in the food. The same fraction felt that electricity had helped their school-children reading. None of the women interviewed indicated that electricity had improved possibilities for their own reading, since none was used to reading habits.

About 77% of the women interviewed felt more secure at home because of electric lights. The security at the streets was still considered to be a problem, mainly because the number of functioning streetlights was small.

About 60% of the women interviewed indicated that the availability of electricity enabled them to perform more activities at night. These activities included ironing of clothes (mainly using charcoal for the ironing), washing clothes, cleaning utensils, doing embroidery and pounding maize and paddy. Electricity also eased the work of preparing things to sell on the market next day, such as doughnuts and oil. Three women indicated that they were thinking about starting a business using their Singer sewing machines as a group. The husbands of these women appeared to be the main obstacle. The activity had

---

<sup>26</sup> Sanga A., 1998.

to take place in the evening when electricity is on and this would interfere with the daily routines as seen from the men's point of view.

As regards use of electricity for industrial activities, the baseline study in 1994 indicated a large interest among operators of the many small industries to use electricity, provided the service would be reliable.<sup>27</sup> In the follow-up study, the number of small industries was found to be increasing but none was found to use electricity for industrial activities. The main reasons given were:

- Electricity is only available during evening time but the industrial operations take place in day-time;
- The electricity is "too weak" for industrial loads;
- Use of own generator sets is cheaper if the generator set has already been purchased;
- Small industries using their own generator sets were garages (using electricity for instance for welding), sawmills and grain mills.

Apparently no industrial activity had been started as a direct result of electrification. As mentioned above, a women's group had discussed formation of a small tailoring business, but the unavailability of electricity during daytime was a major problem also for this activity.

The follow-up study as well as other observations made in Urambo during visits made during 1997, clearly indicate that the high tariff (350 TAS/kWh) is significantly limiting the electricity use. Many households own appliances that are not being used because of the high tariff. Also the use of electric lights is limited to a minimum by most consumers. As mentioned earlier, owners of small industries considered the use of their own generator sets more economical.

The follow-up study identified a number of management issues, primarily related to consumers feeling that they had limited information about the management of the Cooperative and no means to influence decisions. These issues are discussed in section 5.2. It appears that regular meetings need to be arranged where consumers are informed about the situation and are given possibilities to influence decisions according to the by-laws of the cooperative. Failure to arrange such meetings seems to be an important reason for distrust and a general feeling of alienation.

### **5.12 Unresolved issues**

The experiences gained from several years operation of the first rural electrification cooperative in Tanzania has no doubt clarified a number of issues. Some issues however remain unresolved. These justify further technical and management support to UECCO as well as continued monitoring.

A discussion of the unresolved issues can be found in section 9.2.

---

<sup>27</sup> Mvungi A. and Sanga A., 1995.



## **6. DISSEMINATION OF EXPERIENCES**

Information about the progress of the project has been submitted to SIDA through the quarterly progress reports prepared by SEI. TANESCO management has been informed through the Chief Technical Engineer for Research and Development.

The Member of Parliament for Mbinga who comes from and represents the proposed second pilot project site, visited Urambo on his own initiative in February 1996 for collection of information about the experiences from organising and operating a rural electrification Cooperative.

After almost two years of regular service in Urambo, it was decided by TANESCO and SEI that the time was ripe to arrange a seminar for a general discussion of the experiences and dissemination of the experiences to selected District Commissioners. This seminar was held during June 7-9th 1996 in Tabora. A one-day visit to Urambo was included in the program.

There were 25 participants in the seminar. The two participants from SEI, eight from TANESCO and four representing UECCO presented and discussed their experiences from the project in the presence of the Assistant Commissioner for Energy at the Ministry of Energy and Minerals, the District Commissioners of Kasulu, Kibondo, Kisarawe, Tabora and Urambo, the Member of Parliament for Urambo and the Chairman of the newly established electrification cooperative in Mbinga (MECOS).

Further to experiences from Urambo, TANESCO representatives from Tabora and Dar es Salaam had during early 1995 performed an international study on different forms for locally managed, rural power supply. This in co-operation with SEI-staff and including examples from Bolivia, India and Nepal.<sup>1</sup> Inputs based on experiences from the international survey of rural power supply with local management were also made by both TANESCO and SEI-representatives.

The resolutions adopted by the seminar participants are included as appendix G. The experiences from Urambo were found to be encouraging. The unique conditions existing in Urambo before the Cooperative started its operation were however found to justify at least two additional pilot projects, representing different initial conditions. The need for government support of different kinds was emphasised in the resolutions. A clear and coherent government policy on rural electrification by cooperatives was requested as well as establishment of financing arrangements and waiving of taxes and import duties on material imported for rural electrification.

Mbinga Consumers Electricity Co-operative Society (MECOS) which was officially registered in August 1996, was connected to Mbinga Coffee Curing Power plant on April 13, 1997. During the first 2 months, 53 were connected to the MECOS electric consumers supply feeder. Moreover, plans to establish 16 rural power cooperatives along the Songo-Songo to Dar es Salaam gas pipeline were continuing very well. There were also efforts by SEI to study Kasulu and Kibondo for possibilities to establish cooperatives.

---

<sup>1</sup> Gerger, A. and Gullberg, M., 1995.



## **7. EVALUATION OF ENERGY EFFICIENT LAMPS AND PHOTOVOLTAIC SYSTEMS FOR VILLAGES OF URAMBO'S SIZE**

### **7.1 Need for new technologies in rural electrification**

The technologies considered for rural electrification in Tanzania are still more or less the same as those used in the mid 1970:s. Consumers are assumed to be using appliances of the same types as those used in urban areas. The consumers thus need to be supplied with single phase 220 V or three-phase 380 V alternating current. A network for transmission and distribution of electricity to the individual consumers has to be constructed. In the national grid, power is predominantly generated in large-scale hydro power plants. Sites where connection to the national grid cannot be justified are most commonly equipped with two or three suitably sized diesel generator set. (See also appendix A). Urambo is a typical example of such a case.

There are however several reasons why new technologies should also be considered. The high cost for supplying electricity to the consumers in newly electrified rural areas calls for careful examination of possible cheaper technologies. This should be of interest regardless of who is actually paying, the consumer, the national utility or an international donor. Also, rather than automatically expanding the use of fossil fuels in remote areas, considering domestic, renewable energy sources is an aim from the national economies point of view since imported fossil fuels amount to about half of the total export earnings.

Another reason for examination of other options is the growing concern about the global environmental effects of increasing use of fossil fuels. Many donors reflect the international policy tendencies. For instance SIDA has recently adopted an energy policy<sup>1</sup> according to which financial support to projects based on continued or increased use of fossil fuels should only be given in exceptional cases.

In this chapter, the implications of the experiences from Urambo for the potential of two new technologies, namely compact fluorescent lamps (CFLs) and photovoltaic electricity generation will be discussed. The first of these can give lower costs for lighting in ordinary high voltage networks, and the second can be a cost efficient electricity supply option for some applications. Also, photovoltaic electricity generation would certainly comply with greenhouse gas mitigation policies, since it is not associated with any emission of polluting substances when it is used.

### **7.2 Energy efficient lamps**

#### **7.2.1 *Lighting requirements in rural villages and towns***

Lighting accounts for a large part of the load in the electrified rural villages and towns in Tanzania. This is true also for Urambo, although the installation of meters have resulted in people using their lights more carefully. In December 1994, the house to house survey concluded that 59 % of the installed load was lighting. According to the estimations made by Bosco in May 1995, 86% of the total load would be lighting after installation of meters (see also table 5.11). In institutions and guesthouses the proportion of lights was estimated to be even higher, above 90%. About 85% of the total anticipated light load was in the form of incandescent bulbs, and the rest was

---

<sup>1</sup> Sida, *Policy för miljöanpassat energibistånd*, 1996-04-23.

fluorescent tubes, halogen lamps or Compact Fluorescent Lamps (CFLs). The load factor as estimated in the study was 0.9 for the light load and 0.7 for other types of load. This reflects that most lights are kept burning all through the evening when electricity is available. The estimation of average load per consumer made in May 1995 shows relatively good agreement with the actual measured average load per consumer in December 1995.

In August 1997, the inventory of connected loads did not include any estimates of the load factor. A decreased factor would be expected since meters are installed and tariffs have been raised. The load factor for the entire load in August 1997 had dropped to half the value of May 1995. Given the total energy consumption and total installed lighting devices, the load factor for the lighting load must be less or equal to 0.65. If assuming a load factor for lighting devices below or equal to 0.65, the lighting requirements of the average consumer has decreased from 12,000 lumen during four evening hours to below 5,000 lumen during five evening hours, see table 7-1. The energy requirements for lighting have also decreased, one reason being the lower lumen requirements, another the relatively higher amount of fluorescent tubes. While in May 1995 only 12% of the lighting load were fluorescent tubes, the portion had increased to 24% in August 1997.

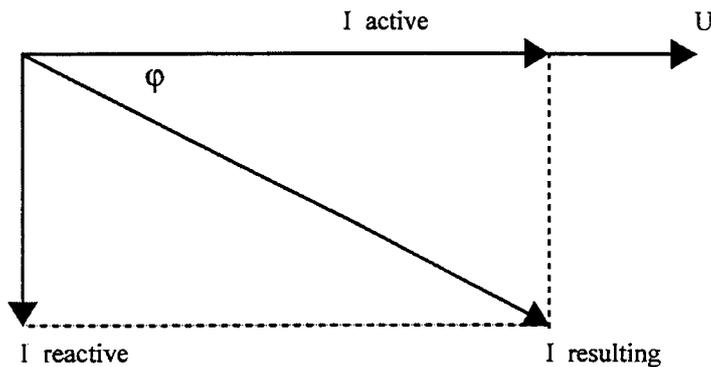
In absence of experiences from other rural villages and towns in Tanzania with tariffs designed for recovery of costs for diesel supplied electricity, it is assumed that the consumption pattern that has developed in Urambo is typical for what will be found in the villages and towns that will be electrified in the future.

### ***7.2.2. Implications of introducing CFLs as seen from the power suppliers end***

CFLs replacing incandescent bulbs in a power system have two important effects from the power supplier's point of view. The CFLs reduce the power demand and increase the relative distribution losses. The reduced power demand can be an advantage since additional investment in power generation and transmission capacity can be postponed. However, the reduced consumption can also mean that fixed costs must be distributed on fewer sold kWh. Increased distribution losses call for an increased energy price.

The total load in a system, be it a single house or an industrial area, is almost always inductive. It means that the required current is composed not only of the 'useful', active component, but also by a 'useless', reactive component, see figure 7-1. The supplying generators have to provide both, i.e. the resulting current. Unfortunately, the reactive component does not contribute to meeting the energy demand, still it renders losses in the distribution system. From the power supplier's point of view therefore, the reactive component shall be kept at a minimum and the  $\cos \phi$  at a maximum.

Figure 7-1. Illustration of the active and reactive current components (one phase)



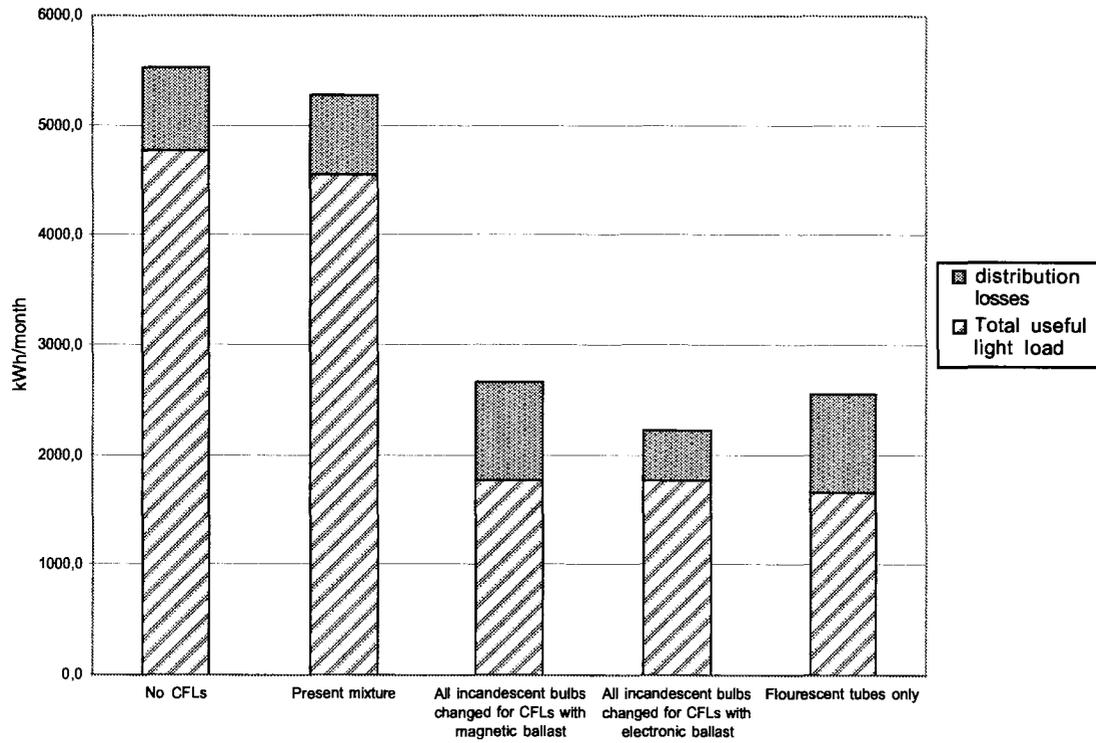
For a system designed for a load with incandescent bulbs, replacement of these with CFLs may therefore make it necessary to increase the tariff. The load of the CFLs with magnetic ballast will certainly lead to a need to increase tariffs as will be illustrated in the following:

An incandescent lamp has a  $\cos \varphi = 1$ , therefore such lamps do not require generation of reactive power in addition to the active, useful power. The situation is different for the CFLs. In the case of CFLs with magnetic ballast, the current and voltage are not in phase, and to the extent that  $\cos \varphi = 0.5$ . There is however no distortion in the wave form of the two curves, meaning that the phase difference can be adjusted for by connecting a capacitor, either at each lamp or centrally at the power supplier. However, the capacitors as well cost money, and generally, phase compensation is only economically justified up to  $\cos \varphi = 0.95^2$

For CFLs with electronic ballast, the  $\cos \varphi$  is relatively high since peaks in current and voltage occur simultaneously. On the other hand, the current's waveform is distorted and is not sinusoidal like that of the voltage. Whether the non-sinusoidal curve form gives rise to further distribution losses or not is not verified. For the discussion here, only losses emerging from the reactive component are considered and  $\cos \varphi$  for CFLs with electronic ballast is set to 0.95. Mercury vapour lamps and fluorescent tubes have a  $\cos \varphi = 0.5$ .

Seen from the power supplier's end, the installation of CFLs or fluorescent tubes leads to reduced power demand per required lumen, but also to increased distribution losses per delivered useful power. To compensate for this, a slightly higher tariff is needed. Figure 7-2 illustrates how the load for a hypothetical system with only lighting load is constituted of distribution losses, and lighting load for five situations.

<sup>2</sup> Lindahl P.E. , *Elkraftteknik*. Studentlitteratur AB, Lund 1983.



**Figure 7-2. Lighting load and distribution losses**

In the first case shown there are no CFLs. The load consists of incandescent bulbs and fluorescent tubes. The second case shows the present Urambo light load with a small amount of CFLs in the system. The extreme situation where the lighting load factor is 0.65 is assumed and the load factor for other loads 0. The different lamps have  $\cos \phi$  as specified above. The following two bars represent cases where all the incandescent bulbs in the present system are exchanged for CFLs, either with magnetic ballast or with electronic ballast. Lastly the right most bar shows the case when fluorescent tubes meet the entire light demand. There are no capacitors installed in the scenarios.

Distribution losses are set to vary with  $\cos \phi$  as in equation 1:

$$\text{Distribution losses} = 0.15 * (\cos \phi_1 / \cos \phi_2)^2 \quad (1)$$

where:

- 0.15 refers to distribution losses in the reference case 'No CFLs' (10% grid losses and 5% generator losses).
- $\cos \phi_1$  is at the outgoing transformer in the 'No CFLs' case =0.92.
- $\cos \phi_2$  is the resulting  $\cos \phi$  at the outgoing transformer for the different lamp mixes.

The increasing distribution losses following on the installation of CFLs in this hypothetical example would increase the overall cost for supplying energy. The required increases of the tariff based on the lighting load factor being 0.65, and thus the average lighting requirement being 5000 lm for five evening hours, are presented in table 7-2.

### ***7.2.3 Bulbs, Tubes, and CFLs and their performance as seen from the consumers end<sup>4</sup>***

The luminous efficacy of fluorescent tubes and CFLs is much higher than that of incandescent lamps. Thus, less energy is needed for the same light output. This is the main advantage promoted by CFL retailers. Table 7-1 shows normal luminous efficacy for some lamp types.

---

<sup>4</sup> Based on: Gwan'gombe F., *Experience with use of efficient lights: Case study of Urambo rural electric cooperative, Tanzania*. TANESCO paper for Demand side Management seminar at Kilimanjaro hotel, Dar es Salaam, 1995. Also EE&D internal technical report series no. 10.

**Table 7-1 Lighting requirements in Urambo**

Energy requirements per lamp type (kWh/month)		CFLs	Incandescent bulbs	Fluorescent tubes	Mercury	Halogen lamps vapour lamps	Total
1995 <sup>a)</sup>	Total	60	5,203	788	22	60	6,133
	Average per consumer	1	75	11	< 1	1	88
1997 <sup>b)</sup>	Total	< 79	< 3,687	< 725	< 25	0	< 4,516
	Average per consumer	< 1	< 30	< 10	< 1	0	< 41
Luminous efficacy for different lamp types (lm/watt) <sup>c)</sup>		CFLs	Incandescent bulbs	Fluorescent tubes	Mercury	Halogen lamps vapour lamps	
		52.5	13	56.5*	50.5	22.5	
Lighting requirements in Urambo							
1995	required lumen	Total	972,000				
		Average	12,000 <sup>d)</sup>				
1997	required lumen	Total	( 620,000				
		Average	( 5,000				

a) Based on actual connected load and anticipated load factors per appliance (source: Bosco Selemani, TANESCO)

b) Based on actual connected load (source: Sabina Daati, TANESCO).

c) Source: Rural Lighting, IT-power & SEI.

d) If the outstanding National Bank of Commerce, requiring 169,000 lumen hours per evening, is included, average lighting requirements are 14,000 lumen hours per evening.

\* Different types of fluorescent tubes have different luminous efficacy: 56.5 is a weighed average based on findings in the TANESCO inventory of May 1995

**Table 7-2 Changes in cost per kWh following on installation of CFLs**

	cos $\phi$	Distribution losses	Increased cost per metered kWh
No CFLs	0.92	15.0 %	-0.3 %
Present Mixture	0.91	15.3 %	0 %
All incandescent bulbs changed for CFLs with magnetic ballast*	0.51	49.1 %	29.3 %
All incandescent bulbs changed for CFLs with electronic ballast	0.74	22.9 %	6.6 %
Fluorescent tubes only*	0.5	50.9%	30.9%

\* Without adjusting for phase differences

Despite the poor energy efficiency, the incandescent lamp offers other conveniences, a reason why it is often opted for. Incandescent lamps have standard screw and bayonet bases that allow for both easy lamp replacement as well as interchangeability among lamps with different effect. Also, lamps can be directly connected to the main voltage (220V) and do not require any additional control gear. An incandescent lamp also provides full light output immediately after it is switched on. Disadvantages with incandescent lamps are their large heat production, increasing with increasing effect. Incandescent lamps are also sensitive to too high voltages; a 5% increase in nominal voltage decreases the incandescent bulb's lifetime by 50%.<sup>5</sup>

Fluorescent tubes do not produce much heat. Also, by changing the mixture of phosphors coating in the lamp's tube, it is possible to achieve a wide range of light colours. However, to operate fluorescent tubes either conventional (inductive) or electronic gear is required and this must match to lamp wattage, i.e., it is not fully interchangeable. If conventional gear is employed, the tube does not switch on immediately, but may require several starts. This is what causes the uncomfortable flickering associated with fluorescent tubes.

CFLs provide a compromise between the incandescent bulb and the traditional fluorescent tube in terms of convenience for the user. CFLs with integrated electronic ballast and screw bayonet bases are easily interchangeable, can be directly connected to the mains voltage, and offer a flicker-free start. Other CFLs are similar to fluorescent tubes in that they require an external ballast for operation (these are lamps with pin-base). Variants of these pin base lamps can be operated either with magnetic or electronic control gear. Luminaries for fluorescent tubes or CFLs with pin bases are therefore somewhat more complicated to fabricate due to the additional wiring, special lamp holders, and control gear that must be incorporated. However, once the luminary is available, the lamps are easily replaced at the end of their lifetime. Also, since the luminaries with adapter normally lasts for 40,000 hours to 50,000 hours, there is an advantage of having it separate from the lamp in that it needs not be changed before its full lifetime is utilised.

In terms of convenience of use, the CFLs have an advantage over standard fluorescent tubes in that they require only one lamp-holder since they have single-ended bases.

<sup>5</sup> Vorwerk I., *Electric Energy Efficiency in the Urambo Power Supply System: Part Two*, Minor Field Study in Tanzania, Department of Electric Power Technology at the Royal Institute of Technology, 1996.

Similar to standard fluorescent tubes CFLs also have relatively cool operating temperatures and are also available in a range of light colours.

An 11 W CFL with integrated electronic ballast and screw base is replaceable with a 60 W incandescent bulb with screw base. The expected main advantage following on replacement is cash savings. This is based on the relatively more expensive CFL having a longer lifetime and a lower energy consumption per light output. Normal rated lifetime for CFLs is 8,000 to 10,000 hours, while an incandescent lamp normally lasts for 1,000 hours. The long lifetime of CFLs, may be shortened due to certain factors. In particular, CFLs with magnetic ballast are sensitive to power cuts and variations in voltages. According to manufacturers though, no significant shortening of the lifetime will be experienced if voltages stay between 207-245 V.<sup>6</sup> In 1994, 84 CFLs of different types were installed in Urambo for testing purposes. Experiences from energy efficient lamps in Urambo are presented in section 5.10.3. Even if the accumulated operating time in Urambo so far is only about 4000 hours the results indicate that lifetimes of CFLs are shorter in Urambo than claimed by the manufacturers. At 1,200 hours no lamps had failed and at 4,000 hours the failure rate was 38%.

A simple cost comparison between CFLs and incandescent bulbs is made in table 7-3, assuming a few different life times for the CFL. The cost comparison shows that with the present tariff in Urambo of 350 TAS/kWh it is less costly than the incandescent bulb if the CFL lasts for more than 673 hours.

**Table 7-3 Cost comparison: 11 W CFL versus 60 W incandescent bulb**

Option	CFL					Incandescent bulb 1,000
	8,000	5,000	2,000	1,000	673	
Expected lifetime (h)						
Light output (lumen)	760	760	760	760	760	760
Cost of one lamp (TAS)*	11,700	11,700	11,700	11,700	11700	250
Total lamp cost, 8,000 h (TAS)	11,700	18,720	46,800	93,600	139200	2,000
Wattage (W)	11	11	11	11	11	60
Total energy consumption, 8,000 h (kWh)	88	88	88	88	88	480
Energy price in Urambo (TAS/kWh)**	350	350	350	350	350	350
Total energy cost, 8,000 h (TAS)	30,800	30,800	30,800	30,800	30800	168,000
Total cost, 8,000 h (TAS)	42,500	68,240	77,600	124,400	170,000	170,000
Total monthly cost (TAS)***	634	1,024	1,164	1,866	2,520	2,520
Total monthly cost (USD)	1.0	1.6	1.9	3.0	4.0	4.0
Total monthly cost for 12,000 lm (USD)	16	25	30	47	63	63
Total monthly cost for 5,000 lm (USD)	6	10	13	20	27	27
Relative total cost for consumer	25%	40%	48%	75%	100%	100%

The comparison in table 7-3 between incandescent bulbs and CFLs applies for Urambo with the present tariff of 350 TAS/kWh. As shown in section 7.2.2., extensive use of CFLs in Urambo would however make it necessary to increase the tariff with up to 30%. With this higher tariff, the lifetime of CFLs must exceed 720

<sup>6</sup> Ibid.

hours if CFLs shall be financially more attractive than the incandescent bulbs. Since the experiences from Urambo indicates that less than 4% of the CFLs fail before that, it must be concluded that CFLs are financially beneficial for consumers in rural areas where the tariff level is on the level of that presently used in Urambo.

Fluorescent tubes however, offer even cheaper lighting. Table 7-4 compares the individual consumers cost for lighting with fluorescent tubes and with incandescent bulbs in the present Urambo system. Fluorescent tubes need only have a lifetime exceeding 153 hours, or 235 with a 30% tariff increase, to come out beneficial, while producers estimate their lifetime to 6000 hours.

**Table 7-4 Cost comparison: 18 W Fluorescent tube versus 60 W incandescent bulb**

Option	Fluorescent tube*					Incandescent bulb 1,000
	6,000	5,000	2,000	1,000	153	
Expected lifetime (h)						
Light output (lumen)	1017	1017	1017	1017	1017	760
Cost of one lamp (TAS)*	3,300	3,300	3,300	3,300	3,300	250
Total lamp cost, 8,000 h (TAS)	4125	5,280	13,200	26,400	172,069	2,000
Wattage (W)	18	18	18	18	18	60
Total energy consumption, 8,000 h (kWh)	144	144	144	144	144	480
Energy price in Urambo (TAS/kWh)**	350	350	350	350	350	350
Total energy cost, 8,000 h (TAS)	50,400	50,400	50,400	50,400	50,400	168,000
Total cost, 8,000 h (TAS)	54,150	55,680	63,600	76,800	222,469	170,000
Total monthly cost (TAS)***	812	835	954	1,152	3,337	2,520
Total monthly cost (USD)	1.3	1.3	1.5	1.8	5.3	4.0
Total monthly cost for 12,000 lm (USD)	15.3	15.3	17.7	21.2	63	63
Total monthly cost for 5,000 lm(USD)	6.4	6.4	7.4	8.8	27	27
Relative total cost for consumer	25%	40%	48%	75%	100%	100%

\* The cost for one 18 Watt, 1350 lumen tube is set to 5.25 USD. For fair comparability, the luminous efficacy is set to 56.5 lm/Watt which represents an average of different tube qualities available.

### 7.3 Photovoltaics

#### 7.3.1 Individual PV-sets as an option to traditional electricity supply

Traditionally, the technologies chosen for rural electrification in developing countries have been the same as those used in urban areas and in the industrialised countries, i.e. centralised generation of alternating current and transmission and distribution of the power to the individual users. At sites that are far away from the national electric grid and where there is no hydropower potential in the vicinity, diesel generators have been used for generation of the electricity. The diesel generators consume a fossil fuel, which must be imported to Tanzania. Minimisation of the use of such energy sources is of global interest since this reduces greenhouse gas emissions and also of national interest to Tanzania for balance of trade reasons.

An alternative approach, that eliminates the need for an imported fossil fuel, would be to use photovoltaic generators, (PV-generators) which supply 12 or 24 V direct current and are located at each consumer. The price of such systems has dropped during recent years and they are therefore often the most economic choice for isolated

locations with a modest energy demand. It is quite possible that this approach can also be attractive for village electrification.

In the case of Urambo, where a transmission and distribution network was already in place when the electrification cooperative was formed, continued use of centralised generation was the only realistic option. The same is true for the second pilot project in Mbinga, where the transmission and distribution system is also available. For future projects, or for potential cooperative members beyond the present distribution network, individual PV-generation may be considered as an option. The implications of choosing individual PV-generators instead of a diesel supplied traditional system in a village like Urambo will therefore be briefly discussed. Aspects of primary interest are the energy services that can be offered, the initial investment, the financial and running cost for the energy service, the potential for expansion of the service and the environmental impacts.

### ***7.3.2 Energy services that can be offered***

With the traditional 415/240 V AC system, where also higher tension can be supplied on request, the only load-limiting factor is the capacity of the generators. Although lighting and household appliances dominate the load in many newly electrified areas, it is an important feature that industrial electricity use is not countered by the power systems design.

Individual PV-systems that supply 12 or 24 V DC, can readily be used for lighting and powering of some appliances like radios, cassette players, fans, small water pumps and refrigerators which are commercially available for 12 or 24 V DC operation. Some appliances are only available for 240 V AC. Use of these with PV-systems require installation of an inverter at an investment of 1- 3 USD per W capacity (available from ~120 W to ~4 kW).

Technically, PV-systems can be designed to cope with the same energy services as the traditional system. The limitations are financial rather than technical. As will be shown in section 7.3.4, the cost per supplied kWh will be at least 2.0 - 2.4 USD when an individual PV-system is used.<sup>7</sup> This is significantly higher than the cost for electricity from a diesel generator, which can be estimated to 0.4 - 0.5 USD/kWh, see section 2.4.3. In most cases, PV-generation is therefore financially realistic mainly for those with small energy consumption, for instance residential consumers requiring electricity only for some basic lighting, a radio and perhaps a small refrigerator.

The supply reliability can be expected to be higher with an individual PV-system than that to be expected in practise with centralised supply from diesel generator sets in rural Tanzania. For some electricity users this might justify a higher cost for the energy service.

The international market for PV-modules is dominated by telecommunication sets, water-pumping sets and sets for 'basic needs' in both households and health care centres.<sup>8</sup> The main advantage over diesel generating sets according to vendors of PV-

---

<sup>7</sup> Net import prices assumed.

<sup>8</sup> Hill R., *Photovoltaics: present status and future prospects*, Newcastle Photovoltaics Application Centre, University of Northumbria, January 1993.

equipment is the high reliability and, in case of remote and small loads, the low energy price. For these applications, PV's may be appropriate as well in Urambo.

PV technologies can be feasible for pumping water for domestic needs or for irrigation. Irrigation has a more intermittent nature than that of domestic water use, and pumps will stand idle for significant parts of the year. Further, for farmers in general, paying ability varies with season. Consequently, although calculations have shown that PV-pumps are cheaper than diesel-pumps for hydraulic energies up to 1000 m<sup>3</sup>/day,<sup>9</sup> the diesel may be preferred due to its lower capital requirements.

### **7.3.3 Investment required**

Comparisons between investments and costs for PV-systems and traditional systems can be very misleading if the comparisons are not made for the same type of energy service. Household lighting will be used here for illustration of the implications of choosing a PV-system or a traditional system. Two options will be assessed, namely:

- Electric lighting with 12 000 lumen used 4 hours daily<sup>10</sup>;
- Electric lighting with 5 000 lumen used 5 hours daily<sup>11</sup>.

For PV systems dimensioning, see appendix H.

When the traditional, diesel supplied system is used for lighting, three options will be considered, traditional incandescent bulbs, compact fluorescent lights and traditional fluorescent tubes.

The investment estimates are shown in table 7-5. The prices for solar system components have been collected from BP-Solar and Neste Advanced Power Systems (NAPS). Prices for diesel generators and distribution network are taken from chapter 2, i.e. prices regard new equipment rather than worn-out. In the diesel case it is assumed that the capacity of the system (170 kW) is fully utilised during the concerned hours. For all imported equipment, a 15% increase in prices is assumed.<sup>12</sup>

---

<sup>9</sup> McNelis B., *Photovoltaics for Developing Countries*, In Hilger Adam Applications of Photovoltaics, Bristol 1989.

<sup>10</sup> Based on average consumer in Urambo, May 1995

<sup>11</sup> Based on average consumer in Urambo, August 1997

<sup>12</sup> Price increase can be due to import duties, taxes or set by the retailer.

**Table 7-5 Investment comparisons between traditional electricity supply and individual PV-generation for lighting (USD)**

Light demand	5000 lumen, 5 hours/day				12000 lumen, 4 hours/day			
	PV-system* Tubes	Traditional*** Bulbs	CFL:s	Tubes	PV-system** Tubes	Traditional*** Bulbs	CFL*s	Tubes
load (W)	72	385	92	72	162	924	228	162
demand (Wh/day)	360	1925	462	360	648	3696	914	648
Investment, USD								
Part of generator sets (import)	-	117	28	22	-	281	64	46
Part of distribution network (local)	-	408	97	76	-	978	241	172
Connection fee, service line (local)	-	6	6	6	-	6	6	6
Metering (local)	-	166	166	166	-	166	166	166
House wiring (local)	-	194	194	194	-	194	194	194
Light bulbs (import)	-	3	-	-	-	3	-	-
CFLs (Import)	-	-	168	-	-	-	374	-
Solar panels (import)	1331	-	-	-	2218	-	-	-
Support structure (import)	271	-	-	-	369	-	-	-
Batteries (import)	302	-	-	-	345	-	-	-
Control unit (import)	133	-	-	-	222	-	-	-
Cables and clips (import)	52	-	-	-	52	-	-	-
Lamps (import/local)	122	5	5	24	274	11	11	54
Tubes (import/local)	21	-	-	21	47	-	-	47
<b>Total</b>	<b>2232</b>	<b>899</b>	<b>664</b>	<b>509</b>	<b>3527</b>	<b>1644</b>	<b>1056</b>	<b>685</b>

\*Design for 5000 lm, 5 hours: 3 solar panels x55 Wp, 4 lamps (for tubes), 4 tubes (18 Watt, 75 lm/Watt), one battery (150 Ah)

\*\*Design for 12000 lm, 4 hours: 5 solar panels x 55 Wh, 9 lamps (for tubes), 9 tubes (18 Watt, 75 lm/Watt), one battery (250 Ah)

\*\*\* Luminous efficacy is set to 75 lm/Watt based on design features for 18 Watt, 26 mm diameter tubes .

#### **7.3.4 Financial and running costs**

The result of a comparison of financial and running costs depends on the interest rate, the lifetime of the various components, the import prices for diesel fuel and the duties and taxes paid on fuel and equipment.

The following equipment lifetimes are assumed:

Diesel generator sets	10 years	
Transmission/distribution network	25 years	
Meters	25 years	
House wiring	25 years	
Solar panels	12 years	
Structure	12 years	}20 years as well discussed
Batteries	3 years	
Control unit	6 years	
Cables and clips	6 years	
Lamps	6 years	
CFLs	6000 hours	
Fluorescent tubes	6000 hours	
Incandescent bulbs	1000 hours	

A very low real interest rate of 2% is assumed here, which is favourable for the PV-option.

Maintenance and service costs for the traditional system is assumed according to table 2-2, while for the PV-system service is assumed to be free.

A diesel cost including duties and taxes of 0.68 USD/litre and an import price of 30 USD/barrel (0.19 USD/litre) is assumed. For all imported equipment, a 15% increase in prices is assumed.<sup>13</sup>

With these assumptions, the financial and running costs for lighting have been estimated as shown in table 7-6.

The financially most attractive solution for lighting in a village like Urambo is having fluorescent tubes in a traditional, diesel based power system. This is true for both the lighting demands considered. It can further be concluded that the PV-system is financially more attractive than the traditional system with incandescent bulbs.

---

<sup>13</sup> Price increase can be due to import duties, taxes or set by the retailer.

**Table 7-6 Comparison of annual costs, USD/year, for lighting with traditional supply and individual PV-generation**

Light demand	5000 lumen, 5 hours per day				12000 lumen, 4 hours per day			
	PV-system Tubes	Traditional Bulbs	CFLs*	Tubes	PV-system Tubes	Traditional Bulbs	CFLs*	Tubes
load (W)	72	385	95	72	162	924	228	162
demand (Wh/day)	360	1925	475	360	648	3696	914	648
<b>Capital costs</b>								
Part of generator sets** (import)	-	13	3	2	-	31	7	5
Part of distribution network** (local)	-	21	5	4	-	50	12	9
Connection fee, service line (local)	-	0,3	0,3	0,3	-	0,3	0,3	0,3
Metering (local)	-	9	9	9	-	9	9	9
House wiring (local)	-	10	10	10	-	11	11	10
Light bulbs (import)	-	4	-	-	-	15	-	-
CFLs (import)	-	-	43	-	-	-	119	-
Solar panels (import)	126	-	-	-	210	-	-	-
Support structure (import)	26	-	-	-	35	-	-	-
Batteries (import)	105	-	-	-	120	-	-	-
Control unit (import)	24	-	-	-	40	-	-	-
Cables and clips (import)	9	-	-	-	9	-	-	-
Lamps (import/local)	22	1	1	4	49	2	2	10
Fluorescent tubes (import/local)	5	-	-	5	15	-	-	15
<b>Maintenance and service costs**</b>								
Part of generator sets	-	32	8	6	-	61	15	10
Part of distribution network	-	8	2	2	-	20	5	4
<b>Fuel and lubricant costs**</b>								
Fuel	-	167	41	31	-	321	79	56
Lubricant (2% of fuel costs)	-	3	1	1	-	6	1	1
Subtotal (financial cost, USD/year)	316	268	123	43	477	525	259	128
Adjusting with respect to increased losses***			+ 7%	+ 31%			+ 7%	+31%
<b>Total financial cost USD/year</b>	<b>316</b>	<b>268</b>	<b>132</b>	<b>98</b>	<b>477</b>	<b>525</b>	<b>277</b>	<b>168</b>
<b>Cost per kWh</b>	<b>2,4</b>	<b>0,39</b>	<b>0,76</b>	<b>0,73</b>	<b>2,0</b>	<b>0,39</b>	<b>0,83</b>	<b>0,71</b>

\* CFLs with electronic ballast.

\*\* based on table 2-2, \*\*\* refer to table 7-2

### **7.3.5 Cost sensitivity analyses**

The cost comparison in section 7.3.4 is based on assumptions about the real interest rate, the price increases added to net import prices, and the degree of utilisation of installed capacity.

It is relevant to convey analyses of the annual cost sensitivity to these factors since they are likely to change over time and for different kinds of power demand. Tables 7-7, 7-8, and 7-9 show the annual cost sensitivity for changes in the real interest rate, under utilised capacity in the traditional system and variations in price increases.

For the PV-option, an increased real interest rate affects the annual cost for lighting more than price increases do. While 15% real interest rate as opposed to 2% results in an annual cost increment of around 93%, 40% price increase on imported equipment as opposed to net import prices results in an annual cost increase around 27%.

In the case of traditional diesel based supply, the individual consumers annual cost for lighting is sensitive to under-utilisation of installed capacity, changes in real interest rate and in the lower load case to diesel tax. Price increases on imported equipment affect total costs to a lesser extent.

If only half of the installed capacity is utilised, annual costs rise with around 92% if using incandescent bulbs, and with around 56% if using CFLs or fluorescent tubes. Still, both the fluorescent tubes and the CFLs in combination with traditional diesel remain lower cost options than the individual PV-system. At 20% utilisation of installed capacity, the PV-option becomes the cheaper.

Applying 15% real interest rate as opposed to 2% results in an annual cost increment of 34% if using incandescent bulbs, 47% in the case CFLs are used and, 66% if fluorescent tubes are used.

Import duties, fuel taxes, and other taxes result in price increments at the consumers end, as do the possible price increase added by the local retailer of imported equipment. These price increments are likely to vary with policies and market development. A sensitivity analyses regarding 0%, 15% and 40% price increases on imported technology as well as 0% and 260% fuel tax gives the results as shown in table 7-9.

Diesel taxes cause a 35-86% annual cost increment in the lower load case, while only around 7% in the higher load case. A 40% price increment on imported equipment result in only 3% increase in annual costs in the case incandescent bulbs are used, 16% for the CFLs, and 6% when regarding the fluorescent tubes.

In all cases shown in table 7-9, fluorescent tubes used in a traditional diesel supplied system come out the least cost alternative. The only case in which the PV-option is financially more attractive than fluorescent tubes in a traditional system is when less than half of the installed capacity in the traditional system is utilised. This is true even if the PV-panels are assumed to last for 20 years. The same accounts for CFLs in a traditional diesel system, although the combination is slightly more sensitive to under-utilisation. In all cases, using CFLs costs more than using fluorescent tubes.

With fuel taxes, a tax-exemption for PV-systems (and no retailers increases), and a 15% price increase for all other imported equipment, the PV-system is financially more attractive than incandescent bulbs in the traditional system for the higher lighting demand, but not for the lower. If though the panels are assumed to hold for 20 years the PV system is preferable over the bulb-option in either load case. The CFLs and the fluorescent tubes however, have even lower annual costs. The same scenario but with a 40% price increase at the PV-retailer, which is totally realistic for Tanzania presently<sup>14</sup>, results in even incandescent bulbs in a traditional diesel supplied system underscoring the PV-system if assuming the low light load and, or the short panel life time.

**Table 7-7 Annual cost sensitivity to changes in real interest rate (USD/year)**

		2%	5%	10%	15%
5 000 lm	PV-system	272	358	434	516
	Diesel+bulbs	268	286	320	359
	Diesel+CFLs	132	145	172	201
	Diesel+tubes	97	111	137	165
12 000 lm	PV-system	403	542	662	792
	Diesel+bulbs	515	557	619	690
	Diesel+CFLs	276	299	341	387
	Diesel+tubes	160	186	220	258

**Table 7-8 Annual cost sensitivity to changes in utilisation level (USD/year)**

		20%	50%	70%	100%
5 000 lm	PV-system	316	316	316	316
	Diesel+bulbs	1244	512	373	268
	Diesel+CFLs	388	196	159	131
	Diesel+tubes	341	159	124	98
12 000 lm	PV-system	477	477	477	477
	Diesel+bulbs	2482	1014	735	525
	Diesel+CFLs	788	405	332	277
	Diesel+tubes	613	279	216	168

<sup>14</sup> SADCC Energy sector, *Study on NRSE Pricing in the SADCC Region*, May 1992. Annex 2.

**Table 7-9 Annual cost sensitivity to changes in price levels (USD/year)**

<b>PV:</b>	Net import prices								15% price increases								40% price increases							
	5 000 lm				12 000 lm				5 000 lm				12000 lm				5000 lm				12000 lm			
<b>Diesel:</b>	PV-system	Diesel+bulbs	Diesel+CFLs	Diesel+Tubes	PV-system	Diesel+bulbs	Diesel+CFLs	Diesel+Tubes	PV-system	Diesel+bulbs	Diesel+CFLs	Diesel+Tubes	PV-system	Diesel+bulbs	Diesel+CFLs	Diesel+Tubes	PV-system	Diesel+bulbs	Diesel+CFLs	Diesel+Tubes	PV-system	Diesel+bulbs	Diesel+CFLs	Diesel+Tubes
Net import prices, no fuel tax	289	143	92	66	430	476	248	153	316	143	92	66	477	476	248	153	362	143	92	66	551	476	248	153
Net import prices, fuel tax	289	266	125	96	430	519	259	163	316	266	125	96	477	519	259	163	362	266	125	96	551	519	259	163
15% price increase, fuel tax	289	268	131	98	430	525	277	168	316	268	131	98	477	525	277	168	362	268	131	98	551	525	277	168
40% price increase, fuel tax	289	272	142	101	430	535	307	172	316	272	142	101	477	535	307	172	362	272	142	101	551	535	307	172

The lack of life length data for PV-systems in Tanzania is an essential limitation for any cost comparison and an important issue to resolve through pilot projects and data collection.

### ***7.3.6 Potential for expanding the service***

As far as the demand for energy is limited to basic lighting and radios, the PV-supply can be extended to any number of consumers in a rural village just by installation of additional individual supply units. The costs for the service will remain the same and there is no large advantage gained by the extension of the service to more users.

With the traditional solution, a significant over-capacity is usually built into the initial transmission and distribution network. The investment per capacity unit will drop as the capacity is increased, the efficiency of the generator sets will be improved with increasing capacity and the fraction the costs for operation and administration that must be covered by each consumer will be reduced. The energy service from a traditional system will therefore grow gradually cheaper as the consumption increases.<sup>15</sup>

Another important advantage of the traditional system is its potential for supplying power to any kind of appliance, also those with significant power and energy demands such as large electric motors, welding sets, and cookers. The traditional system therefore opens possibilities for industrialisation and benefits to women that cannot be realistically provided with the individual PV-system.

Lifetimes of a PV-system are generally 12-15 years, provided batteries, control units, and perhaps lamps are changed when needed (see above). They are designed to meet basic needs. For some applications they will be useful throughout their lifetime. For others, for example a village where industrial activities start developing, they are better replaced with a traditional system at some point. In such cases, investments in inappropriate equipment could become a burden for the electricity users if having opted for the PV-system at an early stage. To overcome the possible problems of reaching an impasse in power systems expansion, it is beneficial if there is a second hand market for PV-systems in the region.

### ***7.3.7 Environmental aspects***

The diesel option impacts the environment significantly more than the PV-option. Main burdens are emissions from combustion, emission from transport, and possibly leakage to soil.

Flue gases from diesel combustion contains carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), sulphur oxides (SO<sub>x</sub>) and particulates of various kinds. Depending on the conditions for combustion the flue gases can also contain hydrocarbons and carbon monoxide. Emissions appear at the plant, but also from the transport of fuels, which is often by truck in Tanzania. Hydrocarbons and carbon monoxide are commonly not emitted in the case of stationary combustion (generating sets), but from truck-engines. The emissions per kWh electricity generated are estimated in table 7-10. A distance of 600 km is assumed between the harbour in Dar es Salaam and the power plant.

---

<sup>15</sup> Note that for the comparisons in tables 7-4 and 7-5 the traditional diesel supply system is assumed fully utilised. Price increase can be due to import duties, taxes or set by the retailer.

Specific fuel consumption at the plant is set to 0.35 litres/kWh. Sulphur content in the fuel for the power plant is assumed 1% (weight percent).

**Table 7-10 Emissions per kWh electricity generated with a stationary diesel engine (g)**

	Fuel transport*	Generation**	Total
CO <sub>2</sub>	21	990	1011
SO <sub>x</sub>	0.027	6.6	6.63
NO <sub>x</sub>	0.26	3.1	3.4
Particulates	0.029	-	0.029
CO	0.097	-	0.097
HC	0.025	-	0.025

\*Source: A-M Tillman, Vattenfall AB, Sweden

\*\*Source: USA Department of Energy, Environmental costs of Electricity, 1991, Table 4.

The dispersion of emission and formation of secondary pollutants, are dependent on local meteorological and terrain conditions. It is therefore not possible to determine the exact concentration occurring in different parts of Urambo and the region with out more thorough investigation of these conditions. It has not been the objective with this study to determine environmental impacts from the UECCO power plant, but rather discuss the environmental disadvantages in more general terms.

Nitrogen dioxide (NO<sub>2</sub>), which is formed when the emitted nitrogen mono-oxide oxidises in air, has negative effects on lungs and other respiratory organs. With respect to the health effects, the Swedish Environmental Protection Agency recommends that concentrations of NO<sub>2</sub> should not exceed 75 µg/m<sup>3</sup> as a daily average value. NO<sub>2</sub> also effects plants. N is a nutrient for plants and too much N can affect the ecosystem. In combination with SO<sub>2</sub>, ozone and other pollutants the NO<sub>2</sub> may damage plants. NO<sub>2</sub> has impact also on the formation of photochemical oxidants such as ozone and aldehydes. The concentrations of ozone are commonly the highest at some distance from the source of NO<sub>2</sub> emissions since ozone is formed under the influence of sunlight.<sup>16</sup>

Ground level Ozone irritates the respiratory organs and has effects on plants. With respect to the health effects, the Institute of Environmental Medicine<sup>17</sup>, recommend that concentrations of ground level ozone should not exceed 120 µg/m<sup>3</sup> as an hourly average value. Plants are regarded more sensitive to ozone than humans. The European Centre for Environmental Studies has estimated the critical level of ozone concentration for plants to be 150 µg/m<sup>3</sup> as an hourly average value. Ozone can, alone or together with SO<sub>2</sub> or NO<sub>2</sub>, give rise to severe effects on plants such as observable damages on blades and reduced growth.<sup>18</sup>

Sulphur dioxides irritate the respiratory organs, especially among people with asthmatic problems. Short exposure of high concentrations may lead to increased resistance in the respiratory passages. Longer exposure of concentrations in the range 100 - 200 µg/m<sup>3</sup> can lead to chronic bronchitis and reduced lung function, especially

<sup>16</sup> Bioenergins miljö och hälsoeffekter (Health and Environmental risks with Bioenergy) Vattenfall Utveckling, 1996.

<sup>17</sup> At Karolinska Institutet, Stockholm, Sweden.

<sup>18</sup> Ibid.

among children and persons with asthmatic problems. With respect to the health effects, the Swedish Environmental Protection Agency recommends that concentrations of SO<sub>2</sub> should not exceed 100 µg/m<sup>3</sup> as a daily average value.<sup>19</sup>

Particles can be dust, soot, small metal fragments, etc. Health effects from particles rely on their size and their chemical structure and what chemical substances are adsorbed on them. Small particles reach farther down in the lungs than do larger particles. A volume of small particles has also a larger surface than the same volume of larger particles, wherefore they adsorb relatively more ambient chemicals. With respect to the health effects, the Swedish Environmental Protection Agency recommends that concentrations of particles should not exceed around 100 µg/m<sup>3</sup> as a daily average value.<sup>20</sup>

Hydrocarbons constitute a broad spectrum of different organic substances that are formed when combustion is incomplete. Among these there are a number of cancerogenic substances. Hydrocarbon emissions are negligible from the stationary diesel generating set, but measurable from the transport of fuel.

The same accounts for carbon monoxide that if inhaled blocks the blood's ability to transport oxygen. Effects from too little oxygen reaching the brain are delayed reaction, sleepiness and, if high CO-concentrations, unconsciousness.

Carbon dioxide is a green house gas. Greenhouse gases are believed to affect our climate. The potential climate change is subject to international discussions and documents such as the United Nations Convention on Climate Change, adopted in 1992, and proceeding protocols from Conferences of Parties to the Convention, serve at regulating different industrialised nation's contributions to the green house effect. This involves limiting the CO<sub>2</sub> emissions but also retaining natural sinks for CO<sub>2</sub> such as forests.

CO<sub>2</sub> emission from the developing countries have in physical terms the same potential effect as from any other part of the world. This being said, it is argued by some that these countries should be permitted to continue or even increase their net green house gas emissions so as to allow for their industrial development. The African continent's contribution to the global greenhouse gas emissions is almost negligible in an international perspective. The total, annual CO<sub>2</sub> emissions in Africa amount to 719 million tonnes, compared to 3,300 million tonnes for the European Community countries together and 22,400 million tonnes for the entire world.<sup>21</sup> If recalculated a per capita value, Africa contributes even less. In a case like Urambo, the UECCO power plant emits around 27 tonnes CO<sub>2</sub> per year.

#### **7.4 Overall assessment**

The introduction of new energy-technologies in Tanzania is definitely worth considering. There is a great potential for demand side management and more efficient end-use of electricity. On the electricity generation side, there are as well several reasons why Tanzania should be considering new and alternative technologies; the high cost for providing electricity services at present in Tanzania,

---

<sup>19</sup> Ibid.

<sup>20</sup> ranging between 90 and 110 for different kinds of particles.

<sup>21</sup> OECD statistics, 1997.

Tanzania's dependence on imported fuels, and Tanzania's reliance on international policy tendencies - particularly as regards green house gases. It is important though that decisions on introduction of new technologies are under-built by more precise evaluations of the respective options.

For electricity consumers in Urambo, CFLs appears an attractive option, since lighting accounts for a large part of the load, and the electricity is expensive. However, in terms of financial benefits, the option of using fluorescent tubes is even better. CFLs may have advantages over fluorescent tubes in that they require only one lamp holder, are smaller and on the whole appear more convenient for the user. This has however not been evaluated in Urambo.

Both CFLs and fluorescent tubes have a higher lumen output per watt than incandescent bulbs, which is the main reason for them being financially more attractive. On the other hand, incandescent bulbs do not give rise to any reactive power, while CFLs with magnetic ballast and fluorescent tubes do. The reactive power requirement results in increased distribution losses. CFLs with electronic ballast render less distribution losses, since the reactive power component is marginal. Increased distribution losses in the system results in higher costs for delivering useful energy, i.e. a higher cost per kWh delivered.

An average consumer in Urambo requires 5000 lm during five hours per day (August 1997), which is equivalent to 7 incandescent bulbs, rated 60 Watt. A comparison of the annual costs at the lighting consumers' end in Urambo and with diesel supply<sup>22</sup>, gives that the fluorescent tubes' option cost about 107 USD per year, CFLs with electronic ballast about 120 USD per year, and incandescent bulbs about 257 USD per year. This is provided electricity tariffs are designed to cover actual costs. The factors having most significant impact on the annual costs for the different options are the degree of utilisation of installed capacity, and the actual lifetime of the different lamps. Potential price increases on imported goods and increased interest rates have less influence on the annual costs for these options.

The possibility that each lighting-consumer has its own individual photovoltaic power system has as well been evaluated for Urambo. This approach has the benefit of eliminating the need of imported fossil fuels. It has also less environmental impact than the diesel option. Disadvantages with individual PV-systems include that they are very expensive if designed for 240 V AC. Although lighting and household appliances dominate the load in many newly electrified areas, it is an important feature in the traditional power supply system that industrial electricity use is not countered by the power systems design.

The international market for PV-technologies is dominated by telecommunication sets, water-pumping sets and sets for 'basic needs' in both households and health care centres. PV-sets are often chosen in these applications because they provide reliable power, but also because comparative costs for other electricity options are higher for small loads and in remote places. In Urambo, and if considering the area within reach of the present distribution network, individual PV-systems are hardly preferable over

---

<sup>22</sup> Note that costs for the diesel gen-sets and distribution network are assumed based on table 2-2 rather than the actual case in Urambo.

the UECCO-services, unless perhaps for some applications where the power reliability is absolutely essential, i.e. for vaccine storage, etc.

From a financial point of view, and if considering the light requirements only, the only case in which the individual PV-system is more attractive than fluorescent tubes in a diesel supplied system is when less than half the capacity is utilised in the traditional system. The same accounts for CFLs in a traditional system.

With a tax-exemption for PV-sets, the lighting-option becomes cheaper than incandescent bulbs in a traditional diesel supplied system, but not than fluorescent tubes or CFLs. That is assuming the installed capacity is fully utilised in the traditional system. Sometimes, PV-equipment retailers add up to 40% to net-import prices.<sup>23</sup> In such cases, even incandescent bulbs in traditional diesel supplied systems are financially more beneficial than individual PV-sets for lighting consumers in villages like Urambo.

If considering the fact that installed capacity is often over-dimensioned in newly electrified villages, and therefore total costs per consumer tends to become very high, PV sets may be an financially attractive option during the first years. It is also likely that remote households in villages like Urambo could benefit from investing in PV-systems for their household needs, rather than relying on non-electric energy sources (see chapter 4).

For electricity consumers for which the PV option is the presently most beneficial for financial reasons, it remains a fact that they are often better replaced with a traditional system at some point. This is true for example for those living in a village where industrial activities are developing. The point in time at which the PV-option becomes more expensive may occur before the full lifetime of the PV-equipment is utilised, and the PV-system then becomes a financial burden to these consumers. A mechanism that facilitates the introduction of the environmentally less hazardous PV-option is therefore an established second hand market.

---

<sup>23</sup> SADCC Energy sector, 1992.

## **8. FUTURE PLANS OF URAMBO ELECTRIC CONSUMERS CO-OPERATIVE SOCIETY**

The plans for future development of UECCO were presented by its chairman at the Rural Electrification Seminar arranged in 1996 in Tabora, see chapter 6. The plans are summarised here. The chairman emphasised that the plans are anticipatory in nature, until UECCO operates financially well and makes a profit.

### **8.1 Planning objectives**

Since electrification of Urambo is based on community management as desired by its members, the main objectives of the future plans have to be based on the wishes of its members as agreed upon during the annual meetings.

The broad objectives of electrification plans are therefore:

- To meet future needs of the community including to address the economic and financial well being of the community. It should be realised that the potential demand for electricity is much higher than can be provided with the present capacity of UECCO. The population of Urambo is about 20 000, out of which only about 93 households (about 651 people) were using electricity in their homes in 1996. Moreover, such institutions like Tobacco Factory, The Government Hospital, The Folk Development College, Police Station and the Lock-up Building were not connected;
- To enable UECCO to operate financially on sound basis;
- To meet the welfare needs of the society by enabling the provision of basic needs e.g. water pumping, medical care, education, etc.

As such, the plans should meet the short term and medium term needs as enumerated below.

### **8.2 Short term plans (within 2 years)**

The short-term plans are to further improve the infrastructure and services to the consumers as detailed below:

- A. To liase with TANESCO Tabora to acquire a plot for future main substation for a high-tension line from Tabora.
- B. To connect the Teachers College, and
- C. To complete the ongoing distribution line extension work to reach:
  - Government hospital and surroundings,
  - Boma village,
  - industrial village,
  - tobacco factory.
- D. To rehabilitate and strengthen the network in the following areas:

Boma line high tension (pole replacement)  
Tabora road low-voltage line (strengthening)  
Rehab Police Station and hospital transformers

- E. Strategic connection of new consumers and proper metering to following assumed numbers:

1994 December,	40 consumers
1995 October,	87 "
1996, June,	100 "
1997 January,	150 "
1999 January,	175 "
2000 January,	200 "

With present 100 single-phase meters, it means that additional 50 to 60 such meters within one year need to be acquired.

- F. Training of plant operators and network crew as well as recruitment of accounts clerk. Provision of more office furniture.
- G. To review the tariff regularly so that the true costs of providing the services to the customers can be charged and to attain operational and financial efficiency.

#### Medium term plans (2-5 years)

The following summarises medium term plans:

- A. To be connected to the national grid via 33 kW line to Tabora and to erect a 33/11 kV substation at Urambo so as to acquire cheap power supply to the members.
- B. Maintenance of the existing gen-sets so that even after connection to Tabora one set may remain as standby facility and the rest can be transferred to Kaliua and Usoke to add more consumers.
- C. Erection of high tension lines to the following areas:
- 3 km to Urambo Secondary School
  - 12 km to Nsenda Agricultural Prison (add about 25 consumers)
  - 2 km expansion along Tabora Road
  - 3 km expansion to Boma village/water pumps
- D. Erection of distribution transformers to the above areas as follows:
- |                  |         |
|------------------|---------|
| Secondary School | 50 kVA  |
| Nsenda Prison    | 50 kVA  |
| Tabora Road      | 50 kVA  |
| Boma village     | 100 kVA |

## **9. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE ACTIVITIES**

### **9.1 Lessons learned and main conclusions**

The attempts to introduce locally managed electricity supply in Tanzania have generally been received very well. There has been a large interest at all the sites that were visited, even when it has been made clear that the tariffs would be significantly higher than those charged by TANESCO. The first pilot project, in Urambo, has been in operation for more than three years. In Mbinga, the second pilot site, the electrification cooperative was registered in August 1996. Operation started in April 1997. Electrification cooperatives are under formation in Kasulu and Kibondo, Kigoma region.

The experiences from the first pilot project in Urambo have been encouraging. It is obvious that the conditions in Urambo were very favourable, since there had already been electricity supply in the village and local initiatives to take over the management, but the experiences are nevertheless valuable for organisation and implementation of new cooperatives.

In essence, the by-laws formulated for UECCO appear to have been adequate and can therefore be used as models for other rural electrification cooperatives. It appears however that 10 members in the Cooperative Development Committee may be too many when the number of members in the cooperative is small. In Urambo, the elected committee has six members. An important observation in Urambo is that the by-laws of the cooperative have not been followed as regards preparation of annual reports and arrangement of general meetings. The Cooperative Development Committee of UECCO and future rural electrification cooperatives in Tanzania must be informed about the importance of fulfilling these formal duties.

The contribution and strong support from TANESCO, and in particular the office in Tabora has been essential for the progress in Urambo. It appears clear that future projects must also be organised so that similar support can be provided from a TANESCO office in the region.

The rehabilitation of the gen-sets has not been cost effective. The reason is that the initial inspection of the gen-sets, made by TANESCO, underestimated the needs for spare-parts. It is not recommended to make further rehabilitation of generator sets unless their condition is very well known.

Metering of the consumption seems to be necessary if the costs of the service shall be recovered by the tariffs. Use of an un-metered flat rate makes it possible to cut down on investments, but it has not been possible in Urambo to make the consumers limit the load to what they are paying for. The cheaper circuit breakers have not been a success. When given the choice between circuit breakers and meters, the consumers prefer the regular meters despite the higher cost for meter and metering.

There have been some problems with the personnel in Urambo. Personnel that was initially selected and trained left or were dismissed for different reasons. Replacements were however recruited and trained and the difficulties have not seriously harmed the operation. Still, it appears that training budgets should not be

limited to the initial personnel since additional training needs may appear during the first years of operation.

Bookkeeping has been a problem in Urambo as a result of difficulties to find a person trained for such task with time to spare for doing the job. Records of income and expenditure have been kept on a chronological basis but annual balance sheets have not been prepared. The capacity to make balance sheets is available in Urambo at District Cooperative office and it appears that the failure to prepare them is mainly a result of giving this task low priority.

When all consumers have installed meters, UECCO's will most probably be able to recover the full operating cost for the service. If the tariff is maintained at the present level of 0,56 USD/kWh and the generation is expanded to about 9000 kWh/month, which can be done with only one gen-set operating, about 30% of the capital cost can also be recovered. Despite the high tariff the number of consumers is increasing in Urambo. This shows that the ability and willingness to pay for electricity is higher than might have been expected.

There has been an interesting shift in load structure from lighting load dominating in 1994 to a situation in August 1997 when lights account for only 30% of the connected load and various appliances for the other 70%. Among appliances, household appliances like electric irons and cookers, kettles and deep freezers account for about 30% of the connected load in August 1997. This has obvious implications for the gender aspects of the project, although it has not been established to what extent these appliances contribute to the electric energy consumption. The high tariff can be expected to act as an obstacle to extensive use of electricity for ironing and cooking. Among entertainment appliances, both radios and videos have increased in number since 1994. The increase is dramatic for videos which have increased in number from 15 to 47. In August 1997, commercial video shows were offered at several locations in Urambo.

Apart from the introduction of electric household appliances, the main benefit for women identified in the sociological follow-up study is improved security and facilitation of household chores as a result of the availability of electric lights.

Energy efficient lamps (CFLs) will be economic in Urambo with the present tariff of 0,56 USD/kWh even if the lifetime of the lamps does not exceed 1000 hours. The experiences from the CFLs that were installed for lifetime testing show that about 60% of the CFLs survive for at least 4000 hours.

During 1997 a new generator set was provided by SEI to replace unit 3 in the powerhouse. After this, there are no apparent technical obstacles for UECCO to provide a reliable service and run a financially sound operation. Follow-ups of the experiences were planned during 1998 and 1999. There are no reasons to believe that the experiences will not be favourable.

There seems to be no reason to wait for the further experiences from Urambo before additional pilot projects are implemented.

## 9.2 Unresolved issues

The experiences presented in section 5 and summarised in section 9.1 are promising and justify initiation of additional electrification cooperatives in Tanzania. There are however a number of issues which remain unresolved. A few of these may be particular to the situation in Urambo but most of these issues can be expected to be of generic interest. A brief discussion of these issues will be useful as a background to the following section where suggestions for future activities are presented.

A very important issue for UECCO, which certainly will be similarly important for other cooperatives supplied by diesel generator sets, is the possibilities to reduce the cost of the service. The cost is dominated by the fuel costs and an obvious way to reduce this cost element is to improve the efficiency of the system. In practice this would mean improving the efficiency of the generator set and reducing the transmission and distribution losses. The experiences from Urambo show some decline of the efficiency of the generator sets (see table 5.2). The distribution losses also appear as relatively high (see section 5.6.5). It is reasonable to assume that the specific fuel consumption can be kept at a lower level by better maintenance and training of the operators. If this can be achieved in practice and the extent of support required is still to be established. The reason for the relatively high distribution losses is unknown and must be established before possibilities to reduce the losses can be discussed.

Another possibility to reduce the costs for the cooperative is to reduce taxes and duties on equipment and fuel needed for rural electrification cooperatives. This obviously requires a government decision. One problem with such arrangements is the possibility for misuse, in particular if there is a refund of taxes and duties on fuel. Provided the government is prepared to support the rural electrification cooperatives in this way, the design of a system that can not easily be misused is an unresolved issue<sup>1</sup>.

Use of circuit breakers instead of meters is sometimes advocated as a means to reduce the capital investment for rural electrification programmes. In Urambo, the electricity consumers were offered to choose between meters and circuit breakers and it was found that meters were preferred. It appears that the restriction on the maximum load associated with the circuit breaker is considered a serious drawback by most of the consumers, but it is of course possible that the few consumers that only use electricity for lights would have found circuit breakers acceptable if such had been installed instead of meters. No attempt to investigate this was made.

The experiences from Urambo show clearly that the maintenance of the generator sets and the distribution system have been inadequate. One reason for this is that the service agreement between UECCO and TANESCO has not been functioning. At present, there are no experiences regarding costs and effects of a functioning service agreement. Such experiences are required for preparation of realistic budgets for coming electrification cooperatives.

---

<sup>1</sup> One possibility is to base the refund of fuel taxes on kWh sold and paid for (according to the bookkeeping) and the rated specific fuel consumption given by the manufacturer of the generator set. This will mean that there will be no refund on fuel spent because the generator set is not well maintained or fuel spent to cover distribution losses or fuel used for other purposes. Whether this system would work in practice remains to be found out.

The studies, carried out by the sociologists, of the consumers' attitudes to UECCO and the Cooperative Development Committee indicate that many consumers feel that they are not sufficiently informed and lack possibilities to influence decisions. These feelings would probably have been less widespread if members meetings had been arranged as stipulated in the by-laws of UECCO. It appears that more pressure from the financiers might be necessary to make the Cooperative Development Committee follow the by-laws on this point. Several possibilities can be considered but it is not possible yet to say what would be effective.

It is evident that household appliances are accounting for a significant and growing fraction of the connected load. It is not clear however how large part of the electricity consumption is actually used for these appliances. More information about this is required for clarification of the effects of the high tariff on the benefits gained by women as a result of the electrification of Urambo.

The provision of regular electricity supply in Urambo has so far not resulted in any industrialisation. The reasons are discussed in section 5.11.3. Limitation of the service to evenings and the high tariff appear as the main obstacles to industrial use. With the financial conditions existing for UECCO, these obstacles can not easily be removed. If daytime service would attract some industrial consumers can not be assessed until such service has been offered.

Although it appears clear that individual PV-systems are costlier than a common solution in Urambo, the theoretical analysis suffers from not having adequate life length data for the components in PV-sets. To analyse under what circumstances the environmentally less hazardous option is appropriate, such data is important.

### **9.3 Recommendations for future activities**

#### ***9.3.1 Additional pilot projects***

Since the first pilot project in Urambo was initiated under extremely favourable conditions, not to be found at any other site in Tanzania, it is important that additional pilot projects are carried out before the rural electrification cooperatives are implemented nation-wide.

Mbinga as the second pilot project has already started operation and should be given the initial support required.

At least two additional pilot projects should be initiated and supported. Both should preferably start from "green-fields" conditions, i.e. without existing distribution network. In order to consider seriously renewable energy technologies for future projects, it is preferable if it can be included in a pilot project.

It is recommended that the performance of the Cooperative in Urambo is closely monitored for at least two more years and that close monitoring of new cooperatives is planned for at least three years from start of operation.

### ***9.3.2 Provision of technical and administrative support to electrification cooperatives***

The technical expertise required for design, construction and operation of a local transmission and distribution system, including a grid connection or a local power plant is not available in the newly formed electrification cooperatives. The need for technical assistance is therefore obvious.

The technical assistance required should be expected to include:

- Pre-feasibility study with tariff estimate;
- Feasibility study with more accurate tariff estimate;
- Design study with specification of equipment to be purchased and construction work to be done;
- Purchase of equipment;
- Construction work;
- Commissioning;
- Training of operators;
- Maintenance and service support;

In Tanzania the national utility, TANESCO, will be able to provide this assistance. Even if other solutions are possible, there are advantages with engaging TANESCO, or an autonomous organisation with TANESCO involvement, for this. If this is done, compliance with national standards is more easily achieved.

Administrative support will be required for:

- Formulation of by-laws for the cooperative;
- Organisation of the management of the operation;
- Organisation of book-keeping;
- Auditing and independent monitoring.
- Formulation and negotiation of agreement with the supplier of electricity (when appropriate);
- Formulation and negotiation of maintenance and service agreement (when appropriate);

For all but the last two tasks, TANESCO will be able to provide the assistance for the pilot projects. When TANESCO would be supplying electricity and/or maintenance and service, an independent body should assist the Cooperative in the negotiations. A suitable organisation in Tanzania that could assist with this needs to be identified.

It is recommended that the government of Tanzania should consider formation of an Advisory Board for Rural Electrification Cooperatives, ABREC, with the expertise required to give technical and administrative support to new and existing cooperatives. This Board could also be given other responsibilities as outlined below.

### **9.3.3 Provision of financial support to rural electrification cooperatives**

The investment required for establishment of a local distribution grid and either connection to the national grid or installation of a stand-alone small power plant can be substantial. Local conditions will influence the size of the investment, but table 9-1 below gives a reasonable indication:

**Table 9-1 Investment required for the establishment of a local distribution grid**

Number of connections (after 4 years)	340
Investment for distribution (kUSD)	305
Distribution transformers (kUSD)	180
Meters (kUSD)	55
Subtotal (kUSD)	540

In addition to this, there will be an investment for either grid connection or a stand-alone power plant. The investment required for grid connection will be about 400 kUSD for a sub-station plus 20 kUSD per km of transmission line. For a village located 80 km from the national grid the investment for grid connection will amount to about 2 MUSD. A stand-alone diesel power plant will cost about 700 USD/kW. A capacity of 500 kW, which should be adequate during the first 4 years will require an investment of about 350 kUSD.

The initial investment distributed on the connected consumers after 4 years would then be as shown in table 9-2.

**Table 9-2 Initial investment distributed on connected consumers (after 4 years in operation)**

Option	Cost per consumer (USD)	Cost per additional consumer (USD)
Grid connection:		
Distribution	1588	
Transmission line	5882	
Total	7470	515
Diesel power plant:		
Distribution	1588	
Power plant	1029	
Total	2617	1500

The investment in the diesel case is comparable in magnitude to the investment required for a small single-phase diesel generator set of 2 kW, which could be an

option for an individual consumer<sup>2</sup>. In both cases however, the marginal investment for additional consumers is much less. The centralised option therefore becomes more economic as the load and the number of consumers increase.

If full recovery of the capital costs is required from the start of the supply, the centralised supply will obviously be un-attractive for the individual users, who will either install a small individual generator set or limit their electricity use to light for a few hours and use a PV-system.

Financial support will therefore be necessary for the investments required in a rural electrification system. Experiences so far from the first rural electrification cooperatives in Tanzania indicate that the initial members are prepared to make a financial contribution of at least 40 USD each. With 100 initial consumers, 4000 USD will be collected. If the District Council is able to contribute the same amount, about 99% of the initial investment must be financed from other sources.

It is possible that a sufficient number of consumers are prepared to contribute more, but even if the contribution could be increased to 400 USD, most of the financing must be found outside of the Cooperative<sup>3</sup>.

Financing could be provided from funds collected by a surcharge on electricity sold in the national grid or from international donors. In order to keep tariffs below the level where individual diesel gen-sets are more attractive, an initial subsidy in some form will be necessary. Giving part of the initial investment as a grant is one possibility. Tax exemption on equipment imported for rural electrification cooperatives should be considered and also possibly tax exemption on fuel used for rural electricity supply<sup>4</sup>. With tax exemption of fuel, there will not be a need for subsidies on capital costs.

### ***9.3.4 Proposed conditions for support***

The expected rapid increase in the interest to form rural electrification cooperatives in Tanzania makes it necessary to develop policy guidelines for support. The situation may easily become unmanageable if the cooperatives are handled on an ad-hoc basis.

A fundamental requirement for support to rural electrification cooperatives must be that the service can be considered as sustainable. Financial sustainability must be a primary objective. This implies that the revenues must cover the full operating expense and also, in the long-term perspective, the full capital cost. Environmental sustainability should also be a long term objective. This implies that there should be a credible strategy for use of renewable energy sources for the generation of the electricity.

Another fundamental requirement must be that the project leads to benefits not only for those connected to the electricity supply but also to other members of the community. This can be achieved in various ways. Installation of streetlights is one

---

<sup>2</sup> A diesel generator set of 2 kW from Yamaha costs the equivalent of about 2600 USD in Sweden. The specific fuel consumption of this generator set is 0.45 liter/kWh at full power.

<sup>3</sup> The accumulated government contribution to rural electrification in Sweden has been estimated to the equivalent of some 300 MUSD.

<sup>4</sup> In order to avoid misuse of tax exemption on fuel, it is suggested that the exemption be based on metered electric output from the generators and the manufacturer's data for specific fuel consumption.

obvious possibility. Other possibilities are provision of a water supply and electrification of hospitals, health centres, schools and other public buildings.

The following guidelines are proposed for discussion:

1. The cooperative shall be officially registered and have a caretaker committee appointed.
2. The cooperative shall have at least 100 members who have paid a membership fee and a share of at least 40 USD.
3. The District Council shall be a member of the cooperative and have contributed the same amount as the total contribution of the other members.
4. A tariff study, with recommendation for a tariff for year one and two of the operation, prepared by or approved by ABREC shall have been presented to the members. The tariff shall be designed to recover the operating costs (including maintenance and service), investments in meters within 4 years and a reasonable part of the other capital investment.
5. Each member shall have confirmed his willingness to pay for the service according to the proposed tariff.
6. There shall be at least one street light for each 10 consumers. The District Council or individuals shall have made a commitment to pay for the streetlights during the first five years. In case the hospital or clinic in the community is not already electrified, this should be part of the project. There should be a guarantee from the District Council regarding payment of a specified number of electric units for the hospital or clinic.
7. There shall be a credible long-term development plan for the cooperative with load projection and a proposed solution for supply from a renewable energy source.
8. There shall be a credible plan for management of the operation, including plans for training of operators, line workers and administrative personnel. In case supply of electricity or service and maintenance will depend on organisations outside of the cooperative, the parties involved shall have agreed to sign the agreements pending the necessary financial support.
9. The cooperative shall agree to hand over all equipment purchased for the funds provided from outside to ABREC in case the cooperative finds it necessary to terminate the electricity supply.
10. The cooperative shall agree to keep technical and financial records according to instructions given by ABREC and make these records available to ABREC for evaluation on an annual basis.

### ***9.3.5 Organisation of future activities***

The initiation and monitoring of the first rural electrification cooperatives in Tanzania has been carried out in co-operation between TANESCO and SEI. These organisations can obviously continue their work and handle at least also the next two projects. It appears as advisable though to arrange for involving, without much delay, the national organisation that shall deal with rural electrification cooperatives in the future. It has been suggested here that this organisation tentatively named the Advisory Board for Rural Electrification Cooperatives, ABREC, shall be independent of TANESCO.

A gradual shift of responsibilities from TANESCO/SEI to ABREC during the pilot projects would allow a natural growth of ABREC from two or three people to perhaps ten within five years.

ABREC could be given an advisory role both to the electrification cooperatives and to the Government of Tanzania. It should rely on the existing infrastructure of TANESCO whenever this would not be in conflict with its role as an independent advisor. This means that much initial data collection as well as initial studies and implementation could be carried out by TANESCO. TANESCO should be paid by ABREC for such services and the costs included in the project costs.

Until ABREC has been formed and is able to take the full responsibility for support to rural electrification cooperatives TANESCO should consider moving the responsibility from the research department to the department of rural electrification.



## **TANZANIA, ITS PEOPLE AND THEIR ENERGY USE**

### **1. GEOGRAPHIC DATA**

Tanzania is located in Eastern Africa and just below the equator. The country borders Kenya, Uganda, Rwanda, Burundi, Kongo, Zambia, Malawi and Mozambique. To the east, Tanzania adjoins the Indian Ocean with the islands Pemba, Zanzibar and Mafia that are included in the territory. The climate varies from tropical in the coastal zone to temperate in the highlands. Highlands are found in the southern and northern Tanzania, with Kilimanjaro mountain in the North as being the highest point in Africa (5,895 m.a.s.l.). The coastal areas are plains while the central and western parts of the country extend on a plateau of about 1000-1500m above sea-level. In total, Tanzania covers 945,090 square kilometres, of which 60,000 square kilometres are water (Lake Victoria, Lake Tanganyika and Lake Nyasa being the major lakes). A map of Tanzania is shown in the main report.

### **2. POPULATION**

The estimated total population in Tanzania for 1995 was 28,701,077 and the annual growth rate 2.55%. On average, each woman brings birth to 6.15 children. Infant mortality rate is at 109 for every 1000 live births. The present life expectancy is 42.5 years, with, on average, somewhat longer average life time for women, and somewhat shorter for men.<sup>1</sup>

The official language in Tanzania is Kiswahili and 59% of the population aged over 15 is able to read a letter or message in this language. The dominating portion of people is native Africans (99%). On the mainland, about 45% of the people are Christians, about 35% Muslims and the rest followers of various indigenous beliefs. In Zanzibar, the Muslims dominate by far, corresponding to about 99% of the population<sup>2</sup>.

Only 5% of inhabitants aged between 15 and 64 years are wage earners, of which 90% is found within the agricultural sector and 10% in industry.<sup>3</sup>

Similar to other African countries, the rural population is in majority in Tanzania. More than 85% of people live in the rural areas. Facts about the total population witnesses that Tanzania is a country with relatively short life expectancy, and relatively many children per woman.

---

<sup>1</sup> *The World Fact Book 1995*, Central Intelligence Agency.

<sup>2</sup> *Ibid.*

<sup>3</sup> Bureau of Statistics, Dar es Salaam: *Statistical abstract 1991*.

### 3. ECONOMY

#### 3.1. Review of macro economic policies in Tanzania

At the independence in 1961, Tanganyika<sup>4</sup> was one of the poorest countries of the world. Its inhabitants were almost solely dependent on subsistence agriculture and a few estate crops. The number of educated people were limited, and the industry accounted for less than 5% of GDP.<sup>5</sup> Tanzanian post-independence development initially followed a pattern similar to other newly liberated countries'. Typically, strong connections with Europe and the trade routes developed by Germany and Britain dominated the monetary economy. The direction of economic policies relied largely on market forces and stressed the objectives of growth in GDP per capita. In this phase, rural development was hardly none.

However, in 1967, the fundamental development objectives and strategies were reassessed in Tanzania. The new priorities, as enunciated in the Arusha Declaration, emphasised broad-based rural development, self-reliance in development efforts, and the development of an education system conscious about the needs of the people. The state would play the leading role in the reform and the creation of new institutions. Initiatives came from Tanzanian top-level bureaucrats who had found that the inherited 'master-slave' relation between decision-makers and ordinary people renders development impossible. Peasants and small farmers should no longer expect that independence and new leaders would automatically solve their problems and help improve their standard of living.

Despite the abrupt major institutional changes, Tanzania managed to achieve significant improvements in the social sector during the 1960's and early 1970's. In the second half of the 1970's though, Tanzanian economy entered a declining trend, which is only now changing for the better.

Thus economic crisis in Tanzania can be traced back to several external factors such as the international oil-crises, a row of draught years, the collapse of the East African Community and the war with Uganda. Nevertheless, it drew attention to weaknesses in the management of the national economy. Among these infirmities were inadequate incentives and resources for the agricultural sector, a poorly implemented industrialisation strategy, excessive administrative controls over economic activity and the continued growth in the size of the public sector without due regard to the limited financial and administrative capacity.<sup>6</sup>

A number of economic recovery efforts were made by the Tanzanian Government during the 1980's, starting with *Economic Survival Plans* (ESP) in 1980 and 1981. Only limited results were reached with the Plans and in 1982 the *Structural Adjustment Plan* (SAP) was launched. With the SAP programme a framework for restoring and retaining economic stability was sought. Aims included stimulating agriculture development and increasing efficiency, while basic social services and other

<sup>4</sup> It became Tanzania in 1964 with the union of Zanzibar and Tanganyika.

<sup>5</sup> *Trends in Developing Economies 1989*. The World Bank, Washington DC.

<sup>6</sup> Ibid.

general conditions for the most vulnerable groups of the society would not be neglected.<sup>7</sup> The programme led to some improvement of the Tanzanian economy, but the results were not sufficient enough to stimulate any major recovery.

In 1986, following evaluations of the previous programmes, and approved by the *International Monetary Fund* (IMF), the Tanzanian Government initiated the *Economic Recovery Programme* (ERP). The first phase of the ERP focused on supporting the production sector, while the second part was basically an economic and social development programme. The ERP has managed to increase economic activities in Tanzania, and at the end of the 1980's the GNP growth rate in Tanzania increased.

While implementing the ERP, Tanzania enjoyed an augmenting degree of multilateral and bilateral development support as opposed to donors' disengagement during the early 1980's. Aid to Tanzania is high in comparison with other developing countries. Between 1960 and 1991, around 9 billion US dollar (current) was disbursed to Tanzania from bilateral donors, while it received a total from all sources of almost 13 billion US dollar between 1970 and 1992. During the 1990's, Tanzania's share of the total global assistance has been around 2.5%. In 1992, net transfers were US dollar 39 per capita and represented an extraordinary 43% of the GNP at the official exchange rate. By contrast, aid to other Sub-Saharan countries averaged roughly US dollar 17 per capita.<sup>8</sup> In 1997, the net official development assistance received by Tanzania had fallen to 13% of GNP, compared to 6.7% of GNP for the Sub-Saharan countries together.<sup>9</sup>

In terms of GNP, Tanzania is still among the poorest countries in the world, although their economic performance during the nineties has been strong relative other African countries as a group. In 1993, the per capita GNP in Tanzania was 90 US dollars, which was the lowest among the Sub-Saharan African countries<sup>10 11</sup>. Per capita GNP in 1996 was about US dollars 210.<sup>12</sup> Agriculture still dominates the domestic economy contributing with 47% to the GDP in 1997<sup>13</sup>. In the latest years, Tanzanian industrial activities have expanded and the sector accounted for 21% of the GDP in 1997. Already by 1993, more than 50% of this was from manufacturing industry.<sup>14</sup>

Clearly, the current macro-economic policies in Tanzania entrust private investors to a much higher degree than did those in the previous post-independence decades. The privatisation is imminent in most sectors, social service, health care and infrastructure included. Following recent decisions, market economy will as well characterise the power sector, a fact that shall be kept in mind while discussing local initiatives to, and management of rural power supply systems.

---

<sup>7</sup> Ibid.

<sup>8</sup> SASDA, *Evaluation of Swedish Development Cooperation with Tanzania*, Ds 1994: 113, 1994.

<sup>9</sup> UNDP 1999, *Human Development Report 1999*.

<sup>10</sup> Mozambique also had a per capita GNP of 90 Usdollar in 1993.

<sup>11</sup> The World Bank, *World Tables 1995*.

<sup>12</sup> UNDP 1999, *Human Development Report 1999*.

<sup>13</sup> Ibid.

<sup>14</sup> The World Bank, *World Tables 1995*.

In the 1995 State Budget, a growth in GNP of 5% and an inflation reduction from the current over 40% to 15% by mid 1996 were the most important targets. Development projects should be kept at a low level, while over 50% of expenditures should be allocated to economic services as a means to stimulate the private sector investments in the country. According to the Minister of State, economic and social services should be regarded as areas of priority in the 1995 budget, i.e. roads, tele-communications, energy and water. Incentives should also be given to the private sector to invest in the economic and social services.<sup>15</sup> At the end of June 1999 the inflation was about 7.7%.<sup>16</sup>

### 3.2 The economy of rural people

Generally, Tanzania is dominated by large households of which over 40% comprise between 5 and 8 persons. Rural settlements and small towns tend to have bigger households than urban areas. Owner patterns for domestic houses in rural Tanzania are dominated by self-reliance. In principle, all rural families own their houses. Only an insignificant number of rural families rent their houses, or are provided them for free. Houses in rural Tanzania are of simple design in most cases. A characterising feature in rural domestic houses is the poor earth floor. As well significant is that people use candles or hurricane lamps for lighting since electricity is rarely available.<sup>17</sup>

Water in rural Tanzania is scarce and is commonly available in form of public or private unprotected wells, uncovered springs, rivers, dams or lakes. Indoor piping is very rare. For cooking, wood-fuel is clearly the dominating fuel in rural parts of the country. Charcoal and paraffin account for less than 4% of the cooking fuels while wood-fuel amounts to 96% in rural areas.<sup>18</sup> Those in rural areas who possibly use electricity for cooking are not even represented in statistics. Rural households having access to electricity predominately use it for other purposes.

In terms of equipment, national statistics show that it is fairly common that rural households have battery-charged radios and bicycles, while assets like telephones and motor vehicles are rare.<sup>19</sup> An observation from Urambo Township however, suggests that households in urban clusters have more electric equipment than what is given by the national household statistics. In the Urambo town centre, many have irons, TV's and fans. Some also possess refrigerators/freezers and electrical stoves.<sup>20</sup> See further chapter 4 in the main text.

Agriculture still provides the largest contribution to GNP in Tanzania. Incomes in rural, poor households are typically mainly from agriculture. For the poorest, still over 80% of their income share comes from the agricultural labour, although it declined slightly after the onset of the Structural Adjustment Programme (SAP) in 1982. A more drastic change was seen among rich rural households, where the informal share

<sup>15</sup> African Research Bulletin, June-July 1995.

<sup>16</sup> Bank of Tanzania. *Economic and Operations Report for the Year ended 30th June, 1999*.

<sup>17</sup> Bureau of Statistics, Dar es Salaam, 1992: *Household Budget Survey 1991/92*.

<sup>18</sup> Ibid.

<sup>19</sup> Ibid.

<sup>20</sup> Bosco Selemani, House to house survey (13).

grew from less than 50% to more than 80% of incomes during the period 1975-1989.<sup>21</sup> The most significant improvement occurred in the end of the period and can be linked to the general liberalisation of the Tanzanian economy.

National household statistics from 1991/92 concludes that in a majority of Tanzanian households, the sum of incomes does not exceed 48,000 TShs, i.e. US dollar 160<sup>22</sup> per annum. The largest groups are those with annual incomes less than 12,000 TShs (see also table A-1). Note that data given in table A-1 cover both urban and rural areas.

**Table A-1 Percentage distribution of income groups in Tanzania.**

Annual Income (TShs)	(USdollar)	Percentage of Households
0-11,999	0-23.9	28%
12,000-23,999	24-47.9	13%
24,000-47,999	48-95.9	15%
48,000-71,999	96-143.9	12%
72,000-95,999	144-191.9	8%
96,000-119,999	192-239.9	5%
120,000-299,999	240-599.9	11%
300,000+	600+	7%

Source: Bureau of Statistics Dar es Salaam, Household Budget survey 1991/92

Economy-wise, rural people joined the general positive trend in Tanzania during the years after the Arusha declaration was signed. In particular, education, health care and other social services were improved during the period. As from the end of the 1970's, conditions hardened.

The trends in welfare of rural people have been analysed by Bevan et al. (1988 and 1990). They found an increase in rural per capita income between 1967 and 1976/77, a very substantial drop between 1976/77 and 1979/80 and a very small further drop in 1982/83. Collier and Gulling (1989) examined changes in rural economy for the period 1983-1989, and found that declines indicated by earlier studies had been arrested, but no substantial real income increases had occurred in rural areas.<sup>23</sup>

Sarris and Van der Brink (1993) have further evaluated household welfare during the crisis and structural adjustment in Tanzania. One of their major conclusions was that the rural poor were the least affected by the changes in the national economy. Middle-class and rich rural households were as well shielded.<sup>24</sup> The standard of living appears to have improved, primarily because of the increased availability of consumer goods, which may enhance welfare, by improving consumer choice. On the other hand, the crisis has definitely affected the rural social welfare sectors such as schools and health-care. For example, the percentage of Tanzanian children joining school has declined since 1975.<sup>25</sup>

<sup>21</sup> Sarris A.H. & Rogier van den Brink R., *Economic Policy and Household welfare during Crisis and Adjustment in Tanzania*, New York University Press, 1993. ISBN 0-8147-7982-4.

<sup>22</sup> Exchange rate 1:300, as of 1992.

<sup>23</sup> Sarris A.H....

<sup>24</sup> Ibid.

<sup>25</sup> TANZANIA, SIDA's information secretariat, 1993.

The crisis has also influenced price-levels and wages applied in the country. Between 1984 and 1993, official real producer prices stabilised or increased, while official real consumer prices increased significantly. Open market prices declined. The most negative consequence hit the average real wages, which declined enormously over the period. However, rural people as well as urban poor have on account of their large agricultural and subsistence orientation managed to overcome the crisis without having become neither significantly better nor worse off in real terms.<sup>26</sup>

Today, the main economic activity among rural poor in Tanzania is subsistence farming, female subsistence farmers representing a slightly larger group than male subsistence farmers. Secondary activities are typically 'house-caring' and studying. Largely, women and partly children carry out the household works, including collecting firewood and farming. Rural men are in general more oriented towards income bringing work, and frequently leaves for larger townships to work for wages. Men do also to a larger extent than women join post-school courses.<sup>27</sup> These courses are not seldom vocational.

---

<sup>26</sup> Sarris A.H....

<sup>27</sup> Household Budget Survey, 1991/92.

## 4. VILLAGES FORMATION AND PEOPLES MIGRATION IN RURAL TANZANIA

### 4.1 Villagisation programmes

The number of rural villages in Tanzania totals about 8,600 today.<sup>28</sup>

In some centuries' perspective, Tanzanian villages have until very recently been exceptional occurrences. Some generations back, rural people were rather living in individual homesteads in a dispersed settlement pattern. Proper villages - in the accepted meaning of nucleated settlements - existed only in Rungwe and Sumbawanga areas.<sup>29</sup> During the colonialism though, settlement schemes were implemented that aimed at forming villages. The idea was that modernisation of agriculture would accelerate if somewhat developed farmers were moved and strategically placed together with other, less developed. The process was met with doubt and unwillingness by most of the farmers and many sociological scholars described it as a mistake.<sup>30</sup>

With the Arusha Declaration came a new wave of villagisation; 'Ujamaa' (family/relative/socialism). Ujamaa as a principle had always been central to Julius Nyerere, Tanzania's Prime Minister 1961-1985, but the villagisation programme would become its embodiment. The hopes were that socialism and self-reliance would bring a new dimension into the villagisation. Village cooperatives would be formed where the inhabitants jointly shared the work and also shared the incomes of agricultural activities. The Ujamaa programme had many phases and was differently performed in different parts of the country. In its later parts, it included massive numbers of people moving. In round figures, all in all thirteen million<sup>31</sup> people were affected by the villagisation, i.e. 90% of the population in the early seventies.

### 4.2. Migration streams

If compared with inter-regional migration prior to the period of the Ujamaa programme, the Ujamaa meant more 'short' migrations, typically between neighbouring regions. Previous peaks in inter-regional migration could be seen in the 1950's with the most notable feature then being the long-distance migration streams, especially between Kigoma, Mbeya, Iringa and Ruvuma (origins) and Tanga (destination). These streams were a reflection of labour movements to the coastal estates, and to small holder farms around the lakes and in the northern Tanzania.<sup>32</sup>

Kilimanjaro region, where Shimbi village is found, experienced a net-loss in people up to 1978 year's census<sup>33</sup>. The majority of out-migrants had left for the Arusha region,

<sup>28</sup> *Rural Electrification in Tanzania*. Björn Kjellström et al.

<sup>29</sup> Kjekhus H., *The Tanzanian Villagization Policy: Implementational Lessons and Ecological Dimensions*, Canadian Journal of African Studies, Volume XI, no 2, 1977, pg 269-282.

<sup>30</sup> Ibid.

<sup>31</sup> Ibid.

<sup>32</sup> Mbaruku H. *Regional population growth and its components*. (Chapter five in the 1978 population census). Bureau of Statistics, Ministry of Planning and Economic Affairs, Dar es Salaam 1983.

<sup>33</sup> Based on *place of birth versus place of residence 1978* statistics.

and after independence especially to Upper Kitete. Arusha is one of the regions in which major development efforts took place to expand export crop production after independence as a means to reinforce investments made during the colonial period. Other such regions are Morogoro, Coast, Mbeya, Tabora, Rukwa, Shinyanga and Kagera. Tabora region embraces both Sikonge and Urambo, and will be further discussed subject to the Urambo pilot project. Ruvuma region, where Mbinga village is located, lost more people than they received up to 1978 year's census. Those who had moved to Ruvuma were born in Mozambique, the Mtwara or Iringa regions, while those who were born in Ruvuma and left the region predominately went to Mtwara, but also to Morogoro and Tanga. According to H. Mbaruku's analysis of the censuses, no one immigrated to and settled down in Ruvuma between 1967-1977, during the Ujamaa programmes.<sup>34</sup>

Tabora region is one of the regions that have experienced a high rate of population growth since independence. In the 1988 census, the population had exceeded 1 million, and had thus doubled since 1967. If compared to the rest of mainland Tanzania, the population in Tabora's growth rate is 11% higher during the period.<sup>35</sup>

Statistics from 1978, show that up to then, almost one third of the increase in population can be referred to immigration, placing the region as the second most receptive after Dar es Salaam.<sup>36</sup> The majority (80%) of people had come from other regions in mainland Tanzania, and primarily from Shinyanga, Singida and Rukwa regions. The residuals were refugees from Burundi. Tabora region alone had received 97% of the Burundian refugees up to 1978, and most of them have settled down permanently.<sup>37</sup>

Tabora as well as other regions showing net-gain in migration during the ten years after independence, were subject to major developments to expand export crop production. The development of new settlement schemes and the early spontaneous Ujamaa villages of the late 1960's, encouraged inter-regional migration. One out of three main destinations in the country was the Tabora region and especially the Urambo tobacco schemes. Urambo district experienced a 9.4% annual population growth rate over the ten years, which placed it among the three fastest growing districts in the country.<sup>38 39</sup>

According to the 1988 census, Urambo district counted to 188,081 residents, of which slightly more than 11% lived in urban parts. The urban clusters were Urambo urban ward with 11,830 inhabitants, Kaliua urban ward with 5,897 inhabitants and Usoke urban ward with 3,577 inhabitants. The urban population had not changed much since 1978, whereas the rural population had increased with an annual growth rate of 4%. There are equally many persons under fifteen and between fifteen and sixty-five, but very few over sixty-five.

<sup>34</sup> Mbaruku H...

<sup>35</sup> Mbaruku H., *Regional Population Growth... and Migration: an analysis...*

<sup>36</sup> Based on place of birth versus place of residence in 1978.

<sup>37</sup> Mbaruku H., *Regional Population Growth ...*

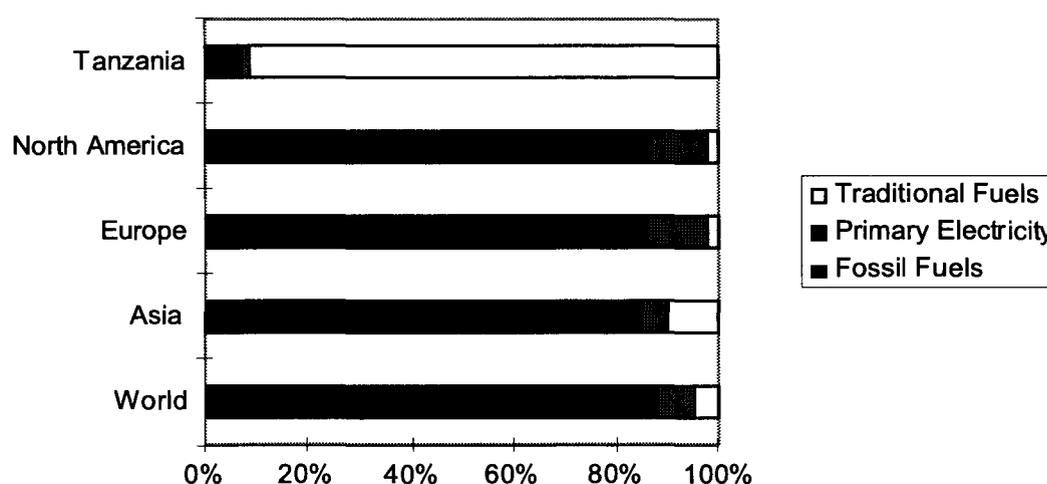
<sup>38</sup> Both Songea sub-urban district in Ruvuma region and Kinondoni district in Dar es Salaam district had an annual growth rate of 9.9%.

<sup>39</sup> Mbaruku H. *Regional Population Growth ...*

## 5. ENERGY SUPPLY AND USE IN TANZANIA

### 5.1 International comparison

The total annual primary energy use per capita in Tanzania is as low as 453 thousand toe (tonnes of oil equivalent) and thus only one fourth of the world's average. For comparison, the East Asian average is 1,004 thousand toe per capita, and the Industrial Countries 5,388 thousand toe per capita. The bulk of primary energy used in Tanzania is derived from traditional indigenous fuels, whereas fossil fuels dominate the energy supply in most industrialised countries.<sup>40</sup>



Source: UN Energy Statistics 1992.

**Figure A-1. Proportion of Fossil fuels, Primary electricity, and Traditional fuels of total primary energy use.**

### 5.2. Indigenous energy sources and utilisation

Biomass fuels are the most widely used indigenous energy resource in Tanzania. This includes fuel-wood, bagasse, charcoal, animal wastes, vegetal wastes and other wastes. In 1992, energy from traditional biomass combustion accounted for 324,000 TJ<sup>41</sup> annually, i.e. 91% of Tanzania's total primary energy supply. By 1996, combustible renewables and waste amounted to 95%. The dominating biomass fuel is wood, in the form of fuel-wood or charcoal.

The total sustainable biomass fuel resources in Tanzania was estimated in 1990 to be 1,130,000 TJ from natural forest, 43,500 TJ from forestry and forest industry surplus and residues and 129,800 TJ from agricultural residues, giving a total biomass resource of 1,303,300 TJ. This estimate of the potential is based on the assumption that 80 percent of the mean annual increment can actually be harvested and that all agricultural

<sup>40</sup> UNDP 1999, *Human Development Report 1999*.

<sup>41</sup> UN, *Energy Statistics YearBook 1992*.

residues can actually be used as fuel. This would indicate that there is a large potential for increased use of biomass fuels in Tanzania. On a local and regional basis however, the resources appear to be over-utilised. Even with the very optimistic assumptions used for estimation of the potential, the biomass fuel balance was estimated to be negative in 1990 for the Kilimanjaro, Mara, Mwanza, Shinyanga and Dar es Salaam regions.<sup>42</sup>

Hydroelectric production contributed with 5,576 TJ<sup>43</sup> to the national energy balance in 1990 and is the second largest indigenous contributor to Tanzania's primary energy production. The hydroelectric potential in the country is estimated to be 4.7 GW installed capacity<sup>44</sup>. To date, 3.8 GW generating capacity is installed. In 1996, the annual hydro electric production had increased to 6,292 TJ (1,748 GWh).<sup>45</sup>

Coal resources in Tanzania were in 1992 estimated at 35,000,000 TJ of which 10,000,000 TJ could be considered proven<sup>46</sup>. However, coal utilisation in Tanzania is very little developed despite the fact that the occurrence of coal was first reported many decades ago. In 1992, indigenous coal accounted for only 117 TJ<sup>47</sup> of the primary energy production in Tanzania.

Natural gas resources in Tanzania were elucidated in the late 1980's. A source found in Songo Songo region contains 25-30 billion m<sup>3</sup>. Another 10-17 billion m<sup>3</sup> are found in Mnazi Bay<sup>48</sup>. Non of the two sources are yet utilised, but there are plans for both direct combustion and electricity generation.

Other energy resources in Tanzania include sun, wind, geothermal energy and uranium. Uranium was discovered during a ground survey in 1976<sup>49</sup> but mining has neither been started nor planned. Geothermal activities were indicated in some areas during reconnaissance appraisal studies in the late 1970's. These areas lie along the East African rift valley system.<sup>50</sup> Harnessing the geothermal resources is mentioned as a possibility in current national energy planning. Geothermal power plants have been built in the Kenyan part of the rift.

Sun and wind resources are poorly harnessed in Tanzania. Low speed windmills have been tried though, and are found to have a potential in the country.<sup>51</sup> Solar water heating is one of many favourable ways of using the insolation in the country and its implementation is included in the energy plan as presented below. Other options are drying of crops and fishes, both of which are traditional methods for harnessing solar energy. Photovoltaic product retailers exist in Tanzania, but their joint turnover is

<sup>42</sup> Ministry of Water, Energy and Minerals, *The Energy Policy of Tanzania*, April 1992. (pg 6-7).

<sup>43</sup> Bureau of Statistics Dar es Salaam, Statistical Abstract: 1991, Tab.H 38. (1,549 Gwh)

<sup>44</sup> Ministry of Water, Energy and Minerals, *The Energy Policy of Tanzania*, April 1992. (pg 4).

<sup>45</sup> OECD 1998, *Energy Statistics & Balances of Non-OECD Countries 1995 - 1996*.

<sup>46</sup> Ministry of Water, Energy and Minerals, *The Energy Policy of Tanzania*, April 1992. Conversion factor: 1 TCE = 0.0293076 TJ.

<sup>47</sup> UN, *Energy Statistics Year Book 1992*.

<sup>48</sup> Ministry of Water, Energy and Minerals, *The Energy Policy of Tanzania*, April 1992. (pg 4).

<sup>49</sup> African Research Bulletin, Economic, Technical and Financial series, August 1985 (pg 7898).

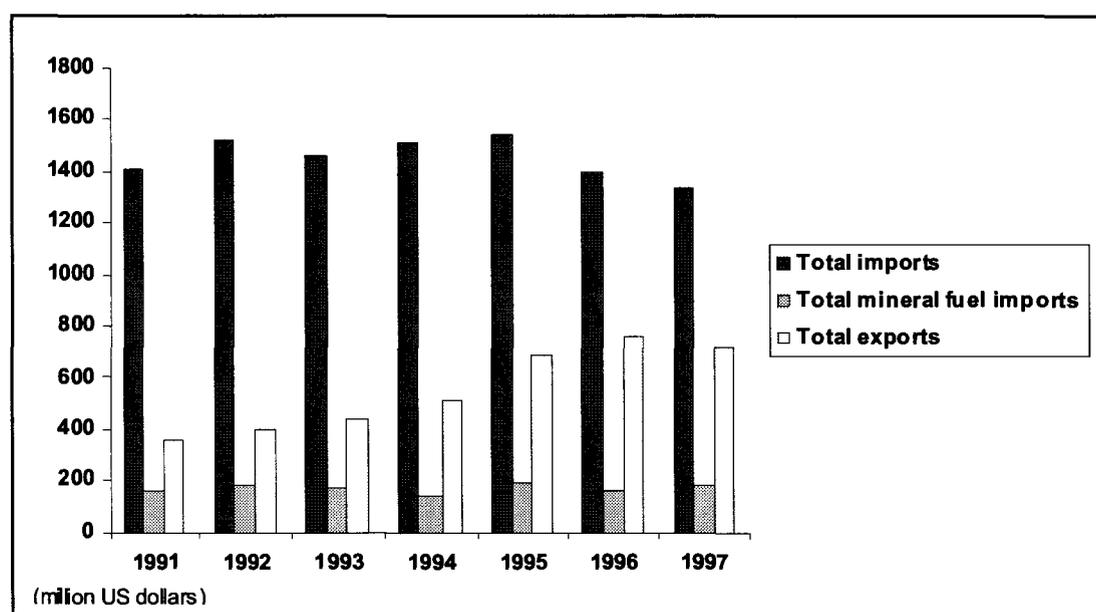
<sup>50</sup> World Energy Council, *International Energy Data 1989*.

<sup>51</sup> Ministry of Water, Energy and Minerals, *The Energy Policy of Tanzania*, April 1992. (pg 4).

unknown and probably not very large. There is also a small and unspecified number of aid projects that have installed photovoltaic panels for their own use (typically health centres, schools and churches). The insolation measures 4.5 kWh/m<sup>2</sup>,day.

### 5.3 Imported energy

Tanzania relies heavily, particularly in economic terms, on imported commercial energy in the form of crude oil and petroleum products. In real terms, the value of imported mineral products was in the order of 200 million US dollar per annum in the 1980's. During the period 1983-1990, mineral fuel imports averaged 48% of Tanzania's total exports. The situation during 1991-1997 averaged 33%.



Source: Bank of Tanzania Bulletin, Vol. XXVIII No 4, 31st December 1998.

Figure A-2. Value of total mineral fuel imports, total imports and total exports 1991 - 1997

In 1992, Tanzania imported 558 thousand tonnes crude petroleum. In 1996 this figure was 600.<sup>52</sup> During 1989-1991 the imported crude petroleum was higher and amounted to about 650 thousand tonnes annually. The imported crude oil is refined outside Dar es Salaam. The total refinery distillation capacity in Tanzania is estimated to 850 thousand tonnes per year. In 1992 the throughput was 575 thousand tonnes and the output 567 thousand tonnes. The difference in throughput and output results from losses during transfers, black-flows and blending of various petroleum products and condensates.<sup>53</sup>

A small amount of refined oil products is exported from Tanzania to neighbouring countries. Tanzanian petroleum exports in 1992, totalled 24 thousand tonnes.

<sup>52</sup> OECD 1998, Energy Statistics & Balances of Non-OECD Countries 1995 - 1996.

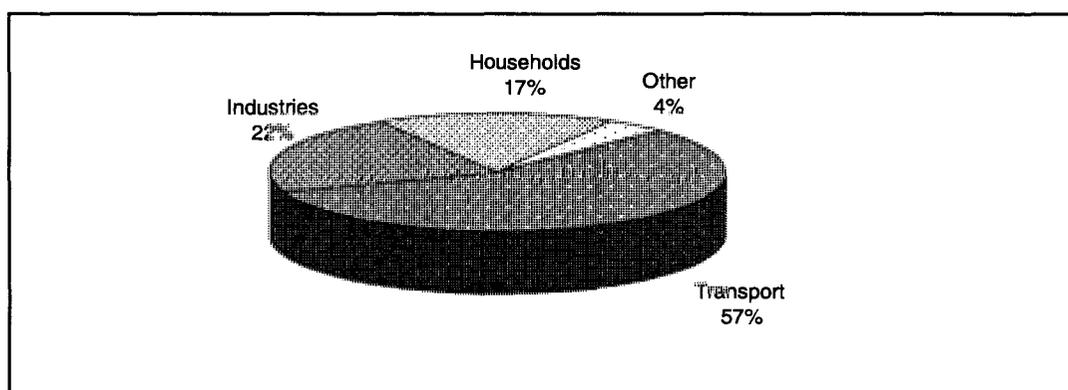
<sup>53</sup> UN, *Energy Statistics YearBook* 1992.

Exported energy petroleum products from Tanzania are motor gasoline, gas-diesel oil and residual oil.<sup>54</sup> In 1996, the export amounted to 29 thousand tonnes.

Tanzania also imports refined petroleum products. A total of 118 thousand tonnes of refined petroleum products were imported during 1992. (Data for 1992 do not include kerosene imports, but in 1989-91 kerosene imports amounted to about 25 thousand tonnes per year.)<sup>55</sup> In 1996, 177 thousand tonnes of refined petroleum products were imported to the country.

In total, 49 tonnes of petroleum products were bunkered during 1992, and thus 612 thousand tonnes consumed (equivalent to 25,665 TJ).<sup>56</sup> Correspondingly, 22 tonnes were bunkered in 1996 and 467 consumed.<sup>57</sup>

The transport sector accounts for about 57% of the total refined petroleum product demand in Tanzania in 1996<sup>58</sup> (versus 42% in 1993)<sup>59</sup>. In 1996, industries and households account for 22% and 17% respectively (versus 22% and 11% in 1993). Other main consumers of petroleum products in Tanzania include commerce and agriculture accounting for 6% and 5% respectively in 1993 (there are no values given in the 1998 OECD energy statistics report).



Source: OECD 1998, Energy Statistics & Balances of Non-OECD Countries 1995 - 1996.

Figure A-3. Consumption of imported fuel by sector in 1996.

Other forms of imported energy include coal, a small amount that is used in tea estates, cement plants and other local industries. In 1992, the solid fuels imported totalled 1 thousand tonnes, equivalent to 29 TJ.<sup>60</sup>

## 5.4 Electricity in Tanzania

### 5.4.1. Electricity supply and its development

<sup>54</sup> Ibid.

<sup>55</sup> Ibid.

<sup>56</sup> Ibid.

<sup>57</sup> OECD 1998, Energy Statistics & Balances of Non-OECD Countries 1995 - 1996.

<sup>58</sup> Ibid.

<sup>59</sup> Mwandosya M.J. and Luhanga M.L., *Energy and Development in Tanzania*, Energy Policy, Volume 21, no. 5, May 1993.

<sup>60</sup> UN, *Energy Statistics...*

Until in the 1960's, the installed power generating capacity in Tanzania had not exceeded 20 MW<sup>61</sup>. Two hydroelectric stations in Pangani River Basin that were completed in the mid 1930's constituted the main power plants in the country. Loads were concentrated to the coastal zone and mainly Dar es Salaam.

In both the first and the second five-year plan<sup>62</sup> of Tanzania, power sector development was brought up as a key to industrial development. Large-scale hydropower schemes were emphasised and the linking up of new urban areas was also mentioned. The new townships to be supplied with power were to be chosen on the basis of their commercial potential a few years ahead. Power sector investments were envisaged to account for 6% of investments in Tanzania during 1970-75.

The most important single undertaking in the power section of the second five-year development plan was the further investigation of Stieglers Gorge with the Rufiji River in it. At that time, the power generating potential in the Rufiji River was estimated to be 400-600 MW<sup>63</sup>. The ultimate potential investigated was 2,100 MW.<sup>64</sup> Second thoughts though, based on subsequent studies on ecological, social and national economic aspects, have led Tanzania to scale down the development of the Rufiji Basin Stiegler's Gorge project to 1400 MW. Low electricity demand in the country and to a less extent environmental concerns delayed the project financing. In the end of the 1960's, planning also started for Kidatu and Mtera hydroelectric power schemes, today being the countries largest with a joint generating capacity of 280 MW.

Between 1966 and 1991, at least 400 million US dollar have been contributed directly to the Tanzanian power sector in the form of bilateral and multilateral aid.<sup>65</sup> Foreign engineers have also carried out a majority of implementations. The Kidatu and Mtera power plants have absorbed most of the money, together about 270 million US dollar. In round figures, the total amount of foreign funds channelled into power sector investments equals not less than 3% of the total development aid received by Tanzania during the same period. During the 1980's and early 1990's, electricity together with water supply has accounted for 10-15% of the gross fixed capital formation in Tanzania.<sup>66</sup> The power sector has over the period contributed to between 1% and 2% of Tanzania's GDP.<sup>67</sup>

In 1990, the total installed generating capacity in TANESCO's national grid and isolated networks had reached 486 MW. Hydroelectric generators accounted for 329 MW, and the rest were diesel-generating sets. The total energy generated in TANESCO's power plants increased from 856 GWh in 1983 to 1,628 GWh in 1990. See also table A-2 below.

---

<sup>61</sup> Kjellström B., Katyega M., Kadete H., Noppen D. and Mvungi, A., *Rural Electrification in Tanzania*, SEI 1992.

<sup>62</sup> The first plan was valid from 1964/65-1969/70, the second for 1969/70-1974/75.

<sup>63</sup> Havnevik K.J., *Tanzania - the limits to development from above*, Nordiska Afrika Institutet, Sweden 1993. ISBN 91-7106-335-8.

<sup>64</sup> TANESCO

<sup>65</sup> Based on notes in the African Research Bulletin over the period 1966 to 1995.

<sup>66</sup> With an exception for 1986 when the sector peaked to 30% of the gross fixed capital.

<sup>67</sup> Statistical Abstract 1991.

Although many foreign engineers have been involved in the up-building of Tanzania's power supply sector, TANESCO has in principle had the leading role in operating the system, maintaining it and also in planning for possible changes or expansions in the power network.

---

<sup>68</sup> African Research Bulletin, July 1992.

## Appendix A

**Table A-2. Installed capacity and units generated per station (TANESCO's power systems)**

Station	Capacity	Electricity Generated (GWh)					Capacity	Electricity Generated (GWh)									
	1990 (MW)	1993	1994	1995	1996	1997	1998	1999	1997 1990	(MW)	1991	1992	1993	1994	1995	1996	1997
National Grid:																	
<b>Hydro:</b>																	
Kidatu	200.0	535.7	585.0	732.7	900.0	990.1	906.9	919.2	891.2	200	978.6	989.8	1107.1	963.5	855.7	988.4	773.3
Mtera	80.0	-	-	-	-	-	185.1	320.4	891.2	80	501.6	411.8	421.5	374.1	233	337.2	205.3
Hale	21.0	69.2	64.2	60.3	14.2	50.4	70.4	94.6	120.2	21	111.4	116.2	80.6	57.4	102.2	91.1	107
Old Pangani falls	17.5	84.8	79.0	46.3	72.3	67.4	53.2	41.2	35.1	12	75.2	87.1	70	41.8	1.3	0	0
New Pangani Falls									68				18.6	308.8	294.8	335.1	
Nyumba ya Mungu 8.0	46.2	42.5	40.7	45.0	31.3	31.3	41.5	49.9	8	55	44.5	19.1	36.3	37.6	36.3	28.3	
Tosamaganga	1.2	7.9	9.0	2.4	0.0	0.0	1.8	2.3	2.0	1.2	3.8	0.5	0	0	0	0	0
Kikuletwa	1.1	3.2	4.0	4.0	1.3	6.3	2.6	0.0	0.0	1.1	0	0	0	0	0	0	0
<b>Thermal:</b>																	
Arusha	3.7	0.6	0.0	0.5	1.5	5.2	7.1	4.2	4.2	1	6.5	3.9	2.3	3.7	0.6	0	0
Ubungo (DSM)	61.6	0.4	0.6	1.8	0.4	2.2	1.3	0.5	0.8	10	4.2	28.7	38.3	44.8	23.4	21.4	6.3
Ubungo Gas Turbines										112				78.1	89.1	47.5	378.1
Dodoma	5.1	10.7	13.4	12.3	2.5	1.3	0.8	0.1	0.1	7.1	0.5	3.5	4.6	9	9.4	7.1	12.7
Mbeya/Iyunga	13.9	18.1	26.0	13.9	0.4	2.6	2.8	2.1	5.0	3.1	5.1	17.8	15.2	24.9	15.6	11.5	15.3
Musoma	7.4	12.6	17.0	10.8	11.7	10.5	11.0	7.5	0.3	2.3	0.01	2.7	1.6	6.5	3.6	0.6	3.2
Mwanza/(Nyakato) 28.9	29.8	36.3	41.9	39.3	36.2	36.1	1.3	3.9	6.5	6	24.8	30	39.1	24.9	2.8	5.4	
Shinyanga	2.3	4.1	5.2	5.4	4.8	5.1	1.5	2.8	0.2	0	0.02	0	0	0	0	0	0
Singida	1.8	1.6	2.3	2.4	2.6	0.1	0.7	0.6	0.1	0	0.01	0	0	0	0	0	0
Tabora	5.0	5.4	10.0	10.5	12.9	12.5	12.2	8.3	1.2	5.5	1.6	5.1	5.3	15.8	9.4	4	8.3
<b>Total</b>	<b>458.5</b>	<b>830.3</b>	<b>894.5</b>	<b>985.0</b>	<b>1109.8</b>	<b>1221.2</b>	<b>1324.8</b>	<b>1446.6</b>	<b>1564.8</b>	<b>538.8</b>	<b>1749.5</b>	<b>1736.4</b>	<b>1795.6</b>	<b>1713.6</b>	<b>1714.6</b>	<b>1842.7</b>	<b>1878.3</b>

(Table A-2 continues on next page)

## Appendix A

**Table A-2. Installed capacity and units generated per station (TANESCO's power systems) (continued)**

Station	Capacity 1990 (MW)		Electricity Generated (GWh)					Capacity 1997		Electricity Generated (GWh)							
	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997		
Isolated networks:																	
<b>Thermal:</b>																	
Bukoba	2.5	3.6	3.4	3.5	5.6	5.9	6.7	6.9	8.9	2.5	10.6	12.3	10.8	0.5	0.2	0.1	0.1
Chamwino	0.7	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.4	1.3	2.1	2.4	2.1	1.4	2	2.3
Babati	0.5	0.0	0.2	0.4	0.5	0.9	1.0	1.1	1.0	0.7	0.3	0.2	0	0	0	0	0
Kiabakari	0.5	0.5	0.0	0.0	0.0	0.1	0.0	0.0	0	0	0	0	0	0	0	0	0
Kigoma	1.6	4.1	5.0	5.6	6.5	6.4	8.6	9.3	9.6	2.5	8.7	10.5	13.2	10.5	10.3	10.2	9.9
Kilwa/Masoko	0.7	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.25	0.6	0.7	0.8	0.7	0.8	0.7	0.7
Kondoa	0.5	0.3	0.3	0.5	1.2	0.9	1.1	0.9	0.8	0.4	0.8	1.9	2	2.1	1.7	2.1	2
Lindi	0.0	0.0	0.0	0.0	0.5	3.3	3.3	4.0	4.5	1.25	5.3	4.8	4.9	5	4.9	4	4.4
Mafia	0.8	0.7	0.8	0.8	0.9	1.0	1.1	1.0	1.0	0.85	0.8	1.1	1	1.2	1.5	1.6	1.4
Mpanda										1.08			0.9	1.7	1.9	1.9	2.3
Mpwapwa	1.1	0.4	0.5	0.5	0.6	1.2	1.5	1.6	2.0	0.85	2.3	2.5	2.5	2	0	0	0
Mtwara	4.4	5.8	7.1	7.1	7.7	7.1	8.1	8.6	8.0	1.96	7.7	8.9	6.8	8.8	8.1	7.9	7.1
Nachingwea	1.0	1.0	1.0	0.9	1.2	2.2	0.7	1.0	0.1	0	0	0	0	0	0	0	0
Njombe Diesel	1.6	1.0	2.0	2.3	2.9	2.9	3.2	2.2	0.0	1.28	3.9	4.4	5.1	6.4	2.5	0.7	1.1
Njombe Minihydro									0.72						2.4	1.5	
Songea	2.6	2.2	3.3	2.5	2.3	8.4	6.8	8.2	10.0	1.7	10.9	12.6	12.2	10.1	8.3	7.3	8.7
Sumbawanga	1.5	1.2	0.5	0.7	1.1	2.0	4.5	4.4	6.3	1.25	7	8	8	7.1	6.5	5.2	6.9
Tukuyu/Mwakaleli	1.7	3.8	4.0	4.4	3.7	4.6	4.9	5.1	4.7	0.7	5.1	2.5	0	0	0	0	
Tunduma	0.4	0.4	0.5	0.6	0.7	0.7	0.9	0.9	0.4	0.4	1.6	0	0	0	0	0	0
Ikwiriri	0.6	-	-	-	-	-	-	-	0.1	0.85	0.2	0.4	0.5	0.5	0.5	0.6	0.6
Masasi	4.5	-	-	-	-	-	2.6	3.7	5.7	3	7.5	8.3	8	9.1	8	6.3	7.3
Liwate	0.1	-	-	-	-	-	0.0	0.0	0.0	0.05	0.05	0.004	0.15	0.05	0.3	0.3	0.4
<b>Total</b>	<b>27.3</b>	<b>26.0</b>	<b>29.4</b>	<b>30.2</b>	<b>35.8</b>	<b>48.0</b>	<b>53.0</b>	<b>55.0</b>	<b>63.7</b>	<b>22.69</b>	<b>74.65</b>	<b>81.204</b>	<b>79.25</b>	<b>67.85</b>	<b>56.9</b>	<b>53.3</b>	<b>56.7</b>
<b>TOTAL</b>	<b>485.8</b>	<b>856.3</b>	<b>923.9</b>	<b>1016.1</b>	<b>1145.6</b>	<b>1269.2</b>	<b>1377.8</b>	<b>1501.6</b>	<b>1628.5</b>	<b>561.49</b>	<b>1824.19</b>	<b>1817.604</b>	<b>1874.85</b>	<b>1781.45</b>	<b>1771.5</b>	<b>1896</b>	<b>1935</b>

Source: ACRES "Power Sector Master Plan," submitted to TANESCO, June 1999/TANESCO

Since 1990 increases of about a nominal 280 MW capacity and improvement in potential available capacity in the interconnected system have come from:

- redevelopment of the Pangani Falls hydro-electric station with two new units adding 2 x 33 MW in 1994<sup>69</sup>;
- addition of two oil-fired gas turbines, with a rated capacity of 2 x 18.5 MW each in service at Ubungo in July to September 1994<sup>70</sup>;
- another total of 75 MW gas turbines at Ubungo, an installation that was completed in November 1995<sup>71</sup>;
- rehabilitation of two units at Kidatu has improved potential available capacity;
- rehabilitation of existing grid-connected diesel power stations has also improved available thermal capacity;
- a 100 MW diesel plant at Tegeta Dar es Salaam was installed in 1998 by an independent power producer IPTL whose commissioning is pending resolution of a dispute under arbitration.

In 1997, the total installed generating capacity in the public, inter-connected system is about 539 MW, of which 391 MW are hydro power and the remaining 148 MW diesel generator sets or gas-turbines. Another 23 MW<sup>72</sup> diesel generating sets are installed in isolated branches of TANESCO, and isolated, private, generating capacity was estimated to be about 43 MW in 1991 in the Power VI report. Electricity generation in the isolated TANESCO systems stands for only 4% of their total generation.

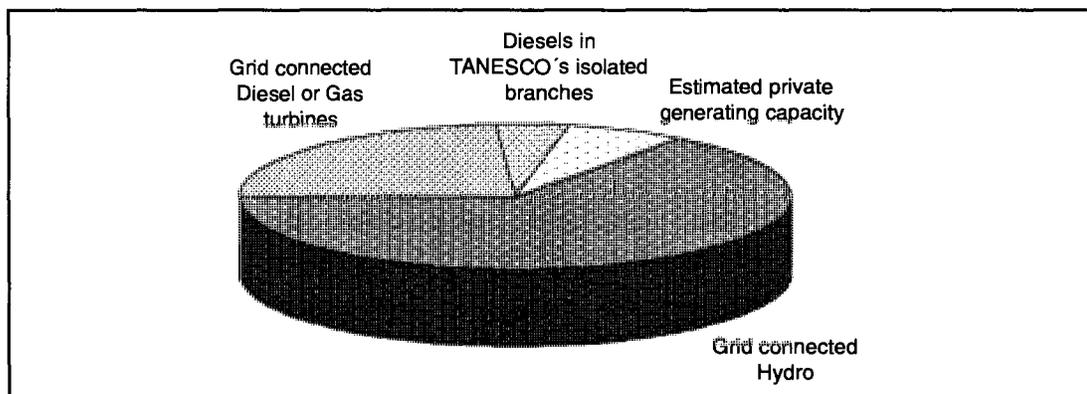
---

<sup>69</sup> Funding from NORAD (42%), SIDA (33%) and FINNIDA (25%). Total estimated cost: 820 million NOK.

<sup>70</sup> By a Canadian joint venture (*TransCanada Pipeline of Toronto and Ocelot Energy Incorporation of Calgary*). Total cost estimated to US dollar 40 million.

<sup>71</sup> TANESCO.

<sup>72</sup> TANESCO, Songo Songo report.



Source: TANESCO

Figure A-4. Total installed electricity generating capacity in Tanzania.

#### 5.4.2 Tendencies in electricity demand

Electricity sales are still concentrated to the coastal zone, and industries and other commercial activities are the main customers. In 1990, TANESCO sold 1,304 GWh all in all. The bulk of electricity was sold to Dar es Salaam (45%), Tanga (9%) and Arusha (7%). More than 60% of the electricity was used in industries and for commercial activities, while residential consumption accounted for 32% of the units sold. The quantity of electricity sold by area and the number of consumers per area, including year 1996, are shown in table A-3.

Table A-3. Number of consumers by area and total electricity sales per area, 1990 and 1996

Area	Number of consumers		Electricity sales (GWh)	
	1990	1996	1990	1996
Arusha	10638	16507	87	167
Kilimanjaro	16566	26358	76	112
Dar es Salaam	69613	107434	590	758
Tanga	15242	22091	119	133
Morogoro	9106	14770	82	102
Bukoba	2363	5027	8	18
Chamwino, Dodoma & Kondea	5795	9308	28	37
Iringa and Njombe	5093	9574	82	89
Kigoma	2848	3698	8	8
Kilwa Masoko	391	551	0	2
Lindi	1687	1984	3	5
Mafia	366	543	1	2
Mbeya and Tunduma	6468	12348	42	59
Mpwapwa	680	1055	2	2
Mtwara	3123	4545	10	16
Musoma	3358	5160	14	18
Mwanza	7459	12853	45	74
Nachingwea	753	985	3	2
Shinyanga	2791	5820	17	41
Singida	2027	3832	5	10
Songea	2296	4061	7	11
Sumbawanga	1639	3468	5	10
Tabora	3505	5870	15	22
Tukuyu	1119	2626	3	9
Zanzibar (bulk sales)			52	86
<b>Total</b>	<b>174926</b>	<b>280468</b>	<b>1304</b>	<b>1792</b>

Source: ACRES "Power Sector Master Plan," submitted to TANESCO, June 1999/TANESCO

Electricity uses in Tanzania are increasing and slowly switching from being totally dominated by large industries towards including more and more residential and small

industrial consumption. Between 1985 and 1991, the following trends could be noticed:<sup>73</sup>

- Total grid sales were growing at a rate of 10% per annum;
- The portion of low voltage (residential and small commercial) connections on the system increased steadily;
- Average consumption of low voltage consumers (residential and small commercial), expressed as kWh/year and consumer, was steadily increasing;
- Average tariffs increased in real terms during the late 1980's. However, high voltage consumers are still subsidising low voltage consumers.

The average annual load factor has been steadily increasing; rising from 50% in 1985 to 67.3% in 1991.

In the interconnected system, electricity sales in 1991 totalled 1,405 GWh. Net generation stood at 1,740 GWh, and losses were 19.5% (10.7% technical and 8.5% non-technical). See also table A-4. The corresponding figure for year 1996 are 1,718 GWh sales, 1,926 GWh net generation and 10.8% losses. The bulk of electricity was sold to large industries, large commercial enterprises and residential consumers.

During 1992 - 1994, hydropower resources have been limited due to droughts, and TANESCO have in periods applied load shedding in the interconnected system. Reservoirs were depleted as rains failed. It also happened that people living downstreams the reservoirs opened them up on their responsibility with the aim to irrigate their fields. The lack of water in the hydropower dams unconditionally put TANESCO in a situation of unsatisfactory supply capability. The main periods of load shedding have been September 1992 to April 1993, and September 1994. TANESCO estimates they could have sold about 20% more electricity than they actually did, had the energy been available.

During 1992 - 1994 load shedding was implemented in all load centres on the interconnected grid. Industries were required to shut down all electricity use except for security lighting during certain days of the week, as well as every night. Other loads were disconnected on schedule. Generally, residential consumers were disconnected every second day from 08.00 to 21.30. Consumption patterns in the interconnected grid changed slightly under load shedding conditions. Residential sales accounted for 37% of total systems sales during 1993, while Large Industrial consumers had dropped to 34%.

TANESCO and World Bank did in 1994 elaborate the loads as anticipated for 1992 and 1993 without load shedding. In table A-4 their estimations are included.

### ***5.4.3 Rural electrification***

---

<sup>73</sup> Songo Songo gas development discussion paper, TANESCO/World Bank 1994.

The rural electrification programme in Tanzania, can be characterised as TANESCO's expansion into district townships, other small townships, villages, settlements and development centres, agro-based industries and other small industries outside of the regional towns. The TANESCO rural electrification programme has so far provided access to electricity in 37 rural towns (30 of these being district towns) and 14 villages.<sup>74</sup>

During the socialistic period, power sector development has been highly dependent on governmental priorities, initiatives and funding. Pre-feasibility studies for rural electrification projects have been initiated by TANESCO, as requested by MWEM. TANESCO-staff have then evaluated the socio-economic benefits of electrifying the area in question, and weighed it with the roughly estimated costs for implementing a power supply system. In a later phase of the planning, a foreign consultant has often been involved, and if the project has still been thought to be financially feasible, financing arrangements have been made, often through a foreign development aid agency.

The map in fig. 2 shows the present extension of the national grid as well as isolated systems managed by TANESCO. Only less than 1% of the rural Tanzanian households have access to electricity. For comparison, 34% of the urban households have access to electricity. The regional distribution of household electrification is illustrated in fig. 3.

All existing TANESCO-managed isolated power supply systems are based on diesel generation. They have typically a rated capacity of a few hundred kW to a few MW. In these systems, the plant load factor is seldom over 0.5, and often less than 0.1. The specific fuel consumption mainly ranges between 0.25 kg/kWh for the larger stations and 0.45 kg/kWh for the smaller systems.<sup>75</sup> The number of staff employed at the stations vary between 9 and 30, or if expressed in relation to the size of the station, between 0.01 and 0.1 persons per kW installed.<sup>76</sup> Based on data from 1988, the cost per unit sold in these systems is ranging from 0.13 to 0.26 US dollar/kWh. The revenues on the other hand, were in the order of 0.03 - 0.04 US dollar per kWh sold, given by current pan-territorial tariffs. All the TANESCO isolated diesel branches run on a loss.

Countrywide electrification continues being an aim from the Tanzanian Government's side, despite high costs and poor benefits in terms of intensified efficacy in production and agriculture. Rather, new approaches are sought for that reduce costs of providing electricity as well as accelerates the positive effects of people's access to electricity.

Still, TANESCO's rural electrification programme is the only activity of any significant scale, for the development of rural power supply in Tanzania. Rural townships and villages have highest priority of which over 30 remains un-electrified.

---

<sup>74</sup> Kjellström B. et al., *Rural Electrification in Tanzania*.

<sup>75</sup> Ibid., table 3-7.

<sup>76</sup> Ibid., table 3-8.

A broad pre-feasibility study<sup>77</sup> carried out in 1986 showed that in 40% of cases evaluated, installation of a local diesel power plant was feasible. Most of the diesel power plants would be viable only as temporary solutions followed by grid connection or by a minihydro power plant. For only 5% of cases studied, the local diesel power plant would be the least cost long-term solution. For the sites where diesel power was found advantageous, the initial power demand mainly ranges between 140 kW and 500 kW. In the town ships that have so far not been considered by TANESCO, people will have to wait indefinitely for electricity supply given today's situation.

However, the presently valid energy policy document of Tanzania (MWEM, 1992), brings up a number of thoughts that encourages departures from the established course of action.

---

<sup>77</sup> Sheya M.S. et al, *Electrification of rural district townships in Tanzania*; feasibility study report, July 1986, Department of Electrical Engineering, University of Dar es Salaam.

Table A-4. Electricity generation, losses and sales in TANESCO's interconnected system

Year	1991	1992*	1993*
Electricity use	GWh	GWh	GWh
Residential sales	436	468	492
Small commercial sales	142	152	160
Light Industry	62	66	70
Large Industry & commercial	569	611	641
Agriculture	64	69	73
Water supply	69	74	77
Public Lighting	7	8	8
Bulk sales to Zanzibar	57	61	64
<b>TOTAL SALES</b>	<b>1,405</b>	<b>1,509</b>	<b>1,585</b>
<b>LOSSES</b>			
Technical	187	210	220
Non-Technical	148	166	174
<b>NET GENERATION</b>	<b>1,740</b>	<b>1,885</b>	<b>1,979</b>
<b>STATION USE</b>	<b>11</b>	<b>14</b>	<b>15</b>
<b>GROSS GENERATION</b>	<b>1,750</b>	<b>1,899</b>	<b>1,994</b>
<b>LOAD FACTOR</b>	<b>66.6%</b>	<b>66.0%</b>	<b>65.0%</b>
<b>SYSTEM PEAK LOAD</b>	<b>300 MW</b>	<b>328 MW</b>	<b>350 MW</b>

Source: Songo Songo Gas-development discussion paper TANESCO/World Bank 1994. (Table 5-1)

\* Scenario: 'Base Case Forecast'.

## 5.5 National energy policy of Tanzania<sup>78</sup>

### 5.5.1. Overall objectives

'The overall policy objective of energy development in the country will be to provide an input into the development process of the country through establishment of an efficient energy production, procurement, transportation, distribution and end-use system in an environmentally sound manner and with due regard to gender issues.' (The Energy Policy of Tanzania, Clause 26).

Much of the demand for petroleum products comes from the transport and industry sectors and, to a limited extent, power generation. Almost all petroleum products consumed as fuels in the industrial sector are used in the production of process heat or process steam. A reduction in the use of these fuels can therefore be achieved by harnessing indigenous energy resources. Tanzania has abundant coal, natural gas, hydropower and biomass in the form of forestry and agricultural wastes, which could potentially be used as a substitute for imported petroleum. (Clause 27)

The overall goals of the National Energy Plan will therefore be the following:

- i) to exploit the abundant hydro-electric resources;
- ii) to develop and utilise natural gas resources;
- iii) to develop and utilise coal resources;
- iv) to step up petroleum exploration activities;

<sup>78</sup> Based on the Energy Policy, published by the Ministry of Water Energy and Minerals (MWEM) in April 1992.

- v) to arrest wood-fuel depletion by evolving more appropriate land management practises and more efficient wood-fuel technologies;
- vi) to develop and utilise forest and agricultural residue for power and cooking energy production;
- vii) to minimise energy price fluctuations in order to contribute to stability of prices in general through strengthening and rationalisation of energy supply sources and infrastructure and rational energy pricing structure;
- viii) to develop human resources for development of energy technologies development; and
- ix) to ensure the continuity and security of energy supplies. (Clause 28)

The above long-term goals implicitly promote the reduced dependence on imported energy sources. Under present conditions though, with the ERP and the Second Union Five Year Development Plan (1988/89-1992/93) emphasising the revival and rehabilitation of the countries infrastructure, short term goals are more oriented towards efforts that effectively utilise existing energy supply systems. Below follows a summary of more specific plans within different energy sectors. (Clause 29)

#### ***5.5.2 Objectives in the biomass sector***

The problem of negative biomass balance is especially acute around the urban centres. Studies will, therefore, have to be done in the very short term to identify the economically and financially least cost methods of meeting the urban cooking demand. (Clause 33)

Preliminary studies of traditional cooking devices and their efficiency show that using improved charcoal kilns and improved charcoal stoves is the least cost option to both the user and the nation. (Clause 34) Further, it is concluded that transportation of biomass to regions with negative balance is generally more expensive than the establishment of fuel-wood plantations in these areas. (Clause 32)

Some of the residues that can be readily used as fuel are those from sawmills and agro-processing industries. Where it is considered economic and where sufficient resources are available, production of carbonised briquettes from the forest and agricultural residues will be developed and utilisation promoted.' (Clause 35)

#### ***5.5.3 Objectives in the petroleum sector***

Quite clearly, the long-term goals of Tanzania include reduced dependence on imported petroleum products. In the short-term, what is emphasised is that petroleum based projects shall only be supported where this prove to have a positive impact on the overall development of the country. (Clause 37/38/39)

Refinery processing facilities tend to be strategic investments. The government will therefore promote public ownership of such facilities, to the extent that resource availability permits.(Clause 48) Tanzania will continue to transfer crude petroleum to its land-locked neighbouring countries, and will also expand the export of refined products to neighbouring countries. (Clause 45) The effective distribution of

petroleum products in the country will be enhanced and financed through revenues from sales. (Clause 51)

Further petroleum exploration activities in Tanzania will continue to rely on the interest of international investors. The government will engage itself in the financing of petroleum exploration activities only to the extent necessary to acquire sufficient data and information to attract international companies. (Clause 56)

#### ***5.5.4 Objectives in the natural gas sector***

Development of natural gas resources at Songo Songo and Mnazi Bay to substitute expensive imported petroleum fuels will be encouraged and promoted. The construction of a gas pipeline from Songo Songo to Dar es Salaam is planned to be constructed, while the Mnazi Bay gas will be used locally. The gas transported to Dar es Salaam is intended both for direct use in the manufacturing processes and for electricity generation in gas turbines. Households and commercial sectors will as well be encouraged to take appropriate measures to convert to natural gas. There are plans also, to electrify villages along the pipeline using natural gas.<sup>79</sup> The main thrust of the development of natural gas resources is to establish necessary infrastructure as well as to make operational the gas utility (GASCO) to carry out management and operation of the system. (Clause 60).

#### ***5.5.5 Objectives in the coal sector***

The use of coal as a substitute fuel in industries such as the Southern Paper Mills and Mbeya Cement Factory, power generation, agriculture and households will be promoted and increased through:

- I. investment to provide an efficient coal transport and distribution system;
- II. investment in the expansion of coal mining;
- III. investments in industrial and agricultural coal-using facilities and conversion of some existing facilities to using coal;
- IV. acquisition of skills in coal usage, including development and popularisation of suitable coal stoves;
- V. investment in mine-mouth power plants, and;
- VI. investment in the improvement of the quality of coal. (Clause 80)

#### ***5.5.6 Objectives regarding wind and solar energy***

Successful exploitation of wind energy is dependent on entrepreneurship on the part of local organisations and businesses to develop a sound design of a local windmill, mounting dissemination programmes with an effective extension network to help in maintenance, training of personnel for the repair and maintenance of windmills and the creation of a national wind characteristics data base to aid in the positioning of windmills. The Government is willing to assist in these endeavours. (Clause 75)

---

<sup>79</sup> TANESCO.

There is a wide potential for using solar water heaters in the country. In order to reduce use of wood and oil for water heating purposes all new community construction projects and hotels will be required to install solar water heating equipment. (Clause 76)

***5.5.7 Objectives regarding geothermal power***

Given that geothermal sources are expensive to develop, geothermal energy has less priority than hydropower, coal and natural gas. Studies in order to assess the magnitude will however be undertaken. (Clause 79)

***5.5.8 Objectives in the electricity sector***

/See chapter 1.3/

***5.6 1999 Policy Document***

During 1999, a new policy was being formulated by the Ministry of Energy and Minerals so as to take stock of the various acts enacted since the prevailing energy policy document was prepared in year 1992. The new policy will seek to liberalise the power sector, introduce competition in areas where it is possible and protection of the environment.



**TANZANIA ELECTRICITY SUPPLY COMPANY LIMITED**  
**ELECTRICITY TARIFFS WITH EFFECT FROM JULY, 1993**  
**BILLING**  
**(71% INCREASE = US CENTS 9 PER UNIT)**

**TARIFF NO. 1: RESIDENTIAL**

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

CONSUMPTION RANGE	CHARGING RATES
0 - 100	0 - 100 Shs. 10.00 per KWh
101 - 7500	0 -1000 Shs. 15.00 per KWh 1001-2500 Shs. 38.00 per KWh 2501-7500 Shs. 60.00 per KWh
Over 7500	0 -1000 Shs. 38.00 per KWh 1001-7500 Shs. 60.00 per KWh Over 7500 Shs. 100.00 per KWh

Service Charge per meter reading period:

0 - 1000 KWh	Shs. 200.00
Over 1000 KWh	Shs. 1,000.00

**TARIFF NO. 2: LIGHT COMMERCIAL**

Applicable to shops, restaurants, theaters, hotels, clubs, harbours, schools, hospitals, airports, lodging houses, group of residential premises with one meter and on premises where similar business or trade is conducted and where consumption is less than 7,500 kilowatt hours per meter reading period:

CONSUMPTION RANGE	CHARGING RATES
0 - 200	0 - 200 Shs. 23.50 per KWh
201 - 1000	201 - 1000 Shs. 42.00 per KWh
1001 - 2500	0 - 1000 Shs. 42.00 per KWh 1001 - 2500 Shs. 75.50 per KWh
2501 - 7500	0 - 1000 Shs. 75.50 per KWh 1001 - 2500 Shs. 90.00 per KWh 2501 - 7500 Shs. 120.00 per KWh
Over 7500	0 - 1000 Shs. 42.00 per KWh 1001 - 2500 Shs. 75.50 per KWh 2500 - 7500 Shs. 90.00 per KWh Over 7500 Shs. 120.00 per KWh
Service Charge per meter reading period:	
0 - 200 KWh	Shs. 500.00
Over 200 KWh	Shs. 2,000.00

**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 industrial process where the main use of electricity is for motive power, or an electrochemical or elector-thermal process and where the consumption is less than 7,500 kilowatt hours (KWh) per meter reading period:

CONSUMPTION RANGE	CHARGING RATES
0 - 1000	0 - 1000 Shs. 21.50 per KWh
1001 - 2500	0 - 1000 Shs. 40.00 per KWh 1001 - 2500 Shs. 75.00 per KWh
2501 - 7500	0 - 1000 Shs. 40.00 per KWh 1001 - 2500 Shs. 75.00 per KWh 2501 - 7500 Shs. 90.00 per KWh
Over 7500	0 - 1000 Shs. 40.00 per KWh 1001 - 2500 Shs. 75.00 per KWh 2501 - 7500 Shs. 90.00 per KWh over 7500 Shs. 120.00 per KWh

Customer service charge per meter reading period all consumers  
Shs. 2,000.00

**TARIFF NO. 4: LOW VOLTAGE SUPPLY**

Applicable for general use where the consumption is more than 7,500 kilowatt hours per meter reading period:

a) Demand charge Shs. 2,900.00 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) Units charge:  
First 150 times B.D (KVA) units Shs. 55.00 per KWh  
Next 150 times B.D (KVA) unites Shs. 50.00 per KWh  
Remainder of unites Shs. 45.00 per KWh

c) Customer service charge per meter reading period Shs. 40,000.00

**TARIFF NO. 4A: AGRICULTURAL CONSUMERS**

Applicable to Agricultural consumers whose consumption is more than 5,000 units per meter reading period engaged in direct raw farm produce production and/or processing.

a) Demand charge: Shs. 2,300.00 per KVA of Billing Demand (B.D) per meter reading period.

b) Units charge:  
First 150 times B.D (KVA) units Shs. 47.50 per KWh  
Remainder of units Shs. 43.00 per KWh

c) Customer service charge per meter reading period Shs. 40,000.00

**TARIFF NO. 5: HIGH VOLTAGE SUPPLY**

Applicable for general use where power is metered at 11 kV and above.

a) Demand charge: Shs. 2,600.00 per KVA of

## Appendix B

Billing Demand (B.D) per meter reading period.

The KVA Maximum Demand (M.D) indicator shall be reset every meter reading period.

- b) Units charge:
- |                                 |                    |
|---------------------------------|--------------------|
| First 150 times B.D (KVA) units | Shs. 50.00 per KWh |
| Next 150 times B.D (KVA) units  | Shs. 41.00 per KWh |
| Next 150 times B.D (KVA) units  | Shs. 37.50 per KWh |
| Remainder of units              | Shs. 30.00 per KWh |
- c) Customer services charge:  
per meter reading period Shs. 40,000.00

### **TARIFF NO. 5A: HIGH VOLTAGE SUPPLY - ENERGY INTENSIVE CONSUMERS**

Applicable to high tension consumers whose demand is above 5,000 KVA and consumption above 800,000 KWh per meter reading period.

- a) Demand charges Shs. 2,450.00 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) Units charge:
- |                                 |                    |
|---------------------------------|--------------------|
| First 150 times B.D (KVA) units | Shs. 45.00 per KWh |
| Next 150 times B.D (KVA) units  | Shs. 41.00 per KWh |
| Next 150 times B.D (KVA) units  | Shs. 37.50 per KWh |
| Remainder of units              | Shs. 30.00 per KWh |
- c) Customer service charge  
per meter reading period Shs. 80,000.00

### **TARIFF NO. 6: PUBLIC LIGHTING**

Applicable to public lighting and places of worship:

- All units Shs. 15.00 per KWh

**TARIFF NO. 8: WATER SUPPLY ACCOUNTS**

Applicable to all Public Water Supply pumping installations with consumption above 10,000 units per meter reading period.

- a) Maximum Demand charge: Shs. 2,200.00 per KVA of Billing Demand per meter reading period.

The maximum demand indicator will be reset every meter reading period.

- b) Units charge: Shs. 43.00 per KWh

- c) Customer service charge per meter reading period Shs. 40,000.00

**TARIFF NO. 9: ZANZIBAR SUPPLY**

Maximum demand Shs. 1,083.57 per KVA of Maximum Demand during each meter reading period

The KVA maximum demand indicator shall be reset every meter reading period.

Unit charge: Shs. 5.70 per KWh

Maximum Demand readings are taken at Mtoni substation while the units reading is taken at Ubungo substation.

**NOTE:**

1. Billing Demand (B.D) is the higher of the KVA Maximum Demand (M.D) during the month and 75% 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 recorded commencing from the month the consumer is connected.
2. Meter reading period is the period of time elapsing between any consecutive readings of the meter and/or maximum demand indicator installed by the Company but with exception of their first and last period; each such a period shall be as near to thirty days as possible.
3. These tariffs are applicable only to supply of electricity to consumers with power factor not lower than 0.95 in case of lighting loads or 0.9 in case of other loads, otherwise power factor surcharge shall be applied on the normal charges.

**TANZANIA ELECTRICITY SUPPLY COMPANY LIMITED**

**ELECTRICITY TARIFFS WITH EFFECT FROM JUNE, 1995  
BILLING**

**TARIFF NO. 1:**

Applicable for general use of electricity; including residential, small commercial and industrial use, where the average consumption is less than 7500 units (KWh) per meter reading period.

CONSUMPTION RANGE	CHARGING RATES
0 - 100 KWh	Shs. 11.50 per KWh
101 - 1000 KWh	Shs. 17.50 per KWh
1001 - 2500 KWh	Shs. 45.00 per KWh
2501 - 7500 KWh	Shs. 100.00 per KWh
over 7500 KWh	Shs. 120.00 per KWh

Service Charge per meter reading period:

0 - 100 KWh	Shs. 200.00
101 - 1000 KWh	Shs. 500.00
501 - 2500 KWh	Shs. 1,000.00
2501 - 7500 KWh	Shs. 1,500.00
over 7500 KWh	Shs. 2,000.00

**TARIFF NO. 2: LOW VOLTAGE SUPPLY**

Applicable for general use where power is metered at 400 Volts and the average consumption is more than 7,500 kilowatt hours per meter reading period:

- a) Demand charge Shs. 4,934.25 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) Units charge: Shs. 51.85 per KWh
- c) Customer service charge per meter reading period Shs. 3,289.50

**TARIFF 3: HIGH VOLTAGE SUPPLY**

Applicable for general use where power is metered at 11 kV and above.

- |    |                |                                                                         |
|----|----------------|-------------------------------------------------------------------------|
| a) | Demand charge: | Shs. 3,157.90 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's charge: | Shs. 53.50 per KWh |
|----|----------------|--------------------|

- |    |                                                       |               |
|----|-------------------------------------------------------|---------------|
| c) | Customer services charge:<br>per meter reading period | Shs. 3,289.50 |
|----|-------------------------------------------------------|---------------|

**TARIFF NO. 4: PUBLIC LIGHTING**

Applicable to public lighting.

- |           |                    |
|-----------|--------------------|
| All units | Shs. 17.25 per KWh |
|-----------|--------------------|

**TARIFF NO. 5: ZANZIBAR SUPPLY**

- |    |                |                                                                           |
|----|----------------|---------------------------------------------------------------------------|
| a) | Maximum demand | Shs. 1,154.00 per KVA of Maximum Demand during each meter reading period. |
|----|----------------|---------------------------------------------------------------------------|

The KVA maximum demand indicator shall be reset every meter reading period.

- |    |              |                   |
|----|--------------|-------------------|
| b) | Unit charge: | Shs. 6.70 per KWh |
|----|--------------|-------------------|

- |    |                                                       |               |
|----|-------------------------------------------------------|---------------|
| c) | Customer services charge:<br>per meter reading period | Shs. 3,289.50 |
|----|-------------------------------------------------------|---------------|

Maximum Demand readings are taken at Mtoni substation while the units readings are taken at Tegeta substation.

**NOTE:**

1. Meter reading period is the period of time elapsing between any consecutive readings of the meter and/or maximum demand indicator installed by the Company but with exception of their first and last period; each such a period shall be as near to thirty days as possible.
2. Billing Demand (B.D) is the higher of the KVA Maximum Demand (M.D) during the month and 75% 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

## Appendix B

Maximum Demand during the month, and 75% of the highest KVA Maximum Demand recorded commencing from the month the consumer is connected.

3. These tariffs are applicable only to supply of electricity to consumers with power factor not lower than 0.95 in case of lighting loads or 0.9 in case of other loads, otherwise power factor surcharge shall be applied on the normal charges, in accordance with the general conditions of supply.
4. Temporary supply with consumption below 7,500 units per month will be charged in Tariff 1, otherwise higher Tariffs will be applicable, corresponding to the proposed consumption.
5. Consumers are entitled to change from tariff one to tariff two or vice versa, once a year, if their average demand over twelve (12) consecutive months is more or less than 7,500 units respectively.

**TANZANIA ELECTRICITY SUPPLY COMPANY LIMITED**  
**ELECTRICITY TARIFFS WITH EFFECT FROM NOVEMBER,**  
**1995 BILLING**

**TARIFF NO. 1:**

Applicable for general use of electricity; including residential, small commercial and industrial use, where the average consumption is less than 7500 units (KWh) per meter reading period.

CONSUMPTION RANGE		CHARGING RATES
0	- 100 KWh	Shs. 17.20 per KWh
101	- 500 KWh	Shs. 27.00 per KWh
501	- 2500 KWh	Shs. 70.00 per KWh
over	2500 KWh	Shs. 130.00 per KWh

Service Charge per meter reading period:

0	- 100 KWh	Shs. 200.00
101	- 500 KWh	Shs. 750.00
501	- 2500 KWh	Shs. 1,500.00
over	2500 KWh	Shs. 3,000.00

**TARIFF NO. 2: LOW VOLTAGE SUPPLY**

Applicable for general use where power is metered at 400 Volts and the average consumption is more than 7,500 kilowatt hours per meter reading period:

- a) Demand charge Shs. 6,250.00 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's charge: Shs. 59.00 per KWh
- c) Customer service charge per meter reading period Shs. 4,000.00

**TARIFF 3: HIGH VOLTAGE SUPPLY**

Applicable for general use where power is metered at 11 kV and above.

- |    |                |                                                                         |
|----|----------------|-------------------------------------------------------------------------|
| a) | Demand charge: | Shs. 4,500.00 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's charge:                                        | Shs. 53.00 per KWh |
| c) | Customer services charge:<br>per meter reading period | Shs. 4,000.00      |

**TARIFF NO. 4: PUBLIC LIGHTING**

Applicable to public lighting.

- |           |                    |
|-----------|--------------------|
| All units | Shs. 21.30 per KWh |
|-----------|--------------------|

**TARIFF NO. 5: ZANZIBAR SUPPLY**

- |    |                |                                                                           |
|----|----------------|---------------------------------------------------------------------------|
| a) | Maximum demand | Shs. 1,500.00 per KVA of Maximum Demand during each meter reading period. |
|----|----------------|---------------------------------------------------------------------------|

The KVA maximum demand indicator shall be reset every meter reading period.

- |    |                                                       |                    |
|----|-------------------------------------------------------|--------------------|
| b) | Unit charge:                                          | Shs. 10.00 per KWh |
| c) | Customer services charge:<br>per meter reading period | Shs. 4,000.00      |

Maximum Demand readings are taken at Mtoni substation while the units readings are taken at Tegeta substation.

**NOTE:**

1. Meter reading period is the period of time elapsing between any consecutive readings of the meter and/or maximum demand indicator installed by the Company but with exception of their first and last period; each such a period shall be as near to thirty days as possible.
2. Billing Demand (B.D) is the higher of the KVA Maximum Demand (M.D) during the month and 75% 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, and 75% of the highest KVA Maximum Demand recorded commencing from the month the consumer is connected.

3. These tariffs are applicable only to supply of electricity to consumers with power factor not lower than 0.95 in case of lighting loads or 0.9 in case of other loads, otherwise power factor surcharge shall be applied on the normal charges, in accordance with the general conditions of supply.
4. Temporary supply with consumption below 7,500 units per month will be charged in Tariff 1, otherwise higher Tariffs will be applicable, corresponding to the proposed consumption.
5. Consumers are entitled to change from tariff one to tariff two or vice versa, once a year, if their average demand over twelve (12) consecutive months is more or less than 7,500 units respectively.

**TANZANIA ELECTRICITY SUPPLY COMPANY LIMITED**  
**ELECTRICITY TARIFFS WITH EFFECT FROM MAY, 1997**  
**BILLING**

**TARIFF NO. 1:**

Applicable for general use of electricity; including residential, small commercial and industrial use, where the average consumption is less than 7500 units (KWh) per meter reading period.

CONSUMPTION RANGE		CHARGING RATES	
0	- 100 kWh	Shs.	18.00 per kWh
101	- 500 kWh	Shs.	30.00 per kWh
501	- 2500 kWh	Shs.	72.00 per kWh
over	2500 kWh	Shs.	130.00 per kWh

Service Charge per meter reading period:

0	- 100 kWh	Shs.	200.00
101	- 500 kWh	Shs.	750.00
over	500 kWh	Shs.	2,000.00

**TARIFF NO. 2: LOW VOLTAGE SUPPLY**

Applicable for general use where power is metered at 400 Volts and the average consumption is more than 7,500 kilowatt hours per meter reading period:

- a) Demand charge Shs. 6,400.00 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's charge: Shs. 59.95 per KWh
- c) Customer service charge per meter reading period Shs. 4,000.00

**TARIFF 3: HIGH VOLTAGE SUPPLY**

Applicable for general use where power is metered at 11 kV and above.

- |    |                |                                                                         |
|----|----------------|-------------------------------------------------------------------------|
| a) | Demand charge: | Shs. 5,000.00 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's charge:                                        | Shs. 57.45 per KWh |
| c) | Customer services charge:<br>per meter reading period | Shs. 4,000.00      |

**TARIFF NO. 4: PUBLIC LIGHTING**

Applicable to public lighting.

All units	Shs. 23.00 per KWh
-----------	--------------------

**TARIFF NO. 5: ZANZIBAR SUPPLY**

- |    |                |                                                                           |
|----|----------------|---------------------------------------------------------------------------|
| a) | Maximum demand | Shs. 1,600.00 per KVA of Maximum Demand during each meter reading period. |
|----|----------------|---------------------------------------------------------------------------|

The KVA maximum demand indicator shall be reset every meter reading period.

- |    |                                                       |                    |
|----|-------------------------------------------------------|--------------------|
| b) | Unit charge:                                          | Shs. 11.00 per KWh |
| c) | Customer services charge:<br>per meter reading period | Shs. 4,000.00      |

Maximum Demand readings are taken at Mtoni substation while the units readings are taken at Tegeta substation.

**NOTE:**

1. Meter reading period is the period of time elapsing between any consecutive readings of the meter and/or maximum demand indicator installed by the Company but with exception of their first and last period; each such a period shall be as near to thirty days as possible.
  
2. Billing Demand (B.D) is the higher of the KVA Maximum Demand (M.D) during the month and 75% 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, and 75% of the highest KVA

## Appendix B

Maximum Demand recorded commencing from the month the consumer is connected.

3. These tariffs are applicable only to supply of electricity to consumers with power factor not lower than 0.95 in case of lighting loads or 0.9 in case of other loads, otherwise power factor surcharge shall be applied on the normal charges, in accordance with the general conditions of supply.
4. Temporary supply with consumption below 7,500 units per month will be charged in Tariff 1, otherwise higher Tariffs will be applicable, corresponding to the proposed consumption.
5. Consumers are entitled to change from tariff one to tariff two or vice versa, once a year, if their average demand over twelve (12) consecutive months is more or less than 7,500 units respectively.

**TANZANIA ELECTRICITY SUPPLY COMPANY LIMITED**  
**ELECTRICITY TARIFFS WITH EFFECT FROM NOVEMBER,**  
**1997 BILLING**

**TARIFF NO. 1:**

Applicable for general use of electricity; including residential, small commercial and industrial use, where the average consumption is less than 7500 units (KWh) per meter reading period.

CONSUMPTION RANGE		CHARGING RATES
0	- 100 KWh	Shs. 23.00 per KWh
101	- 500 KWh	Shs. 37.00 per KWh
501	- 2500 KWh	Shs. 155.00 per KWh

Service Charge per meter reading period:

0	- 100 KWh	Shs. 200.00
101	- 500 KWh	Shs. 750.00
over	500 KWh	Shs. 2,000.00

**TARIFF NO. 2: LOW VOLTAGE SUPPLY**

Applicable for general use where power is metered at 400 Volts and the average consumption is more than 7,500 KWh per meter reading period:

a)	Demand charge	Shs. 7,300.00 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's charge:	Shs. 67.00 per KWh
c)	Customer service charge per meter reading period.	Shs. 4,000.00

**TARIFF 3: HIGH VOLTAGE SUPPLY**

Applicable for general use where power is metered at 11 kV and above.

## Appendix B

- |    |                                                       |                                                                         |
|----|-------------------------------------------------------|-------------------------------------------------------------------------|
| a) | Demand charge:                                        | Shs. 5,700.00 per KVA of Billing Demand (B.D) per meter reading period. |
| b) | Unit's charge:                                        | Shs. 64.00 per KWh                                                      |
| c) | Customer services charge:<br>per meter reading period | Shs. 4,000.00                                                           |

### TARIFF NO. 4: PUBLIC LIGHTING

Applicable to public lighting.

All units	Shs. 26.45 per KWh
-----------	--------------------

### TARIFF NO. 5: ZANZIBAR SUPPLY

- |    |                |                                                                           |
|----|----------------|---------------------------------------------------------------------------|
| a) | Maximum demand | Shs. 1,700.00 per KVA of Maximum Demand during each meter reading period. |
|----|----------------|---------------------------------------------------------------------------|

The KVA maximum demand indicator shall be reset every meter reading period.

- |    |                                                       |                    |
|----|-------------------------------------------------------|--------------------|
| b) | Unit charge:                                          | Shs. 13.00 per KWh |
| c) | Customer services charge:<br>per meter reading period | Shs. 4,000.00      |

Maximum Demand readings are taken at Mtoni substation while the units readings are taken at Tegeta substation.

#### NOTE:

1. Meter reading period is the period of time elapsing between any consecutive readings of the meter and/or maximum demand indicator installed by the Company but with exception of their first and last period; each such a period shall be as near to thirty days as possible.
2. Billing Demand (B.D) is the higher of the KVA Maximum Demand (M.D) during the month and 75% 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, and 75% of the highest KVA Maximum Demand recorded commencing from the month the consumer is connected.
3. These tariffs are applicable only to supply of electricity to consumers with power factor not lower than 0.95 in case of lighting loads or 0.9 in

case of other loads, otherwise power factor surcharge shall be applied on the normal charges, in accordance with the general conditions of supply.

4. Temporary supply with consumption below 7,500 units per month will be charged in Tariff 1, otherwise higher Tariffs will be applicable, corresponding to the proposed consumption.
5. Consumers are entitled to change from tariff one to tariff two or vice versa, once a year, if their average demand over twelve (12) consecutive months is more or less than 7,500 units respectively.

**TANZANIA ELECTRICITY SUPPLY COMPANY LIMITED**  
**ELECTRICITY TARIFFS WITH EFFECT FROM JANUARY,**  
**1999 BILLING**

**TARIFF NO. 1:**

Applicable for general use of electricity; including residential, small commercial and industrial use, where the average consumption is less than 7500 units (KWh) per meter reading period.

CONSUMPTION RANGE		CHARGING RATES	
0	- 100 KWh	Shs.	24.00 per KWh
101	- 500 KWh	Shs.	38.00 per KWh
501	- 2500 KWh	Shs.	88.50 per KWh
Over	2500 KWh	Shs.	165.50 per KWh

Service Charge per meter reading period:

0	- 100 KWh	Shs.	200.00
101	- 500 KWh	Shs.	750.00
over	500 KWh	Shs.	2,000.00

**TARIFF NO. 2: LOW VOLTAGE SUPPLY**

Applicable for general use where power is metered at 400 Volts and the average consumption is more than 7,500 KWh per meter reading period:

a)	Demand charge	Shs. 7,660.00 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's charge:	Shs. 70.35 per KWh
c)	Customer service charge per meter reading period.	Shs. 4,000.00

**TARIFF NO. 3: HIGH VOLTAGE SUPPLY**

Applicable for general use where power is metered at 11 kV and above.

- |    |                |                                                                         |
|----|----------------|-------------------------------------------------------------------------|
| a) | Demand charge: | Shs. 5,950.00 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's charge: | Shs. 67.50 per KWh |
|----|----------------|--------------------|

- |    |                                                       |               |
|----|-------------------------------------------------------|---------------|
| c) | Customer services charge:<br>per meter reading period | Shs. 4,000.00 |
|----|-------------------------------------------------------|---------------|

**TARIFF NO. 4: PUBLIC LIGHTING**

Applicable to public lighting.

- |           |                    |
|-----------|--------------------|
| All units | Shs. 27.80 per KWh |
|-----------|--------------------|

**TARIFF NO. 5: ZANZIBAR SUPPLY**

- |    |                |                                                                           |
|----|----------------|---------------------------------------------------------------------------|
| a) | Maximum demand | Shs. 3,350.00 per KVA of Maximum Demand during each meter reading period. |
|----|----------------|---------------------------------------------------------------------------|

The KVA maximum demand indicator shall be reset every meter reading period.

- |    |              |                    |
|----|--------------|--------------------|
| b) | Unit charge: | Shs. 21.50 per KWh |
|----|--------------|--------------------|

- |    |                                                       |               |
|----|-------------------------------------------------------|---------------|
| c) | Customer services charge:<br>per meter reading period | Shs. 4,000.00 |
|----|-------------------------------------------------------|---------------|

Maximum Demand readings are taken at Mtoni substation while the units readings are taken at Tegeta substation.

**NOTE:**

1. Meter reading period is the period of time elapsing between any consecutive readings of the meter and/or maximum demand indicator installed by the Company but with exception of their first and last period; each such a period shall be as near to thirty days as possible.
2. Billing Demand (B.D) is the higher of the KVA Maximum Demand (M.D) during the month and 75% of the highest KVA Maximum Demand for the preceding three months; provided that during the first

## Appendix B

year of operation or when a consumer installs power factor correction equipment, the Billing Demand shall be the higher of the KVA Maximum Demand during the month, and 75% of the highest KVA Maximum Demand recorded commencing from the month the consumer is connected or the date when the power factor correction equipment is commissioned.

3. These tariffs are applicable only to supply of electricity to consumers with power factor not lower than 0.95 in case of lighting loads or 0.9 in case of other loads, otherwise power factor surcharge shall be applied on the normal charges, in accordance with the general conditions of supply.
4. Temporary supply with consumption below 7,500 units per month will be charged in Tariff 1, otherwise higher Tariffs will be applicable, corresponding to the proposed consumption.
5. Consumers are entitled to change from tariff one to tariff two or vice versa, once a year, if their average demand over twelve (12) consecutive months is more or less than 7,500 units respectively.

**BY-LAWS OF URAMBO POWER CO-OPERATIVE SOCIETY**

**PART I: NAME AND ADDRESS**

1. NAME:

The name of the Society shall be URAMBO ELECTRIC CONSUMERS CO-OPERATIVE SOCIETY LIMITED (UECCO).

2. ADDRESS

The Society address shall be P.O. Box 127, Urambo.

3. AREA OF OPERATION

All that area defined as Urambo District and nearby rural areas. The area of operation may be extended for as long as there is no contradiction with the Laws of Tanzania.

**PART II: OBJECTIVES AND FUNCTIONS**

4. MAJOR OBJECTIVES:

The major objectives of the Cooperative shall be:

- a) to promote the social and economic welfare of its members.
- b) to provide safe and reliable electric energy to its members.
- c) to further the development of electric energy Cooperative on the basis of the principles and procedures of power supply.

5. SPECIFIC OBJECTIVES:

The Cooperative shall achieve its major objective through the generation, transmission and distribution of electricity. More specifically the Cooperative shall:

- a) establish, develop or expand its business through the acquisition of appropriate plants, machines, tools and equipment for the generation, transmission and distribution of electricity.
- b) negotiate, secure, purchase and stock safely the materials and equipment necessary for its business.
- c) charge the tariff in the most effective and efficient manner.

- d) progressively expand the Cooperative's business in accordance with the member's demand through better methods including diversification.
- e) to develop the skills and knowledge of its members through the appropriate training as may be deemed fit by the Cooperative.
- f) to acquire land and wayleave necessary for the generation, transmission and distribution of electric energy and other purposes related thereto.
- g) to borrow money for the purposes of enhancing its business.
- h) to do all such things incidental to or expedient for the accomplishment of its objectives and functions in accordance with the Laws of Tanzania and specifically the Cooperative Societies Act 1991 and the Rules and Regulations of these by-laws.

### **PART III: MEMBERSHIP**

6. **MEMBERSHIP:**

Any person, firm, association, corporation or body politic or subdivision thereof may become a member of the Urambo Electric Supply Cooperative (hereinafter called the Cooperative) upon receipt of electric supply and services from the Cooperative, and have made a written application for membership in the Cooperative.

7. **QUALIFICATION FOR MEMBERSHIP:**

Persons who qualify for membership to the Cooperative shall include those who:

- a) have paid a membership fee of shs. 5,000.00 and have acquired at least one share valued at 7,000.00 to the Cooperative.
- b) have agreed to purchase electric energy from the Cooperative as hereinafter specified.
- c) have agreed to comply and be bound by the articles of incorporation and by-laws of the Cooperative and any Rules and Regulations adopted by the Cooperative Development (CDC).
- d) have reached the age of majority and are of sound mind, in the case of natural persons.
- e) Provided that it shall always be a condition precedent for a member to be domiciled within the area of operations of the Cooperative. No member may hold more than one membership in the Cooperative, and no

membership in the Cooperative shall be transferable, except as provided in these by-laws.

8. MEMBERSHIP CERTIFICATE:

Membership in the Cooperative shall be evidenced by a membership certificate which shall be in such form and shall contain such provisions as shall be determined by the CDC. Such certificate shall be signed by the Chairman and by the Secretary of the Cooperative and the Corporate Seal shall be affixed thereto and shall bear the signature or right thumb print of the member upon the payment membership fee as fixed in these bylaws. In case a certificate is lost, destroyed or mutilated a new certificate may be issued therefor upon such uniform terms and indemnity to the Cooperative as the CDC may prescribe.

9. MEMBERSHIP FEES AND SHARES

- i) membership fee shall be T.shs. 5,000.00.
- ii) the cost of shares shall be shillings 7,000.00 per share.

10. PURCHASE OF ELECTRIC ENERGY:

Each member shall, as soon as electric energy shall be available, purchase from the Cooperative all electric energy used on the premises specified in his application for membership, and shall pay therefor at rates which shall from time to time be fixed by the CDC. It is expressly understood that amounts paid for electric energy in excess of the cost of service are furnished by members as capital and each member shall be credited with the capital so furnished as provided in these bylaws. Each member shall also pay all amounts owed by him to the Cooperative as and when the same shall become due and payable.

11. TERMINATION OF MEMBERSHIP:

- a) Any member may withdraw from membership upon compliance with such uniform terms and conditions as the CDC may prescribe. The CDC may, by the affirmative vote of not less than two-thirds of all the members of the CDC, expel any member who fails to comply with any of the provisions of the articles of incorporation, by-laws or rules or regulations adopted by the CDC, but only if such member shall have been given written notice by the Cooperative that such failure makes him liable to expulsion and such failure shall have continued for at least ten days after such notice is given. Any expelled member may be reinstated by vote of the CDC or by vote of the members at any annual or special meeting, upon satisfactory proof that the reasons for the expulsion have been removed.

The membership of a member who for a period of six (6) months after service is available to him, has not purchased electric energy from the Cooperative, may be cancelled by resolution of the CDC.

- b) Upon the withdrawal, death, insanity, cessation of existence or expulsion of a member the membership of such member shall thereupon terminate, and the membership certificate of such member shall be surrendered forthwith to the Cooperative. Termination of membership in any manner except in the case of death or insanity shall not release a member or his estate from any debts due to the Cooperative.
- c) In case of withdrawal or termination of membership in any manner, the Cooperative shall repay to the member the amount of the Shares paid by him, provided, however, that the Cooperative shall deduct from the amount of the same the amount of any debts or obligations owed by the member to the Cooperative.

12. RIGHTS AND LIABILITIES OF MEMBERS

All members shall have such rights, duties and obligations as are mentioned in the by-laws and the General provisions of the Cooperative Societies Act.

13. NON-LIABILITY FOR DEBTS OF THE COOPERATIVE

The private property of the members shall be exempt from execution or other liability for the debts of the Cooperative and no member shall be liable or responsible for any debts or liabilities of the Cooperative. The liability of members for the debts of the Cooperative shall always be limited to the nominal value of the Shares.

**PART IV: SOURCES OF FUNDS**

14. Sources of finance of the Cooperative shall consist of:

- i) shares and membership fees
- ii) deposits from members for electricity to be consumed
- iii) surplus funds resulting from the operations of the society
- iv) a reserve fund and any other funds established with the approval of the registrar of Cooperative societies
- v) undistributed balance of accumulated funds
- vi) donations and/or grants
- vii) loans from financial institutions and other sources as approved by the registrar.
- viii) money received or realised through and other lawful means.

17. The Cooperative may impose cess and or fee to its members so as to ensure the proper and efficient running of the electric power/electricity in the society's areas of operation.
18. The Cooperative shall, through members and resolved by the General Meeting, establish a special fund for the rehabilitation of machines and other installations.

**PART V: MAXIMUM LIABILITY OF THE COOPERATIVE**

19. The general meeting shall decide from time to time the maximum amount up to which the Cooperative may become indebted subject to the Laws governing Cooperative societies.

**PART VI: DISPOSAL OF SURPLUSES**

20. The Cooperative shall establish and maintain the following funds from any surplus remaining in the Cooperative after all current liabilities have been met or set aside:
  - i) a statutory reserve funds constituted by 40% (forty percentum) of the total surplus for the maintenance of the Cooperative's affairs and for discharging Cooperative's liabilities on dissolution
  - ii) a share transfer fund constituted by 10% (ten percentum) to meet expenditure which may be incurred by the Cooperative in purchasing the shares of the members whose membership has terminated with the consent of the Cooperative Development Committee. The amount standing to the credit of the share transfer fund shall not exceed 10% of the subscribed share capital.
  - iii) an amount not exceeding 5% (five percentum) of the shares may be paid as interest on shares.
  - iv) payment of an honoraria to the members of the Cooperative Development Committee as authorised by a resolution of the General Meeting and the approval in writing by the Registrar of Cooperative Societies.
  - v) the net balance together with any sums available for distribution from previous years may be distributed after approval by the General Meeting for:
    - a) payment of patronage dividend to members
    - b) payment of bonus or staff incentive scheme
    - c) any other payment which may be approved by the Registrar Cooperative Societies.

21. APPLICATION OF FUNDS:

The funds of the Cooperative shall be used solely for the objectives stated in by-laws and elsewhere in these by-laws.

22. FINANCIAL YEAR:

The financial year of the Cooperative shall be from 1st July to 30th June.

**PART VII: CONTROL AND MANAGEMENT OF THE CO- OPERATIVE**

General Meeting:

The supreme authority of the Cooperative shall be vested in the General Meeting to which all duly registered members of the Cooperative shall be entitled to attend and vote.

23. ANNUAL GENERAL MEETING:

- i) The Annual General Meeting of the Cooperative shall be held in the month of October or within six months after closing the financial year of the society if there are sound reasons of delaying it.
- ii) The Annual General Meeting shall have inter-alia the following functions:
  - a) to consider and adopt the Annual Report and statement of accounts for the past financial year tabled by the Committee
  - b) to consider an audited balance sheet of the Cooperative, the auditors' report and the insertion NOTES of the registrar.
  - c) to consider and sanction the disposal of any surplus funds in accordance with these by-laws, the Cooperative Societies Act of 1991 and the rules made thereof.
  - d) to consider and sanction the acquisition or disposal of any movable or immovable property of a value in excess of Shs. 100,000.00 (Tanzanian Shillings One Hundred Thousand Only).
  - e) to take decisions on all matters included in the Agenda.

24. ORDINARY GENERAL MEETING

- i) Ordinary General Meeting shall be held at least twice in every financial year of the Cooperative.
- ii) Matters to be amended at the Ordinary General Meeting may include but shall not be limited to the following:
  - a) to confirm minutes of the previous meeting and to resolve all matters arising therefrom.
  - b) to receive and consider progress report by the CDC.
  - c) to consider and approve any improvements in work standards in order to improve efficiency in the operation of the Cooperative.
  - d) to deal with membership matters as necessary including admission or expulsions
  - e) to consider and approve the Cooperative's budget for the ensuing year.
  - f) to fix the maximum liability of the Cooperative for the ensuing year.
  - g) to elect members to the CDC including them Chairman and Vice-Chairman.
  - h) to elect delegates as necessary to represent the society in various relevant for a/or or organisation.

25. SPECIAL GENERAL MEETING

A Special General Meeting shall be held as and when circumstances dictate and shall be convened;

- a) following a written request stating the object of such a meeting by not less than one third (1/3) of the total membership.
- b) by the Registrar

26. NOTICE OF GENERAL MEETING

- i) The notice specifying the date hour and place of a general meeting and the business to be transacted shall be given to the members in a manner customarily used to disseminate information in the area of the Urambo Electric Supply Cooperative Society including, but not limited to positioning such notice on the Cooperative's notice board.

- ii) The notice referred to in sub-section of this by-laws shall be given at least:
  - a) twenty one days (21) prior to holding an annual general meeting.
  - b) fourteen days (14) prior to holding an ordinary general meeting.
  - c) seven days (7) prior to holding a special general meeting.

27. QUORUM AT GENERAL MEETING

- i) the quorum of an annual general meeting or ordinary general meeting convened in accordance with these by-laws shall not be less than half of the total numbers of registered members or 100 members whichever is the smaller number.
- ii) if in the case of an annual general meeting or an ordinary general meeting the quorum is not forthcoming within three (3) hours of the time appointed for the meeting, the Chairman shall postpone the meeting to the time and designated place seven days later and the business to be transacted at the postponement for the original date of the meeting.
- iii) if in case of a special general meeting convened at the request of members in accordance with the provision of by-laws 25(a) a quorum is not present the time appointed within two (2) hours of the time appointed for the meeting then the meeting shall be considered cancelled and no further actions shall be taken.

28. VOTING:

Each member shall be entitled to only one vote upon each matter subjected to a vote at a meeting of the members. All issues shall be decided by a vote of a majority of the members voting thereon in person, except as otherwise provided by law, the articles of incorporation on these by-laws.

29. THE CHAIRMAN OF THE GENERAL MEETING:

The Chairman shall preside at every general meeting of the society other than special general meetings convened by the registrar which shall be chaired by the registrar himself or an officer to whom the registrar has duly delegated such responsibilities if there is no such Chairman or if at any meeting he is not present within thirty minutes (30) of the time appointed for holding the meeting the chair shall be taken by the Vice-Chairman if there is no Chairman or Vice Chairman or if the two are not present within an hour after the appointed time for holding a meeting or there are indisposed to act, the members present shall elect one of their members for chairing, solely for that specified meeting.

30. COOPERATIVE DEVELOPMENT COMMITTEE:

General Powers:

The business and affairs of the Cooperative shall be managed by a CDC of ten members which shall exercise all of the powers of the Cooperative except such as are by-law, the articles of incorporation or these by-laws conferred upon or reserved to the members.

31. ELECTION AND TENURE OF OFFICE

The persons named as CDC members shall compose the CDC until the first annual meeting or until their successors shall have been elected. Members of the CDC shall be elected by secret ballot at each annual meeting of the members beginning with the year 1993 by and from the members to serve until the next annual meeting of the members or until their successors shall have been elected, if an election of CDC members shall not be held on the day designated herein for the annual meeting, at any adjournment thereof, a special meeting of the members shall be held for the purpose of electing CDC members within a reasonable time thereafter.

32. QUALIFICATIONS

No person shall be eligible to become or remain a member of CDC who:

- a) is not a member and bonafide resident in the area served or to be served by the Cooperative: or
- b) is in any way employed by or financially interested in a competing enterprise or a business selling electric energy.
- c) is a body Cooperate member.

Upon establishment of the fact that a CDC member is holding the office in violation of any of the foregoing provisions, the CDC shall remove such CDC member from office.

Nothing contained in this section shall affect in any manner whatsoever the validity of any action taken at any meeting of the CDC.

33. NOMINATIONS TO FUNCTIONAL COMMITTEES

It shall be the duty of the CDC to appoint, not less than thirty days and not more than sixty days before the date of a meeting of the members at which CDC members are to be elected any functional committee on nominations

consisting of not less than three nor more than five members who shall be selected from different sections so as to insure equitable representative.

34. REMOVAL OF CDC MEMBER(S):

Any member may bring charges against a CDC member and, by filing with the Secretary such charges in writing together with a petition signed by at least ten percentum of the members or whichever is the lesser, may request the removal of such CDC member. Such CDC member shall be informed in writing of the charges at least ten days prior to the meeting of the members at which the charges are to be considered and shall have an opportunity at the meeting to be heard in person or by counsel and to present evidence in respect of the charges; and the person or persons bringing the charges against him shall have the same opportunity.

The question of the removal of such CDC member shall be considered and voted upon at the meeting of the members and any vacancy created by such removal may be filled by vote of the members at such meeting without compliance with the foregoing provisions with respect to nominations.

35. VACANCIES

Subject to the provisions of these by-laws with respect to the filling of vacancies caused by the removal of CDC members by the members, a vacancy occurring in the CDC shall be filled by the affirmative vote of a majority of the remaining CDC members for the unexpired portion of the term.

36. BOARD OF TRUSTEES:

There shall be a Board of Trustees nominated by the CDC and confirmed at the Annual General Meeting or Special Meeting of the members. The Board of Trustees shall consist of three persons who have achieved prominence in Society.

37. FUNCTIONS OF THE BOARD OF TRUSTEES:

The Board of Trustees shall:

- i) provide guidance and advice of the performance of the Cooperative activities without being involved in the day to day functions thereof.
- ii) facilitate contracts with persons without the Cooperative for the purposes of acquiring such assistance as may be necessary for the Cooperative.
- iii) meet as often as is convenient but not less than twice per year.

## **CONTRACT FOR SERVICE BETWEEN TANESCO AND UECCO**

This contract made by and between TANZANIA ELECTRIC SUPPLY COMPANY of P.O. Box 9024, Dar es Salaam, hereinafter called the "Company", and URAMBO ELECTRIC CONSUMERS COOPERATIVE of P.O. Box 127, Urambo, hereinafter called the "Cooperative".

WHEREAS, the Cooperative is desirous of purchasing regular services on their local power and its connected distribution system in the area described as Urambo Township and nearby areas.

WHEREAS, the Company agrees to carry out and charge for the said regular services on the local power plant and its connected distribution system, and also to provide, if needed, basic electrical training to the cooperative operators, mechanical fitters and electricians.

NOW, THEREFORE, in consideration of the premises and mutual covenants herein contained, the parties hereto agree as follows.

### **ARTICLE I**

#### **Cooperative's Installations**

Any and all equipment on the Cooperative's facilities shall be furnished, installed, maintained and operated at the expense of the Cooperative, are in accordance with the specifications as to the type and capacity of such apparatus as may be prescribed by the approved standard engineering practice as provided under the Electricity ordinance Cap. 131. The Company shall, should it be necessary, provide overhaul service every thirtieth (30<sup>th</sup>) day. The Company shall also assist in the procurement of spare parts and other equipment as shall be required from time to time.

### **ARTICLE II**

#### **Scope of agreements on generation**

The Company's responsibilities are limited to the service on installed equipment. The purchase of fuel and lubricating oil shall be the Cooperative's responsibility. The Company may assist in obtaining agreements between the Cooperative and the appropriate petrol company for the supply of fuel and lubricants at cost.

**ARTICLE III**

**Contract ...**

The initial total commitment of the Company at the power plant shown in Exhibit "A" at the effective date of this contract, as specified in ARTICLE XI, shall be a maximum of 318 kilovolt amperes from three generating sets type Caterpillar 3304 pc arrangement No. N3302 Serial No. 4B14700 and 4B14781 each rated 85 Kilowatts with ..... The Cooperative may from time to time request an increase over the said maximum commitment of the Company, provided that the Cooperative shall give the Company reasonable notice in writing of its desire to increase its requirements from the Company, specifying the power or power plants at which any increase will be required and the approximate date upon which the increase will be required.

In the event that needed initial training of local operators and following regular overhaul service at the desired location and in the desired amount is not available from the Company's existing facilities, the terms and conditions under which it might be made available shall be negotiated between the parties hereto.

**ARTICLE IV**

**Metering**

The Cooperative shall be responsible for the acquisition of all meters, and metering equipment for the measurement of electric energy consumed and the company agrees to render advice on the type of appropriate meters and equipment best suitable and fit for the purpose.

**ARTICLE V**

**Payments of Bills**

The service provided hereunder shall be paid for at the designated office of Company at Tabora monthly and within fifteen (15) days of the mailing of the bill to the Cooperative. The Company reserves the right to discontinue service if the Cooperative is in breach of any of the provisions of this contract or fails to pay any bill accrued hereunder at the expiry of thirty (30) days following the mailing of the bill.

Provided however that the Company shall give a fifteen days notice to the Cooperative of its intention to discontinue the services, the Company reserves the right to charge interest at the prevailing bank rate in case of continued default by the Cooperative from the date of the notice to discontinue the services.

**ARTICLE VI**

Right of Access

Either party shall give all necessary permission to the other to enable the agents of the other party to carry out this contract, and shall give the other the right by its fully authorized agents and employees to enter the premises of the other at all reasonable times for the purposes of reading or checking meters, for inspection, testing, repairing, renewing or exchanging any or all of the equipment owned by said party, which may be located on the property of the other, or for performing any other work incident to rendering the service herein stated.

**ARTICLE VII**

Continuity of Service

The Company shall not be liable to the Cooperative hereunder nor shall the Cooperative be liable to the Company hereunder for the reason of failure of the Company to deliver or the Cooperative to receive required service as the result of fire, strike, riot, explosion, flood, accident, breakdown, acts of God, public enemy or other conditions beyond the control of the party affected, it being the intention of each party to relieve the other of the obligation to carry out the service or to receive the service either party may be unable to deliver or receive, in whole or in part the service herein contracted to be delivered or received.

**ARTICLE VIII**

Liability

The power plant or power plants where service by the Company to the Cooperative shall be carried out are the power plant or Exhibit "A". The Cooperative shall not in any manner connect lines to any other authorized supplier of electric energy without written notification to the Company and without engineering coordination to assure that the local grid will not be jeopardized by such interconnection.

**ARTICLE IX**

Approval and Succession

This contract shall be binding upon and ensure to the benefit of the Successors, legal representatives and assigns of the parties hereto.

**ARTICLE X**

Term

This services Agreement shall remain in effect for five (5) years. Either party may terminate the agreement by giving the other party one year notice in writing. Any changes to this agreement shall be effected by mutual agreement by the parties, with the party wishing to effect any changes making an application thereto by giving three (3) months' notice to the effect.

**ARTICLE XI**

Modification

Nothing contained herein shall be construed as affecting in any way the right of the party furnishing service under this rate schedule to unilaterally make application to the governmental body having jurisdiction for a change in rates and charges under laws of Tanzania and pursuant to the Rules and Regulations promulgated thereunder.

**ARTICLE XII**

Arbitration

All disputes arising under this agreement shall be determined by Arbitration as provided for under the Arbitration Ordinance, Cap. 15 of the Laws of Tanzania.

Signed for and on behalf  
TANESCO

Signed for and on behalf of  
UECCO

-----

-----

Date: -----

Date: -----

Witness: -----

Witness: -----

## TRAINING PROGRAMME FOR UECCO-OPERATORS

### SKELETON OF THE PROGRAMME

- 1) Operation & Maintenance
- 2) Data control
- 3) Trouble shooting & Machine

#### DETAILS

- 1) Operation & Maintenance
  - daily routine
  - daily maintenance
  - preventive maintenance schedule
  - shift round - pyrometer check up
  - engine attendance
  - basic working principal of diesel engines
  - switchgear and loading principles
  - E.start & stop procedure
- 2) DATA CONTROL
  - Machine log
  - Operation log
  - 24 hrs operation meter reading
  - Computation of engine data
    - Machine hrs
    - Units gen
    - Max load
- 3) TROUBLE SHOOTING
  - Change of engine on overload
  - Mechanical nock
  - Fuel nock
  - Faulty of fuel system
    - poor nozzle
    - poor pump element
  - Overspeed tripping
  - Lub oil low tripping
  - Cooling water system

## THERMAL STATION OPERATION PROGRAMME

The following is an operation Programme for Diesel Engine Operators and attendants in a thermal power station.

### DURATION:

The programme will take 3 weeks.

No. of participants: 3

### DETAILS OF PROGRAMME:

- 1) Operation & Maintenance
- 2) Data control
- 3) Trouble shooting

### PROGRAMME:

#### WEEK 1: OPERATION AND MAINTENANCE

- |                          |                                                                                                                                                                                                                                                                                                           |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Daily routine: Operators | <ul style="list-style-type: none"><li>- Shift handover</li><li>- Running sets</li><li>- Condition of sets</li><li>- Monitoring of loading</li><li>- How to start the engine</li><li>- How to stop it while loaded</li><li>- Auxiliaries monitoring</li></ul>                                              |
| Attendants               | <ul style="list-style-type: none"><li>- Shift handing over</li><li>- Condition of set -<br/>oil level, jacket water system, cooling water air system, fuel system</li><li>- Auxiliaries -<br/>fuel separation - separator &amp; maintenance.</li><li>- Air compressor - draining of water daily</li></ul> |
| Attendants               | <ul style="list-style-type: none"><li>- Cleanness of power station &amp; engine: -<br/>reporting of faults</li><li>- Daily maintenance - turbocharger oil, centrifugal filter, diesel filtering</li></ul>                                                                                                 |
| Daily maintenance:       | <ul style="list-style-type: none"><li>- to make sure filter is clean</li><li>- inspect loose nuts and other fastenings</li></ul>                                                                                                                                                                          |

PREVENTIVE MAINTENANCE SCHEDULE: -

- Period for changing oil sump & T/charger
- Period for changing filters
- Period for changing other components
- Period for auxiliaries service
- Period for maintenance schedule
- How to report breakdown
- Shift round:
- Hourly interval check round for
  - Ally pyrometer
    - lub oil pressure
    - cooling water
    - exhaust pyrometers
    - change air, etc.
- Engine attendance:
- To learn behaviour of engine
- To learn causes of engine:
- Pressure low
- Overheating of engine
- To differentiate smoky engine, etc.
- Basic working principal of diesel engine
- Introduction of diesel engine
- Types of diesel engine
- How it works
- Fuel system
- Cooling system and importance
- Protection of engine operations
- Switchgear and loading principal
- Engine breaker and control unit
- Feeders and synchronising procedure
- Offloading and stopping the engine
- Period to stop loaded set
- How to start dormant set

2. DATA CONTROL - WEEK 2

- Machine log
- How to read and fill, the machine log sheets for engine attendants

- OPERATION LOG

- How to read and fill operation data
- Computation of engine data
- Daily (24 hrs) running hrs
- 24 hrly units generated
- max load recording
- preparation of daily/weekly reports

3. WEEK 3

TROUBLE SHOOTING

- To learn change of engine round
- To detect fuel nock and mech. nock
- To detect change caused by engine overspeed or fuel faulty
- Fuel nock happens along cylinders
- Fuel system faults
- Causes - poor automisation
  - poor pump elements
  - poor fuel timing
  
- Engine doesn't start
- Causes - operation of overspeed tripping
  - engine blocking caused by - lub oil low pressure
  - cooling water temp high
  - air system pressure low

SUMMARY

- How to be good operator
- How to be good engine attendant
- Better ways to run the engine

Prepared by: R.H. Tuppa

## 1st WEEK - DATA CONTROL 24-11-1993 -- 27-11-1993

Date	Duration	Subject
24.11.93	09.00 - 10.30	Machine log
	10.30 - 11.00	Tea break
	11.00 - 12.30	Machine log
	12.30 - 14.00	Lunch break
	14.00 - 16.00	Practicals on machine log
25.11.93	09.00 - 10.30	Daily maintenance
	10.30 - 11.00	Tea break
	11.00 - 12.30	Daily maintenance
	12.30 - 14.00	Lunch break
	14.00 - 16.00	Practicals on machine log
26.11.93	09.00 - 10.30	24 hrs operation meter reading
	10.30 - 11.00	Tea break
	11.00 - 12.30	24 hrs operation meter reading
	12.30 - 14.00	Lunch break
	14.00 - 16.00	Practical on 24 hrs operations meter reading
27.11.93	09.00 - 11.00	Computation of engine data
	11.00 - 11.15	Break
	11.15 - 13.00	Practicals on computation of engine data
29.11.93	09.00 - 10.30	Daily routine (for SBO)
	10.30 - 11.00	Tea break
	11.00 - 12.30	Daily routine (for EA)
	12.30 - 14.00	Lunch break
	14.00 - 16.00	Practicals on daily routine
30.11.93	09.00 - 10.30	Daily routine (for SBO)
	10.30 - 11.00	Tea break
	11.00 - 12.30	Practicals on daily maintenance
	12.30 - 14.00	Lunch break
	14.00 - 16.00	Preventive maintenance
1.12.93	09.00 - 10.30	Preventive maintenance contn.
	10.30 - 11.00	Tea break
	11.00 - 12.30	Preventive maintenance contn.
	12.30 - 14.00	Lunch break
	14.00 - 16.00	Preventive maintenance pract.
02.12.93	09.00 - 10.30	Shift round
	10.30 - 11.00	Tea break
	11.00 - 12.30	Practical on shift round
	12.30 - 14.00	Lunch break
	14.00 - 16.00	Engine attendance (theory & practical)
03.12.93	09.00 - 10.30	Basic principals of diesel engine
	10.30 - 11.00	Tea break
	11.00 - 12.30	Switch gear and loading principal
	12.30 - 14.00	Lunch break
	14.00 - 16.00	Engine start & stop procedures

**Appendix E**

06.12.93	09.00 - 10.30 10.30 - 11.00 11.00 - 12.30 12.30 - 14.00 14.00 - 16.00	Change of engine load Tea break Practicals on the above sub. Lunch break Mechanical nock (theory & practical)
07.12.93	09.00 - 10.30 10.30 - 11.00 11.00 - 12.30 12.30 - 14.00 14.00 - 16.00	Fuel nock Tea break Practicals on fuel nock Lunch break Faulty of fuel system
08.12.93	09.00 - 10.30 10.30 - 11.00 11.00 - 12.30 12.30 - 14.00 14.00 - 16.00	Faulty of fuel system contrn. Tea break Practicals on the above subject Lunch break Overspeed tripping (theory and practical)
10.12.93	09.00 - 10.30 10.30 - 11.00 11.00 - 12.30 12.30 - 14.00 14.00 - 16.00	Lub oil low tripping Tea break Cooling water system Lunch break Practicals on the above subjects

**URAMBO ELECTRIC CONSUMERS CO-OPERATIVE SOCIETY  
(UECCO)  
CALL FOR ENERGY CONSERVATION**

Dear member,

UECCO was registered on 30/9/1993 after the District Council failed to run the power system. Since UECCO took over, massive technical and financial assistance has been rendered by SEI/TANESCO Research Cooperation. One genset out of three has been fully rehabilitated, the rest awaiting minor spares. Also, the distribution network has been extended to hospital and industrial area including the Tobacco Factory.

Power outages experienced before UECCO took over resulted into membership falling from 120 to current 68. Following rehab of one set, reliable power supply has been provided hence inducing consumers to increase their loads. Initially it was few bulbs, but now we have TV/Video sets, electric kettles, fridges and radio sets. Welding and compressor units also feature in garages. The increased loads are responsible for overloading of our genset. Also, total fuel consumption has remained high despite reduced number of consumers.

Research findings from SEI/TANESCO indicate that members consume more than twice energy units than what they pay for, which is as follows:

<u>Consumer category</u>	<u>Amount</u>	<u>60 W bulbs</u>	<u>40 W bulbs</u>
Domestic	300 W	5	7
Commercial	470 W	8	12
Guest House	550 W	9	14
Institutions	1360 W	23	37

These are maximum continuous loads to be put on.

While efforts to install meters is ongoing, customers are requested to limit their loads as suggested above. Tips to serve the Cooperative from operational losses are:

1. Use 25W, 40W and 60W bulbs or 20W and 40W tube lights, avoid 100W bulbs. All unoccupied premises should be switched off. Not more than five 60W bulbs should be continuously on.
2. Switch off lights when you retire for the night.
3. Bar owners are advised to use 5W and 25W bulbs or 20W and 40W tube lights.

4. Guest Houses can use 40W bulbs or 20W tube lights.
5. Until all gensets have been rehabilitated and meters installed, use of compressor and arc welding units are prohibited.
6. Until all gensets have been rehabilitated and meters installed, use of hot plates for cooking is prohibited.

**If we fail to conserve electricity, we shall have to close the power plant until metes are installed in consumer premises.**

## **Resolutions from the Rural Electrification Seminar in Tabora, June 7-9, 1996**

During the period June 7-9, 1996, 25 participants drawn from Urambo, Kasulu, Kibondo, Kisarawe, Tabora and Mbinga districts; TANESCO staff from Tabora, Songea and Dar es Salaam; University of Dar es Salaam; and Stockholm Environment Institute discussed on the experiences, strategies and future action plan for rural electrification based on power cooperatives in Tanzania. The first day involved seminar paper presentations. On the following day, a study tour to Urambo was arranged by Urambo Electric Consumers Cooperative (UECCO). During the last day, seminar participants discussed various issues touching upon policy, legal and institutional framework, power project implementation strategies and future tasks. The following are seminar observations and necessary recommendations pertaining to each observation:

**Observation 1:** There is declined government resources to finance rural power projects. It is therefore a good idea to have locally managed electric schemes in the rural areas.

Recommendation:

- 1) At least two more pilot projects are needed. They shall be selected to represent different initial conditions:

**Observation 2:** Commitment of the members, initiative and drive is an important factor for the sustainability of the Cooperative.

Recommendation:

- 1) Prospective consumers must be informed that initially, self-sacrifice is needed but in the long run an incentive package is required for those employed.

**Observation 3:** More pilot projects are needed so as to broaden the experience and to stimulate rural electrification by rural power cooperatives.

Recommendation:

- 1) The government should formulate a clear and coherent policy on rural electrification by cooperatives.

**Observation 4:** To avoid power scheme failures, appropriate criteria must be used to select the sites for rural electrification by cooperatives.

### Recommendations:

The following criteria shall be used for selection:

- 1) Economic base
- 2) Willingness
- 3) Local initiative
- 4) Project viability

**Observation 5:** A pre-feasibility study has to be carried out before executing a project.

### Recommendation:

- 1) The pre-feasibility study can be done by the Ministry of Energy and Minerals, utility, NGOs, private consultants or the group itself where possible.

**Observation 6:** The human factor is a crucial factor in the cooperative activities, hence proper organisation is necessary.

### Recommendation:

- 1) Relevant by-laws of the electric cooperative society should be adopted.
- 2) Contractual arrangements with other parties be in place.
- 3) A simple organisation structure is essential.

**Observation 7:** Financing is a critical factor in the successful establishment of the electric cooperatives.

### Recommendation:

- 1) Local contribution by members of the Cooperative is essential. A 5-10% contribution to the initial investment is non un-reasonable.
- 2) The government must establish financing arrangements to encourage rural power cooperatives by setting up a fund through a levy on electric projects and/or electric consumption.
- 3) The government should consider waiving tax on equipment and material imported for rural electrification as its contribution for enhancing rural electrification.
- 4) Donor financing should be solicited.
- 5) Grants and contributions should be looked for.
- 6) Bank loans can be used as a last resort.

**Observation 8:** The success of the project depends on the implementation strategy.

Recommendations:

- 1) To lower project cost, local labour and material contribution is essential.
- 2) Simple technologies should be adopted e.g. single phase lines, ready boards, simple lay-outs, innovative metering etc.
- 3) Technical support from the utility or consulting firms may be necessary for certain specialised services not yet available within the Cooperative. These can be done following contractual arrangements e.g. service contracts.

**Observation 9:** For successful operation of the project, training is essential.

Recommendations:

- 1) Training of the members of the electric cooperatives in technical aspects, financial management, operational transparency and managerial skills is essential and must therefore be included on the budget.
- 2) Initial on the job training of various technical staff is necessary.
- 3) Review workshops, seminars and tailor made training of various groups of the Cooperative should be arranged.
- 4) Where possible, study tours to other cooperatives be encouraged.

**Observation 10:** To ensure the success of the Cooperative, continuous monitoring, review and evaluation of the Cooperative performance has to be done.

Recommendations:

- 1) The Ministry of Energy and Minerals should form a unit to assist with the monitoring.
- 2) The regional and district Cooperative offices should closely monitor financial performance.



### PV-dimensioning

Dimensioning of PV-systems for lighting demand in Tanzania (two cases based on actual conditions at two different dates in Urambo):

	May -95	August -97
Lighting demand	12000 lumen	5000 lumen
Number of hours	4 hours	5 hours
Illumination per unit of power tubes	75 lumen/watt	75 lumen/watt
LAMP(S) selected	<b>9 X 18 W</b>	<b>4 X 19 W</b>
Load	162	72
Energy demand	648 Wh/day	360 Wh/day
Nominal system voltage	12 V	12 V
Maximum battery discharge (% left)	40 %	40 %
Regulator efficiency	0.9	0.9
Battery efficiency	0.8	0.8
Energy demand from panel (Energy demand/(Reg. Eff.xBatt.Eff.))	900 Wh/day	500 Wh/day
Insolation	4.5 Wh/day	4.5 Wh/day
Degree of utilisation	0.85	0.85
Required power out-put, panel (Demand from Panel/(Deg. of Utilisation x Insolation))	235 Wh/day	131 Wp
PANEL(S) selected	<b>5 x 55 Wp</b>	<b>3 x 55 Wp</b>
<i>Installed power</i>	275 Wp	165 Wp
Battery requirement (Ah) (Energy demand/voltage) x 3 days+40%	227	126
BATTERY selected	<b>250 Ah</b>	<b>150 Ah</b>



**AGREEMENT BETWEEN THE URAMBO DISTRICT COUNCIL (UDC) AND  
THE URAMBO ELECTRIC CONSUMERS CO-OPERATIVE SOCIETY  
(UECCO)**

1. Generator sets belong to UECCO in Urambo District;
2. UECCO cannot sell the sets without written approval of UDC;
3. UECCO will regularly report to UDC the status of the machines based on TANESCO's assessment as part of service contract;
4. UECCO can use sets as a collateral for taking loans provided UDC is involved and UECCO's financial soundness is confirmed to avoid possibility for banks to sell the machines;
5. There will be regular consultations between UDC and UECCO on operation of plant and possibilities for UDC to do welding activities on concessionary terms;
6. If any above clause is not fulfilled UDC can take back the sets.



## REFERENCES

African Research Bulletin, July 16th-August 15th 1992, pg.10933.

*African Research Bulletin*, June-July 1995.

Dr. Amos, Mhina, *Rural development under the changing development paradigm: the case of co-operatives*, University of Dar es Salaam, Department of political science and public administration, paper presented at 2nd State of Politics Conference, Dar es Salaam from July 4th to July 6th 1994.

Andersson, Emma Catrin, *Electric Energy Efficiency in Urambo Power Supply System, Part One*. A SIDA Minor Field Study in Tanzania, 1995.

Bank of Tanzania, *Economic Bulletin for the Quarter Ended 31st December, 1998*.

Bank of Tanzania. *Economic and Operations Report for the Year ended 30th June, 1999*.

*Bioenergins miljö och hälsoeffekter (Health and Environmental risks with Bioenergy)* Vattenfall Utveckling, 1996.

Bryceson, Deborah, *Second Thoughts on Marketing Co-operatives in Tanzania: Background to their Reinstatement* (Development series 5) Plunkett Foundation for Co-operative Studies, 1994. ISBN 0 85042 056 3.

Bureau of Statistics Dar es Salaam, 1991: *Statistical abstract 1991*, .

Bureau of Statistics Dar es Salaam, 1992: *Household Budget Survey 1991/92*.

Bureau of Statistics Dar-es-Salaam, 1993: *Statistical Abstract 1991* , January 1993.

Daati, Sabina, Technical Report from Urambo Power System. TANESCO, 1997.

Dr. Festus, Limbu, *Rural development under the changing development paradigm: the case of co-operatives*, University of Dar es Salaam, Economics Department, paper presented at 2nd State of Politics Conference, Dar es Salaam from July 4th to July 6th 1994.

Gerger, Åsa and Gullberg, Monica, *Rural Power Supply with Local Management: Examples from Bolivia, India and Nepal*, SEI 1997. ISBN 91 88714 31 4.

Gwan'gombe, Florence, *Experience with use of efficient lights: Case study of Urambo rural electric co-operative, Tanzania*. TANESCO paper for Demand side Management seminar at Kilimanjaro hotel, Dar es Salaam, 1995. Also EE&D internal technical report series no. 10.

Gwang'ombe, Florence, *Technical comparative study on rural public power supply versus community managed power supply: Urambo/Mafia*, TANESCO, 1995.

Havnevik, Kjell J. , *Tanzania - the limits to development from above*, Nordiska Afrika Institutet, Sweden 1993. ISBN 91-7106-335-8.

Hill, Robert, *Photovoltaics: present status and future prospects*, Newcastle Photovoltaics Application Centre, University of Northumbria, January 1993.

Katyega, M.J.J. et al., *Feasibility Study on Electrification of Shimbi and Sikonge villages*, SEI, Dar es Salaam University and TANESCO, 1994.

Katyega, Maneno and Sumari, Christopher, *Establishment of Urambo Rural Power Co-operative: Tariff Study*, TANESCO 1994.

Kjekhus, Helge, *The Tanzanian Villagization Policy: Implementational Lessons and Ecological Dimensions*, Canadian Journal of African Studies, Volume XI, no 2, 1977, pg 269-282.

- Kjellström, Björn; Katyega, Maneno; Kadete, Henry; Noppen, Dolf and Mvungi, Abu, *Rural Electrification in Tanzania: Past Experiences – New Approaches*, SEI, 1992.
- Kjellström, Björn; Katyega, Maneno; and Kadete, Henry, *Report on a technical fact collection visit to Babati, Arusha region 11 to 19 July 1989* (Table 5-1). SEI 1990 (EE&D series no.2).
- Lindahl, Per Erik, *Elkraftteknik*. Studentlitteratur AB, Lund 1983.
- Mbaruku, H., *Regional population growth and its components*. (Chapter five in the 1978 population census). Bureau of Statistics, Ministry of Planning and Economic Affairs, Dar es Salaam 1983.
- McNelis, B., *Photovoltaics for Developing Countries*, In Hilger Adam Applications of Photovoltaics, Bristol 1989.
- Ministry of Water, Energy and Minerals (MWEM), 1992. *The Energy Policy of Tanzania*.
- Mvungi, Abu and Sanga, Anku, *A Base Line Study of Urambo*, dar es Salaam University, 1995.
- Mwaipopo, Rosemary, *Study on attitudes towards electrification: Urambo*, Dar es Salaam University, 1993.
- Mwandosya, M.J. and Luhanga, M.L., *Energy and Development in Tanzania*, Energy Policy, Volume 21, no. 5, May 1993.
- OECD statistics, 1997.
- OECD 1998, *Energy Statistics & Balances of Non-OECD Countries 1995 - 1996*.
- Ross, J. E., *Co-operative Rural Electrification: Case Studies of Pilot Projects in Latin America*, Preager Publishers, 1972.
- SADCC Energy sector, *Study on NRSE Pricing in the SADCC Region*, May 1992. Annex 2.
- Sanga, Anku, *New approaches to Rural electrification in Tanzania: A Follow Up Study of Urambo Electricity Consumers Co-Operative*, University of Dar es Salaam, 1998.
- Sarris, Alexander H. & van den Brink, Rogier, *Economic Policy and Household welfare during Crisis and Adjustment in Tanzania*, New York University Press, 1993. ISBN 0-8147-7982-4.
- SASDA, *Evaluation of Swedish Development Cooperation with Tanzania*, Ds 1994:113, 1994.
- Selemani, Bosco *House to house survey: electrical load and consumption data: Urambo*, TANESCO 1995.
- Sheya, M.S. et al., *Electrification of rural district townships in Tanzania; feasibility study report*, July 1986, Department of Electrical Engineering, University of Dar es Salaam.
- Sida, *Policy för miljöanpassat energibestånd*, 1996-04-23.
- The World Fact Book 1995*, Central Intelligence Agency.
- The World Bank, *World Tables 1995*
- Trends in Developing Economies 1989*. The World Bank, Washington DC.
- World Energy Council, *International Energy Data 1989*.
- UN, *Energy Statistics Year Book 1992*.
- UNDP 1999, *Human Development Report 1999*
- Vorwerk, Ingrid, *Electric Energy Efficiency in the Urambo Power Supply System: Part Two*, Minor Field Study in Tanzania, Department of Electric Power Technology at the Royal Institute of Technology, 1996.

## SEI BOARD

**Chairman:**

Maurice F. Strong

Canada

**Vice Chairman:**

Bert Bolin

Sweden

**Executive Director:**

Nicholas C. Sonntag

Canada

Antonia Ax:son Johnson

Sweden

José Maria Figueres Olsen

Costa Rica

Claude Fussler

Switzerland

Crawford S. Holling

USA

Nay Htun

Myanmar

Ashok Khosla

India

Kerstin Niblaeus

Sweden

Andres Tarand

Estonia

Alvaro Umana

Costa Rica

Alexey V. Yablokov

Russia

---

## SEI MISSION STATEMENT

*The Stockholm Environment Institute (SEI) is an independent, international research organisation committed to the implementation of practices supportive of global sustainable development. SEI conducts a comprehensive research, consulting and training programme that focuses on the links between ecological, social and economic systems at global, regional, national and local levels. In its commitment to bridge the gap between science and policy-making, SEI employs innovative methods to communicate its work to governments, the private sector and society-as-a-whole. To meet these challenges, SEI has created an international network of centres and has established partnerships with sustainable development organisations throughout the world.*

---

**Stockholm Environment Institute**

Executive Director: Nicholas C. Sonntag

Address: Lilla Nygatan 1  
Box 2142  
S-103 14 Stockholm  
**Sweden**Telephone: +46 8 412 14 00  
Fax: +46 8 723 03 48  
E-mail: postmaster@sei.se  
WWW: www.sei.se/**SEI-Boston**Director: Paul Raskin  
Address: 11 Arlington Street  
Boston, MA 02116-3411  
**USA**Telephone: +1 617 266 8090  
Fax: +1 617 266 8303  
E-Mail: seib@tellus.org  
WWW: www.seib.org/**SEI-York**Director: Johan Kuylenstierna  
Address: Biol. Dept. Univ. of York  
P.O. Box 373,  
York YO10 5YW  
**UK**Telephone: +44 1904 432 897  
Fax: +44 1904 432 898  
E-mail: ac29@york.ac.uk  
WWW: www.york.ac.uk/inst/sei/sei/**SEI-Tallinn**Director: Olavi Tammemäe  
Address: Lai 34, Box 160  
EE-10502, Tallinn  
**Estonia**Telephone: + 372 6 314 200  
Fax: + 372 6 313 240  
E-mail: postmaster@seit.ee  
WWW: www.seit.ee/

## THE STOCKHOLM ENVIRONMENT INSTITUTE

SEI is an independent, international research institute specialising in sustainable development and environment issues. It works at local, national, regional and global policy levels. The SEI research programme aims to clarify the requirements, strategies and policies for a transition to sustainability. These goals are linked to the principles advocated in Agenda 21 and the Conventions such as Climate Change, Ozone Layer Protection and Biological Diversity.

## THE HISTORY AND DEVELOPMENT OF SEI

The SEI mission developed from the insights gained at the 1972 UN Conference on the Human Environment in Stockholm (after which the Institute derives its name), the work of the (Brundtland) World Commission for Environment and Development and the 1992 UN Conference on Environment and Development (UNCED). The Institute was established in 1989 following an initiative by the Swedish Government to develop an international environment/development research organisation.

## IMPLEMENTING THE MISSION

SEI examines the policy connections and implications of scientific and technical analysis. This includes management strategies for environment and development issues of regional and global importance. The results of SEI research are made available to a wide range of audiences through publications, electronic communication, software packages, conferences, training workshops, specialist courses and roundtable policy dialogues. Contacts and collaborative relationships are vigorously maintained within the scientific, political, administrative, intergovernmental and business communities on a world-wide basis. Through its staff experience and diverse global network, SEI is equipped to handle a wide variety of complex research and policy projects as well as assessments, scoping studies, capacity building, communications, training and professional consulting.

## THE SEI GLOBAL NETWORK

The Institute has its headquarters in Stockholm with a network structure of permanent and associated staff world-wide and centres in Boston (USA), York (UK) and Tallinn (Estonia). SEI employs over seventy research and support staff. The collaborative network consists of scientists, research institutes, project advisers and field staff located in over 20 countries. SEI is a flexible international research network rather than a more traditional single-site institute.

## PROGRAMME AREAS

A multidisciplinary rolling programme of research, consulting and training activities has been designed around the following main themes, which are being executed via internationally collaborative activities with similar institutions and agencies world-wide:

- *Sustainable Development*
- *Sustainable Energy*
- *Atmospheric Environment*
- *Water Resources*
- *Urban Environments*
- *Environmental Assessment*
- *Institutional Development*
- *Disseminating Global Knowledge*



Lilla Nygatan 1  
Box 2142  
S-103 14 Stockholm  
**Sweden**  
Tel: +46 8 412 14 00  
Fax: +46 8 723 03 48  
E-mail: [postmaster@sei.se](mailto:postmaster@sei.se)  
[www.sei.se/](http://www.sei.se/)

SEI-Boston  
11 Arlington Street  
Boston, MA 02116-3411  
**USA**  
Tel: +1 617 266 8090  
Fax: +1 617 266 8303  
E-Mail: [seib@tellus.org](mailto:seib@tellus.org)  
[www.seib.org/](http://www.seib.org/)

SEI- Tallinn  
Lai 34, Box 160  
EE-10502, Tallinn  
**Estonia**  
Tel: + 372 6 314 200  
Fax: + 372 6 313 240  
E-mail: [postmaster@seit.ee](mailto:postmaster@seit.ee)  
[www.seit.ee/](http://www.seit.ee/)

SEI-York  
Biol. Dept. Univ. of York  
P.O. Box 373,  
York YO10 5YW, **UK**  
Tel: +44 1904 432 897  
Fax: +44 1904 432 898  
E-mail: [ac29@york.ac.uk](mailto:ac29@york.ac.uk)  
[www.york.ac.uk/inst/sei/sei](http://www.york.ac.uk/inst/sei/sei)