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And Then They Lived Sustainably Ever After?

-Experiences from Rural Electrification in Tanzania, Zambia and Kenya

Elisabeth Ilskog

Doctoral Thesis 2008

KTH Royal Institute of Technology
School of Technology and Health
Stockholm, Sweden

Contact information:
Address: KTH School of Technology and Health
Royal Institute of Technology
S-136 40 Haninge
Sweden

Web-link to:

- the KTH School of Technology and Health:
  http://www.sth.kth.se

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Abstract

Accelerating the introduction of basic, clean energy services is seen as a key strategy for promoting sustainable development in rural areas. Still, many people worldwide lack access to modern energy, such as electricity, and Africa lags behind other developing regions of the world. Support to rural electrification is therefore given high priority by the national governments and donor organisations.

There is a trend to encourage the involvement of other actors than national utilities for implementation of rural electrification. At the same time, it is required that the activities shall contribute to sustainable development.

The objective of the work presented in this thesis has been to reach increased knowledge on the impact from organisational factors on project sustainability, and to examine whether rural electrification implemented by private entrepreneurs or other non-governmental organisations contribute more effectively to sustainable development than the conventional approach where rural electrification is the responsibility of a government utility. A key activity of the research work has therefore been to improve and develop the present methodologies used for evaluations, as to attain a more functional in-field evaluation method.

The thesis presents findings from seven rural electrification cases in Eastern and Southern Africa and shows how these can be used to illustrate different dimensions of sustainability by means of indicators. The evaluation indicates that the national utilities perform better from a social/ethical perspective, whereas the private organisations and the community-based organisations manage their client-relation issues in a more sustainable way.

In addition, a literature survey shows that among stakeholders there are a number of "concepts-taken-for-granted" as regards to rural electrification. These are not supported by the findings from the seven cases. The observed deviations between expectations and realities can obstruct the development since leading decision-makers may have unrealistic expectations when planning for new electrification activities. Instead, activities have to be implemented with the empirical reality in mind. By doing so the ambiguities, complexities and all the paradoxes of rural electrification can hopefully be better managed.

The study has been funded by The Swedish International Development Agency, Department for Research Cooperation (SAREC), and Ångpanneföreningen's Foundation for Research and Development (ÅFORSK).

Language: English with an additional abstract in Swedish.

Keywords: Rural Electrification, Sustainable Development, Indicators, Evaluations, Interdisciplinary, Africa.

The PhD has now come to a close.
Screen, mind.
All is blank.

Sammanfattning

En hållbar utveckling handlar om att fördela jordens ändliga resurser mellan dagens och morgondagens generationer. En hållbar utveckling av ett samhälle förutsätter att invånarna har tillgång till elektricitet. Trots det saknar stora delar av befolkningen runt om i världen el. Det gäller framförallt de som bor på landsbygden. Stöd till landsbygdselektrifiering ges därför hög prioritet bland många myndigheter i utvecklingsländer och av internationella utvecklingsorgan. Trenden i dag är att främja privata aktörer inom elektrifieringssektorn. Utvecklingen måste också vara långsiktigt hållbar.

Syftet med denna doktorsavhandling har varit att bidra till en ökad förståelse för de kritiska faktorerna kring landsbygdselektrifiering, och att få en större insikt i hur den organisationsform som valts påverkar den långsiktiga hållbarheten i det område där organisationen verkar. Är det så att ett privat företag eller någon annan form av enskild organisation bättre bidrar till en hållbar utveckling i det område där det bedriver sin verksamhet, jämfört med den traditionella formen där landsbygdselektrifiering drivs av statliga organisationer?

Det finns förhållandevis få publicerade utvärderingar av genomförda elektrifieringsprojekt på landsbygden som i detalj visar hur utvärderingen har gått till och vilket underlag som har samlats in. Många rapporter och utredningar är i stället redovisade på en mer strategisk nivå eller på ett sådant sätt att resultaten från dem inte går att jämföra.

För att kunna utreda forskningsfrågan har därför en metod tagits fram med syfte att samla information och sammanställa den på ett transparent sätt. Det underlag som samlas in via denna metod presenteras med hjälp av 39 föreslagna indikatorer inom områdena teknik, ekonomi, sociala indikatorer, miljö och organisation. Urvalet av dessa indikatorer har skett genom litteraturstudier och via fältstudier av genomförda elektrifieringsprojekt. Syftet har varit att få en transparent och robust utvärderingsmetod som fungerar i fält.

Metoden har kompletteras med en SWOT-analys för att inkludera ytterligare information till utvärderingen. Analysen har genomförts via diskussioner med ledningarna för de olika organisationerna.

Doktorsavhandlingen presenterar metodens tillämpning på sju organisationer för landsbygdselektrifiering i Tanzania, Zambia och Kenya. De genomförda studierna indikerar att statliga organisationer tenderar att lyckas bättre med den sociala långsiktiga hållbarheten. Bland annat är fler av de boende i området anslutna till elnätet och viss gatubelysning finns, vilket är en fördel ur ett genderperspektiv. De enskilda organisationernas styrka är framförallt deras goda kundrelationer. Studien har dock inte kunnat fastställa att någon enskild organisationstyp är bättre för att genomföra en långsiktigt hållbar landsbygdselektrifiering i utvecklingsländer. När ett beslut om organisationsform ska fattas, måste hänsyn tas till de specifika lokala förutsättningarna på platsen.

Den genomförda studien har gett intressanta erfarenheter om såväl den långsiktiga hållbarheten i de undersökta projekten, som utvärderingsmetoden i sig. Det är dock viktigt att påpeka att det krävs upprepade utvärderingar av respektive projekt, för att kunna dra några långtgående slutsatser.

Bland många aktörer inom utvecklingssektorn runt om i världen finns ett antal ”allmänt accepterade sanningar” om landsbygdselektrifiering och dess effekter på en hållbar utveckling. De observationer från de sju projekt som studerats inom ramen för denna avhandling, överrensstämmer inte med dessa ”allmänt accepterade sanningar”. Det finns därför anledning att anta att sektorn präglas av en empirisk och teoretisk dubbelhet, där ett försök att skapa en rationell utveckling i ett projekt kan få en rakt motsatt verkan. I stället bör projekten hanteras utifrån den verklighet de befinner sig i för att på så sätt bättre ta vara på den komplexitet, mångtydighet och alla de paradoxer elektrifieringen rymmer. Arbetet med att utvärdera genomförda insatser inom landsbygdselektrifiering bör fortsätta.

Studien har finansierats av Sidas avdelning för forskningssamarbete (SAREC) samt av Ångpanneföreningens forskningsstiftelse (ÅFORSK).

Språk: Engelska med en sammanfattning på svenska.

Nyckelord: Landsbygdselektrifiering, hållbar utveckling, indikatorer, utvärdering, tvärvetenskaplig, organisationsanalys, Afrika.

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Although I see this thesis as a milestone for myself, I realise that I have not become the wise person I thought I would be. There is still a lot to learn, which I hope to be able to do under my new devise - Schysst tempo!

Tack/Liza

List of Appended Papers

This doctoral thesis is based on the following papers, referred to by Roman numerals I-VI, where the publications I-IV have also been included in a licentiate thesis, published in 2005[1].

I **Electrification Co-operatives**
- Bring New Light to Rural Tanzania
Ilskog, E., Kjellström, B., Gullberg, M., Katyega, M. and Chambala, W. Energy Policy. Volume 33, Issue 10. July 2005, p 1299-1307.
doi:10.1016/j.enpol.2003.12.006

II **Simple Organisation Analysis as a Tool for Raised Awareness of Interdisciplinary Perspectives on Rural Electrification**
- Case Studies from Zambia and Tanzania
Ilskog, E and Katyega, M.
Workshop on Rural Energy Delivery Mechanisms, Bagamoyo, Tanzania, October 2003.
Seminar on Rural Energy Delivery Mechanisms, Stockholm, Sweden, January 2004.

III **New Markets in Sub-Saharan Africa**
- Myth or Reality?
Ilskog, E.
International Conference & Exhibition on Small Hydropower, Falkenberg, Sweden, June 2004. http://www.managenergy.net/products/R654.htm

IV **Village Electrification Technologies**
- An Evaluation of Photovoltaic Cells and Compact Fluorescent Lamps and their Applicability in Rural Villages Based on a Tanzanian Experience
Gullberg, M., Ilskog, E., Katyega, M. and Kjellström, B.
Energy Policy. Volume 33, Issue 10. July 2005, p.1287-1298.
doi:10.1016/j.enpol.2003.12.005

V **Indicators for Assessment of Rural Electrification**
- An Approach for the Comparison of Apples and Pears
Ilskog, E.
Manuscript accepted for publication in Energy Policy. March 2008.
doi:10.1016/j.enpol.2008.03.023

VI **And Then They Lived Sustainably Ever After?**
- Assessment of Rural Electrification Cases by Means of Indicators
Ilskog, E., Kjellström, B.
Manuscript accepted for publication in Energy Policy. March 2008.
doi:10.1016/j.enpol.2008.03.022

The papers are appended as Appendix I – VI at the end of the thesis.

[1] Ilskog 2005

Table of Contents

[2] Ilskog 2008

1. Introduction

1.1. Background

Access to basic, clean energy services is essential for sustainable development and poverty eradication, and can provide major benefits in the areas of economy, health, literacy and equity. Still, many people worldwide lack access to modern energy, such as electricity. At present, it is estimated that approximately 1.6 billion people worldwide lack access to electricity and about 2.5 billion rely on traditional fuels as their primary source of energy[3].
Policy makers have realised the vital role that electricity plays and have taken interventions to address the energy needs of the bulk of the population. Because of this, power sector reforms are currently on going or have been initiated in over 20 African countries, mainly as a result of the electricity sectors poor performance. Numerous of these studies appear to equate poor performance in the electricity sector with high state intervention[4]. Most power sector reforms of today therefore consist of deregulation and privatisation. This means that rural electrification projects will not necessarily be implemented by national utilities and that new institutional arrangements will be used. There are however few documented experiences from such new arrangements.

The Swedish International Development Agency, Department for Research Cooperation (SAREC), is financing a research cooperation programme between Makerere University in Kampala, Uganda and a number of universities in Sweden, of which The Royal Institute of Technology (KTH) is one. The programme aims at strengthening the co-operation between the Universities, and contributes to the exchange of experiences between students of both universities. The work presented in this thesis is part of that programme, and has mainly been performed through funding from SAREC.

Additional financing has been received from Ångpanneföreningen's Foundation for Research and Development (ÅFORSK).

1.2. Objectives of the Thesis

The aim of the study has been to investigate the reasons behind successful/less successful implementation of rural electrification, with the overall objective to facilitate for decision-makers to improve their basis for future decisions and measures on rural electrification activities. This has been especially interesting in the light of the on-going trend towards private sector led projects, which have introduced new elements influencing possibilities and barriers for a sustainable rural electrification development.

The research objective of the work has been to reach increased knowledge of the impact from organisational and institutional factors on project sustainability, through interdisciplinary field studies, and studies of literature on rural electrification. The main issue for the research work has been to examine whether rural electrification implemented by private entrepreneurs or other non-governmental organisations contribute more effectively to sustainable development than the conventional approach where rural electrification is the responsibility of a government utility.

[3] GNESD 2007
[4] Karakezi and Kimani 2002, Sida 2005(a)

1.3. Scope of the Work

From the perspective of sustainable development, this doctoral thesis presents an analysis of rural electrification, based on interdisciplinary empirical studies of seven rural electricity cases in Tanzania, Zambia and Kenya. With the organisational aspects as a starting-point, the thesis deals with the following central issues within the area of rural electrification;

- To what extent has implemented rural electrification been evaluated, and are there any means for additional research to contribute to the "accumulated knowledge" and to the evaluation methods presently used?
- Are there any differences in the performance of the various organisations involved in rural electrification, when it comes to sustainable development, and to what degree are the organisations capable to manage the essential activities on long-term-basis?
- What is the probability of international private investments in the African power sector, and especially in the rural areas?
- What are the costs for elimination or reduction of greenhouse gas emissions caused by small-scale electrification?
- In what way is electricity in practice contributing to poverty eradication?

Prior to this thesis, findings on critical factors of importance for the sustainability of electricity services in electrified rural areas, have been published in a licentiate thesis[5].

1.4. Methodology

The research objective has been approached by three main activities, namely:

1. To study literature on evaluation of rural electrification and sustainable development.
2. To conduct fieldwork as to study and learn from areas where rural electrification has been implemented.
3. To improve and develop present methodologies used for evaluations, as to attain a more functional in-field evaluation method. The method developed is presented in full text in Appendix VII.

The main part of the work is based on field surveys, where selection of respondents has been made through random sampling and stratified sampling (subdivision). In addition, data has been received through inspection and measurements of technical components, review of client ledgers, logbooks, economic reports and other documentation available on the sites. The situation for each specific case surveyed, has been assessed by means of indicators developed during the work. Lastly, SWOT-analyses have been made based on information received from discussions with stakeholders.

The data collected has been compiled either in SPSS or on simple Excel Spread Sheets. The analysis of the data and the calculation of the indicators have been made on Excel Spread-Sheets.

The methodology and its limitations are further discussed in Chapter 6.

[5] Ilskog 2005

1.5. Thesis Outline

The result of the study has been presented in six papers, appended to this thesis. The thesis starts with a general discussion on the present situation of electrification in Africa (Chapter 2), where concepts on rural electrification and power sector development conveyed in literature are introduced. The chapter also includes a discussion on the context of sustainable development and the approach applied in the thesis. Chapter 3 discusses the need of evaluations, as well as the use of indicators and index. Chapter 4 presents a summary of the results from the field studies, and a desk research on the investment climate in Africa. In Chapter 5, a discussion of the result of the study is given, followed by a discussion on methods and need for further work (Chapter 6). The conclusions from the study are presented in Chapter 7, and the nomenclature used in the thesis is found in Chapter 9.

2. The Development of Rural Electrification in Africa

2.1. Overview

Most people in Africa today do not have access to modern energy services with a majority of them living in rural areas. As seen in Figure 1 below, the rural access to electricity is less than 5 % in most countries in southern and eastern Africa.

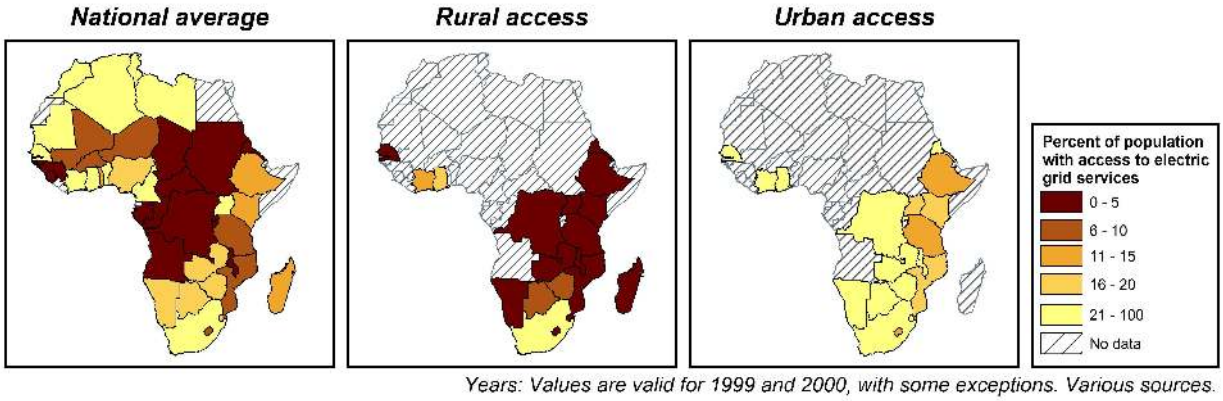

Figure 1. Access to electric grid services in Africa *(Source: Gustavsson, Ellegård, 2004).*

Africa's low overall access rates are partly explained by negligible service coverage in rural areas where the bulk of the population still resides[6]. Accelerating the introduction of modern energy is seen as a key strategy for promoting sustainable development in rural areas, and increasing the current low level of access to electricity services is considered a high priority and a major challenge among national governments in developing countries and the donor society. In fact, it is well documented that one of the most important energy indicators to track the progress of the MDGs (Millennium Development Goals) is access to electricity[8].

Increased access to electricity services obviously requires not only installation of the necessary infrastructure, i.e. equipment for electric power generation and distribution of electric power, but also provision of the electricity services at a cost that is considered affordable by the population. In all African countries included in this study, until now parastatal national electricity utilities have been responsible for providing the electricity services. Rural electrification has been achieved either by extension of the national electric transmission grid or by construction of isolated distribution networks supplied mainly by diesel generator sets. To make electricity affordable also for low-income groups, pan-territorial tariffs that result in subsidies for clients in rural areas and clients with low consumption have been applied, and are still in practice.[9] Additional measures have been implemented in many national energy policies, including deregulation and privatisation of national utilities, underlining the role of private actors as important. One example being Uganda, where the role of private participation has been emphasised as one of the key means of achieving greater efficiency and improved performance in the electric power sector[10]. In

[6] World Bank 2007(a)
[8] GNESD 2007
[9] Lyimo 2006
[10] The Republic of Uganda 1999

other countries, private actors have been pointed out as crucial "development partners" and efforts to motivate private companies to establish activities in the country has been advocated[11]. Private sector was expected to step in when infrastructure gaps were acknowledged as a constraint to meeting growth targets and achieving welfare improvements[12].

In general, the private sector involvement in the electric power sector began in the 1980s with a comprehensive privatisation program in Chile and a few projects in other developing countries. Since then, the private sector has played an important though minority role in financing investments in this sector in developing countries. Between 1984 and 2003, approximately 90 countries had achieved 952 electricity projects with private sector participation. The majority of the project had been launched in countries in Latin America and East Asia. On a total, 70 percent of the investments made by the private sector were made in electricity generation[13].

For those countries in Africa were private participation has been implemented, it has been claimed that private ownership is the best institutional means to create profit, which in turn is pointed out as a precondition for a well-functioning business sector[14]. Many countries in Africa have during the last decade also been characterised by an economic growth that has resulted in new investment incentives[15]. Between 1995 and 2005, the private sector had invested almost $37 billion in infrastructure in African countries south of Sahara. These market-oriented solutions have been promoted as a means to overcome apparent constraints posed by state-provided services. Governments in developing countries are therefore in the process of establishing institutional frameworks for regulation of the new market structures.

The main reason held forward to why the government public services have failed is stated to be a "problem of a 'principal agent', where political and bureaucratic leaders control information and resources that allow them to pursue their own individual aims and ambitions, rather than operating in the public interest. Reformers present private sector participation as an institutional solution to poor governance", where poor governance can be characterised with "bureaucratic inertia and disincentives to innovate, low technical and managerial capacity at all levels of service delivery, lack of accountability to consumers, absence of incentives for workers to perform, political constraints to laying-off under performing or unneeded workers, and corruption"[16]. The need of private participation is also stressed by donor organisations. Sida for instance, states that "the public sector will have to contribute to play a major role in financing needed investments but a significant part of the capital, in both local and foreign currency, must be mobilised from private investors and financial markets".[17]

The main argument against privatisation of public services is that the expectations of having private actors investing in such utilities have not been fulfilled. "Based on market incentives alone, private investment does no go to the areas of greatest need" [18]. Investments in energy sectors in third world countries requires high investment costs, long payback periods, and coping with a political situation that in practice often imply a difficulty to charge tariffs that ensure a commercial return. Therefore, it is argued, governments in developing countries have been burdened with high costs for motivating private sector investments, such as tax-

[11] The Revolutionary Government of Zanzibar 2004
[12] World Bank 2007(a)
[13] Covindassamy et al. 2005
[14] Sida 2000
[15] DBSA et al. 2000
[16] Bayliss and Fine 2007
[17] Sida 2005(b)
[18] Bayliss and Fine 2007

exemptions, and specific contract arrangements that minimize or even eliminate contract risks for the private participant. Moreover, the focus of investors on cost recovery has not promoted social objectives, such as reducing poverty and promoting equity[19].

These changes of the energy policies of governments in Africa, encouraging private participation, are supported by the donor community. The influence of the donors is strong since most of the financing for investments in the electricity sector is provided as development aid or soft loans. Another effect of donor policies is the promotion of renewable energy technologies, in particular solar PV (photovoltaic) for electricity generation. For scattered electricity users at remote locations with a small demand for electric power, solar PV is often the cheapest supply alternative available today. The justification used by the donors for the promotion of solar PV is however also that stand-alone diesel generation is avoided, thereby avoiding use of fossil fuels and release of CO_2 that would contribute to the risk for a global climate change.

2.2. Power Sector Participation by Different Organisation

The implementation of rural electrification can be realised by utilising different organisational forms, including government, private actors, communities and non-profit organisations. Historically, the most used form is implementation of electrification through government or ***governmental parastatal organisations***[20].

A number of African countries have turned their electricity utilities to corporations (parastatals). A few countries such as Kenya, Nigeria and Zimbabwe have gone a step further to commercialise their power utilities.[21] A further development in many African countries such as South Africa, Tanzania and Uganda, is the introduction of private sector involvement in the energy sector. This has mainly been done through introduction of ***Independent Private Producers (IPPs),*** which are allowed to own electricity production plants and to sell the electricity to the government owned utility.

Other form of private sector involvement in the electricity sector is the ***contract management-form***, which has become a common feature, particularly in West-African countries. Most of these contracts involve an agreement through which the operational control of a company or part of a company is delegated to an external operator, while the host company remains the owner of installations and controls all investment decisions.[22] This is an institutional form commonly used in Western Europe as well.

The above presentation mainly concerns the urban areas of a country, and areas connected to the national power grid. In many rural areas electricity, if any, is provided through decentralised systems. These decentralised systems are mainly owned and run by ***local branches of government utilities***, and commonly equipped with a diesel generator set for electricity generation. The tariff applied is the same as in the rest of the country concerned.

Another organisational form implemented in rural areas, in for instance Zambia and South Africa, is an ***Energy Service Company (ESCO***), which can be described as a form of contract management. The ESCO is typically a private business, sub-contracted by the government to provide the energy service and to maintain the equipment, which can remain as a property of

[19] Bayliss and Fine 2007, Hall 2007
[20] Karekezi and Kimani 2002
[21] Karakezi and Kimani 2002
[22] Karakezi and Kimani 2002

the government or handed over to the ESCO. The energy end-user (the client) buys an "energy service", such as light but not the equipment itself[23].

Electricity can also be produced locally by others than the government utility or organisations contracted by the government. Examples of this are ***rural based agricultural industries***, such as sugar, coffee, and tea industry, wattle-companies and sawmills. However, the major part of the electricity produced is used within the industry itself. Systems where electricity is sold to private clients are unusual and not allowed in most countries in sub-Saharan Africa[24]. One exemption however, being electricity produced and distributed by ***co-operatives*** or different forms of ***community based organisations*** (CBOs). The management in these organisations is generally composed of a steering committee or an executive committee, working under by-laws set up in collaboration with the government.

Community enterprises are a specialised form of community-based organisation that has both commercial as well as social aims and objectives. In this respect, the commercial objectives of a community enterprise are the business methods and practices that drive its organisational functions and determine its operational style. This is claimed to distinguish the organisational form from other forms of community-based organisations as discussed above.[25] These organisations are however still rare in African countries.

In general, the existence of decentralised power companies in Africa has been substantially lower than in developing countries on other continents. In China for instance, decentralised power companies play an integral role in the delivery of power to rural areas. In large parts of the country, the success of rural electrification and subsequent economic development has relied heavily upon their initiatives. The organisations have however been dependent upon governmental subsidies, and are now challenged by a market orientation and demand on technical efficiency[26].

2.3. Development Issues Related to Rural Electrification

Lighting up rural areas is a longed-for change among the rural population, and electricity for TV, radio and charging of mobile telephones is highly appreciated for facilitation of access to news and communication. Better health services, water services and improved security resulting from installation of streetlights are possible results from electrification that will benefit the majority of the population in an electrified area. In addition, electricity has been pointed out as important for reduction of fuel wood consumption, thereby preventing deforestation[27].

For economic development, also income-generating activities are needed to create employment opportunities through activities performed in households, in micro enterprises[28], in industries of different types and sizes, and in agriculture. [29] Access to 24 hours of electricity services is generally seen as important for the establishment and growth of businesses. Even a limited level of electricity service has been pointed out to be able to have positive effects on

[23] Ellegård and Nordström 2001
[24] Oral information from AFREPREN, Kimani and Kithyoma 2002
[25] Boyd 2003
[26] ESMAP 1999
[27] Sida/BITS electrification projects in Botswana, Ghana and Lesotho, Sida 2002 (Orgut)
[28] A micro enterprise is a very small business that produces goods or services for cash income (NREL 2000)
[29] Gullberg et al. 2004

operating hours, working conditions, mechanisation/automation, product preservation, communication and education[30].

There are different opinions about the gender aspects of rural electrification[31]. Some are of the opinion that rural electrification is an energy sub sector that does not have any different impact on women versus men. Other energy experts feel strongly that energy projects have the potential to provide special positive benefits for women. More efficient stoves, drinking water pumping and agro-processing can reduce women's workloads, improve their health, and provide income-earnings. Some of these benefits depend on electrification. Better lighting can extend the day for both productive and reproductive work and strengthen education and health services. Irrigated agriculture can provide better income-generation and employment opportunities. Elimination of indoor air pollution and elimination of the need to spend time and efforts on collection of cooking fuel by switching from cooking with wood fuel to electric cooking[32] is also sometimes claimed to be a benefit of electrification that is important for women.

Electricity may however also bring negative effects on development. Such effects could be prolonged working hours, increased consumption of alcohol at bars, prostitution, negative influences on youth from video films etc.

What needs to be further clarified is if the type of organisation that provides the electricity services has any influence on the public benefits and the distribution of them in the rural community. In addition, it is of interest to find out whether the type of organisation used for electricity supply makes any difference from a gender perspective and from a perspective of bringing other effects on the community.

2.4. Sustainability Issues Related to Rural Electrification

Ever since the release of the definition on sustainable development by the 1987 World Commission on Environment and Development[33], the sustainability issue has received increased attention, and is now taken into consideration in all research involving development issues and evaluations in particular (see for instance: Kennedy 2002, and Dewulf & Van Langenhove 2005). The Commission's frequently quoted definition of sustainability as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*, concerns the distribution of resources between and among generations and is focussed primarily on preservation of the environment and management of exhaustible natural resources such as fossil fuels.

Sustainable development however, requires more than conservation of the environment and the natural resources. A Swedish official study[34] used the following, more elaborated definition: "*Sustainable development concerns the distribution of resources between and among generations. Economic growth and equitable distribution of the growing resources derived from this growth are prerequisites for sustainable development. The growth most be of good quality, such as material- and energy efficient, and be able to satisfy human needs such as health and education. The growth must not jeopardise the balance of essential ecological systems*". Another study on the sustainability of the energy sector in particular, Johansson & Goldemberg, (2002) also acknowledged the economic and social aspects and concluded that: "*sustainable energy development will require electricity services that are reliable, available and affordable for all, on a sustainable basis, world-wide*".

[30] NREL 2000
[31] Cecelski 2000
[32] OECD 2007
[33] Bruntland, G. (ed.) (1987)
[34] Swedish Ministry of Finance 1999/2000

In this thesis, an even wider approach to sustainability than those implied by the definitions quoted above will be taken but applied on the local grass-roots level of electricity services at selected project sites.

With the grass-roots perspective, one fundamental requirement for sustainability is that the services must be ***economically sustainable***. This means that the payments received for the services must cover all operating costs and allow sufficient accumulation of capital for re-investment when the economic lifetime of the equipment has been reached. The services should also promote economic development and this requires that tariffs are affordable for entrepreneurs that would use the electricity services for improvement of their productivity. Affordability is also an issue for non-productive uses like residential lighting, electricity for health centres and streetlights. This means that there must be a sustainable market for the services.

Another important requirement is that the services are ***technically sustainable***. This implies that supplies of fuel, spare parts, maintenance and service, personnel for management, administration and operation must be possible to maintain for the period of interest. The area of ***organisational/institutional sustainability*** covers issues on how the project is managed, the degree of client-satisfaction with the energy services, and if both women and men are represented in the decision-making in the project.

The perspective on ***social and ethical sustainability*** is the most complex of the sustainability aspects, and does not only cover a broad area, but is also dependent and influenced by the development as a whole, which cannot be directly connected only to the impact of the actual project. The perspective includes issues such as the share of population in the area with access to electricity, development of health institutions and the education level in the area. These are important issues when financing from the government or a donor is needed but it may be less important for the organisation providing the services. It is obvious that the services must also be ***environmentally sustainable***, but the implications of this requirement might be different from a local, national or global perspective. Environmental sustainability in a broad global perspective is important for donors' decisions about project financing, but is a less important issue for the development and survival of the schemes that have already been implemented.

The performance of the seven selected projects with respect to these aspects of sustainability was evaluated during the field work presented in Chapter 4 and is further discussed in Chapter 5 and Chapter 6. Since the risk for undesirable climate change as a consequence of continued use of fossil fuels is receiving increased attention and is highlighted for instance by Sida in a recent policy document[35] some possibilities to minimize the CO_2-emissions caused by small scale electricity generation was also studied. The result of this study is presented in Section 4.4.

[35] Sida 2004

3. Impact Assessments and Evaluations by Means of Indicators

3.1. Impact Analysis and Evaluations of Rural Electrification

As described above, access to basic, clean energy services is essential for sustainable development and poverty eradication, and can provide major benefits in the areas of economy, health, literacy and equity. As many people worldwide still lack access to modern energy, electrification of rural areas has been emphasised by governments in developing countries and the donor community among others during the last decades, both through extension of the national grid and through local solutions.

Different forms of evaluations of such electrification efforts have been made by several organisations[36]. In addition, the adoption of the Poverty Reduction Strategy Papers in many countries, along with the Millennium Development Goal (MDG), has led to an increased need for more systematic analysis of the poverty and social implications of reforms[37]. Despite this, one of the studies made by the World Bank, states that "in the field of development evaluation, there is a widespread concern that the utilisation rate of evaluations, even for methodologically sound evaluations, is very low". The World Bank points out that many reasons have been given for this low rate of evaluation utilisation, such as that "findings are not disseminated in a timely way to the potential users; or information not presented in a way which makes it easy to use".[38]

In addition, as can be illustrated by evaluations assigned by different organisations[39], base-line data is often missing. In one of the studies[40], the intention was to compare rural electrification of seven cases in Botswana, Ghana, and Lesotho. The evaluation was planned to be undertaken by comparison of two dimensions: before and after the implementation of the project. The study however found out that no baseline data where available, nor was the possibility to find such data at country level "fulfilled to any significant degree"[41]

The conclusion of the study of the evaluations listed above is that they contribute with important observations but are difficult to compare since they are not performed in a similar way. In addition, it seems as simple comparable measures of the effect of electrification are missing, a conclusion that is supported by Gaunt (2005) and Ugwu & Haupt (2007). One example is the way in where the share of population with access to electricity is presented. Of what size are the audited areas of concern? Are the presented figures including also those with individual arrangements, such as separate diesel generator sets, solar PVs, etc? The figures are not transparently presented and therefore difficult to compare. In addition, the effects on sustainable development of leaving the responsibility for rural electrification to new actors have not been evaluated.

An extensive evaluation of rural electrification was performed by NRECA in 2002[42]; where close to 4 000 interviews were made. The broad objective of the study was to assess economic

[36] Kjellström et al. 1992, NORAD 1994, the World Bank 1996 (b) (c), 2003 (a) (b), 2005, Sida 2002
[37] World Bank 2003(b)
[38] World Bank 2005
[39] Sida 2002, and NRECA 2002
[40] Assigned by Sida 2002
[41] Sida 2002
[42] NRECA 2002

and social impacts of a Rural Electrification Program in Bangladesh. The evaluation resulted in a substantial amount of data collected. No detailed description have however been given on the underlying definitions and methods to compile the collected material.

As indicated above, a number of evaluations have also been made under the umbrella of the World Bank Group (WBG). In 1996, a study evaluated the reasons behind why the power projects of the World Bank were less successful in Sub-Saharan Africa than in other regions. The study evaluated the performance of 41 power projects completed from 1978 to 1993, which showed that the institutional development and policy reforms, were inferior the situation in other regions, as well as low operational efficiency and failure to recover costs.

The evaluation from 1996 was followed by an extensive review of the World Bank Group's Experience with Private Participation in the Electricity Sector, published in 2003[43]. The review evaluated the performance of the WBG activities in all regions, during the 1990s in promoting private sector development in the electric power sector (PSDE). In general, the study recommended that the WBG continue to systematically pursue PSDE, as more than 50 percent of projects evaluated was concluded to "have a good outcome", compared to the objectives of the projects. The study also emphasised the importance of monitoring and evaluation of impacts. The study concluded that there "is no universal blueprint for PSDE; rather, there is a continually evolving menu of options whose validity depends on country-specific objectives and conditions. Good project level outcomes are a necessary condition for good sector-level outcomes, but this is achievable only with strong government commitment to country-sector reform objectives. To achieve these reforms was pointed out to be difficult in most of the WBG's client countries".

In 2005, The World Banks Operations Evaluation Department (OED) presented a report with the intention to illustrate the potential benefits from evaluations. The report includes eight case studies where evaluations were found to be highly cost-effective and of considerable practical use for the intended users. Although the report did not include any case of rural electrification, it shows that well-designed evaluations, conducted at the right time and developed in close consultation with intended users, can be a highly cost-effective way to improve the performance of development interventions.

In 2007, a study supported by the World Bank and African Union among others, was presented. The study was based on a pooled database that draws upon the entire body of household surveys conducted in Africa in the last fifteen years. The difficulties to compare various surveys as discussed above, is also pointed our by the authors of this study. In particular, the infrastructure categories used and expenditure surveys varied widely[44].

3.2. Indicators as Means for Evaluation and Assessment

Analysis and communication of changes and trends by means of indicators have become commonly used by different organisations. One main reason is that reports often tend to be bulky and consist of extensive statistical information, which have in many cases been difficult for decision-makers to interpret. To compile this extensive information by means of indicators – which present data in a comprehensive form and at the same time display an appraisal message, has therefore been an important task.

The recognition of the role that indicators can play was made earlier by the 1992 Earth Summit. This recognition is articulated in Chapter 40 of Agenda 21, which calls on all institutions and organisations to develop and identify indicators of sustainable development

[43] World Bank 2003(b)
[44] World Bank 2007(a)

that can provide a solid basis for decision-making at all levels.[45] The need of indicators as well as proper monitoring and evaluation has also been emphasised by OECD[46], where it is stated that "strategies should be based on structured indicator systems to assist in monitoring progress and to serve as quantitative targets".

The response from the international community has been large, and has resulted in the development of a number of indicators on sustainable development. A selection of the most significant work is given below.

3.2.1. Guidelines and Methodology, Developed by the UN Commission on Sustainable Development

The UN Commission on Sustainable Development performed an extensive work on development of guidelines and methodologies on sustainability indicators, during 1995-2001. The work was a direct response on the call articulated in Chapter 40 of Agenda 21. Moreover, Agenda 21 specifically called for the harmonisation of efforts to develop sustainable development indicators at the national, regional and global levels, including the incorporation of a suitable set of these indicators in common, regularly updated and widely accessible reports and databases[47].

The indicators presented by the UN (CSD-ISD) have been organised "*under the four primary dimensions of sustainable development: social, economic, environmental, and institutional"*[48], and the thematic framework, guidelines, methodology sheets and indicators set out are based on a conceptual approach widely used for environmental indicator development.

The methodology developed during 1995-2001 has further been reviewed and assessed by an expert group.[49] The revision was made as to assess proposals to revise the previous developed CSD-ISD made by international agencies and organisations, and to assess the coherence between CSD-ISD and the Millennium Development Goal (MDG) indicators.

3.2.2. Energy Indicators Developed by the IAEA

In addition to the indicators developed by the UN, a specific emphasis has been put on energy indicators. The work has been performed by the International Atomic Energy Agency (IAEA) in cooperation with the United Nations Department of Economic and Social Affairs, the International Energy Agency, Eurostat, and the European Environment Agency (*Energy Indicators for Sustainable Development: Guidelines and Methodology* 2005)[50]. The aim of the work was to select, define, and validate an appropriate set of energy-related indicators consonant with the larger effort on Indicators of Sustainable Development developed by the Member States of the UN, as presented above.

The central characteristic of the CSD-ISD indicators, and the energy specific indicators developed by IAEA, is their national focus, whereas the MDG indicators are primarily used for global monitoring of the internationally agreed Millennium Development Goals.

[45] UN 2005
[46] OECD 2006
[47] UN 2001
[48] UN 2001
[49] UN 2005
[50] IAEA 2005

3.2.3. Guidelines, Toolkits, and Performance Indicators Developed under the Umbrella of the World Bank Group

Under the umbrella of The World Bank Group (WBG), different forms of guidelines have been developed. In 1995, indicators of relevance for the micro-level (field-level), was developed and categorised on sector-level, implementing entity-level, and project-level[51]. The work to develop performance indicators was initiated by the Wapenhans Report "*Effective Implementation: Key to Development Impact*"- July 1992[52], which found that project ratings made by the World Bank were not providing adequate feedback on progress towards development impact. The reasons identified were:

- Too much emphasis was placed on the mechanics (physical and financial) of project implementation.
- The risks and factors that mostly influence project outcomes were poorly identified.
- Objective criteria, transparency, and consistency across units were lacking.
- Ratings tended to be overly optimistic.

As to improve the possibilities for proper monitoring and evaluation, the World Bank initiated the development of standard performance indicators to measure the effectiveness of project implementation, which place greater emphasis on performance to assess the quality of projects at entry, and subsequently to monitor implementation performance. The work has resulted in a large number of indicators ("notes") covering 16 sectors, including Power, Environment, Poverty Reduction, and Private Sector Development. The indicators are listed at an internet based page.[53]

The indicators/notes listed by the Word Bank are merely suggestions and statements such as "the performance indicators must be based on the unique objectives of individual projects".

In 2001, ESMAP[54], a joint programme by UNDP and The World Bank, presented a "Best Practice Manual" with the aim to review methods of decentralised electrification intervention and to provide a step-by-step approach for implementation of decentralised electrification (DE) projects. The manual provides a brief overview and summary of rural electrification options, and discusses the key factors necessary to create a conducive environment for the promotion of DE. This includes the legal, regulatory, and fiscal incentives, sustainable financing mechanisms, and necessary technical assistance to promote projects.
The document also provides a systematic guide for task managers implementing a DE project, including questionnaires, business plan forms etc. It also gives short examples from implemented projects in developing countries.

In 2003, the same programme (ESMAP), made a comprehensive attempt to develop a demand-oriented approach/methodology to monitor and evaluate rural electrification projects. The aim of the program was to develop a sound methodological approach for improving the design and effectiveness of rural electrification projects, with a specific focus on poverty and gender implications. In the evaluation approach, the use of both quantitative and qualitative techniques was advocated, and the need to begin the evaluation process already in the initial stage of the project preparation was stressed on as important. The report presented a large number of variables and key indicators. In addition, detailed descriptions were given on structure of questionnaires, and approaches for applying the participatory assessment tools. Based on the findings from the case studies included in the program, the most obvious conclusion was that a greater emphasis on monitoring and evaluation of socioeconomic

[51] World Bank 1996(a)
[52] World Bank 1992
[53] http://www.worldbank.org/html/opr/pmi/contents.html
[54] ESMAP 2003(b)

development impact is necessary. However, the program did not perform any evaluation of real cases of rural electrification. Nor did the report include any detailed description of the underlying context of each suggested indicator, such as its underlying definition and concept, its measurement method and limitation.

In 2005, the "Community Development Toolkit" was presented by ESMAP[55]. The toolkit was stated to be a "pioneering new approach in support of sustainable development in the extractive sector". The aim of the project was to develop new approaches and tools to support government, industry, and community efforts to realise more sustainable community development around mining and mineral processing operations. The Toolkit included 17 tools intended for use throughout the project cycle and which cover the assessment, planning, management, and evaluation phases of community development as well as stakeholder relationships. Examples of the tools suggested are; social baseline studies, community mapping, and development of indicators.

Lastly, guidelines have been developed recently (2007)[56] where the goal has been to promote the use of the modules in forthcoming living standards measurement studies (LSMS), and to monitor which questions work best in different country contexts. It has been anticipated that data sets from these enhanced LSMS survey modules can be used to formulate indicators that can be used in the energy sector as key decision-making tools. The developed guideline gives detailed suggestions on topics and specific questions to include in household questionnaires, and provides some information on selected indicators for countries in Latin America and Asia. The aim is to provide information on household energy uses that will give important insights into the role that energy services play in household welfare, and the policies that would be most effective in accelerating the household transition from traditional to modern fuels.

3.3. Indicators of Sustainable Development on a Micro-level

The literature review on evaluation and evaluation of rural electrification in particular, indicates a lack of documented field-experiences from developing countries[57]. In addition, it appears that simple comparable measures of the effect of electrification are missing.[58] As can be seen from the literature study presented above, several manuals, and toolkits etc. have been developed. However, the implementation of these on real cases seems to be limited.

Neither has the literature review carried out as a part of this study identified any previous study on the effects of the organisational form on sustainable development of rural electrification projects on field-level. This conclusion is also supported by other studies. For instance, a study performed by The World Bank/ESMAP concludes that "unfortunately, data sets on which to base evaluation of energy services' are in remarkably short supply".[59]

It appears as if specific research on rural electrification often has been focused either on technological issues or on environmental impacts.[60] Other areas for study have been the

[55] The project was jointly coordinated and managed by the World Bank Group's Oil, Gas, and Mining Policy Division and the International Council on Mining and Metals (ICMM). ESMAP 2005
[56] O'Sullivan & Barnes 2007
[57] Meadows 2003, Kozloff & Shobowale 1994, Ilskog 2005
[58] Gaunt 2005, Ugwe & Haupt 2007
[59] O'Sullivan & Barnes 2007
[60] See for instance Fraenkel. et al. 1991, Amelin & Hersoug 1997

household energy use[61], how households' access and use of energy are related to poverty[62], and the specific relation between household energy and gender issues.[63]

The review of literature on sustainability research indicates that most of the initiatives have been focused on macro-level definitions. "*The process of translating national strategic sustainability objectives into concrete action at micro (i.e. case-specific) levels remains a difficult task*".[64]

There are however sectors where a larger focus has been set on the development of indicators on micro-level, with one of these being the water sector. The literature on the use of indicators in this sector is substantial.[65] Water is increasingly seen as one of the most critically stressed resources in many countries worldwide. Much effort has therefore gone into the development of indicators of water problems. *"These have been critically reviewed and shown to be lacking as they fail to reflect the current agenda in water resources management nor do they direct data collection efforts. Effective water indicators need to focus on the structural impediments to the sustainable supply of water, so as to facilitate policy responses."*[66] The considerable research on water poverty indicators can contribute to the development of indicators in other sectors, although the indicators presented are sector-specific.

3.3.1. Indicators as Foundation of Index

The development of different types of index has been advocated by several researchers.[67] The argument is that an index links together the physical, economic, and social drivers, with the aim to target crosscutting issues in an integrated way.[68] It is also argued that an index would facilitate comparison of different alternatives along various dimensions of the sustainability envelope; economy, environment, resource utilisation, health, safety, and project administration.[69]

Examples of survey instruments and methodology used[70] is based on the assessments/ranking made by different stakeholders on the importance of a number of specified indicators, covering economy, environment, society, resource utilisation, health and safety, and project management/administration. The ranking data has further served as input in a mathematical model, which is an essential requirement to be able to perform a multi-criteria analysis that will result in a final index.

Others[71] suggest that well-known index, such as the Human Development Index (HDI) can be used in combination with different indicators, as to generate an integrated index.

However, critical assessments on the use of index can also bee seen. For instance, Feitelson & Chenoweth (2002) raise the issue that the aggregation of any such multi-dimensional index "*is always fraught with conceptual and practical problems. Using a collective expert judgement to determine the weightings of a multi-dimensional index results in an index that is subject to the value judgements and cultural biases of those who created it, while arbitrarily*

[61] ESMAP 2003 (a)
[62] Pachauri & Spreng 2003
[63] ESMAP 2004
[64] Ugwu & Haupt 2007
[65] Sullivan 2002
[66] Feitelson & Chenoweth 2002
[67] Sullivan 2002, Ugwu & Haupt 2007, Feitelson & Chenoweth 2002
[68] Sullivan 2002
[69] Ugwu & Haupt 2007
[70] Ugwu & Haupt 2007
[71] Olsson 1999

adopting an equal weighting for all components of an index is a de facto weighting itself that is no less problematic".

Aggregating indicators for generation of sustainability measures and combining these results in a sustainability index, clearly involves serious methodological difficulties. This is further discussed in Chapter 6 of this thesis.

Hence, the work of the different organisations described above, have served as valuable input into the study presented in this thesis, in particular considering the selection of sustainability dimensions (themes), and structure of the methodology sheets.

4. Field Studies and Results

The following chapter consists of a summary of results from field studies and literature research, each section based on issues addressed in the six papers appended to the thesis. In Section 4.1 experiences from an implemented electrification project in Tanzania is presented based on results from a number of socio-economic studies and technical follow-ups. The evaluation of the project in Tanzania is followed by a study on six organisations engaged in rural electrification in Zambia, Tanzania and Kenya (Section 4.2), based on SWOT-analysis as the evaluation tool. Section 4.3 presents findings from a study mainly based on literature research and interviews concerning opportunities and constraints of small-scale power investments in developing countries and experiences from Swedish actors on business opportunities in Africa related to small-scale power generation. In Section 4.4, some technological aspects on rural electrification are presented, again with the project in Tanzania serving as the case for the study. Section 4.5, presents a method for sustainability evaluation based on the use of 39 indicators. In the final section of this chapter, Section 4.6, the findings from field visits to seven rural electrification areas in Eastern and Southern Africa, and implementation of the evaluation method on these, are presented.

4.1. Experiences from 10 years of Electricity Services in Urambo, Tanzania

In Urambo District in northwest Tanzania, a pilot project on rural electrification based on a co-operative approach has been on going since 1993. Urambo Rural Electric Consumers Co-operative (UECCO) was formed and registered as the first power co-operative in Tanzania. The main purpose of the pilot project was to find out how much administrative, technical and financial support a new electrification co-operative will need in order to survive and develop in a sustainable way. During 1994 to 1997, researchers have made several visits to Urambo for monitoring the progress of the project. In 2002, a follow-up was made for evaluation of the performance of the co-operative.

4.1.1. Methods for Fact Collection

The method used for monitoring and evaluation during the years 1993-1997 has mainly been discussions with the co-operative Committee, the District Office in Urambo and Tanzania Electric Supply Company Ltd. (TANESCO). In addition, researchers from Tanzania and Sweden have conducted several socio-economic studies. More details of the progress during 1994-1997 can be found in a special report.[72]

In 2002, the follow-up of the pilot project was performed through open-ended interviews and information collected at meetings with the management of the co-operative, the District Office and TANESCO. Also interviews with electricity clients, based on a pre-prepared questionnaire where carried out. The interviews covered approximately 20 % of the total number of electricity connections in Urambo. 27 of the respondents were men and 8 were women. In addition, inspection of the distribution network, measurements of the load at three of the substations and performance tests of the power plant were made as well as reviews of the logbooks kept in the powerhouse and the consumer ledgers.

[72] Gullberg et al. 1999

The methods used for fact collection are further discussed in Chapter 6.

4.1.2. Findings from the pilot project in Urambo, Tanzania

Approximately 80 000 persons is living in Urambo District of which roughly 20 000 in Urambo town[73]. Agriculture is the dominating activity, and tobacco is an important cash crop[74]. The electricity is distributed to the members/clients through a local grid during 4-5 evening hours per day. The generation of the distributed electricity is made by two diesel generator sets with a working capacity of 193 kW. Fees for consumption are collected by UECCO-staff monthly. The consumption is either metered or paid on a flat rate basis.

The electricity clients are assumed to be among the most affluent citizens of Urambo. Of the clients interviewed, 1/3 was categorised as high-income, and almost 2/3 as middle-income. Only one client was classified as low-income in accordance with the definition of Tanzania Bureau of Statistics in 2000/2001[75].

Table 1 shows a selected number of indicators on the operating record of the power plant; the development of the load, the consumption of fuel, the development of the tariff, the development of the number of members/clients, the average amount of energy generated per client and the operation results of UECCO during different periods 1994-2002.

Table 1. The development of operation records of the power plant, electricity tariff, member/client numbers and economic results for the organisation in Urambo, 1994-2002. *(Observe that the presented periods vary for the different indicators.) (Source: various sources complemented with evaluations made by the follow-up team.)*

Period	Availa-bility [a] %	Average load [b] kW	Fuel use [b] litres/kWh	Diesel Price [c] TAS/litre	Energy Charge in Urambo [c] TAS/kWh	Number of active clients [d]	Client monthly use [e] kWh	UECCO Period balance [f] 1000 TAS
1994	80.7	-	-	-	-	67	110	-1 831
1995	87.5	64.4	0.38	300	200	66	53	- 2 514
1996	96.2	36.8	0.38	328	260	99	41	+ 601
1997	94.5	36.2	0.45	425	350	101	45	+ 166
2001	97.5	-	-	-	-	193	32	-
2002	97.0	66.3	0.34*	650	450	241	35	+ 3 379

[a] 1994 July-Nov, 1995 Jan-Dec, 1996 Jan-Dec, 1997 Jan-June, 2001 Nov-Dec, 2002 Jan-Oct.
Records for the period 1998-2000 are not available.

[b] 1995 Jan-June, 1996 Jan-June, 1997 Jan-June, 2002 Jan-June.

* Incomplete data for January 2002.

[c] 1995 Oct., 1996 Sept., 1997 July, 2002 Oct.

[d] 1994 Dec., 1995 Dec., 1996 Dec., 1997 June, 2001 Oct., 2002 Oct.

[e] Monthly average value per client. 1994 Dec., 1995 Dec., 1996 Dec., 1997 June, 2001 Oct., 2002 Oct.

[f] 1994 July-Dec, 1995 Jan-Dec, 1996 Jan-Dec, 1997 Jan-June, 2002 Jan-Dec.

As can be seen from the table, the availability of the plant has increased considerably since the start in 1994, from 80.7 % to 97.0 % in 2002. The average system load has dropped despite an increasing number of clients. This is a result of a more than three-fold decrease in average monthly electricity consumption, which has dropped from 110 kWh to 35 kWh per month during 1994 to 2002. This has occurred in three steps, the first when a system of flat rates were abandoned and the consumption was charged on basis of actual consumption, the second as a consequence of a tariff increase in 1996 and the third as a result of an increase of

[73] Assessments made by the Urambo District Council (Urambo District 2001)
[74] Gullberg et al. 1999
[75] National Bureau of Statistics, Tanzania 2002(a)

the tariff in 2001. In 2002, the system load was back to approximately the same level as in 1994, however with more than 3.5 times as many electricity clients.

The specific fuel consumption of the generator sets has decreased to 0.34 litres/kWh in 2002, which is well below the range 0.43-0.72 litres/kWh observed for TANESCO high-speed diesel power plants[76].

The operating costs for electricity generation are composed of fuels costs, costs for lubricants, maintenance costs and staff salaries. In Urambo, the fuel costs dominate and were in 2002 responsible for 80 % of the operating costs. In 2002, the un-paid electricity was 37 %, which likely can be explained by an over-consumption by remaining flat-rate clients and a relatively high amount of technical losses.

Payments for sold electricity are the main cash flow into the co-operative. As can be seen from the table, the capital balance of the organisation has improved since 1994. Experiences from the project however show that the cash flow is not sufficient to bring financial sustainability to the project, i.e. to make adequate savings for coming re-investments. Financial support from The Swedish International Development Cooperation Agency (Sida) and TANESCO has been necessary for investments in and renovation of the generator sets. In addition, TANESCO has been given technical support and training to the co-operative.

In addition, the observations made in 2002 during the inspection of the distribution network, show that the funds set aside for maintenance are not sufficient. When the distribution system was inspected, it showed signs of maintenance shortcomings. Some transformers had oversized fuses, and the conductors used in the system were undersized in a few areas. As the distribution system was gradually becoming overloaded, this also was most likely contributing to the increase in technical losses, described above.

As shown in Table 1, the energy charges in Urambo has increased with more than 200 % since the start in 1994. In 2002, the price per unit amounted to 450 TAS, which was more than 15 times higher than the tariff charged by TANESCO on households[77]. Converted into USD, the energy charge in Urambo in 2002 was 0.47 USD/kWh and the tariff charged by TANESCO was 0.030 USD/kWh.

The electricity clients in Urambo can be divided into four categories: institutions (police, bank etc.), public (churches and mosques), businesses (bars, guest houses, hotels) and households. In 2002 there where also 15 bulbs in use for street lighting. Electricity is predominately used for lighting and household appliances. In 2002, 70 % of the electricity consumed by the clients was used in households. This can be compared with the figures from 1997, when 46 % of the electricity was consumed in households. Most households use one lighting point in every room. It appears that the reduced average use of electricity, a result of the changed and increased tariff system as discussed above, to a large extent has been achieved by disconnection of lights with lower priority and un-utilisation of fans and electric irons. A finding from the survey made in 2002 was that 20 % of the connected households where lacking electric lights in the kitchen.

All of the men interviewed in Urambo stated that women and children benefit most from the electricity in the household. The women on the other hand stated that the children benefit most, whereas men and women equally benefit from electricity. The female respondents were however few in number.

In 2002, slightly more than 80 % if the interviewed clients spent up to 30 % of their income on energy (electricity for lighting and power, kerosene and batteries for lighting, cooking and power, and charcoal and firewood for cooking). The remaining 15-20 % used a higher share of their income on energy.

[76] Kjellström et al. 1992

[77] TANESCO pan-territorial rate for the first 100 kWh consumed per month

A further comparison of the figures of electricity consumption in different categories shows that businesses have lost in relative importance, from 44 % in 1997 to 15 % in 2002.[78] Shown in direct numbers, businesses have decreased from 28 in 1997 to 16 in 2002. The average electricity consumption among businesses was almost three times as high as in households (approximately 100 kWh/month compared to 35 kWh in households). Of the electricity clients interviewed, 22 % claims that the present electricity services have raised business and economic opportunities in the village. Guesthouses, bars and shops have extended their hours of business and other businesses such as hair salon; video-rooms and groceries (selling of cold drinks) have started afresh. Close to 15 % of the interviewed clients also said that they have started income-generating activities after they have been connected to electricity. The proportion of additional income-generating activities performed in households is however unknown.

More than half of the clients interviewed (54 %) claim that they are considering to start income-generating activities if Urambo will be provided with 24 hours electricity, with a tariff at the same level as the subsidised tariff of TANESCO. Activities planned for are presented in Figure 2.

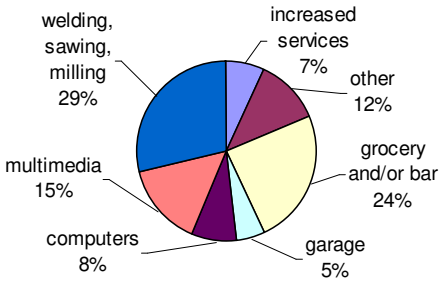

Figure 2. Plans for new or expanding businesses with 24 hours electricity services in accordance with TANESCO tariff (*Source: summary of 38 answers from surveys made by TANESCO/Ministry of Energy and Minerals (MEM)/Luleå University of Technology (Paper I) and University of Dar es Salaam in 2002).*

The results from Urambo show that a village organisation in Tanzania can manage its own electricity supply system if it is given adequate technical, management and financial support. The example also shows that it is possible to find a fraction of the population that has the ability and willingness to pay a relatively high price for electricity. As per 2002, approximately 10 % of the households in Urambo Township are electrified by the co-operative. The co-operative management has however had difficulties fulfilling important formal requirements of the by-laws for the co-operative, like preparation of audited annual reports and arranging annual meetings. In addition, some of the practices in the co-operative have not been entirely transparent. The main weakness in the performance of the co-operative is its inability to increase tariffs at the same rate as fuel prices increase and to set a tariff that allows an adequate budget for maintenance and re-investment. In addition, the use of un-metered flat rate as a tariff system should have been avoided.

The result from the study is further discussed in Chapter 5. In addition, the main findings of the visits and follow-ups to Urambo are presented in Paper I appended to this thesis.

[78] Many Micro Enterprises and Small and Medium Enterprises (SMEs) are however operating in households, making it difficult to make a clear distinction between businesses and households.

4.2. Experiences from Different Rural Electricity Organisations

An analysis or an evaluation of an implemented project can be performed in many ways mainly depending on the purpose of the analysis. The previous section (Section 4.1) contained results from a detailed follow-up of a project. In this section, the result of the application of another analysis tool on rural electrification projects is presented. The analysis has been applied on five organisations engaged in electricity services in rural areas in Africa, with the purpose of getting a better insight in the prevailing situation of these organisations. The analysis is presented in Paper II, appended to this thesis.

In addition to the analysis presented in the paper, this section has been supplemented with initial findings from a rural electrification project in Kenya. These findings are presented at the end of this section (4.2.3).

4.2.1. SWOT-analysis

The method used for the analysis is a simple form of SWOT-analysis. The SWOT-analysis can be described as the examination of an organisation's:

- ***Strengths*** and ***Weaknesses***, which are internal factors directly related to the business and under the control of the organisation.
- ***Opportunities*** and ***Threats***, created by external conditions related to the organisations environment and which the organisation itself cannot control. These conditions however, are important for the organisation to be aware of.

SWOT-analysis is a general tool designed to be used in preliminary stages of decision-making and as a precursor to strategic planning in various kinds of applications[79]. When correctly applied, it is possible for an electricity service organisation to get an overall picture of its present situation in relation to the community where it serves, its potential clients etc.

To be able to quantitatively compare the strengths, weaknesses, opportunities and threats among the organisations, a weighting process has also been conducted. In the process, the parameters have been valued on a scale from 1-5, where 5 being either a considerable strength or a considerable weakness, etc. The results have been plotted in diagrams. It has to be observed however, that the process of utilising weighing of the parameters is a subjective process where qualitative observations are transferred to quantitative data.

A further discussion of the strengths and weaknesses of SWOT-analysis is given in Chapter 6.

4.2.2. Findings from Case Studies in Zambia and Tanzania

The method of the SWOT-analysis has been utilised in discussions with five organisations engaged in electricity services in rural areas of Zambia and Tanzania. The fieldwork has been conducted in Tanzania (Urambo) in November-December 2002, in Zambia (Nyimba, Chipata and Lundazi) in May 2003 and in Tanzania (Liwale) in August 2003. The analysis presented in Paper II is based partly on information collected during these discussions, and partly on the author's own conclusions.

[79] Johnson et al. 1989, Bartol et al. 1991

The five organisations included in the study represent the private sector through three PV Energy Service Companies[80], the government through one local grid branch[81] and finally a community organisation through an electric co-operative[82] (Table 2).

Table 2. Organisations included in the study. *(Source: information from the included organisations).*

Type of organisation	Technology used	Number of clients *(May 2003)*
Local branch of government owned utility	Local grid supplied by diesel generator set	430
Private Company (Ltd.)	Solar PV	150
Private Company (Ltd.)	Solar PV	150
Private Company (Ltd.)	Solar PV	100
Co-operative	Local grid supplied by diesel generator set	240

The result for each organisation has been compared with the results for the other organisations with the aim to identify similarities and disparities between them. Below (Figure 3) is a presentation of the result from a perspective of finding similarities between the organisations. As can be seen from the figure, a majority of the organisations included in the study (3 out of 5) points out their staff and management as internal strengths of their organisations, whereas macro-economical issues were identified as major threats. All five organisations bring up rising exchange rate and a high inflation rate as threats to their businesses.

The information collected from the five organisations have also been scrutinised from the perspective of detecting strengths, weaknesses, opportunities and threats solely raised by each type of organisation (government, private and co-operative).

The quantitative comparison of the organisations strengths and weaknesses is given in Figure 4. In the figure, the strengths of the organisations have been plotted on the x-axis and the weaknesses on the y-axis. This implies that a high number on the x-axis is a considerable strength, whereas a high number on both the x-axis and the y-axis is a considerable strength as well as a considerable weakness. One such example is that the potential clients see electricity as a good product, which means that only limited marketing is needed, at the same time as electricity is regarded as too expensive by most rural poor.

As can be seen in the figure, it is interesting to note that client-relation issues appear to be the best-off issues. This group embraces strengths such as familiarity to the local area and a good client base. The economic issues brought up, appear to be the greatest problems for all organisations included in the study. The issues of economics cover weaknesses such as the non-existence of funds for re-investments and audited income statements. The issue of infrastructure and logistics gives the most dispersed result among the organisations included. For two of the organisations the geographically dispersed client stock and inadequate staff transport is assessed as strong weaknesses, whereas well functioning offices and Internet facilities are considered as strengths for two of the other organisations.

The discussion and conclusions drawn from the analysis are presented in Chapter 5 and 7. The main findings are further summarised in Paper II appended to this thesis.

[80] The SWOT-analysis with representatives from the private organisations where performed through workshops with each organisation.

[81] The analysis was performed with the local branch management team, complemented with issues raised by a research team at the utility head office.

[82] The SWOT-analysis for the co-operative has been carried out by the authors, based on discussions with the management committee of the co-operative as well as on results from a questionnaire performed on a random sample of the electricity clients/members of the co-operative.

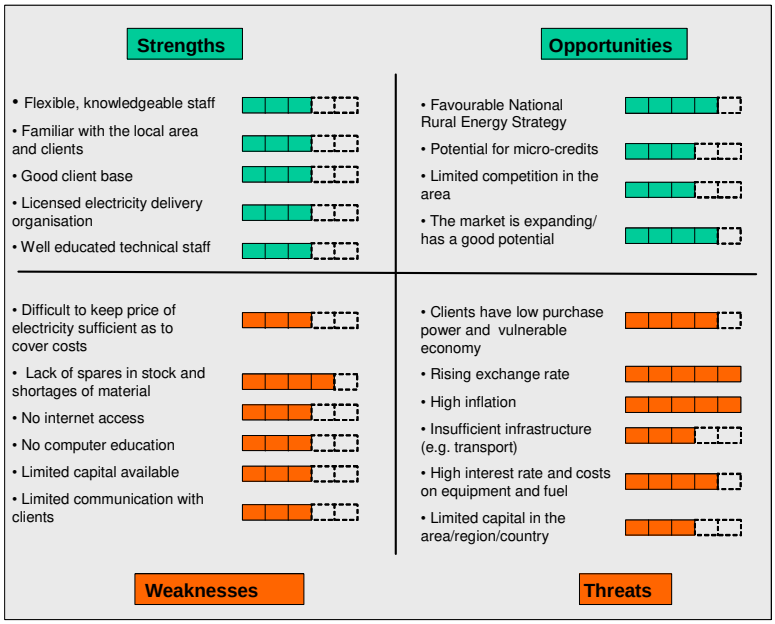

Figure 3. Strengths, Weaknesses, Opportunities and Threats considered by the majority of the five electricity service organisations included in the study. *(Number of organisations to consider the issues are indicated by the bars.)* (*Source: information from ESCOs in Zambia, TANESCO in Tanzania and UECCO in Tanzania.)*

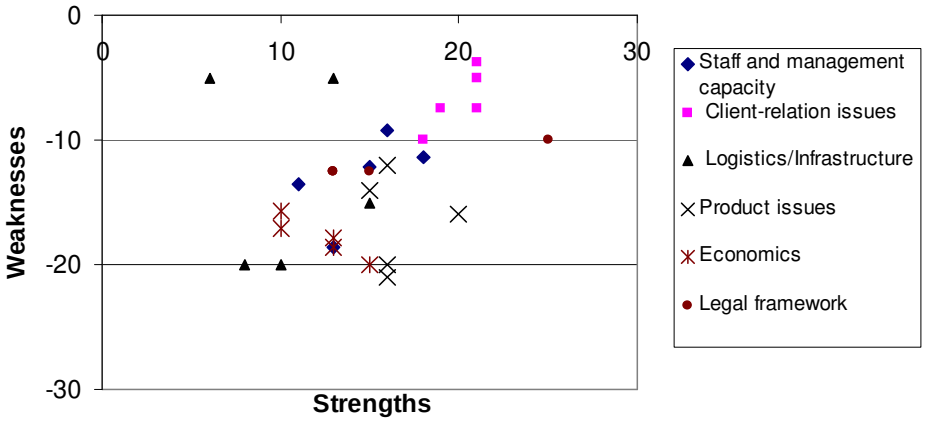

Figure 4. Strengths and Weaknesses for the studied organisations in Tanzania and Zambia (based on an analysis where issues brought up have been weighted dependent upon their assessed importance). (*Source: information from ESCOs in Zambia, TANESCO in Tanzania and UECCO in Tanzania.)*

4.2.3. Findings from a Case Study in Kenya

In addition to the findings from the case studies in Zambia and Tanzania presented above, an analysis of a project in Kenya has been made. The analysis is based on a fieldwork conducted in Tungu-Kabiri in Kenya in October 2003, where information was collected from discussions with the leadership of the community corporation and the project leader from the Intermediate Technology Development Group, East Africa (ITDG-EA).

In Tungu-Kabiri a micro-hydro project has been on-going since 1998, with the first electricity being produced in June 2001. The project has been initiated by ITDG, and is based on a concept with a business centre. In the centre, premises to let to business enterprises or public services have been established. The power to the centre is supplied during the day from 8.00 am to 4.00 pm. In 2003, power was used in eight separate stalls for a hair saloon, a barbershop, charging of mobile phones, selling of cold beverages, a video show room, and for welding. The tariff was based on flat rate, meaning that all clients paid the same monthly amount. No electricity was in 2003 supplied to the surrounding households. However, this was a planned development. Another planned development of the scheme was water pumping, which was specifically advocated by the women in the community. The reason why these plans had not yet been implemented was mainly due to lack of capital.

Financing of the scheme has been made through UNDP/GEF and ITDG and implementation jointly through the Ministry of Energy, ITDG and the community. The community contributed labour to the project estimated at 30 % of total costs.

The intention is that the project will be handed over to a community group formed as a corporation, which will own, operate and manage the scheme. In 2003, the community group had a leadership composed of 15 persons, of which 6 were women and 9 were men. The total number of members was initially approximately 200, but had in 2003 decreased to 150.

From the initial findings in Kenya, it appears as many of the strengths, weaknesses, opportunities and threats found in the other organisations presented above, are also valid for the project in Tungu-Kabiri. On the positive side is that the client base is good and an expanding market can be expected. There is also a new National Energy Policy in progress that will be favourable for the project. On the negative side are the difficulties to keep price of electricity sufficient as to cover costs, a low purchase power at the present market, and limited operational skills among staff. Also for this project, high and unpredictable inflation, low value of local currency in relation to USD, poor infrastructure and difficulties in obtaining proper spare parts, are external threats.

Additional findings show that although the community has been involved in the construction of the micro-hydro power plant it appears as the management is not aware of the need to keep revenues high enough to cover costs for operation of the plant. One indication of this is the system with a low flat rate tariff.

No ranking of the findings from the project in Tungu-Kabiri has been done.

4.3. Opportunities and Constraints of Investing in Developing Countries

As discussed in Chapter 2 of this thesis, different forms of power sector reforms are currently on-going or have been initiated in many developing countries, most power sector reforms consisting of deregulation and privatisation. This means that future electrification projects will not necessarily be implemented by national utilities, and that new institutional arrangements will be used, opening up possibilities for new actors.

The establishment of Clean Development Mechanisms (CDM) under the Kyoto Protocol can further increase the interest for energy markets in developing countries. The Protocol is a result of the intensified worldwide activities on climate change and reduction of greenhouse gas emissions. The aim of the Clean Development Mechanism is to contribute to the reduction of greenhouse gas emissions, by enabling industrialised countries to meet some of their obligations beyond their own borders through implementation of projects generating greenhouse gas emissions reductions. Examples of projects can be development or rehabilitation of a hydro power plant or a wind power plant. In 2003, projects in developing countries constituted the majority of the carbon dioxide trade in the world[83]. In 2006 the market had grown rapidly, and was now dominated by the sale and re-sale of EU Allowances. Project-based activities through CDM and Joint Implementation (JI) had also grown, where China continued to have a dominant market-share of the CDM[84]. The African share of the overall carbon market volume increased to 1.4% in 2006, and 5.1% of the project-based market. The primary market for CDM credits increased to 5.7%. The numbers account for very small share of the global market and occur even though the overall investment climate across many African countries has improved over the past years.[85]

In many of the developing countries, large energy programmes are also present or planned for through support by the World Bank or other development organisations such as Sida.

The possibilities for Swedish and other European private sector actors to participate in the development of the energy markets in developing countries have been investigated and are presented below. The main findings of the analysis on energy markets are further summarised in Paper III appended to this thesis.

4.3.1. Methods for Fact Collection

The study has been based on literature research and open-ended interviews with actors from Sweden and from developing countries (Vietnam, Tanzania, Zambia and Kenya). Private companies, trade organisations as well as governmental organisations such as the Swedish Energy Agency and Sida represent the contacted actors.

4.3.2. Findings from the Study

The international energy market is constantly under transformation and development. The European market is still of outmost importance for a European actor, but competition among different companies is significant at the same time as the demand is only marginally

[83] CF (the World Bank) 2003
[84] World Bank 2007(b)
[85] World Bank 2006

increasing. The development of the markets in developing countries as discussed above opens up new possibilities for export activities or for the establishment of foreign business organisations in these countries. Taking Sweden as an example, there are sectors of particular export interest, such as technology for small- and large-scale power production which is built on many years development of knowledge and experience bringing out effective equipment[86].

Actors interested in export or establishment of their businesses in foreign countries, will however be confronted with new unfamiliar obstacles when entering into new markets in developing countries. A thorough knowledge of the potential market is therefore necessary. Besides knowledge of technical and institutional conditions, knowledge of economic, and socio-economic requirements and opportunities are essential factors for the organisations adoption to the new markets. In addition, the business culture in many countries can make it difficult for new and foreign companies to be established. In addition, a majority of the companies' active in the small-scale renewable energy sector in Sweden and Europe are relatively small and with limited financing possibilities.

Continuing with Sweden as an example, the Swedish export market to Africa is today relatively small, although it has been growing in recent years. In 2003, less than 5 % of the Swedish export of goods and services reached the developing countries in Africa, the Middle East and South America[87], of which Africa represented only a minor part. However, in many countries in Africa the last decade has been characterised by an economic growth bringing out investments in infrastructure, such as telecommunication and electricity services. This has resulted in new investment incentives[88].

Still, major constraints for the development of the markets in many African countries remain. These can be summarised as; lack of technical standards for production of electricity and distribution on a regional level, the development of the industrial market in many African countries is slow and cooperation among donors and local actors not enough developed, resulting in investment in energy equipment but not in long-term services and maintenance after the end of the project. Other factors mentioned are that foreign investors are reluctant to invest in African markets, mainly as a result of uncertainty of the stability of the development of markets, level of taxes and lack of information in general.[89]

As an example, the implemented small-scale hydropower project in Tungu-Kabiri in Kenya can be used (see the presentation of the project in section 4.2.3). The common problems for many projects in developing countries emphasised above are valid also for this project, e.g. high inflation, poor infrastructure and difficulties in obtaining proper spare parts. This example from Kenya indicates the present constraints of an electricity market in Africa. These constraints have also been stressed in another study, were the difficulties to forecast changes in inflation and rates are pointed out as the major obstacles for investing in developing countries. Of the countries in Africa south of Sahara, South Africa is highlighted as the country with greatest investment potential, from where other countries in the SADC-region[90] can be reached in a second stage[91].

In order to be able to expand and compete on new markets, a thorough planning has been pointed out as necessary. An increased cooperation among actors in the Energy Sector – including private companies, trade organisations and governmental organisations, is of outmost importance. In addition, focus should be on areas where actors are able to compete with actors from other countries. Continuing with Sweden as an example, these areas are

[86] Miljöteknikdelegationen 2000
[87] Swedish Trade Council 2004
[88] DBSA et al. 2000
[89] DBSA et al. 2000
[90] Southern African Development Community (SADC)
[91] CSAE, CREFSA 2002

foremost; new technology, building of systems, and sustaining the quality of products and services. A potential development of the global energy market trade, highlighted by contacted Swedish actors, is schematically illustrated in
Figure 5. In the figure, the need of combination between comparative advantages in different countries is illustrated. Swedish and other European actors have advantages in know-how through many years of experience of building systems and quality assurance, whereas many Asian countries such as India, China and Vietnam has a reputation as good production sites, with well trained and relatively low-costing labour. The potential market is mainly found in developing countries, where also the possibility of Clean Development Mechanisms (CDM) in the future can play a substantial role for income generating.

In the case of capital, this can mainly be found in the European countries but also in some countries in Asia. China and India are such examples.

It is also important to consider different institutional forms when establishing a business in a new country, and joint venture has been pointed out by interviewed actors as a suitable form. It is also good to start on a small scale, to keep control and stay patience in order to keep initial risks low.

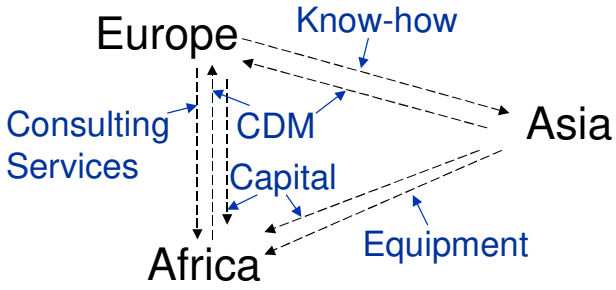

Figure 5. Schematic illustration of possible flow of services, investments and know-how between actors on different continents. (*Source: based on information from Swedish actors involved in businesses in developing countries.)*

In summary, the study presented in Paper III, has resulted in an identification of the following constraints for establishment of foreign actors in developing countries;

- Low prices of electricity,
- Imperfect infrastructure and incomplete standards,
- Immature markets and legal structures,
- High import duty and tax.

In addition, the following internal constraints have been identified for European companies to enter into new energy markets;

- Weak home market (the domestic market)
- Difficulties in finding financing for expansion of the business,
- Limited experience of export and to perform business in a foreign country,
- Insufficient and inadequate information of the foreign market,
- Difficulties in finding suitable partners in the countries of the planned establishment.

The result from the study is further discussed in Chapter 5.

4.4. Reduction of CO_2-emissions from Small Scale Rural Electrification

Electrification of remote sites in developing countries has often been realised through diesel generator sets and a local electric distribution network. The growing awareness of climate change caused by CO_2-emissions however calls for decreased fossil fuel combustion worldwide and different energy technologies are gradually being developed. For many developing countries, promotion of indigenous renewable energy sources is also essential, since import of fossil fuels represents a considerable fraction of the total import expenditures. Where hydropower of sufficient capacity and reliability is available not far from the community to be electrified, this is clearly an option to consider, but in most cases other solutions are needed. Solar photovoltaic generation is a commercially available option often advocated as the best alternative to diesel generation. Wind generators can be considered at sites with good wind conditions. Biomass can be used for steam power plants or engines operated on gasified biomass, where a sustainable supply of biomass fuel can be assured.

As mentioned in section 2.4, Sida´s policy is to promote energy systems based on renewable energy sources. Still, it is clearly stated in a later policy document[92] that Sida may support electrification projects based on fossil fuels provided that the systems are "*carefully designed in order to minimise negative environmental impacts"*. In Paper IV, the costs for different technical options for electricity supply to a rural community have been compared. The result of that study is assessed to be of interest in this context.

4.4.1. Methods for Fact Collection

The village of Urambo in Tanzania, described in section 4.1, was selected for a case study. Since most of the load in that village is for electric lights, the costs for providing a given light service using different technical solutions were compared. Three of the options were based on diesel generators and a local transmission and distribution network. These options differed with respect to the appliances used for the light service. Incandescent bulbs, tube lights and compact fluorescent lamps (CFLs) were considered. These options were compared to individual photovoltaic (PV) electricity generation in combination with tube lights. For the comparison between these options, the costs for power generation and distribution, including – for the diesel supplied cases - service line, house wiring and meters, have been based on those for new equipment. The costs are depending on factors such as expected lifetimes of various components, interest rates, import duties, taxes and local competition. In the calculations the following data were used; 100 % system load factor, 2 % real interest rate, annual maintenance and service costs of 20 % of fuel costs for the generator set and 2 % of investment costs for the distribution network and diesel costs as in Urambo, October 2002 (0.68 USD/litre). The service costs for the PV system were assumed to be negligible.

For the reason of technical and financial comparability, it is the connected lighting demand of the clients that is in focus. In order to prepare a base for comparison between the technologies, lighting demand has been expressed in average continuous light output in lumen during 4 – 5 hours each evening with a high load case (12,000 lumen) and a low load case (5,000 lumen). The low-load case represents Urambo in 2002. Further the environmental impacts associated with the different options were quantified with an emphasis on their emission of carbon dioxide (CO_2) to the atmosphere.

[92] Sida 2005(b)

4.4.2. Findings from the Study

In 2002, the annual cost for the average electricity client of Urambo Rural Electric Consumers Co-operative (UECCO), amounted to in the order of 225 USD. This includes cost for connection to the local service network, lighting equipment and energy at the cost of 0.47 USD/kWh[93]. The calculations are based on lighting almost equally shared between incandescent bulbs and straight fluorescent tubes. Only a small fraction of the lighting was constituted by CFLs at that time

Compared to incandescent bulbs, CFLs and tubes are more energy efficient. As regards CFLs in a system of Urambo's size and performance, the actual lifetime has not been tested on a significant scale. Therefore, 84 CFLs were installed in Urambo for testing purposes. The result from the test indicates that the lifetimes of CFLs are shorter than claimed by manufacturers. At 4000 hours the failure rate was 38 %. This however also includes failures in the lamp holder, which as it is designed for incandescent bulbs sometimes cannot hold the slightly heavier CFL. Based on the monitored failures[94] an estimation of the mean lifetime for CFLs in Urambo has been made, resulting in life times for both fluorescent tubes and CFLs being about 6000 hours.

Seen in the power supply perspective, the installation of CFLs or fluorescent tubes leads to a reduced power demand per required lumen, but also to increased distribution losses per delivered useful power compared to incandescent bulbs, as the luminous efficacy and cos φ differ.

In financially sound electricity supply systems the energy per unit cost will reflect the total system cost. In recognition of this, and with the low-load case, the calculations applied for the individual client, give that fluorescent tubes constitute the least cost lighting alternative in a power distribution system similar to that in Urambo where generating costs are 2.6 USD/kWh or lower. Above this cost, CFLs are less expensive. The results depend on the cost of generating electricity, the system load's reactive component and the equipment costs for lamp holders and lamps. Incandescent bulbs can compete first when generating costs are below 0.01 USD/kWh. Such low costs can perhaps be achieved in micro- or mini-hydro supplied distribution grids, if investments and labour costs are moderate at the establishment and load management is successful.

An alternative approach to a diesel supplied traditional system, would be to use solar PV-systems, installed at each client, that supply 12 or 24 V direct current to tube lights.

Table 3, based on the results presented in paper IV, shows a comparison of the main results of the study for the low load case, 5000 lm. With the assumptions given above, the clearly less expensive option is the traditional diesel system in combination with fluorescent tubes, with the CFL-option coming close behind. When applying a cost-sensitivity analysis on interest rate and utilisation degree, the situation remains the same for both the low load (5,000 lumen) and the high-load (12,000 lumen) case.

The most expensive option for the individual client would be the PV option for the low load case (5,000 lumen), whereas the traditional system with incandescent bulbs is the most expensive option for the high load case (12,000 lumen). It has to be observed however that facts on solar panel life lengths in Tanzania are scarce.

The diesel option impacts the environment significantly more than the PV option, even if there are impacts associated with manufacturing, delivery and mounting of the PV system. The main environmental burdens from the diesel option are emissions from combustion, emission from transport, and possibly fuel and lubricant oil leakage to soil.

[93] See Paper I (Section 4.1)
[94] Johnson 1994

In the table, the electricity client cost for the PV-system has been expressed also as cost for CO_2 reduction, showing that the PV-system allows for CO_2 reductions at the approximate price of 300 USD per ton CO_2 saved.

Table 3. Summary of evaluated technical options, costs and CO_2 emissions. *(Source: calculations made by the authors.)*

Technical solution for village electrification [a)]	**Annual full financial cost, USD per household** **b <c**	**Annual CO_2 emission, kg per capita**	**Cost for CO_2 reduction relative the present solution (USD/kg)**
Diesel generators in a traditional distribution system with a mix of devices for lighting as for the present situation in Urambo	**160**<300	64	
Diesel generators in a traditional distribution system, incandescent bulbs for lighting	**230** <430	101	-
Diesel generators in a traditional distribution system, fluorescent tubes for lighting	**80** <160	27	-0,25
Diesel generators in a traditional distribution system, CFLs with electronic ballast for lighting	**100** <190	25	-0,14
Individual PV-sets with fluorescent tubes	**260** <470	(0)	0,30

a) The comparison is based on lighting services equivalent to 5000 lm continuous light output during five hours per night.

b) Reference cost conditions: 15% tax on imported equipment, fuel tax (258%) for diesel, 2% interest rate and full utilisation of installed capacity.

c) High cost conditions: 15% tax on imported equipment, fuel tax (258%) for diesel, 15% interest rate, and in the diesel cases only 20% utilisation of installed capacity.

The result from the study is further discussed in Chapter 5.

4.5. Need for Systematic Evaluations

Despite the large number of rural electrification projects being implemented in developing countries, there are few published in-depth evaluations of the effects of these projects on sustainable development.

To obtain an impact from experiences of rural electrification, it is necessary to generate a critical mass of interest and support among host nation's policy makers, and the international donor society. Awareness of differences between the dimensions of electrification; and especially economic, socio-economic, and social objectives is important. Indeed, the focus on rural electrification where the objectives often claims to have a strong social emphasis, especially calls for this awareness.

Systematic use of an evaluation method, with clearly defined indicators could contribute to an improved basis for decisions regarding design and organisation of future rural electrification projects. Indicators have become commonly used by different organisations for analysis and communication of changes and trends, as a means to presents data in a comprehensive form. It is important that the indicators are transparent in the sense of underlying data being realistically traceable: robust in the sense of being replicable: comprehensive by covering the important dimensions of sustainable development and fair in the sense of gender, child labour, and social differences. An evaluation method is proposed based on this interdisciplinary approach, with the aim to throw light on the whole context of electrification.

4.5.1. Context and Framework of the Evaluation Method

For an evaluation method to be comprehensive, the major aspects of sustainable development have to be defined. However, the definition of sustainability and its application is still under debate, and the task of making the concept operational has been stated as difficult[95]. "*Like many basic ethical, political and legal ideas, sustainable development is a regulatory idea, which cannot be made more precise by a good definition, but can only be implemented by continuous discussions in any new situation*".

The concept of sustainable development is often discussed in terms of economic, social, and environmental sustainability, and in recent years also the organisational aspect has been included.[96] In the proposed method, sustainable development is discussed in five dimensions: technical, economic, social/ethics, environment, and organisation/institution. The fifth dimension has been included to put an additional focus on the technical dimension, as it has a direct influence on the sustainability of the local project. To further facilitate the interpretation of the context, key variables have been added, with the aim to bring the five sustainable dimensions down to a more legible level of relevance for electrification projects. The approach is illustrated in Figure 6.

For the five sustainability dimensions a number of indicators have been developed, with each indicator accounted for through a specific pre-structured "sheet". The method of utilising sheets for indicators is based on a format originally developed by the UN Commission on Sustainable Development – the CSD Work Programme, during 1995-2000[97], which has later been reviewed[98] , and developed[99] in cooperation with other international organisation. The

[95] Villavicencio 2002

[96] UN 2001, IAEA 2005

[97] UN 2001

[98] UN 2005

advantage of the pre-structured sheets is that the general criteria for the indicators, as described above, become readily obtained by all professionals. Every separate sheet accounts for the relevance of sustainable development attributed to the specific indicator. In addition, a detailed measurement method is described for each indicator.

The selection of indicators has been made through an iterative process, namely:

- From literature studies on indicators utilised by researchers and consultants;
- Through practical tests in the field where the indicators have been tested based on their suitability in a local context, and the possibility to procure necessary data and information.

The selection of indicators is further described in Chapter 6.

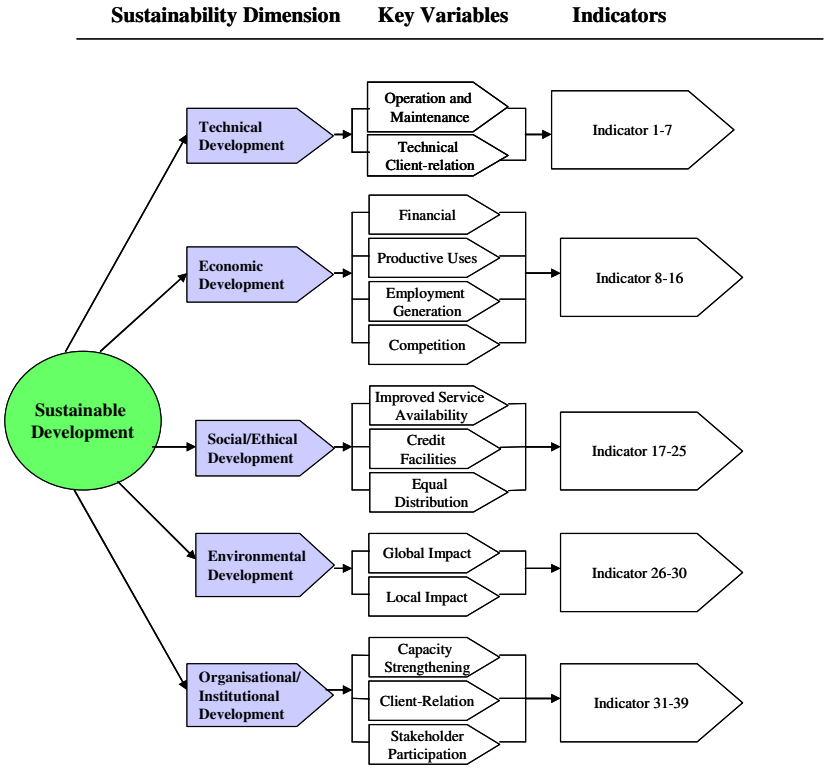

Figure 6. The sustainability criterion process of the evaluation method.

4.5.2. Indicators Included in the Assessment Method

The procedure has resulted in a number of 39 indicators. The number was originally higher, but has through the iterative process been reduced to the present number. In addition, the indicators have been re-valuated on basis of their suitability in accordance with the general criteria for indicators. A summary of the indicators included in the method is given in Table 4. A thorough definition of each indicator is given in Ilskog (2008)[100], appended to this thesis (Appendix VII).

[99] IAEA 2005
[100] Ilskog 2008

Table 4. *Indicators Selected for Assessment of Sustainable Development in Rural Electrification.*

Sustainability Dimension	Key Variable	Indicator	Linked Millennium Development Goal (MDG)
Technical Development:	**Operation and maintenance:**	• Efficiency • Conformance with national standards • Technical losses[1] • Compatibility with future grid service • Availability of support infrastructure	-
	Technical client-relation issues:	• Daily operation services	1
		• Availability of services	1,3
Economic Development:	**Financial perspective:**	• Profitability • Costs for operation and maintenance • Costs for capital and installation • Share of profit set aside for re-investment in electricity service business • Tariff lag	-
	Development of productive uses:	• Share of electricity consumed by businesses (F/M)[2]	1
		• Share of electrified households using electricity for income-generating activities (F/M)[2]	1
	Employment generation:	• Business development (F/M)[2]	1
	Competition:	• Number of electricity service organisations in the area	1
Social/Ethical Development:	**Improved availability of social electricity services:**	• Share of health centres and schools with electricity	2,5,6
		• Number of street lights in the area	3
		• Share of public places and specialised businesses where TV/telecommunication/internet is provided	-
	Credit facilities:	• Micro-credit possibilities available for electricity services connection	1
	Equal distribution:	• Share of population with primary school education (F/M)[2]	2
		• Share of population with access to electricity (F/M)[2]	2
		• Distribution of electricity client households in income groups (F/M)[2]	-
		• Subsidies offered for electricity services	1
		• Share of economically active children (F/M)[2]	2
Environmental Development:	**Global impact:**	• Share of renewable energy in production	7
		• Emissions of carbon dioxide from production[3]	7
	Local impact:	• Share of electrified households where electricity has replaced other energy sources for lighting[4] (F/M)[2]	2,3
		• Share of electrified households where electricity has replaced other energy sources for cooking of main meals[5] (F/M)[2]	2,3,4
		• Any serious local environment impact identified	7

Sustainability Dimension	Key Variable	Indicator	Linked Millennium Development Goal (MDG)
Organisational/Institutional Development:	**Capacity strengthening:**	• Share of staff and management with appropriate education (F/M)[2]	-
		• Degree of local ownership	-
		• Number of shareholders (F/M)[2]	-
		• Share of women in staff and management	3
		• Staff turnover in organisation (F/M)[2]	-
		• Number of years in business	-
	Client-relation:	• Share of non-technical losses/Default rate[6] (F/M)[2]	-
		• Level of satisfaction with energy services	
	Stakeholder participation:	• Auditing of financial reports on yearly basis	-

1: Constituted by distribution losses, over-consumption by clients (flat-rate), and thefts. *In other documents the expression "un-paid electricity generation" can be seen.*
2 : To the indicator can be added an indicator distinguishing between female- (F) and male-headed (M) households/businesses. 3: Calculated on input energy. 4 : Mainly kerosene and candles. 5 : Mainly charcoal and firewood. 6 : Constituted by losses through non-paying clients. *In other documents the expression "un-paid electricity generation" can be seen.*

The implementation of the proposed method is recommended to be based on utilisation of pre-structured questionnaires: inspections and measurements of technical components: review of client databases, logbooks and financial reports. However, research on rural electrification is a matter of putting together the perspective of not only electrification itself, but also the impact it has on the development of a community. The fieldwork in the selected project areas is therefore of outmost importance, and shall be designed using both quantitative and qualitative methods. Still, even if using an in advance planned and carefully structured questionnaire, it is important to take into consideration that the data collected is effected by both the interviewees and the interviewers: in the way the questions are put forward, any individual biases, age, sex, level of education, religion etc. The methodology is further discussed in Chapter 6.

It is also important to realise that no method applied can fully cover the complex reality of a project context, and it cannot be more than a tool to be used as a basis for analysis and decisions. The method therefore needs to be complemented by specific project indicators, as well as the use of other tools for analysis. One such example is the SWOT-analysis presented in section 4.2.

The result from the study is discussed in Chapter 5.

4.6. Assessment of Rural Electrification Cases

The evaluation method proposed in section 4.5, has been implemented on seven electricity service organisations operating in Tanzania, Kenya, and Zambia. The organisations represent the private sector through three PV Energy Service Companies, and the government through a small isolated local grid branch and a larger utility connected to a national grid. In addition, the study includes a co-operative and a Community Based Organisation (CBO). Figures of the organisations are presented in Table 5.

4.6.1. Methods for Fact Collection

The evaluation of the electricity service organisations are based on interviews with management, staff, and case facilitators; surveys with electricity clients; inspections of physical assets; and reviews of available written documentation for each case included in the study. The written documentation covers mainly inspection of production units, distribution networks and substations, operational data in logbooks, client databases, and financial reports.

Approximately 800 stakeholders were interviewed. The surveys covered women and men, households, businesses and institutions. Teams of 2-7 fieldworkers that included both women and men, trained to fill in the questionnaires, collected the data. All were knowledgeable in the local languages and had at least secondary school education.

Table 5. Organisations included in the study. *(Source: information from the included organisations and Statistical Bureaus in the countries included).*

Type of organisation	Technology used	Number of clients	Total population within concession area	Price for Electricity Services (USD/kWh)
Larger Government Organisation/Utility *(Government L)*	Main national grid supplied mainly by hydro power. The organisation also has a smaller local grid supplied by diesel generator sets	59 000 *(year 2004)*	985 000[1]	0.03 - 0.11[2] (average: 0.07)
Smaller local branch of government owned utility *(Government S)*	Local grid supplied by diesel generator sets	430 *(year 2003)*	75 000[3]	0.03 - 0.11[2] (average: 0.07)
Co-operative *(Co-operative)*	Local grid supplied by diesel generator sets	240 *(year 2002)*	82 000[4]	0.47
Community Based Organisation *(CBO)*	Small hydro power	8 (Business Centre) *(year 2003)*	NDA	0.006
Private Company (Ltd.) *(Private A)*	Solar PV located at each clients premises	100 (Solar Home Systems, SHS) *(year 2003)*	70 000[5]	1.6
Private Company (Ltd.) *(Private B)*	Solar PV located at each clients premises	150 (Solar Home Systems, SHS) *(year 2003)*	365 000[5]	2.1
Private Company (Ltd.) *(Private C)*	Solar PV located at each clients premises	150 (Solar Home Systems, SHS) *(year 2003)*	235 000[5]	1.6

Source: [1]: "*Tanzania 2002 population and housing census*", National Bureau of Statistics Tanzania, 2002(b). [2]: The lowest tariff is applied for low-consuming households only. [3]: "*Household Budget Survey 2000/01*". National Bureau of Statistics Tanzania, 2002(a). [4]: "*Taarifa ya wilaya ya Urambo*", Urambo District 2001. NDA: No Data Available. [5]: "*Zambia 2000 Census Report*", National Bureau of Statistics Zambia, 2003.

A ranking system was used for comparisons between the seven cases. For each indicator, scores from 1 to 7 were given to each case, where the case with the best performance was given the highest score and that with the lowest performance the lowest score. If several cases showed the same performance, the score was divided among them.

The total score for each sustainability dimension was then calculated by simple averaging of the scores for the relevant indicators, which means that the indicators were given equal weights.

4.6.2. Findings from the evaluation of the seven cases

The number of indicators proposed in Section 4.5 is 39, out of which eight were formulated after the fieldwork had been completed. The case studies have therefore included determination of 31 of the proposed indicators.

Figure 7 shows the total scores attained by the seven cases for the five sustainability dimensions. It is not possible to draw general conclusions regarding the effect on the sustainability of rural electrification from the result of this study. The cases included in the study are few, and the performance is partly a result of conditions imposed by the external financing organisations.

However, the implementation of the evaluation has generated valuable experiences and the proposed indicators give a good picture of the situation in rural electrification. The main strength of the three private electrification enterprises is their ability to manage client-relation issues whereas their main weakness concerns the social sustainability perspective, and that they are owned by only one person/family. For the national utilities their main advantage is in the social/ethical sustainability dimension, with the highest share of population with access to electricity. The main weakness of the utilities concerns the organisational dimension. For the two Community Based Organisations the main strengths and weaknesses are found in the organisational/institutional sustainability, with a specific weak issue being their inability to raise the tariff, as this decision has to be supported by the majority of members, which are also the electricity clients themselves. Rural electrification through small private and local community based organisations can be applied when this appears as the most effective way to achieve sustainable development. Special attention must then be given to the organisational/institutional sustainability so that for instance loss of key persons does not lead to collapse of the service.

Lastly, it is an important observation that all the organisations rely on external financial support to some extent, and especially on financing of the initial investment; none of the organisations is able to accumulate capital for reinvestment. This opens possibilities for external influence that could be used to promote sustainable development.

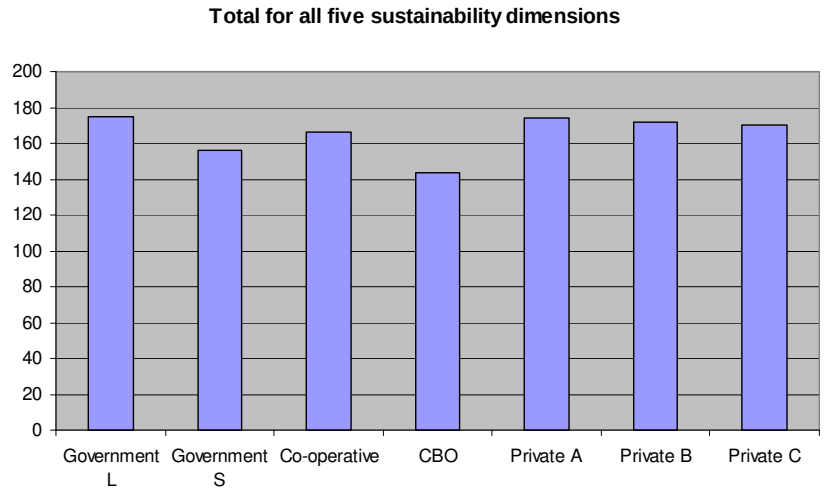

Figure 7. Total scores reached by the organisations for all dimensions. The indicators have been summarised per case through comparative ranking and given equal weights. For the calculation of total scores, all dimensions have been given the same weight.

It is believed that the information included in the indicators give a reasonably good picture of the situation. However, sustainability is a matter of development over time. Data from a single evaluation are therefore not sufficient for assessment of sustainability, even if the data can certainly be used for identification of areas where improvements will be necessary.

The choice of units was found to be a difficult issue for some of the indicators. Percentages are a reasonable choice for several of the indicators, but in particular for some of the economic indicators it was found that absolute values give a better understanding of the performance. When these indicators are expressed in percentages, the result depends on the reference value used. Large absolute differences may be hidden by this and small absolute differences exaggerated. Regardless of how indicators are measured and aggregated, important information about differences between cases evaluated may be lost and it is therefore important that also the data for the individual indicators are reported when projects are compared on basis of aggregated indicators.

If systematic evaluations were made of all projects, this would contribute to improved sustainability of rural electrification projects. The indicators proposed could be used as a basis for discussions of the most relevant and suitable indicators. The evaluations should include a baseline study and repeated evaluations on at least three occasions after commissioning, for instance after one year, three years and ten years.

The result from the study is discussed in Chapter 5, and presented in detail in Paper VI appended to the thesis.

5. Discussion

As discussed above, it is not possible to draw far-reaching general conclusions based on the result of the study of the seven organisations in Tanzania, Zambia and Kenya. The cases included in the study are few. The technology and the organisational form used may also be either a consequence of historical decisions, when there were fewer options available, or a result of conditions imposed by the financing agency.

However, the findings will hopefully assist in enlarging the knowledge on organisational aspects of rural electrification, and serve as a basis for further analysis and discussion. This chapter consists of a summarised discussion of the main findings derived from the six papers presented in Chapter 4.

5.1. Organisational and Institutional Aspects

The survival of an organisation is to a large extent dependent on its internal factors, which are directly related to the business, and under the control of the organisation itself. Among these factors, energy pricing is essential for the economic sustainability. When taking decisions on tariffs, the organisations studied have been facing the dilemma of all enterprises operating a growing business where the capital investment is high. Charging the full capital cost to the few initial clients will make the product too expensive for the individual client. Not recovering the capital investment within the economic lifetime of the equipment will on the other hand not be sustainable. It is consequently important that the market is expanded rapidly so that the capital costs can be shared by many clients. Also important is that the clients are charged according to their consumption, and that flat-rate tariffs are avoided.

The results from the study show that all of the organisations included, are having difficulties with recovering the investment costs. The running costs are covered by the revenues of the projects managed by the private companies and the co-operative, but not in the projects managed by the national utilities or the community group (CBO). The survival of the project managed by the national utilities is through cross-subsides in the national tariff, and for the community group through support from external institutions. There is however no reason to believe that given sufficient economic and management/educational support, an electrification project can manage to survive and develop, regardless of its organisational form.

It is interesting to note that local markets with a substantial purchase power exist, even though constituted by only a small fraction of the rural population. One example being the co-operative project where the price of electricity is 15 times higher than the price charged by the state owned utility in other areas of the country, and the extent of connection still being approximately the same. This is also seen from the SWOT-analysis (Paper II), where client-relation issues appear to be the most well-off issue. For all cases included, there are new clients waiting to be connected. Especially for the private companies, the number of clients waiting to receive energy services is significant. The extent of electricity consumed for productive uses is also an important factor for a project, as it increases the market, and can lead to an improved purchasing power at the local market. The issues related to productive uses of electricity are further discussed below.

Findings from the study show that the private companies tend to investigate possibilities for side businesses to a greater extent than the other studied organisations, which likely is an advantage from a perspective of consolidating sources of income. In addition, the private

organisations have also been found to manage their client-relation more successfully than the other organisations included in the study.

Organisational weaknesses are mainly found among the government utilities included in the study, and can be illustrated by their low share of local ownership, and their inability to reduce the high non-technical losses[101], which can mainly be explained by non-payment of electricity bills by different government institutions/clients. This is in line with experiences from other developing countries where the rate of outstanding payment has been proved higher if the services are operated by the government, than if private companies or CBOs are responsible.[102] Also in the case of the co-operative the level of non-technical losses is high. This high level can probably be explained by an over-consumption by remaining flat-rate clients.

Transparency in the studied organisations concerns the possibilities for clients, partners, owners and government institutions to follow the development of a project through annual reports etc. None of the studied organisations has a desirable degree of transparency, mainly as they are not succeeding to perform audited annual reports[103]. The private organisations have an additional disadvantage, as they are owned by only one person/family and this reduces other stakeholders' possibilities for insight into the activities of the business. In addition, sole ownership can be a severe risk for the projects, as they are often located in areas with a relatively high level of HIV/AIDS.

For the two Community Based Organisations the main strength is the advantage of community participation, whereas the main weakness is their inability to raise the tariff, as this decision has to be supported by the majority of members, which are also the electricity clients themselves. Adjustment of the tariff is to some extent also a problem for the government utilities, where decisions on tariffs are made by the government and increasing tariffs can be politically sensitive.

It is obvious that a high degree of educated staff and a base from where recruitment can be made is important as a means for adequate management and operation of an electricity service. It is also obvious that an organisation of the size of the national utility included in the project has superior resources in this sense, compared to the smaller organisations. This is shown by the less successful measures taken in the technical installations made by the smaller organisations, even though a service contract has been available with the national utility, as in the case of the co-operative.

Additional conclusions concern the involvement and awareness of local stakeholders in project implementation. With involvement of local management already in the initial project planning, it appears as if their awareness and responsibilities are strengthened. Examples being the co-operative and the private companies studied were the awareness on the effects of energy pricing on project sustainability seems to be higher than those of the community group. The national and local economic development is essential for the survival of the organisation. Inflation is a major problem as it is difficult for the organisation to adjust energy prices at the same pace as the inflation. In fact it has been pointed out in other studies that it is the difficulties to predict the pace of the inflation that create most problems, not the level itself[104].

It is important to note that the renewal of the energy polices in many developing countries is seen as positive from an organisational perspective, although the effects of it in many cases not yet has been seen on a local level[105]. This is a clear example on how strategic policy and

[101] Also referred to as "un-paid electricity services" and "default rate"
[102] ESMAP 2000
[103] For the community group this is still a preliminary conclusion, and further research has to be conducted
[104] CSAE, CREFSA 2002
[105] Okure 2004

institutional levels and local organisational level are inter-linked. The question is however whether there are a sufficient number of organisations – entrepreneurs - that can carry on the intentions of the national energy polices.

Again, the conclusion from the evaluation of the seven projects included in the study is that there is no single most appropriate organisation for electricity services in rural areas. Every organisation form has its strengths and weaknesses, and the most suitable way to organise a project is to a high extent depending on the local context. Hence, when a choice between different organisational set-ups is possible, case-specific conditions that may influence the strengths, weaknesses, opportunities and threats, identified here, should be considered.

5.2. Prospects for Foreign Investments

Many countries in Africa have during the last decade been characterised by an economic growth. Still, low prices of electricity, imperfect infrastructure, incomplete standards, immature markets and legal structures, as well as a high import duty and tax, are constraints leaving foreign investors likely to remain scarce in the energy sector in many countries in Africa, at least for the next coming years. In addition, corruption in the power sector has been pointed out to be a major risk factor for investors[106].

In rural areas where the purchase power is lower than in urban areas, the introduction of foreign investors is especially unlikely. This has also been observed in a study recently done by the World Bank, were private sector interest in rural electrification has been stated as "moderate to low"[107]. However, with a combination of comparative advantages from different countries at different continents; such as know-how and consulting services from Europe, production of equipment in Asia and a growing market in Africa, there are possibilities for increased business activities in Africa, at least in some countries. South Africa has been pointed out as a country with potential to lead the way as a gateway for such development. Also the potential for Clean Development Mechanisms (CDM) can play a significant role in income-generation of future electrification of Africa.

[106] Covindassamy et al. 2005
[107] World Bank 2004

5.3. Public Benefits

Beyond dispute, access to capital is a prerequisite for all form of electrification as the initial investments are very high. As discussed above, the tariffs applied among the cases studied were too low to allow accumulation of capital for re-investment. In addition, no capital costs for the initial investment were paid, except to some extent by the larger government utility. All the cases were therefore depending on external financial support.

As concluded above, it is unlikely that foreign private investors will be substantially engaged in rural electrification in developing countries in Africa during the next coming years. Neither can it be realistic to assume that local private actors will take the role as investors to an extent that will have an impact on the development. It therefore remains for national governments and donors to finance most of the initial investments. An important implication of this is that the financing organisation should be able to ensure for instance environmental and social/ethical sustainability by attaching suitable conditions to the financing decision. The motive of donors to engage in rural electrification, should fully call for the project to be of use also for those who cannot initially afford to connect to electricity – the rural poor, which means that the public benefits of a rural electrification project are important, even if these have no direct effect on the sustainability of the project itself. Fundamental issues such as food preservation, pumping of water, education, health care and streetlights are important for improved social welfare. Such conditions could include requirements for a generation technology using renewable energy and supply of some fraction of the generation for social benefits like health centres, schools, and streetlights.

It is not possible to state whether any specific organisational form will have a particular impact on this, but it is reasonable to believe that the private market will only deliver these energy services if the full costs for these services are covered.

Whether the type of organisation used for electricity supply makes any difference from a perspective of bringing negative effects on the community, has not been possible to draw any conclusions on.

5.4. Aspects on Productive Uses of Electricity

The productive uses of electricity in the rural areas studied in this project are generally limited to low-load uses, such as lighting for extension of working hours for bars, groceries etc., and to enable income-generating activities in households. Such activities are common in most developing countries. In Tanzania for instance, some 42 % of the households reported having a business in year 2000[108].

This limited range of application of electricity for productive uses is not what has been expected. Instead, a growing demand of electricity for more value-added activities and small-scale industries could have been assumed to take place, at least over a longer period. The restricted services of the co-operative might perhaps explain the unequal consumption growth among different user categories. For the private organisations, the limitations in power from the solar panels may be restricting the growth.

As seen from Paper I, more than half of the clients interviewed in the co-operative project claim that they consider to start income-generating activities, such as welding, garage and groceries if they would be provided with 24 hours electricity services to the lower tariff

[108] National Bureau of Statistics Tanzania 2002

charged by the national utility. However, even in areas served by the grid, were 24 hours of electricity services is prevalent, the situation appears to be similar. From the projects studied it is therefore clear that even though electricity has been brought to the area, the effects on productive uses of electricity among the electricity clients are low. This shows that electricity by it self does not lead to a sustainable economic development, and that other causes than merely availability and price of electricity are influencing the decisions of the local population and their opportunities to engage in productive activities. Such factors are the availability of tools and machines for productive applications, credit for fixed assets and working capital, the human resources necessary for technical and business management, and a market for the products. The intentions expressed by many of the interviewed clients in the area served by the co-operative might therefore not be realistic.

This limited use of electricity for value-added activities has also been pinpointed in other studies[109]. Among reasons given were factors outside the direct control of the electricity organisations, namely shortage of capital, transport problems and lack of skilled labour.

As no substantial increase in productive uses has been seen in any of the projects, the effect of supply technology has not been able to be studied. However, it is likely to believe that a substantial increase in productive uses would require installation of additional generation capacity in all projects. The systems based on distribution grids would be more adaptable to such an increase.

5.5. Gender Aspects

Of the organisations studied, the major part had women involved in management and decision making of the organisations activities, although the female participants in the management are clearly in minority.

Whether female of male electricity clients' benefit most from electricity services cannot be assessed from the study. Interesting is however that all of the men interviewed in the area where the co-operative operates stated that women and children benefit most. The women on the other hand stated that the children benefit most, whereas men and women equally benefit from electricity. The female respondents were however few in number. As seen from the case studies, electricity is mainly used in households for lighting and electric appliances[110]. From a woman's point of view, lights in the household should preferable by in the kitchen and workroom, as to facilitate her work. Substantial parts of women's income-generating activities are home-based. Men on the other hand, usually perform their income-generating activities outside of the household, and therefore have other electricity preferences at home, for example TV and entertainment.[111] This difference in preferences is important to take into consideration in areas where households only can afford a few lighting points. If progress in foremost economic development is to be achieved through lighting up households, the lighting points should preferably be in the kitchen and in a workroom if such a room exists. However, as seen from the case operated by the co-operative, 20 % of the connected households where lacking electric lights in the kitchen (Paper I).

Streetlights have been found to be appreciated in particular by women, as these reduce the feeling of insecurity when walking the streets after dark. Of the cases studied, streetlights are only present in the area operated by the co-operative, and to a very small degree in the area where the larger government utility operates.

[109] See for instance Kjellström et al. 1992, and Kittleson 1998
[110] With the exception of the project in Kenya, were electricity not yet has been distributed to the households
[111] Cecelski 2000

Like in other electrified rural areas, electrification has not resulted in a significant shift from fuel wood and charcoal to electricity for cooking in electrified households, regardless of the tariff level and the service schedule. Only a small fraction of the households in the electrified communities are connected many years after the start of the service (see Appendix VI, Table 5 and 6). It should be obvious that conservation of natural forests is not a valid justification for rural electrification. Taking Tanzania as an example, this is also the situation for the country as a whole, even in electrified urban areas. In the Household Budget Survey from 2000/2001[112], 12 % of the households reported having electricity, while electricity for cooking was found to be used by only 0.9 % of the households. In Dar es Salaam, the amount of households utilising electricity for cooking were 4.4 %, whereas 60 % of the households were connected to electricity.

Other studies[113] reports that one of the most spectacular influences of electricity was found on the infant mortality rate, where the rate in the electrified households was 25% less than the national average and 35% less than the national rural average.

As discussed above on the aspects on public benefits, the emphasis on different aspects exercised by national government and the donor society is likely to influence the extent to which there is a supportive policy environment for gender issues. A national sector policy for rural energy programs should emphasize on sustainability and equity as explicit goals. In addition, it matters to what extent policies are aimed at enabling people of different genders and social classes to participate.[114]

5.6. Technological Aspects on Rural Electrification

For long, diesel generators have been the cheapest electricity supply alternative for rural communities that are not located in areas with favourable conditions for mini-hydro power generation such as in the case of the project of the CBO in Kenya. Today, the price of renewable technologies have fallen, one example being solar PV systems were the price has decreased to a level were these are clearly cheaper for low-load power needs, and many donors now promote installation of solar PV-systems for rural electrification in Africa.[115] The main reason for the promotion is that these, in contrast to diesel generators, do not contribute to the emissions of carbon dioxide (CO_2) that are expected to lead to a global climate change.

However, as shown in this study (see Paper IV), electricity produced from diesel generators may be cheaper for the client than solar PV, also when the load is limited to a few electric lights per household, if effective light appliances such as fluorescent tubes or compact fluorescent lamps (CFLs) are used. It is also shown in Paper IV that the contribution to global emissions of CO_2 by use of diesel generators in a small community is low in comparison to the current situation in the OECD countries. On a per capita level, household use of electricity from diesel generation in the area were the co-operative operates, emits less than 10 % of the CO_2 emitted in OECD countries.

Since the study presented in Paper IV was completed, the international diesel prices have increased considerably. In March 2008, the Rotterdam price was approximately 0.8 USD/litre and the price with taxes in Sweden about 2 USD/litre. With these high fuel costs, the difference between the costs for lighting with the cheapest diesel option and the solar PV will

[112] National Bureau of Statistics Tanzania 2002
[113] NRECA 2002
[114] ESMAP 2004
[115] The three projects in Zambia included in this study are examples of this

be less. With other cost data un-changed, the diesel price must however reach above 4 USD/litre, for the solar PV to be cheaper than the diesel generator combined with tube lights.

Switching from the traditional use of incandescent bulbs to tube lights in a diesel supplied system will reduce the CO_2-emissions by a factor of almost 4 and will lead to lower costs for the client – a clear win-win situation. Complete elimination of the CO_2-emissions by use of solar PV will lead to significantly higher costs for the client, even at diesel prices far above the present price in Sweden with taxes. It is clearly questionable if the rural population in developing countries shall pay this price for reduction of the global emissions of greenhouse gases. It seems reasonable to assume that a diesel supplied system where the clients uses efficient appliances should qualify as a system "*carefully designed in order to minimise negative environmental impacts",* as required by policies stated by Sida[116].

Although the technical losses are high among the studied cases involving distribution of electricity, the information collected in the field studies indicate that the service can be maintained for the technical lifetime of the installations for all the cases (see Paper VI). The historical operating records of the two government utilities and the co-operative indicate that the weaknesses in some technical indicators are not a major threat to continued service. From a client perspective however, the availability of electricity services is important. If the availability is not satisfactory, clients may for instance invest in their own generating sets. The limited service periods of some of the organisations (co-operative, the CBO, and the private solar PV-companies) are therefore a threat to technical sustainability.

5.7. Rural Electrification in Practice

As seen from the empirical case studies presented in this thesis, they represent partly another reflection of the reality than that given in the literature on rural electrification introduced in the background (Chapter 2). A sum up of the differences between "concepts taken-for-granted" and the reality for the studied organisations can be described in the following way:

Table 6. Concepts and facts on rural electrification in practice. (*Source: Conclusions from studied organisations in Tanzania, Zambia and Kenya.)*

Aspects	Concepts taken-for-granted	The reality in studied organisations
Rural Electricity Market	The market is too small	There are many clients on waiting-lists
Price (tariff)	Rural population are unable to pay a high price for electricity	No differences in degree of connected clients in rural high-cost areas and rural low-cost areas
Organisations	Private organisations are more suitable than governmental	There is no single most appropriate organisational form
Productive Uses of Electricity	24 hour services will result in a substantial increase in income-generating-activities	Productive uses are mainly composed of low-load uses in households, and no major difference is seen in cases with 24 hours service than in those with limited service hours.
Uses of Electricity	Electricity will be used for cooking	Electricity for cooking is hardly used at all
Capital	Foreign private actors will provide funding	Foreign investors are likely to remain scarce in rural areas for many years

[116] Sida 2005(b)

As shown in the table, the picture of rural electrification emerging from the case studies is partly in contrast with the "concepts taken-for-granted" as the "ideal" image of expected development of rural electrification that appears to be common among actors engaged in planning and implementation of rural electrification. The fact that a number of development expectations have not been fulfilled has also been pointed out in earlier studies[117]. In the studied literature, the concepts discussed above mainly have been found to be prevailing in programs, strategies and project justifications, and not in literature presented by those who have studied the situation in practice. One example being the concept stating that electrification will have a positive impact on deforestation by reducing the uses of wood fuel for cooking[118], which is not supported by literature presented by researchers[119].

An additional observation from the study is that the advantages of privatisation and private sector involvement are far from obvious, implying that there is a risk of marginalising other forms of organisations, such as community based organisations and co-operatives. Monitoring of the progress for a longer period is desirable for comparison between different types of organisations.

It is not known what consequences are caused from these differences between the "concepts taken-for granted" and the situation in the studied projects, but it seems as they can to a substantial degree obstruct the development by leading decision-makers to draw incorrect conclusions when planning for new electrification activities. Instead the opportunities and constraints have to be tackled with the empirical reality in mind, as to be able to better manage the ambiguities, complexities and all the paradoxes of rural electrification. There is an additional need of integrating electrification with other measures for rural development. Maybe it is then possible to touch down closer to a "sustainable-ever-after-life" for rural citizens in developing countries?

[117] See for instance Kjellström et al. 1992, Sanghvi and Barnes 2001, and Marandu 2002

[118] See for instance Malawi SDNP 1998 and Landstrategi Sverige Uganda 2001-2005, Sida 2001

[119] See for instance Cecelski 1998, and ICIMOC 2001

6. Methodological Analysis and Discussion

Extended energy supply is a matter of making wise decisions on what to implement and how. To increase the understanding of the context of rural electrification and to contribute to a sustainable development of new projects in developing countries, it is important to:

1. Study and learn from already implemented rural electrification
2. Improve and develop present methodologies and tools used for studies and evaluations, as to attain a more functional evaluation method.

This has been the purpose of the PhD study. As the focus of the study has been on how the organisation is functioning in its context, technical issues have not been discussed in detail. Neither has the macro-perspective received high attention, even though it is recognised by the author that the impact of macro-perspective issues on a local organisation is considerable (see previous chapter).

The cases included in this study have been selected from a number of decentralised rural electrification projects in Africa. The criteria for the selection have been that the electricity supply should have been on going for a minimum of two years[120], and that the generated electricity should be sold to private clients. As the legal framework in many countries in eastern and southern Africa is not yet allowing for electricity produced by others than government utilities to be sold to private clients, and that organisations and private companies only recently have been allowed to produce electricity in other countries, the actual number of qualified projects is presently still low.

In Section 6.1 the generalisation of the findings from the study is discussed. The methods utilised are addressed in Section 6.2, and in Section 6.3 the need for further work in this area is recognised.

6.1. Generalisation of the Findings

The majority of the cases included in the study qualify for the criteria stipulated above. The two decentralised systems (the smaller government utility and the co-operative), as well as the larger government utility, have all been supplying electricity to clients during more than 10 years. The three private projects commenced in 1998 and the supply of electricity services to clients started in year 2000. Finally, the project run by the CBO has been on going since 1998 with its first electricity produced in 2001. The cases have been studied through the utilisation of a number of different tools, briefly described in Chapter 4, and further discussed below (Section 6.2).

The performance or context of any organisation is never completely similar to the situation for another organisation. This implies that the results from one organisation are unique. In addition, using other methods and tools for studying the project will likely give other results than those received by applying the tools selected in this study. In addition, as discussed above the studies have been performed in only a few and different rural areas in Africa, rising the question on whether the findings from the studies are possible to consider as general for rural areas in eastern and southern Africa. Examples of unique results concerns areas such as transport distance to clients. This is pointed out as a problem for one of the private organisations (Paper II). Other examples are staff education, specific conflicts within the organisation, and political interference.

[120] With exception of the project run by the CBO

The fact that many findings are similar for all seven studied electrification cases indicates however that some degree of generalisation can be made.

Other researchers have also pointed out similar reasons for difficulties in rural electrification projects. Kjellström et al. (1992), concluded in an comprehensive study that; "*most of the area managers that the survey team met during the survey were found to be competent and keen to provide a good service to the electricity consumers*." For economic reasons however, the number of trained staff was limited and service maintenance and repairs was not carried out or heavily delayed. "*Organisational changes and strengthening of the organisation for operation of the services in the rural areas are necessary to improve the situation*".

6.2. Methods and Assumptions

There are many different methods of collecting information, depending on the type of research and the area in which the work is conducted. Often the resources in time, staff and financing are also affecting the choice of method. Research on rural electrification is a matter of putting together the perspective of not only electrification itself, but also the impact it has on the development of a community[121]. The need of fieldwork at the selected project areas are therefore of outmost importance.

The methods utilised for the research presented in this thesis are;

a) Field Surveys and situation assessment by means of indicators,
b) SWOT-analysis,
c) Open-ended discussions with stakeholders.

The methods are further presented below.

6.2.1. Field Surveys and Situation Assessment by Means of Indicators

6.2.1.1. Data Collection and Preparation

The details of the method used for the fieldwork on which Paper I, IV, and VI are based, are given in Table 7. The fieldwork has included both quantitative methods and qualitative methods, which are further presented below. The fieldwork has mainly been performed with Sida as the main client (Zambia and Tanzania). The fieldwork in Kenya has been performed entirely within the research project.

Quantitative data on the case studies have been gathered through inspection and measurements of technical components, review of client ledgers, logbooks and economic reports etc.

In addition, a questionnaire (see Appendix VII) has been used in the fieldwork. When utilising questionnaires, there is a need for standardisation and systematisation of data and the process under which the data are collected. A questionnaire can be designed in different ways: from the simplest form of a checklist, through a semi-structured questionnaire and finally as a structured questionnaire. By using a structured questionnaire, the respondents are asked the questions in the same way; both in terms of sequences and in the way a specific question is formulated. The results presented in Paper I, IV, and VI are partly based on the use of a

[121] Although the approach used in this thesis has been limited.

structured questionnaire that has been designed by University of Gothenburg[122], which was used in the fieldwork performed by University of Gothenburg, in Zambia (see Table 7 below).

For the collection of information needed for the selected indicators (see 6.2.1.3 below), the questionnaire was further developed before applied on the studied cases in Tanzania.

The questionnaire has been prepared in English. The languages used when the respondents were approached with the questionnaire are; English (Zambia) or Swahili (Tanzania) [123].

6.2.1.2. Sampling

To include a whole population in an area where research is conducted is difficult to accomplish. Instead, sampling usually has to be done through a selection of informants. Methods used in this research are random sampling and stratified sampling (subdivision). Random sampling however – if performed strictly – requires that every individual have an equal probability to be selected. This usually requires a total census of the local population of a research community, which again is difficult. Instead, other simplified ways like sampling by designing every n^{th} unit or event can be used. This is the approach used in this research. As to be able to reach all groups of stakeholders, such as women, stratified sampling has also been used. Here the criteria used for selection are set up as to find a sample in a specific layer.

6.2.1.3. Data Compilation and Analysis

The data collected from the questionnaires applied on the fieldwork has been compiled either in SPSS (Zambia), on simple Excel Spread Sheets (two of the cases in Tanzania), or both in SPSS and on Excel Spread Sheets (one of the projects in Tanzania)[124]. The analysis of the data, and the calculations for the preparation of the indicators (see 6.2.1.4 below), has been made by the author of this thesis. The calculations have been prepared and made on Excel Spread-Sheets.

[122] Gustavsson, M. Human Ecology Section, University of Gothenburg
[123] No questionnaire was used for data collection in Kenya.
[124] As no questionnaire was used in Kenya, compilation of such data was consequently not made.

Table 7. Presentation of background and methods for data collection for each case included in the study. (*For further details see Paper VI*).

Case	Year of Evaluation	Role of the Author	Method	Number of evaluators and/or enumerators	Selection criteria
Larger Government Organisation/ Utility	2004	- Project leader and participating in the survey - Partly data compilation - Analysis of data	• Survey covering 268 electricity clients and non-clients in their homes/businesses/institutions • Survey covering 120 electricity clients at the organisations sales office • Inspection of production and distribution assets • Review of financial reports and databases • Interviews with staff and management of the organisation • Language used was swahili	9 field workers. The team consisted of 3 women and 6 men from the area	The interviewees were randomly selected from an existing database used for an on-going household census
Smaller Government Organisation/ Utility	2003	- Project leader - Analysis of data	• Survey covering 27 electricity clients in their homes/businesses/institutions • Discussions with staff and management of the organisation • Review of logbooks and relevant reports • Language used was swahili	2 field workers. The team consisted of 2 men, one from the area and one from outside of the area	The interviewees were randomly selected from the client ledgers of the organisation
Co-operative	2002	- Team member and participating in the survey - Data compilation and analysis	• Survey covering 35 electricity clients in their homes/businesses/institutions • Inspection of production and distributions assets • Discussions with staff and management of the organisation • Review of logbooks and relevant reports • Language used was swahili	5 field workers. The team consisted of 1 woman and 4 men. None of them were from the area	The interviewees were randomly selected from the client ledgers of the organisation
Community Based Organisation (CBO)	2003, 2004	- Project leader and participating in the survey (note that no questionnaire was used) - Analysis	• Discussions with staff and management of the organisation • Inspection of production and distributions assets • Review of logbooks and relevant reports • Review of a study carried out by UNEP (*Wamukonya, 2004*)	2 field workers. The team consisted of 1 woman and 1 man. None of them was from the area	No interviews were made with clients
Private Organisation A, B, C	2001, 2003	- Recipient of information from the survey made by Göteborg University - Participant in survey of the management - Partly analysis	• Survey covering 360 electricity clients, potential clients and non-clients in their homes/businesses/institutions[125] • Review of financial reports • Interviews with staff and management of the organisation • Language used was English	7 field workers	Private A: All clients were interviewed Private B and C: the interviewees were randomly selected

[125] *The survey was performed by Gustavsson, Human Ecology Section, Göteborg University, Sweden. Data from the survey has generously been granted for use in this study.*

6.2.1.4. Methodological Framework and Indicators

The data collected in the fieldwork and discussed above, has further been analysed by means of indicators.

As described in Section 4.5, the methodological framework for the indicators has been based on five dimensions of sustainable development: technical, economic, social/ethics, environment, and organisation/institution. For each of these dimensions a number of indicators have been developed. For the indicators to be useful in field, they have to fulfil some essential criteria. The criteria for the indicators are listed in Table 8 below.

Table 8 Criteria for Indicators.

Distinguishing Features of Indicators	Remarks
Simple to understand and apply	No method will be used in practice unless the potential users feel comfortable and can understand the structure of the method as also of each indicator included. "There is no point in delivering yet another set of sustainability indicators that in practice is not applicable" [126]
Transparent and inter-subjective	The underlying data has to be easily availably and realistically traceable, as also the definition of the indicators. Everybody within the profession shall be able to use the method and receive the same results from the same data[127]
Robust	The indicators shall be formulated clearly enough to be replicable in their application
Comprehensive	The pre-designed set of indicators need to cover all major aspects of sustainable development
Fair	The indicators used have to emphasise the issues of equality, covering gender sensitiveness, and effects of the development on different social groups in the society concerned. The indicators also have to be fair in respect of comparing projects in different areas

The selection of the indicators has been made from literature studies on indicators utilised by researchers and consultants, and from an analysis based on key issues within each sustainability dimension. The procedure is illustrated in Figure 8. The indicators selected have then been practically tested in the field based on their suitability in a local context, and the possibility to procure necessary data and information (A). In addition, the indicators have been re-valuated (B) on basis of their suitability in accordance with the general criteria for indicators (Table 8Table 10). The procedure has resulted in a number of indicators which have originally been higher, but through the iterative process been reduced to the present number (C).

It is important to notice that a number of the selected indicators can find their place in more than one of the five dimensions of sustainable development. One example being the share of staff with appropriate education, which can be used both as an indicator of the status of the organisation (the Organisational/Institutional Dimension), and for the technical sustainability by indicating the level of adequately trained operators (the Technical Dimension).

[126] Heuberger et al. 2003
[127] Hansson 2003

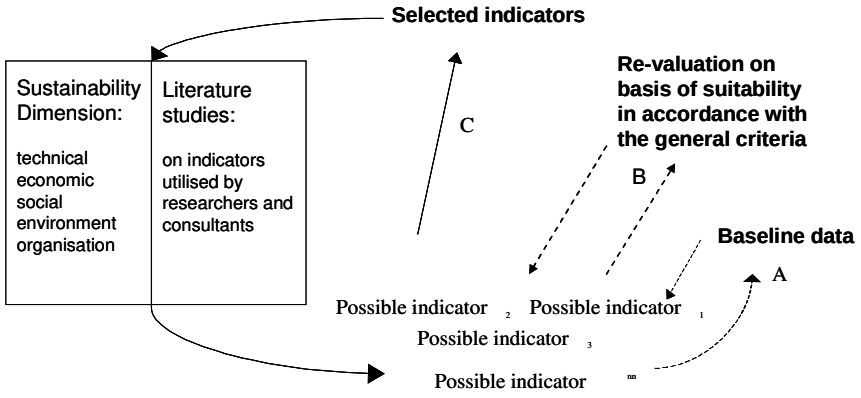

Figure 8. Procedure of selection of indicators. Possible indicators are tested based on their suitability in the field (A), re-valuated based on their fulfilment of the general criteria (B), before accepted as part of the proposed method (C).

Hence, the indicators finally selected to be included in the proposed method are designed to fulfil the stipulated criteria as described above. Nevertheless, they can be discussed with regards to their suitability for a specific project, especially when projects in varying cultural contexts are subject for analysis. The alternative however, with an infinite number of indicators, is likely to be cumbersome and time consuming to deal with. Therefore, the most suitable way forward is suggested to be through evaluations where the suggested indicators are supplemented with case specific indicators. The efforts for determination of the indicators will always be case-specific and depend mainly on the remoteness of the site and the availability and quality of the records kept by the local management.

An additional difficulty is the attempt to attribute a development/a change in the project area to the specific project. Research on rural electrification is a matter of putting together the perspective of not only electrification itself, but also the impact it has on the development of a community and its context. It is therefore important to realize that all conclusions and subsequent decisions must be based on a combination of analysis and assessments, both with consideration taken to the result from the analysis and in proportion to other possible conclusions. No method applied can fully cover the complex reality of a project context. A method cannot be more than a tool to be used as basis for decisions, and for case-specific comparisons.

The number of indicators included in the proposed method is 39 out of which eight were formulated after the fieldwork had been completed. The case studies have therefore included determination of 31 of the proposed indicators. The choice of units has been a difficult issue for some of the indicators. Percentages are a reasonable choice for several of the indicators, but in particular for some of the economic indicators it was found that absolute values give a better understanding of the performance. When percentages are used to express these indicators, the result depends on the reference value used. Large absolute differences may be hidden by this and small absolute differences exaggerated.

The selected indicators have then been accounted for through a specific pre-structured "sheet". Every separate sheet accounts for the relevance of sustainable development attributed to the specific indicator. In addition, a detailed measurement method is described for each indicator.

The method of utilising sheets for indicators is based on a format originally developed by the UN Commission on Sustainable Development – the CSD Work Programme, during 1995-2000[128] . The advantage of the pre-structured sheets is that the general criteria for the indicators (Table 8) become readily obtained by all professionals. The original structure of the sheet has been developed to suit indicators on a national level. Therefore, the structure has been modified and adapted for indicators on a local level. This includes the removal of headlines such as "Policy Relevance", "International Conventions and Agreements", and "International Targets/Recommended Standards". Finally, the headline "Gender Relevance" has been added to the sheet.

A full description of all the included indicators and their respective sheet is given in a separate document[129] specially developed during this PhD assignment. The document is also appended to the thesis (Appendix VII).

6.2.2. SWOT-analysis and Open-Ended Discussions

Depending on the specific subject of study, questionnaires vary a lot in complexity. However, even if using an, in advance, planned and carefully structured questionnaire the data collected are heavily effected by both the interviewees and the interviewers: in the way the questions are put forward, any individual biases, age, sex, level of education, religion etc. This shows that no matter how much we need surveys we also have to bear in mind the context in which the surveys are to be set. "*It is clear that many of these methodological precautions require extensive supporting field work-participant observation, interviewing, and other qualitative back-up research, to give reality and meaning to the numbers and percentages*."[130]. This implies that there is a need of using ***qualitative methods*** in the research, especially in interdisciplinary themes such as rural electrification, which is distinctly influenced by social and cultural contexts.

The qualitative method used for the fieldwork is SWOT-analysis (Paper II, Section 4.2). SWOT-analysis is based on workshops and discussions with the management and staff of the organisations. When utilising SWOT as an analysis tool, it is important to consider the drawbacks that goes with it. One of the most apparent disadvantages is that no single person is objective – implying that the analysis is highly dependent on the subjective views and choices of the person/persons carrying out the analysis. In addition, reasonable definitions of what to include in the analysis are difficult to make. Narrow limits most likely exclude important actors and sectors. Generous, all embracing, limits on the other hand results in non-apprehensible amounts of information. The list of questions used for discussion on the SWOT-analysis is included in Appendix VII.

The findings in Paper III (Section 4.3) are mainly based on literature research and open-ended interviews with market actors.

[128] UN 2001
[129] Ilskog 2008
[130] Pelto 1970

6.2.3. Overall Comparisons of Sustainability

Aggregating indicators for generation of measures for the different dimensions of sustainability and combining these results for a simple overall assessment of the sustainability, clearly involves serious methodological difficulties. Large differences between the cases can be hidden when the aggregated measure for the dimension of interest shows small differences. The outcome would of course change and could change dramatically if the indicators were weighted, but this leads to the problem of selection of the weights to use for the different indicators.

In addition, the use of ranking for generation of common scales for the indicators within each dimension is also problematic, because it can either reduce large absolute differences or exaggerate small absolute differences. There are several alternative approaches. One would be to define target levels for the indicators and use the number of indicators that reach the target level as a measure of the sustainability. For indicators that fall below the target level, the ratio between the indicator value and the target could be used as a measure. Such an approach would focus more on absolute sustainability than the present, where the performance of cases is compared relative to each other. At least for some of the indicators, definition of the targets would present problems.

Regardless of how indicators are measured and aggregated, important information about differences between cases evaluated may be lost and it is therefore important that also the data for the individual indicators be reported when projects are compared on basis of aggregated indicators.

Finally, sustainability is a matter of development over time. Data from a single evaluation is therefore not sufficient for assessment of sustainability, even if the data can certainly be used for identification of areas where improvements will be necessary. Information about the trends of the indicators would lead to considerably improved possibilities to assess sustainability. In particular, for some of the social/ethical indicators the development over time can be a very important measure of the impact of electrification.

6.3. Further Work

"We speak of data as if it was out there waiting for us. Of course, it is not: "data" is only a convenient summary term for the documented and memorised results of conducting research either based on our first-hand experiences or based on those of others set down in texts"[131]. Reality always differs from theory, calling for a constant development and adaptability of the theory. To develop, but still to remain with results that can be compared also with future evaluations is to walk a tightrope.

As stated above, the obvious conclusion from the study is that there is no single most appropriate organisation for electricity services in rural areas. It seems plausible that a large utility regardless of its organisational form would be able to implement a rural electrification project that is sustainable from all aspects, provided that the financial resources are accessible from the government or from a surcharge on the tariff paid by other electricity clients. The availability of financial resources are however in the reality limiting the number of projects that can be implemented and there will certainly still be a large number of communities that

[131] Ellen 1984

must wait many years to be electrified through such a scheme. The alternative approaches, where the electrification is implemented by a smaller organisation such as a co-operative, a private entrepreneur or a community enterprise company, are interesting as they open up possibilities for local and private initiatives.

The following actions would contribute to improved evaluation of sustainability of rural electrification:

- Systematic evaluations shall be made of all projects, using a standard set of sustainability indicators. The indicators suggested in this thesis could be used as a basis for evaluation and for further discussions of the most relevant and suitable indicators. For assessment of the sustainability of the services, repeated evaluations are necessary.

- Aggregation of indicators to give simple measures for the different sustainability dimensions should be avoided. Instead, a minimum acceptable level and a target level for each indicator may be defined and projects assessed on basis of the number of indicators where the minimum level and the target level were exceeded.

- It is important that the indicator sheets will remain open for enhancement, refinement, amendment and change as a result of degree of availability of data and as input from other researchers and stakeholders is received. International Conventions and Agreements, and International Targets/Recommended Standards, are specifications that, when available, can be added to the sheets.

- To many of the indicators can be added an indicator distinguishing between female-headed and male-headed households. This can be further developed.

- All evaluations of electricity clients can be supplemented with a reference group constituted by non-clients (e.g. citizens that are not at present electricity clients).

- An advantage is if the results from evaluations performed could be reported to an internet-based homepage, from where interested actors could access information.

7. Conclusions

Since the history of man began, we have moved forward by developing and learning from the successes and mistakes made by ourselves or others; in other words from different scales and forms of evaluation. Still, in many areas in our society we exclude evaluations as a proper tool for handling more complex and interdisciplinary situations.

This thesis has dealt with the issue to investigate the reasons behind successful/less successful implementation of rural electrification, with the overall objective to facilitate for decision-makers to improve their basis for future decisions and measures on rural electrification activities. This has been especially interesting in the light of the on-going trend towards private sector led projects, which have introduced new elements influencing possibilities and barriers for a sustainable rural electrification development. The main important issue for the research work has been to examine whether rural electrification implemented by private entrepreneurs or other non-governmental organisations contribute more effectively to sustainable development than the conventional approach where rural electrification is the responsible of a government utility.

The following main conclusions from the study have been highlighted:

- **The proposed method for evaluation has generated valuable experience**

Despite the large number of rural electrification projects being financed by the international donor community there are few published in-depth evaluations of the effects of these projects on sustainable development, in particular on the organisational aspects.

The implementation of the evaluation method proposed in this thesis has generated valuable experiences regarding collection of data for evaluation of rural electrification projects. The proposed indicators give a good picture of the present situation for the cases evaluated. However, for assessment of the sustainability of the services, repeated evaluations are necessary.

SWOT-analysis is seen as a simple and useful complement to the evaluation method. Through the SWOT-analysis, the management of an organisation is given the opportunity to highlight their views on the development. This can bring additional information to the evaluation, which will not be covered by the selected indicators.

- **Subsidised tariffs does not necessarily lead to a higher share of population with access to electricity**

Local markets with a substantial purchase power do exist, even though constituted by only a small fraction of the rural population. One example being the co-operative studied, where the price of electricity is 15 times higher than the price charged by the state owned utility in other areas of the country, and the extent of connection still being approximately the same. This implies that a subsidised tariff does not necessarily lead to a higher share of population with access to electricity.

- **Diesel generation combined with energy efficient lights can be a cost effective means to reduce CO_2 emissions from small-scale electrification**

The costs for Solar Home Systems (SHS) are still substantially higher that those for diesel generation combined with efficient light appliances.

It is clearly questionable if the rural population in developing countries shall pay the price for complete elimination of greenhouse gases. If such elimination is seen as essential, the additional costs have to be covered by the donor community.

- **Electrification alone will not lead to the development of productive activities**

Electricity by it self does not lead to a sustainable economic development. Other causes than merely availability and price of electricity are influencing the decisions of the local population and their opportunities to engage in productive activities. Such factors are the availability of tools and machines for productive applications, credit for fixed assets and working capital, the human resources necessary for technical and business management, and a market for the products. The intentions expressed by many of the interviewed clients during the fieldwork, on taking up productive uses when connected to electricity, might therefore not be realistic.

- **Governments and the donor community have unrealistic expectations on impacts of rural electrification**

As has been pointed out in Chapter 5.7, many actors involved in planning and implementation of rural electrification in Africa, appear to have unrealistic expectations on the impacts of rural electrification, such as effects of deforestation, reduced work-load for women, and the financing willingness by private actors on the local and international scene. If this is true, it could indicate that results reported in several evaluations of rural electrification experiences have not had much effect, and that new emphasis on private solutions is based more on ideology than on a realistic assessment of the empirical situation. The possible consequences are ineffective use of available funds for rural electrification and implementation of privately organised electrification schemes with uncertain long-term prospects.

What instead seems as necessary is that the actual experiences from existing rural electrification schemes are taken into account when new projects are planned for and that development goal are carefully prioritised. If additional measures are necessary for achieving the high priority goals, these should be included in the electrification projects.

- **Private investors cannot be expected to take responsibility for all aspects of sustainability. Therefore, additional financing from the donor community will continue to be essential**

It is not possible to state whether any specific organisational form will have a particular impact on the issues of public benefit and gender, but it is reasonable to believe that the private market will only deliver these energy services if the full costs are covered. Full cost recovery will be difficult to obtain especially in rural areas where the load development and purchasing power is lower than in urban areas. The probability of international private investments in rural areas of the African power sector is therefore low, which implies that donor support will continue to be of importance. Donor agencies that provide financing for rural electrification projects should use their influence to ensure that all-important aspects of sustainability are considered by the implementing organisation.

- **The is no single most appropriate organisation for electricity services in rural areas**

The results from the research show that all of the organisations included are having difficulties with recovering the investment costs. There is however no reason to doubt that an electrification project can manage to survive and develop, regardless of its organisational form, if given sufficient economic and management/educational support.

The organisational weaknesses have mainly been found among the government utilities included in the study, and can be illustrated by their inability to reduce the high non-technical losses, their low share of local ownership, and to raise tariffs.

The private organisations included had their main weakness in the limited possibility for stakeholders' insight into the activities of the business. In addition, sole ownership can be a severe risk for the organisations, as they are often located in areas with a relatively high level of HIV/AIDS.

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9. Nomenclature

Afrepren	African Energy Policy Research Network
CBO	Community Based Organisation
CDM	Clean Development Mechanisms
CFL	Compact Fluorescent Lamp
Client	Energy end-user (*also referred to as costumer*)
Costumer	Energy end-user (*also referred to as client*)
CO_2	Carbon dioxide
CSD	UN Commission on Sustainable Development
CSD-ISD	CSD Indicators of Sustainable Development
DE	Decentralised electrification
Diesel Genset	An electric generator powered by a diesel engine
ESCO	Energy Service Company
ESMAP	The Energy Sector Management Assistance Program (*Joint UNDP/ World Bank Programme*)
ITDG-EA	Intermediate Technology Development Group, East Africa (*name changed to Practical Action*)
KTH	The Royal Institute of Technology in Stockholm
kV	Kilovolt
kVA	Kilovolt ampere
kW	Kilowatt
kWh	Kilowatt hours
LSMS	Living Standards Measurement Studies
MDG	Millennium Development Goals
MW	Megawatt
NGO	Non-Governmental Organisations
OECD	Organisation for Economic Co-Operation and Development
PV	Photovoltaic
SADC	Southern African Development Community
SAREC	Swedish International Development Agency, Department for Research Cooperation
SEI	Stockholm Environment Institute
Sida	Swedish International Development Agency
SME	Small and Medium Enterprises
SPSS	SPSS is a computer program used for statistical analysis (originally, Statistical Package for the Social Sciences)
SWOT-analysis	An analysis tool for Strengths, Weaknesses, Opportunities and Threats
TANESCO	Tanzania Electric Supply Company Ltd.
TAS	Tanzania Shillings
UECCO	Urambo Electric Consumers Cooperative Society
UNDP	United Nations Development Programme
USD	US Dollars
VAT	Value Added Tax
W	Watt
ÅFORSK	Ångpanneföreningen's Foundation for Research and Development