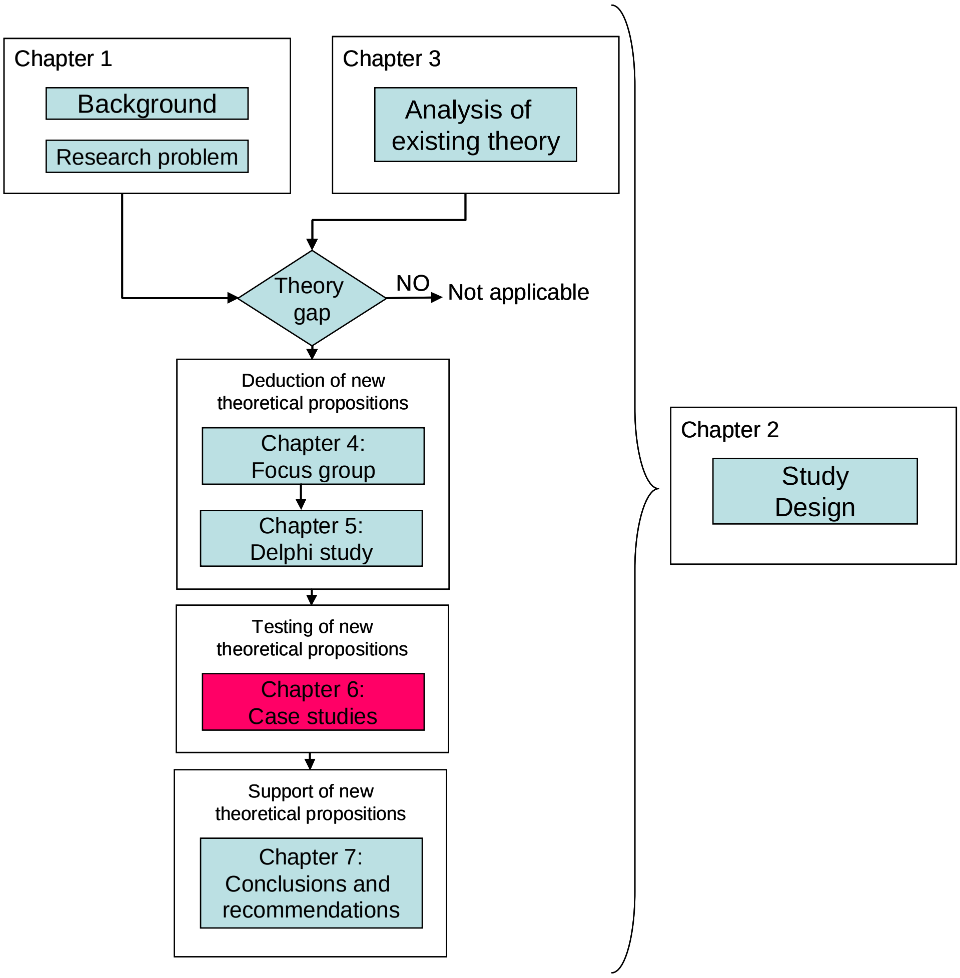
CHAPTER 6: Case Study



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6.1 Introduction

The high level case study methodology (Yin 2003) was followed for this case study; the methodology is shown in Figure 6-1. The methodology consists of the design of the case study; the case study is then conducted by preparing for data collection and collecting the case study evidence; the data is then analysed; and finally the report is generated.

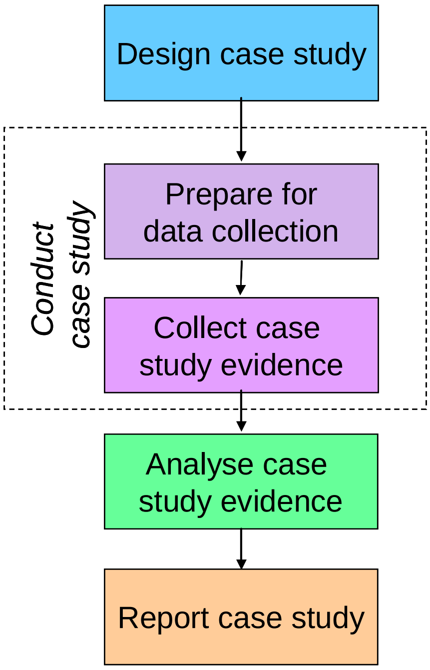

Figure 6-1: High level case study methodology (Yin 2003)

6.2 Case study design

For purposes of this study, it was decided to use a multiple embedded case study design. The use of multiple case study designs over single case study designs is advisable (Yin 2003). This is because the benefits of the analysis of multiple case studies. Among the benefits is the possibility of directly replicating case studies, and improving generalisability if a common conclusion can be reached in different contexts.

As the study is focussed on renewable energy projects in Africa, it was decided that the multiple cases would be three different countries in Africa. The units of analysis would be different renewable energy initiatives in each country.

The multiple case study method used in this study is shown in Figure 6-2 (Yin 2003). The define and design phase involves developing the theory that is to be tested, which in this case is the factors defined in the Delphi study. The cases are then selected using convenience sampling and the data collection protocol is designed. The prepare, collect and analyse phase involves collecting data for each case study and writing up the individual case study reports. The analyse and conclude phase involves drawing cross-case conclusions, modifying the developed theory, developing policy implications and writing the cross-case study report.

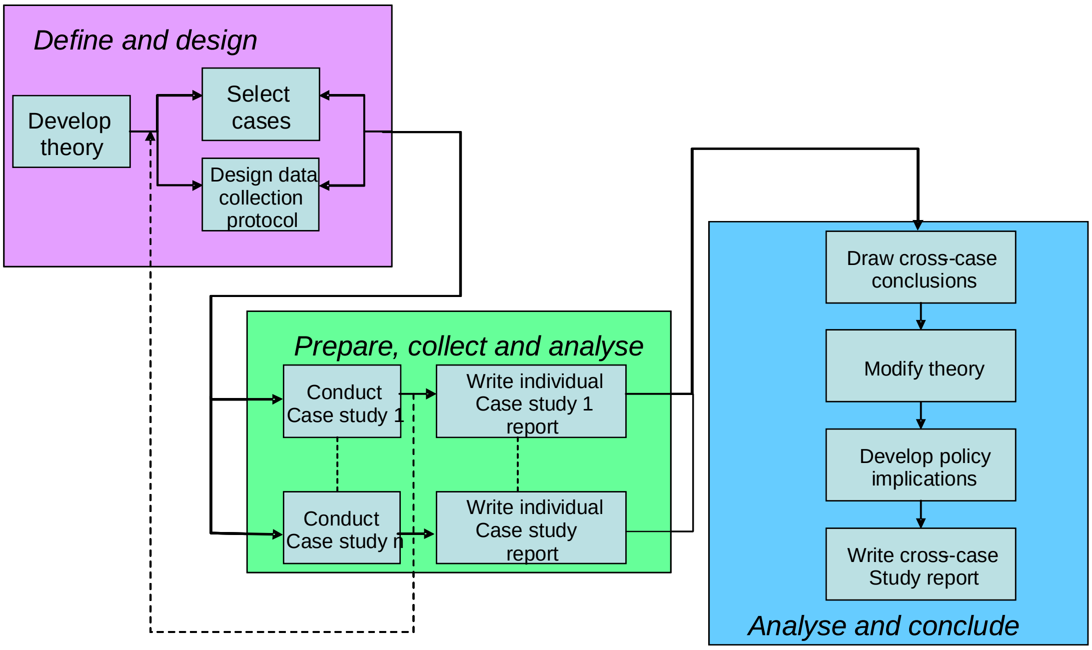

Figure 6-2: Multiple case study method (Yin 2003)

6.3 Execution of case study

6.3.1 Preparation for data collection

When preparing for data collection the elements shown in Figure 6-3 need to be taken into consideration (Yin 2003).

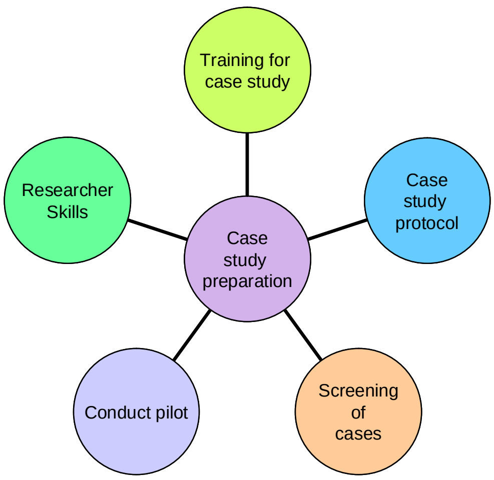

Figure 6-3: Elements to consider in preparation for data collection (Yin 2003)

The main elements that need to be considered are: training of the researcher; the researcher skills; conducting a pilot study; screening of case studies; and case study protocol development.

For this case study, two researchers worked together during the data gathering phase, each gathering data for two separate case studies.

The generation of a case study protocol to ensure validity of the case study is advised (Yin 2003). The protocol for a case study is attached in Appendix K.

As part of the case study protocol, two questionnaires for data collection were also generated. Two questionnaires were required as two different levels of participants were interviewed during data collection. Interviews were conducted with government institutions and implementers and the other level of interviews was with end users. The two questionnaires are attached in Appendix L and Appendix M respectively.

Processes for screening are proposed which included a unique case, specific cases and more than 30 cases (Yin 2003). In this case, the researcher had access to specific cases[1] which where then chosen as the case studies thus convience sampling was used. The specific cases where diverse enough to satisfy the requirements of the case study. For this reason it was decided to investigate the cases to which access was readily available in three African countries. The cases selected are shown in Table 6-1 . The cases are distributed over three countries namely Rwanda, Tanzania and Malawi.

Table 6-1: Summary of case studies

Country	Type of renewable energy service	Implementation model
Rwanda	Household biogas Institutional biogas	SNV with government support
Tanzania	Solar PV Biogas for cooking Efficient ovens Efficient stoves	Non government aid agency
Malawi	Efficient stoves Efficient barns	Government driven with support from ProBEC

A pilot case study was conducted with Mr Maxwell Mapako, of the South African Council for Scientific and Industrial Research. A biogas implementation programme in Zimbabwe was used for the pilot study. For the pilot study no secondary

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[1] Access to the case study information was obtained via the South African Council for Scientific and Industrial Research (CSIR) with the help of Mr Maxwell Mapako.

documentation was available and data gathering consisted of an interview only. The interview was helpful to test the questionnaire for government and implementers and after the pilot interview; the questionnaire was updated to clarify some of the questions.

6.3.2 Collection of evidence

The six sources of evidence which can be used during the collection of case study evidence are shown in Figure 6-4 (Yin 2003). The six sources of evidence are: documents; physical artifacts; participant observations; direct observations; interviews and archival records.

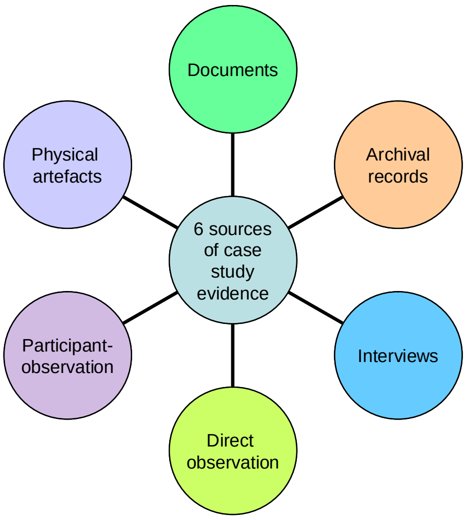

Figure 6-4: Six sources of case study evidence (Yin 2003)

Three principles of data collection were used namely: multiple data sources, the creation of a case study database, and maintenance of the chain of evidence (Yin 2003).

In this case study, the multiple sources of evidence which were used were: documents, interviews and direct observations. Direct observations were limited to observing the trained users use the equipment and the templates that were supplied and supported the finding that training had been successfully completed.

A detailed database of case study evidence is included in Appendices N to P.

6.4 Analyses of case study evidence

6.4.1 Introduction

The preferred strategy for analysing case study evidence is to rely on theoretical propositions (Yin 2003). The proposition of this study was that the factors identified during the Delphi study were the most important factors for the selection of renewable energy technologies in Africa. Pattern matching is the most preferred technique for analysing case study data as it compares an empirically based pattern with a theoretical pattern (Yin 2003). In this study, pattern analysis was used and the data gathered was analysed by comparing it to the findings of the Delphi study.

6.4.2 Background to case study countries and technologies employed

6.4.2.1 Biogas for cooking in Rwanda

Rwanda is a small poor rural third world country in Africa and is landlocked by Democratic Republic of Congo (DRC), Uganda, and Tanzania. With a population of 10 million people, Rwanda is the most densely populated country in Africa and 90% of the population is engaged in agricultural activities (CIA 2010a).

The energy need of 94% of Rwandese is met by biomass which is made up of combustible wood and vegetal residue (MINITERE 2006). The current production of electricity is dependant on hydro schemes, which are susceptible to droughts and there have been prolonged periods of drought in Rwanda in the last 20 years (MINITERE 2006).

Most of the Rwandan population needs energy for cooking and lighting. The main lighting fuel sources are: oil (64%), wood (17.5%) and kerosene (10%) (even in urban areas like Kigali only 37% of households use electricity) and the main rural cooking fuel sources are: firewood (90.4%), charcoal (7.4%) and agricultural residue (2.2%) (Dekelver*, et al.* 2006).

One of the goals of the government's National Adaption Program of Action (NAPA) is the reduction of wood energy utilization form 94% to 60% by 2010 and to 50% in 2020 (MINITERE 2006). NAPA has identified the low capacity of human and financial resources, focusing on hydroelectricity to the exclusion of mixed solutions and resistance to change as the main risks for this programme.

Two case studies were selected in Rwanda namely the domestic biogas programme and the institutional biogas programme. One of the projects started by the Ministry of Infrastructure (MININFRA) to support NAPA is the National Domestic Biogas Program (NDBP). The goal of the NDBP is to implement 15,000 biogas plants for Rwandan households with two to three zero grazing cows (i.e. cows kept in a pen) by December 2011 (NDBP 2008).

The NDBP was selected as a case study for the research as it is an example of a renewable energy implementation in Africa where a development organization is working together with the government of an African country to implement the programme.The household biogas programme was initiated by the Rwandan government in 2003 when discussions started with SNV. SNV is a professional development cooperation organisation, based in the Netherlands, which currently operates in 32 countries in the world and has extensive experience in biogas implementation especially in Nepal (SNV, 2009). Biogas is environmentally friendly as a biogas plant replaces 4.6 tons of carbon dioxide annually (SNV, 2007). Advantages of biogas plants for individuals include (SNV, 2007): less smoke which improves health due to less respiratory diseases and eye infections; less dirt on pots from fires; less or no wood collection required; better fertilizer and better sanitation available.Primary data was gathered by conducting interviews with the implementing organizations as follows: informal introductory discussions with a senior advisor to MININFRA; formal interview using technical questionnaire with a senior biogas technician; formal interview using technical questionnaire with a biogas senior advisor from SNV. Secondary data in the form of reports were provided by the interviewees (see Table 6-2).

Interviews with two households that have biogas plants were conducted in the Rulindo district. Rulindo has a population of 261,018 inhabitants with a high average population density of 448 inhabitants per square kilometre (Huba and Paul 2007). The district has 25,126 cattle-raising households of which 99.6% practice zero grazing and 90% of the population work in agriculture on a surface of 226 km^2 (Huba, E.M. 2007).

The households interviewed were all part of the pilot biogas pilot programme initiated in 2007. The first user interview was with a mother who is the head of a household with five teenagers. She is very satisfied with her biogas digester and manages to cook all the family meals using biogas. Biogas in this household is used for both cooking and lighting. The cow at this household was very well-fed and the biogas pressure was 10 KPa which means that there is sufficient biogas for their daily needs.

The second user interview was with the father of a household of nine. The household consists of the parents and seven children, two of whom are over 18. In this household the father indicated that the major impact of the biogas digester in the household was that the children did not need to spend so much time collecting wood every day and that money was saved because they did not have to purchase firewood so often. In this household however, wood is still used twice a week to cook beans which is one of the staple foods in Rwanda. In this household the cow was less well-fed and the pressure on the biogas meter was below 6 kPa.

Twenty eight biogas systems have been installed in institutions in Rwanda since 2001 while another eight are under construction. Of the total of 36 units, thirteen were installed in secondary schools, eleven in prisons, seven in community households, two in military camps, two in training centres and one in a hospital (Munyehirwe and Kabanda, 2008).

In 14 (50%) of the 28 operating biogas digesters only human waste is being used (typically for the prisons and some schools) while others use a combination of human and animal waste, mainly cow dung. It has been found that 11 of 28 completed digesters operate very well, 5 operate with major defects while 6 were abandoned or even never operated due to wrong design. The survey found that schools were the worst performers with only 2 out of 10 installed systems in operation.

The major causes for malfunctioning of the systems were found to be lack of commitment of the management and/or a lack of a qualified biogas operator and this was found more the case in the bigger institutions than in small systems operated by missions and farms

There is also a serious shortage of technical support to assist institutions in carrying out simple modifications and reparations of leakages and damaged stoves. More capacity is required in this area to ensure that the existing systems function properly which will give confidence to other institutions to follow the example.

Primary data was gathered by conducting interviews with the implementing organizations as follows: informal introductory discussions with a senior advisor to MININFRA; formal interview using technical questionnaire with a senior biogas technicial. Secondary data in the form of reports were provided by the interviewees (see Table 6-2).

6.4.2.2 Energy sources other than wood in Tanzania

Tanzania is situated in east Africa. The borders of the country include the Indian Ocean, Kenya, Uganda, Rwanda, Burundi, the Democratic Republic of Congo, Zambia, Malawi and Mozambique (CIA 2010b). Tanzania has a population of more than 40 million people and 80% of the population is involved in agricultural activities (CIA 2010b).

The main source of electricity in Tanzania is hydro-electric plants with over 90% of the energy in Tanzania coming from hydro (CIA 2010b) with thermal plants providing for peak loads (Tanzania Ministry of Energy and Minerals 2009). In terms of household energy consumption, 97.7% of all household energy for cooking, heating and lighting derives from biomass (Mwakaje 2008).

Tanzanians have limited access to electricity with only 10% of the population connected to the grid, of which only 1% of the population is in rural areas (Tanzania Ministry of Energy and Minerals 2009).

The Tanzanian energy policy (Tanzania Ministry of Energy and Minerals 2009) emphasises the need for a more reliable, environmentally friendly energy supply to improve economic sustainability and eradicate poverty.

In terms of rural energy supply, the energy policy (Tanzania Ministry of Energy and Minerals 2009) has the following objectives: the support of research and development into rural energy alternatives; promotion of energy sources other than wood fuels to reduce deforestation, indoor smoke and time spent collecting firewood; promotion of entrepreneurship and involvement of the private sector in developing the rural energy market; continued electrification to make electricity affordable and accessible to the low income group; establishment of norms, standards guidelines and codes of practice for affordable rural energy supply.

Four case studies were selected in Tanzania namely domestic biogas technology, solar energy, efficient stoves and efficient ovens. A study was done by Mwakje (2008) regarding the opportunities and constraints of biogas use in the Rungwe district in south west Tanzania . The history of biogas in Tanzania started in 1975 when the small industries development organisation constructed 120 floating drum plants in Arusha. At the end of 1989, 200 biogas plants had been installed all over Tanzania and in 1992 this increased to 600 plants. No further figures are given from 1992 to the present.

The study found that there is opportunity for implementation of biogas use in Tanzania due to: availability of zero grazing cows (i.e. cows kept in pens); the general dependence on and shortage of firewood; the government energy policy supporting a diverse range of renewable energy; the benefits to the environment; impact on poverty alleviations including better environmental conditions, labour saving and energy cost saving; and the high cost of firewood.

Primary data was gathered by conducting interviews with a biogas implementer and a biogas user. Mr Elisa (2008) is an employee of the Kilimanjaro Industrial Development Trust (KIDT). KIDT was started in 1978 by the government of Japan to industrialise the Kilimanjaro region of Tanzania, to disseminate knowledge and to provide on the job training. KIDT have constructed eight tubular type biogas plants which have been running for a year. Mr Kidini (2008) lives in the foothills of Kilimanjaro. He has had a biogas installation for 15 years. His biogas installation is still operational. He also has electricity and an electric stove, but prefers not to use biogas for cooking due to the prohibitive cost of electricity. He is an influential man in the community.

The solar energy case study is being implemented by Tanzania Traditional Energy Development and Environmental Organisation (TaTEDO), a non-governmental organisation (NGO) based in Tanzania that specialises in the development of sustainable modern energy services for Tanzanian residents (TaTEDO, 2007). The main goals of TaTEDO are: to improve the quality of life of Tanzanians by facilitating access to modern energy services; to minimise harm to the environment and to contribute to the reduction of Tanzania's dependence on imported energy (TaTEDO, 2007).

Primary data was gathered by interviewing two TaTEDO employees Arnold Nzali and Thomas Mkunda. Secondary data was gathered from three websites, TaTEDO (2007), Mwanza project (Mwanza, 2009) and the Tanzania Solar Energy Association (TASEA, 2009). Secondary data was also obtained from Banks et. al. (2007).

The efficient stove case study is also being implemented by TaTEDO. The project involves the construction of stoves in Hai and Rombo districts in Tanzania. The aim is to install stoves for 6000 to 10000 household over 2 years. Primary data for this case study was gathered during an implementer interview with two TaTEDO employees Arnold Nzali and Thomas Mkunda as well an end user interview with Mr Kidini (2008).

The efficient oven case study is also being implemented by TaTEDO. There are more than 200 small scale bakers using the improved TaTEDO charcoal ovens. Primary data was gathered by interviewing one of the small scale bakers. A shorter interview than ideal had to be conducted due to lack of time. Beatrice Exaud is a small scale baker who uses TaTEDO's efficient charcoal ovens. She was interviewed while she was preparing her batch of bread for the day.

Secondary data in the form of reports were provided by the interviewees (see Table 6-2).

6.4.2.3 Efficient stoves in Malawi

The Republic of Malawi is a small country in southern Africa. It shares borders with Zambia, Tanzania and Mozambique. Malawi is one of the least developed countries in the world, ranking 168 out of a total of 174 countries (GTZ 2009) and more than 90% of the export revenue of the country comes from agricultural products.

The deforestation rate in Malawi is 2.8% per year and is the highest in Africa which is contributed to by the fact that 95% of Malawi's primary energy supply and 90% of total energy is from biomass, mainly in the form of firewood and charcoal (GTZ 2009). Other energy sources used in Malawi include electricity (mainly from hydro) petroleum products, coal and other renewable energy sources but these account for only 7% of the total supply with only 6% of the population of Malawi having access to electricity (GTZ 2009).

Generation of hydro electricity is susceptible to droughts which have become more prevalent and in the south with the progressive deforestation and this has caused deposition of silt and debris in rivers which affects the operation of the hydro plants (GTZ 2009).

In terms of use of biomass, more than half of urban households use charcoal while 38% of peri-urban households use firewood and 97% of rural households use wood (GTZ 2009).

At government level, energy issues are managed by the Ministry of Energy, Mines and Natural Resources which has a Department of Energy Affairs. This department us currently attempting to promote alternatives to charcoal (nine tonnes of wood is required to produce one tonne of charcoal) in the form of gel fuel stoves and ethanol stoves (GTZ 2009). The government energy policy is known as the National Energy

Policy (NEP) and this policy emphasises the reform of the energy sector to ensure a more flexible, private sector-driven energy supply industry (GTZ 2009).

The National Sustainable and Renewable Energy Programme (NSREP) has the goal of promoting renewable energy technologies in Malawi which include solar photovoltaic and photo-thermal, wind energy, biogas and biomass briquettes (GTZ 2009).

The energy policy of Malawi has the target of allowing access to electricity to 10% of the population by 2010, where currently only 7.5% of the population has access to electricity with access to 1% of the rural population and 30% of the urban population (Department of energy affairs 2006).

Two case studies were selected in Tanzania namely efficient stoves and efficient tobacco barns.

The Department of Energy Affairs in Malawi has started substantial energy programmes in Malawi. The goal of these programmes is to decrease the large scale use of charcoal in the country (Chitenje 2008).

The Department of Energy Affairs in Malawi is working with the Programme for Basic Energy and Conservation in Southern Africa (ProBEC) is a programme started by the Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ) in the Southern African Development Community (SADC).

The goal of ProBEC is to ensure that low-income population groups in SADC are enabled to satisfy their energy needs in a social and environmentally sustainable manner and this is done by promoting improved energy solutions through market development and policy support (GTZ, 2009). ProBEC follows a commercial approach actively trains producers to manufacture energy saving cooking devices in order to ensure that a market is developed which will be sustainable once ProBEC funding is no longer available. ProBEC uses results based monitoring to measure the success of projects (GTZ, 2009).

ProBEC has several initiatives in Malawi including the promotion of clay stoves, metal efficient stoves and targeting of employers to install efficient stoves for their workers in their homes. Primary data was gathered for the efficient stoves by conducting implementer interviews with the deputy minister of Energy affairs, ProBEC employees and an employee from one of the tea estates where a fixed type stove is manufactured as well as end user interviews with a group of women involved in stove building and promotion as a business, a metal stove manufacturer, a domestic efficient stove user and a small scale metal stove producer. Secondary data in the form of reports were provided by the interviewees (see Table 6-2).

The efficient tobacco barns were developed for small scale farmers in conjunction with the tobacco industry and NGOs in order to address the damage caused to the environment due to the fact that conventional tobacco drying method uses a lot of wood to cure tobacco. Primary data was gathered by interviewing a GTZ employee. Secondary data in the form of reports were provided by the interviewees (see Table 6-2).

6.4.3 Units of Analysis

The Units of Analysis for the case studies are shown in Figure 6-5.

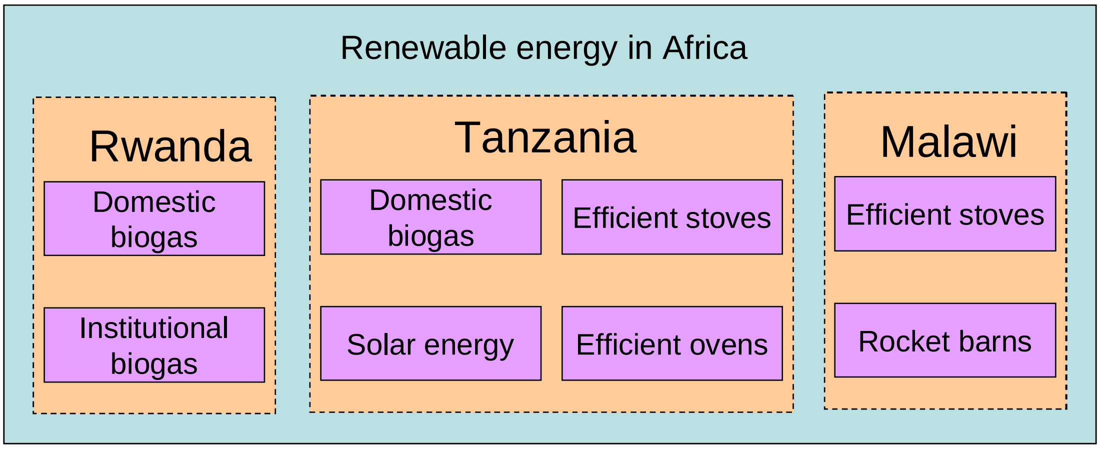

Figure 6-5: Case studies units of analysis

The case studies conducted with primary and secondary data are summarised in Table 6-2.

Table 6-2: Summary of case study primary and secondary data

Case description	Primary data	Secondary data
Domestic biogas in Rwanda	**Implementer interviews:** (Uwizeye 2008a) (Dekelver 2008) **User interviews:** (Speciose 2008) (Gervais 2008) Observation	(Dekelver, *et al.* 2005) (Dekelver, *et al.* 2006) (Huba and Paul 2007) (Bajgan and Shakya 2005)
Institutional biogas in Rwanda	**Implementer interview:** (Uwizeye 2008b)	(Munyehirwe and Kabanda 2008)
Domestic biogas in Tanzania	**Implementer interviews:** (Elisa 2008) **User interview:** (Kidini 2008a) Observation	(Mwakaje 2008)

Case description	Primary data	Secondary data
Solar energy in Tanzania	**Implementer interviews:** (Nzali and Mkunda 2008b)	(TaTEDO 2009) (Banks, *et al.* 2007)
Efficient stoves in Tanzania	**Implementer interviews:** (Nzali and Mkunda 2008a) **User interview:** (Kidini 2008b) Observation	(TaTEDO 2009)
Efficient ovens in Tanzania	**User interview:** (Exaud 2008) Observation	
Efficient stoves Malawi	**Implementer interviews:** (Chitenje 2008) (Gondwe, *et al.* 2008) (Vutuza 2008) (Sukasuka 2008a) **User interviews:** (Mwalimu, *et al.* 2008) (Chipyoza 2008) (Chilewe 2008) (Banda 2008) Observation	(Department of energy affairs 2006) (Gondwe 2007) (Nyengo 2006) (Brinkmann 2004) (Malinski 2008)
Improved tobacco barns	**Implementer interview:** (Sukasuka 2008b)	(Scott 2008)

6.4.4 Case study analysis

In order to facilitate the analyses, the sources of data presented in Table 6-2 are given in Table 6-3 with labels. In the paragraphs that follow, the case study sources are listed using these labels.

The factor numbering which is used in Table 6-5 is explained in Table 6-4.

Table 6-3: Alphabetical sources with labels

Label	Source description
a	(Bajgan and Shakya 2005)
b	(Banda 2008)
c	(Banks, *et al.* 2007)
d	(Brinkmann 2004)
e	(Chilewe 2008)
f	(Chipyoza 2008)
g	(Chitenje 2008)
h	(DeGabriele and Msukwa 2007)
i	(Dekelver, *et al.* 2005)
j	(Dekelver, *et al.* 2006)
k	(Dekelver 2008)
l	(Department of energy affairs 2006)
m	(Elisa 2008)
n	(Exaud 2008)
o	(Gervais 2008)
p	(Gondwe, *et al.* 2008)
q	(Gondwe 2007)
r	(Huba and Paul 2007)
s	(Kidini 2008a)
t	(Kidini 2008b)
u	(Malinski 2008)
v	(Munyehirwe and Kabanda 2008)
w	(Mwakaje 2008)
x	(Mwalimu, *et al.* 2008)
y	(Mwanza 2010)
z	(Ndiwo 2008)
aa	(Nyengo 2006)
ab	(Nzali and Mkunda 2008a)
ac	(Nzali and Mkunda 2008b)
ad	Observation domestic biogas Rwanda, 2008
ae	Observation domestic biogas Tanzania, 2008
af	Observation efficient ovens Tanzania, 2008
ag	Observation efficient stoves Malawi, 2008
ah	Observation efficient stoves Tanzania, 2008
ai	(PAESP 2006)
aj	(Scott 2008)
ak	(Speciose 2008)
al	(Sukasuka 2008a)
am	(TaTEDO 2009)
an	(Uwizeye 2008b)
ao	(Uwizeye 2008a)
ap	(Vutuza 2008)

Table 6-4: Factor descriptions for each factor number

Factor Number	Factor description
	Technology factors
T1	Ease of maintenance and support over the life cycle of the technology
T2	Ease of transfer of knowledge and skills to relevant people in Africa
	Site selection factors
SS1	Local champion to continue after implementation
SS2	Adoption by community
SS3	Suitable sites ready for pilot studies
SS4	Access to suitable sites can be secured
	Economic/ financial factors
E1	Economic development
E2	Availability of finance
	Achievability by performing organisation
A1	Project management
A2	Financial capacity
A3	Technological capacity
	Newly identified factors
N1	Government support
N2	Environmental impact

The analysis of the case studies per factor is based on the summary in Table 6-5. The detail of this analysis is discussed in Appendix N to P. The number of each factor from Table 6-4 is listed in the left-most column. For each factor an indication is then given by using a '√' to indicate which source of evidence supports the inclusion of this factor into the framework of factors.

Table 6-5: Summary of case study data

	Domestic biogas			Institutional biogas		Biogas			Solar		Efficient stoves			Efficient ovens		Efficient stoves			Improved tobacco barns	
Factors	Interviews	Documents	Observation	Interviews	Documents	Interviews	Documents	Observation	Interviews	Documents	Interviews	Documents	Observation	Interviews	Observation	Interviews	Documents	Observation	Interviews	Documents
	Technology factors																			
T1	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√
T2	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√	√	√	√
	Site selection factors																			
SS1	√	√	√		√	√		√	√	√	√		√	√		√	√	√	√	
SS2	√	√			√	√	√		√	√	√	√		√		√	√		√	√
SS3	√	√							√	√						√			√	
SS4	√	√					√		√	√						√	√		√	
	Economic / financial factors																			
E1	√	√		√	√	√	√		√	√	√	√		√		√	√		√	
E2	√	√		√	√	√	√		√	√	√	√		√		√	√		√	√
	Achievability by performing organisation																			
A1	√	√		√	√	√			√	√	√					√	√		√	
A2	√	√				√			√	√	√					√	√		√	
A3	√	√			√	√	√		√	√	√					√	√		√	
	Newly identified factors																			
N1	√	√				√	√		√	√	√					√	√			
N2	√	√					√				√	√				√	√		√	

The paragraphs that follow discuss the case study data captured from each data source for each factor in detail. In order to aid readability, the labels indicated in Table 6-3 are used to reference the sources rather than the Harvard system which is used in the rest of this study.

6.4.4.1 Technology factors

6.4.4.1.1 T1: Ease of maintenance and support over the life cycle of the technology

Ease of maintenance and support over the life cycle of the technology was found to be very important in all the cases examined. The main reason for this is that if the technology is not in working condition, the users will simply abandon it and return to their traditional methods (ai, h, aa, d).

Ease of maintenance and support is ensured in the various cases by implementing the following:

Quality installations. There is a strong focus on quality of installation in the Rwandan domestic biogas programme (i, j, ad). Quality is ensured by monitoring and supervision by the government (j) enforced design, quality and service criteria (a) as well as implementation of national standards (k). In the Tanzanian solar implementations standards to ensure quality were also identified as being important (c). The Malawian efficient stove programme is also monitored and evaluated by the government (g, q). Poor quality undermines end user confidence in technology (ai, h, aa, d, af, ag)

Maintenance plans. Maintenance plans are in place for the Rwandan domestic biogas programme (j). Installing companies are contractually bound to do maintenance for the Rwandan domestic biogas programme (ao and o). This includes follow up visits to ensure operation and optimal use of the biodigestors (k) and a record which is kept by the owner of each plant (ao). A maintenance plan was not drawn up during the implementation of institutional biogas digesters in Rwanda and there is now a serious shortage of technical support for these digesters (ao and v). The biogas digesters installed by KIDT in Tanzania are supported for six months after which the users have to pay for maintenance (m). Maintenance plans should also address the maintenance funding model to be used (c)

Training of technicians. It is important that local technicians be trained (ao, v, s, w, ab, an). Lack of technical support is one of the largest problems in the biogas installations in Tanzania (s and w) as well as for the institutional biogas installations in Rwanda (an). The lack of trained technicians to maintain the solar systems has resulted in a lack of confidence in the systems by the users (y) and the users are also not getting value for money with these systems (am). The solar systems need to be maintained by a technician every six years (ac). The lack of sufficient technicians for the efficient ovens in Tanzania means that users sometimes need to wait for maintenance which creates a problem as the stoves are used in businesses (n).

Maintenance training for users. A formal booklet in the local language is left with the plant owner that describes the maintenance activities required (ao, k). There is no user manual for the Rwandan institutional biogas plants (an) and this has been identified as necessary to help users solve and avoid minor technical problems (ao, ad and v). User training is also required for these plants (v). Users are trained in the use of the new technology in Malawi in order to ensure that they use the technology optimally (q, h, ag).

Keeping maintenance simple. User maintenance is done by the women and children for the biogas plants in Rwanda (ak and o). Maintenance is limited to cleaning of the chimney on a regular basis for the efficient stoves in Tanzania; this means that maintenance can be done by the owner (ac, ae, ah). Maintenance of efficient stoves in Malawi is very simple and close to what the people know (ap, al, ag)

Adapting the technology to the specific environment. Technology implemented in Africa must be robust and easy to handle (r), obtaining spares is a large problem in developing countries (w) and thus the technology selection must take into account the availability of local material (i, aj) and continued research is required to ensure optimal utilisation of the technology (j). Technology must be adapted to the specific environment and requirements of the users (ac, ab, ah, ag). In Malawi the government follows the principle of selecting technology which is as close as possible to what the people already know (g) and continued research is done to ensure durability (u, d). In Malawi for example, the technology was adapted so that the structures of traditional barns could be used to build the efficient barns which saves on material costs (aj). Peripheral issues such as availability and sizes of pots to use must also be taken into account when adapting the technology (h).

6.4.4.1.2 T2: Ease of transfer of knowledge and skills to relevant people in Africa

In general, the simpler the technology selected, the easier the transfer of knowledge and skills to the relevant people in Africa. This is because of the shortage of trained people in Africa in general. The shortage of trained people is more severe in rural areas.

To ensure proper transfer of skills, the following must be considered:

Stakeholders to train. It is important that the correct target group be selected for each training session (h). The following target group must be trained: users (ao, k, ak, o, a, al) including women (i, j), installers / producers (ao, k, a, al), financial institutions (j, a), field facilitators or extension officers (p, aa), trainers (ai), national government (a) and local government (a). In Tanzania, shop owners were selected as the local champions for the technology, and they had to nominate technicians to be trained (ac). This presented a problem during training as some technicians were not adequately skilled and were consequently not trainable - training took longer than anticipated (ac). Sometimes village chiefs also nominated trainees without skills or interest (ac). In Tanzania an awareness programme as also implemented for decision makers to inform them on the benefits of solar technology (c).

Methods of skills transfer. The following methods can be used: user manuals (ao, k, ac, h, d), formal workshops (ac, ai), informal training during and after installation (ak, o), demonstrations (z). Training must be practical (ak, h, ae, ah, af, af). Users are often not willing to pay for training (z). In some cases the performance testing of the technology as well as comparison with the old technology is a prerequisite (h, ag). In Rwanda the private sector federation arranged some of the training workshops (j). Training should be developed in cooperation with women's groups, breeder unions, agricultural and veterinary extension technicians, schools and local NGOs (r). In some of the cases, users are trained by the installers / producers as recommended by the implementing agency (al, h).

Skills to be transferred to users. Training should include technical aspects of operation and maintenance (r, ae, ad, ah) but should also include topics outside of the technology, as for example, cooking techniques (r, aa, u, ag), slurry application (r, ad, ae), hygiene (r), household management (u) and recipes (p, u). The first issue which must be addressed in user training is what the advantages are of adopting new technology rather than keeping the old technology and this can be hampered if influential people in the community, for example, traditional doctors, oppose the implementation (aa).

Skills to be transferred to installers/ producers. Installers/ producers must be trained in installation, (ao), manufacture (u), maintenance (ao, v), quality control (d, u), pricing (u) marketing (p, d, u) and management (ao, y). In the solar PV project in Tanzania, it was found that the majority of technicians did not have electrical installation certificates. It was decided that these technicians could receive limited training which excluded the sizing of installations which would enable them to install and maintain systems (y). In Malawi, a study was conducted to determine whether the people had skills in pottery before the efficient stove project was implemented (p). In cases where the technology is simple as for example the efficient stoves in Malawi, producers who are trained by ProBEC can then train other producers (al).

Quality of training. High quality training is needed (h). Quality of training is ensured by tracking the progress of trainees and supplying additional training if required (ac, ab). Skills transfer can be problematic as trainees often do not have the correct initial skills (ac, y, z). When the technology is basic as for example the efficient ovens implemented in Tanzania, user training is simple (n). In Malawi, the initial training of stove producers was followed up with more training to improve the quality of the stoves and because of the simple technology, the transfer of skills was easy (x, ap, e). Training is necessary when implementing renewable energy technologies to ensure that benefits accrue as expected (q). The quality of the tobacco barns is ensured by ProBEC as each barn is checked after construction (al).

Formalisation of skills transfer. The transfer of knowledge of renewable energy technologies can be formalised by updating school curricula (ac, d, ab) and academic curricula (ao). In Tanzania a course in solar PV is now presented at the Vocational Education Training Authority (y, c)

6.4.4.2 Site selection factors

6.4.4.2.1 SS1: Local champion to continue after implementation

Local champions of renewable energy technologies in Africa are required because much information in rural Africa is communicated by word of mouth as most households do not have access to modern communication technology. Projects in Africa are often successful in the short term when the donor agencies or NGOs are on site with the implementation, but fail when these agencies leave.

Identification of local champion. Local champions in the case studies varied from households (ak, m, s, c, n, t, ad, ae, ah), producers / installers (ac, y, p, e, ai, ab) donor agencies (h, i) specially selected promoters (d) and partner organisations (al). For the Rwanda domestic biogas programme, local champions were identified as the project progressed (ao) but the implementation plan emphasised the use of women as local champions (j, r).

Value of the local champion. Local champions are used for social marketing (Malinski 2008). Demonstration sites are often installed at the houses of the champions and prospective adopters are then brought to these households for demonstrations (ak). It is important that the owners of the demonstration technology are satisfied with the performance of the technology (k, j, r, t). As renewable energy technologies are often new to the areas where they are implemented, innovative individuals who are prepared to take the risk of implementation are required (i, r). In the institutional biogas implementations in Rwanda, the cases where there is a local champion for the plant are successful in the long run (v). Local champions assist in training (al, h), quality control (al), promotion (ai, a, c, x, t), installation (ai), service (ai), .monitoring and supervision (h). If the local champions are properly trained, they can also assist in conflict resolution (aa).

6.4.4.2.2 SS2: Adoption by community

It is important that before a renewable energy project is implemented the capacity in the community be determined. To facilitate adoption by the community the benefits of adoption must be determined and the information must be distributed to the community. Client satisfaction is very important - without this other members of the community will not be willing to adopt a new technology.

Capacity determination. It is important to determine how many households have the capacity to implement the technology (ao, j). Capacity does not necessarily lead to adoption if the cost of the technology is too high (m, s).

Benefits that facilitate adoption. The benefits identified for renewable energy implementations include: smoke reduction (k, d, f, ab), time saving for women and children (k, o, j, r, a, y, ac, am, ai, q, d, ab), improvement in health (k, i, j, r, a, v, w, y, ac, ai, h, z, aa, d, al, an), improved fertiliser (ak, o, a, w), improved effluent management (ak, j, r, a, v), having light at night (ak, w), environmental benefits (k, ak, j, v, ac, am), financial benefit because of the need to purchase less firewood, kerosene and fertiliser (o, r, v, m, s, w, am, ai, h, z, d, f, t), improvement in health services (y), improved time for cooking and curing (h, z, aj) and convenience (j).

Information distribution. It is important that people are made aware of the benefits of the technology to change their attitudes (a, b, z) as negative attitudes can hamper implementation (ap, al). The awareness of the population was raised about solar energy during the Tanzania solar implementation. Before the implementation very few households were aware of the benefits of solar technology (ac, c). This raised awareness resulted in increased enquiries about solar energy (c, y). If the value of the technology is perceived to be low by the community, adoption will be limited (al). Awareness campaigns are necessary to ensure that the consumer population can make rational choices about energy (ai). It was found that the higher the education level of the community the better the adoption rate (d). If people feel that they do not have access to the information about a new technology they will not adopt that technology (d).

Client satisfaction. Quality control is important (ao) to ensure adoption. Client satisfaction is very important to ensure success (a). The technology selected must be close to what the people know and involvement by the community is important (g). The needs of the community must be understood before implementation (p, al). During the implementation of efficient tobacco barns in Malawi, client satisfaction was the main driver in the success of the project (al, aj).

6.4.4.2.3 SS3: Suitable sites ready for pilot studies

In three of the cases, namely the implementation of institutional biogas in Rwanda, domestic biogas in Tanzania and efficient ovens in Tanzania, no evidence was found that pilot studies are important. However, in all the other cases pilot sites were found to be important. The two issues considered were the selection of pilot sites and the value of pilot sites.

Selection of pilot sites. Pilot sites can be selected using partner organisations that work in the local community (ao, al). Implementation at the selected pilot sites must have high quality of implementation and training (j, r, a). Public places such as school or health facilities can be used for pilot sites (ac, y, p).

Value of pilot sites. Pilot sites can be used for training (ao), as part of the promotion campaign (r), iterative development (a, al) and as demonstration plants (ac, al, ab).

Lessons learnt during the pilot phase can be used to improve future implementation (y).

6.4.4.2.4 SS4: Access to suitable sites can be secured

To secure access to suitable sites, the case study implementations used the following methods: determining the priorities of the population in to decide what type of technology is the most important; setting of implementation targets; identification of the criteria that a site must meet before the technology can be implemented there; and identification of suitable sites.

Determine priorities of the population. Energy plans and policies can be investigated (i). Household priorities were investigated and it was determined that replacement of lighting energy had a priority for the households because of the cost of kerosene and candles (r). It is important to understand the priorities of the population as the population might not understand the benefits of a specific technology (ac).

Set implementation targets. Implementation targets can be set in phases (ao, c, ac). Estimates can be made of the number of possible sites (k, y, l, ab).

Identify site criteria. For the biogas plant installations the following criteria were identified to determine suitable sites: climatic conditions must be favourable (i, j), zero grazing is in place (i, r, w), at least two head of cattle (r), water is available at the sites (i), at least 20 kg of dung can be collected per day (j, r), there is a scarcity of firewood (r) and there are community groups in the area which can train and network (r). Lack of connectivity to the grid is also a site criterion (ac, y, l). In the case of tobacco barns in Malawi, the following criteria were identified: farmers must have at least one hectare of land, must be interested in the technology and have the ability to pay for the technology (al).

Identification of sites. Suitable sites can be identified in cooperation with partner organisations (ap, al).

6.4.4.3 Economic/ financial factors

6.4.4.3.1 E1: Economic development

The economic development potential of renewable energies is generally twofold, namely, income generation and household savings. The cost of renewable energy technologies in Africa is kept to a minimum, and large profits are not planned for (k). At national level there is also potential for income and savings.

Income generation. Income is generated from being involved in installing (ao, i, ac, ab) producing (g, p, x, e, b, aa, u), maintaining (i, ac) or providing training for the renewable energy technology (p), or by utilising the product of the renewable energy technology to generate income. Most of the case study implementations focussed on creating a continuous market or sector for the renewable energy technology implemented which contributes to job creation (i, j, r, a, w, ac, am, g, p, ap, e, al, d, ai, ab). In the case studies, income is generated utilising the product of the renewable energy technology as follows: charging batteries (ac), selling fertiliser (ao), mobile phone charging (y, c), radio repair (c), raising chickens (c), packaging milk (c), fish egg aeration (c), cassette sales (c), guest house (c), shop lighting (c), barber shop (y, c), baking bread (am, n) and pasteurizing and selling milk (ac, ab). Improved agricultural production is also possible in the case of biogas and efficient tobacco barns (i, j, r, s, w, al).

Cost and time savings. Households and institutions save money in that they no longer need to buy wood, charcoal, kerosene, candles, batteries and where available, electricity (ao, i, j, r, a, ao, v, s, w, ac, am, e, q, d, u, t, f, ab, an). Women and children save time as they no longer need to gather as much wood (r, w, ai, z, aa, u, ab) and this saved time can be used for economic activities (w, ai, z). These savings are on a monthly basis as renewable energy technology normally has a once off payment and except for maintenance then is “free” (ak).

National income and savings. Countries benefit from renewable energy projects as carbon credits (k, r) can be sold and less expensive energy sources need to be imported (j). Countries further benefit as the renewable energy technology implementations in the case studies also contribute to skills development which is a priority in most African countries (i, j, m, ac, am, g, p).

6.4.4.3.2 E2: Availability of finance

Availability of finance was cited in most of the interviews and documentation as the main stumbling block to the implementation of renewable energy technologies in Africa. The main reasons for this are that the rural population in Africa is very poor, some renewable energy technologies have a high initial installation cost and the availability of firewood (ai) means that the rural population does not see the value of renewable energy technologies. Obviously the initial costs must be kept as low as possible (aj, t).

Payment methods. The main ways of payment were found to be cash (s, u), materials (s), produce (barter) (u) or labour (s, p). Cash is normally raised by selling produce (ak, o, r) or employment (r, n). The savings achieved using renewable energies can be used to pay off loans (v, d). Some of the institutional biogas facilities in Rwanda were funded by donors (an).

Finance methods. Methods used by the programmes to make finance available include subsidies (ao, i, j, a, e, ai), credit loans (k, o, i, j, r, a, m, w, ac, y, c, x, ai, al) and the giving of the renewable energy technology to the population for free (ap, d, u) or on loan (g). Subsidies are provided by donor agencies (ao, c, h) or government (ao). The government can subsidise renewable energy technology by providing financing or by removing duties and taxes (g, ai) on the technology. The rural poor do not normally have access to loans (s) and for this reason the implementing agency must negotiate with banks for favourable rates and payment periods (k, i, r, a, m, ac, y, c, ai). One of the problems that has not yet been solved is the provision of finance to households with seasonal income (ac, y, ab). Subsidies are carefully managed, in some cases subsidy is paid directly to the bank (k, c) and in other cases directly to the installer. Cash was raised through milk sales (ak).

6.4.4.4 Achievability by performing organisation

6.4.4.4.1 A1: Business management

Project management was identified during the focus group and Delphi study as a necessary skill for the performing organisation. During the case studies however it transpired that the skills required by the performing organisation are rather business management skills. In some of the case studies business management training (ab, an) had been implemented whilst in other case studies had been identified as an important requirement. Lack of business skills was identified as a reason why some businesses failed (ac).

Business management skills required. The following business management skills were found to be important during the case studies: market development (ao), marketing (j, ac, al. aa, d, u), entrepreneurship (ao, k, ac, ai), management (ao, k, m, al), personnel management (j), business development (c), price determination (d), financial management and organisational management (j, c, m)

Transfer of business management skills. Skills are transferred through formal training (c) and by doing the work with assistance and support (k, i).

Where skills are lacking. If the performing organisation does not have the required business management skills, the donor organisation or the government can help the performing organisation especially in terms of marketing and market development (p, x, e).

6.4.4.4.2 A2: Financial capacity

Financial capacity refers to the capacity of the performing organisation to finance the components and materials required for technology implementation. Especially when the performing organisation first starts up financial capacity can hinder the organisation from succeeding. With capital intensive technologies such as solar photovoltaics it was found that some performing organisations stop supplying the technology because of financial constraints (y, l).

Methods of dealing with financial capacity. The following methods were implemented to ensure that the performing organisations would have the financial capacity to implement the technologies: financial model of the project set up in such a way that the performing organisation has minimum capital outlay (ao, k, al, ab), subsidies (i, j, r, a, y, l), training to cluster work (k) and using technology that has very little capital outlay (ac, p, x, e, h).

6.4.4.4.3 A3: Technological capacity

Technological capacity of the performing organisation is of paramount importance (d) as poor quality products give renewable energy technologies a bad name in the community (aa, d). Technological capacity was found to be a problem as skills in Africa in general are problematic (y, l, ac, ai). In the case studies, the following methods were utilised to overcome these difficulties:

Quality assurance. Quality control is enforced (a, H, u) and is done by the implementing organisations (j, r, e, al) through monitoring and evaluation (j, u). Subsidies are linked to the quality control system (i, r, a).

Training. Training involves installation (k, v, m, w, ac) and maintenance (v, m, w, ac) training. Refresher courses (ao, r, x) are offered to correct mistakes and also to introduce adaption of processes (h). Training installers on quality is also important (j). Assessment of the skill level in the community was done before the project implementation (p, al, ab).

Support. Support is given by the programme implementers in the form of technical backstopping (ao, e, h, al) and supervision for a time during installation (r).

Regulation. Regulation is twofold, namely certification or registration of installers (ao, r, v, h) and dictating standards (j).

Technology selection. Technology was selected so that it could be installed by semi-skilled workers (i).

Client support. Clients were given technical guarantees (r, a, h) and after sales service (r, a, v).

6.4.4.5 Newly identified factors

The purpose of the case study was not only to confirm the factors identified during the Delphi study but also to determine whether some of the factors that were not rated “Feasible”, “Highly desirable” and “Highly important” during the Delphi study were also important for the case study. These factors were identified by asking the interviewees at the end of the interview to identify other factors which were important and then confirming the importance from the secondary data.

6.4.4.5.1 N1: Government support

In the cases examined, governmental support was stated as being important whether it was available for the specific project or not. Acceptance by the government of the specific renewable energy programme is important (k, g) as was one of the lessons learned in the solar photo voltaic implementation in Tanzania (ac). The government has to support policies to save the environment by banning the cutting of trees for example, and by ensuring that alternatives are available for the population (t, ab).

Governmental support is required in a number of areas including: regulations such as strategies (j), policies (w, l, c) and legislation (s, ai); standards (c); reduction in or elimination of duties and taxes (y); funding or subsidies (ac, y, ai, ab); licensing of technologies (g); setting up energy regulation agencies (l); partnering with donor organisations (r); building technical capacity (c, y, ai); public awareness (ai); market promotion (ai; forest law enforcement (ac, s, ai); health and safety; and monitoring and evaluation (ai).

6.4.4.5.2 N2: Environmental benefits

Environmental benefits were found to be important largely during the implementer interviews and in the supporting documents.

The main environmental benefit of renewable energy technology is that it halts deforestation (ao, i, j, r, s, am, g, e, al, ai, h, d, u, al, t). Other benefits include release of fewer greenhouse gasses (i, j, r, am, ai), protection of fragile ecosystems (am, ai) as well as halting soil erosion (i, am, d), desertification (am) and fresh water pollution (i, ai, d).

6.5 Conclusions

The case studies conducted in three developing African countries have confirmed that the all the factors identified in the Delphi study are important. The wording of one of the factors namely business management has changed from project management. Two new factors, government support and environmental benefitshave also been added to the list.

The final factors identified during the case studies are shown in Figure 6-6.

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Achievability by performing organisation Business management Technological capability Financial capacity	***Economic*** Contribution to economic development Availability of finance	Government support
Site selection Suitable sites for pilot studies Local champion Adoption by community Access to suitable sites can be secured	***Technology*** Ease of maintenance and support Ease of transfer of knowledge and skills	Environmental benefits

Figure 6-6: Final factors as identified through the case studies

Chapter 7 will discuss these findings, and present conclusions and recommendations on the findings.