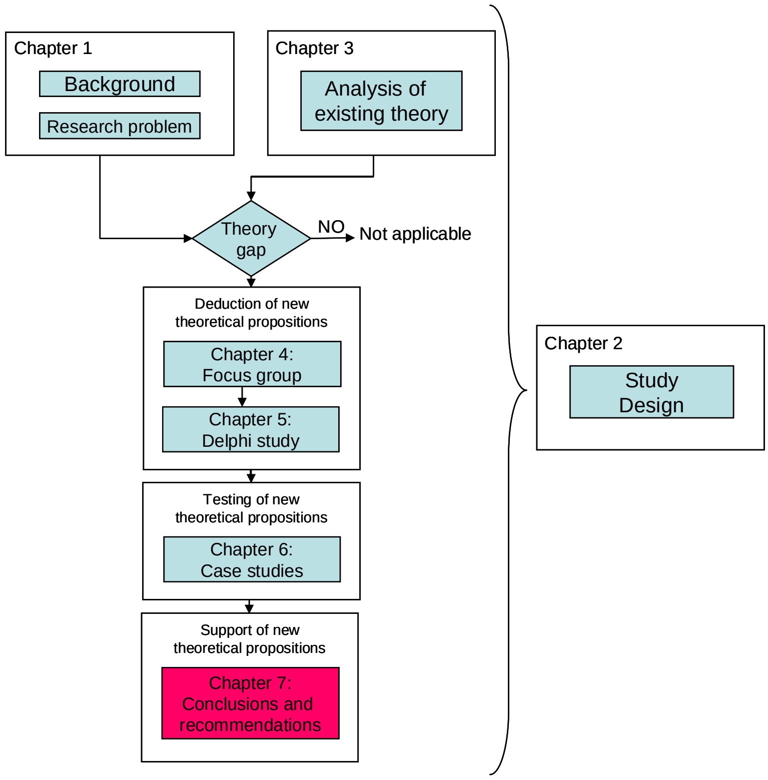
CHAPTER 7: Discussion, conclusions and recommendations



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7.1 Introduction

To date, implementation of renewable energy technologies in Africa has not been sustainable in the long term. Various methodologies for the selection of projects and technologies exist in the literature on the topic. A framework of factors for the selection of renewable energy technologies in Africa had not been summarised until this study was undertaken.

This chapter contains a discussion of the proposed framework for the selection of renewable energy technologies in Africa, followed by recommendations for future work. The data gathered during the focus group, Delphi study and case studies in consolidated in this chapter.

7.2 Discussion of the framework for the selection of renewable energy technologies in Africa

This section contains a discussion of the framework which is proposed as one which could be valuable for the selection of renewable energy technologies in the future. As stated in Chapter 3, the selection of technology requires: a selection methodology, a framework of factors, measures for the factors and rating scales for the factors. Essentially selection methodologies are populated with the framework of factors. This section is a brief discussion of the framework of factors as developed throughout this study from the focus group, through the Delphi study and the case studies (see Table 7-1) and suggestions are made as to the measures and ratings which can be applied for each factor.

Table 7-1: Changes in the factors from focus group through the Delphi study and case studies

Factor description	Focus group identification	Delphi study definition	Important issues for each factor from case studies
Technology factors			
Ease of maintenance and support over the life cycle of the technology	Maintenance/ support	Security of supply is enhanced. It also implies that spares are affordable and can be easily acquired.	Quality of the installations, the maintenance plans, the training of technicians, maintenance training for users, keeping maintenance simple and adapting the technology to the specific environment
Ease of transfer of knowledge and skills to relevant people in Africa	Transfer of knowledge and skills	Transfer of knowledge and skills to the community involved. Dedicated personnel to run the facility are required.	Identification of stakeholders to train; methods of skills transfer applicable to the environment; quality of training; and formalization of skills transfer.

Factor description	**Focus group identification**	**Delphi study definition**	**Important issues for each factor from case studies**
Site selection factors			
Local champion to continue after implementation	Local hero – champion to continue after implementation	Facilitators of the technology exist which will ensure that the facility will continue after implementation.	Local champions must be identified during technology selection, their responsibilities must be clearly defined and they must be aware of the long term implications of their role
Adoption by community	Passion/ ownership/ buy-in/ adoption by community, responsibility	Community adopting the technology, accepting ownership, demonstrating buy-in and taking responsibility	A determination must be done of the capacity of the population to adopt the new technology, the benefits of the new technology must be determined and communicated to the community and that measures must be in place to ensure client satisfaction
Suitable sites ready for pilot studies	Pilot study site selection issues	Pilot studies are necessary to demonstrate technology to decision makers	Selection of pilot sites is very important and valuable; pilot sites must be selected in such a way that they will be accessible for demonstration purposes to the community
Access to suitable sites can be secured	Not applicable	Access for implementers to sites where the technology can be implemented must be secured up front	Determine priorities of population; set implementation targets; identify site criteria; and identify site
Economic/ financial factors			
Economic development	Economic development (community eventually able to pay), economic sustainability	Economic development translates into (a) the community being able to pay for services and (b) economic sustainability	Income generation, cost and time saving and national income and savings all contribute to economic development
Availability of finance	Available budget – the finances to support a project	The determination of the required budget and the availability of finance for this budget are addressed here. The type of finance whether debt, equity or grant must also be taken into account.	Finance can be facilitated by implementing payment methods which are applicable for the households, as for example, bartering and that finance methods must be in place before the technology can be implemented on a large scale

Factor description	Focus group identification	Delphi study definition	Important issues for each factor from case studies
Achievability by performing organization			
Business management	Proper project management	The performing organization having the business management capacity and procedures in place to ensure that the implementation of technology can be done successfully	Which business management skills should be transferred, how the skills are to be transferred and what to do in the short term when the skills of the organization are lacking
Financial capacity	Financial capacity	Both the administrative capacity to manage finances and the ability to deliver, given the payment conditions.	Financial capacity for performing organizations can be problematic at the outset but that various methods can be used to alleviate the financial capacity required by the performing organization.
Technological capacity	Capacity	The performing organization has the correct technology necessary for implementation of the project at their disposal.	Technological capacity is directly related to quality. Quality assurance must be enforced; regulation of performing organizations and the dictating of standards also contribute to quality installations.
Other factors			
Government support	Regulatory financial incentive, tax regimes must be supportive" and does it fit under national priorities	Governmental support has been obtained for the technology	In the first place, the government must be aware of the new technology and support its implementation. If the government is also prepared to assist in the implementation, success of implementation is further enhanced.
Environmental benefits	Environmental impact assessment	The implementation of the technology will have a positive impact on the environment	Environmental benefits may include: decrease in the release of greenhouse gasses; protection of fragile ecosystems; halting soil erosion; halting desertification; prevention of fresh water pollution.

7.2.1 Ease of maintenance and support over the life cycle of the technology

The definition of this factor, namely ease of maintenance and support over the life cycle of the technology, is as follows: *ease of maintenance and support means that the security of supply is enhanced. It also implies that spares are affordable and can be easily acquired.*

This factor was first identified in the focus group as “maintenance/support” and was expanded to the final description during the first round of the Delphi study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The case study showed that this factor relates to the quality of the installations, the maintenance plans, the training of technicians, maintenance training for users, keeping maintenance simple and adapting the technology to the specific environment. The first round of the Delphi study comments emphasised that spares must be affordable and available.

During the selection phase, it can be difficult to measure the quality of the proposed technology. One way of ensuring quality is to ensure that a high-level quality plan is in place before the selection decision is made. The quality plan must address: the standards that the installations must comply to; monitoring methodology of installations; evaluation to ensure that standards are being applied; types of corrective action required for non-compliance and a clear statement on the responsibility for quality processes.

Long term maintenance and support is also difficult to ensure when selecting the technology. Ensuring that an overall maintenance plan is in place before technology selection and comparing the quality of the various sections for different proposals can help in the selection decision. The maintenance plan must address operator maintenance, sustainable technical maintenance, responsibilities for maintenance and, very importantly, the maintenance funding model.

The training of technicians, maintenance training for users and keeping maintenance simple can be assessed by studying the training plan.

It is not always possible to implement renewable energy technologies that operate successfully elsewhere in a new setting without adapting the technology for the social, environmental and maintenance conditions in the new setting. The level of adaptation of technology can be determined by assessing whether it is: an off the shelf implementation; adapted for another developing country outside Africa; adapted for another country in Africa; or, adapted for the specific application within the country. It is also important to determine whether the adaptation has been verified.

The measures and rating methods proposed from the case study are summarised in Table 7-2.

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Table 7-2: Measures and rating method for ease of maintenance and support over the life cycle of the technology

Measure	Method of measurement	Rating method
Quality plan	The quality plan addresses:	
	Standards defined	In detail; very generally; not at all
	Monitoring defined	In detail; very generally; not at all
	Evaluation defined	In detail; very generally; not at all
	Corrective action defined	In detail; very generally; not at all
	Responsibility for quality processes defined	In detail; very generally; not at all
	Warranty	Duration of warranty:
Maintenance plan	The maintenance plan addresses:	
	Simplicity of operator maintenance	Minimal operator maintenance; irregular operator maintenance; regular operator maintenance
	Sustainable technical maintenance	Technical maintenance dependant on external supplier; technical maintenance dependant on local supplier
	Responsibilities for maintenance	Maintenance responsibility mainly with operator; maintenance responsibility mainly with local supplier; maintenance responsibility mainly with external supplier
	Maintenance funding model	Cost of maintenance per annum after warranty expires: Responsibility for funding identified
	Availability of spares	Local off the shelf; in nearest town off the shelf; ordered from external supplier
Adaptation of technology	Off the shelf implementation:	Yes/ No
	Adapted for another developing country outside Africa	Yes/ No
	Adapted for another country in Africa	Yes/ No
	Adapted for specific application	Yes/ No
	Adaptation has been verified	Yes/ No

7.2.2 Ease of transfer of knowledge and skills to relevant people in Africa

The definition of this factor, "ease of transfer of knowledge and skills to relevant people in Africa" is as follows: *at macro level this refers to transfer of knowledge and skills to the African state involved. At micro level it refers to transfer of knowledge and skills to the community involved. At both levels, dedicated personnel to run the facility are required.*

This factor was first identified in the focus group as "transfer of knowledge and skills" and was refined to the current wording during the first round of the Delphi study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The case study research indicated that this factor relates to: identification of stakeholders to train; methods of skills transfer applicable to the environment; quality of training; and formalisation of skills transfer. The comments gathered in the first round Delphi study also emphasised that dedicated personnel are required if a large scale facility is under consideration.

Measuring the ease of transfer of knowledge and skills to relevant people in Africa can present challenges when selecting technologies.

The lack of skills in Africa hampers the transfer of knowledge and skills. The first step therefore is to determine the level of skills of all the stakeholders in Africa who are involved in the technology to ascertain the level of training which will be required for the specific technology.

Language diversity is another challenge. Operator and technical manuals may exist in the European language of the original developers of the technology. As a result of the colonisation of Africa by various European countries, there is no common European language which is understood by all the people of Africa. African countries are most often occupied by various tribes which means that even in the same country there may be more than one local language. Operator and technical manuals written in a language which is not understood by the operators and technicians will obviously hamper the transfer of knowledge and skills. In some cases the technical language required to describe the operation and maintenance activities required may not exist in the local language. The more technologically advanced the solution, the bigger the problem this will pose.

Operator and technical manuals must also be adapted to the specific environment in which the technology will be implemented. Operator and technical training must be of sufficient duration that the knowledge and skills can be successfully transferred. The method used to transfer knowledge and skills during the training is also very important. In the case studies hands-on methods were preferred.

Another consideration is the model for funding of training. Users, technicians and installers are not usually willing to pay for training. This is mainly because they cannot afford to do so. It is therefore important that a funding model for training be put in place at the outset.

Further, it is crucial to clearly assign an organisation which will be responsible for the training effort. This organisation will be responsible for developing the training material, presenting the training or ensuring that others are trained to present the training, monitoring and evaluating the training and ensuring that follow up training is arranged if required.

The life cycle of the technology when planning training activities is important. Previously trained individuals may leave the area for various reasons and retraining may be required.

Before selecting the technology the various stakeholders must be identified and it must be determined which of these stakeholders requires training. Training is not limited to operators and technicians but could also include financial institutions which will provide financing, field facilitators, local and national government.

In some cases skills peripheral to the technology must also be transferred. In the case of efficient stoves for example, people need to be taught kitchen management and how to adapt recipes.

The measures and rating methods proposed from the case study are summarised in Table 7-3.

Table 7-3: Measures and rating method for ease of transfer of knowledge and skills to relevant people in Africa

Measure	Method of measurement	Rating method
Training plan	The training plan addresses:	
	Skills levels of local people	Skills level has been determined and major training is required; skills level have been determined and minimal training is required; skills level has not yet been determined
	Operator training	Duration; method to be used
	Operator manual	Operator manual in European language; operator manual in local language Standard operator manual; operator manual adapted for specific environment
	Technician training	Duration; method to be used

Measure	Method of measurement	Rating method
	Technical manual	Technical manual in European language; technical manual in local language Standard technical manual; technical manual adapted for specific environment
	Training funding model	Cost of training per annum after warranty expires: Responsibility for funding identified
	Responsibility for training addressed?	Yes/ No
	Is training quality assured through tracking process of trainees as well as monitoring and evaluation? Is additional training provided if required?	Yes/ No
	Is the training plan sustainable over the life cycle of the technology?	Yes/ No
Identification of stakeholders to train	Are the following entities part of the training schedule: Users; installers or producers; financial institutions; field facilitator; national government; local government.	Yes/ No If any of the parties is not being trained, specify why.
Methods of skills transfer	What specific method will be used for skills transfer?	Hands on with follow up; hands on; workshop; presentation
Skills to be transferred	Are user-taught skills peripheral to the technology (e.g. cooking methods and recipes in the case of efficient stoves, slurry application in the case of biogas, hygiene)? Has a baseline study been done to determine the skills levels in the area of application? If the skills levels are lacking, has this been appropriately addressed?	Yes/No

7.2.3 Local champion to continue after implementation

The definition of this factor, “local champion to continue after implementation”, is as follows: *facilitators of the technology exist at governmental or local level, which will ensure that the facility will continue after implementation. The facility benefits most of the citizens.*

This factor was first identified in the focus group as “local hero – champion to continue after implementation” and was refined to the current wording during the first round of the Delphi study. In the second round of the Delphi study, it was found that

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it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The comments in the first round Delphi study also emphasised that the proposing organisation would have to show whether there were facilitators and would have to conduct campaigns if and when necessary. The case study showed that local champions must be identified during technology selection, their responsibilities must be clearly defined and they must be aware of the long term implications of their role.

Local champions who will be able to continue promoting and supporting the technology after the implementation team has left must be identified at the outset. In the various case studies the local champions had diverse responsibilities. The responsibilities of the local champions must be clearly identified and communicated to the selected champions.

The measures and rating methods proposed from the case study are summarised in Table 7-4.

Table 7-4: Measures and rating method for local champion to continue after implementation

Measure	Method of measurement	Rating method
Identification of local champions	Have local champions been identified? Have the responsibilities of the local champions been clearly identified? Are local champions aware of their responsibility to continue their work after project hand over?	Yes/No

7.2.4 Adoption by community

The definition of this factor, “adoption by community”, is as follows: *this factor relates to the community adopting the technology, accepting ownership, demonstrating buy-in and taking responsibility. The implications of the proposed ownership structure must also be indicated in the proposal.*

This factor was first identified in the focus group as “passion/ ownership/ buy-in/ adoption by community, responsibility” and was refined to the current wording during the first round of the Delphi study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The comments in the first round Delphi study also emphasised that addressing this factor properly would lead to smoother implementation. The case study showed that a determination must be done of the capacity of the population to adopt the new technology, the benefits of the new technology must be determined and communicated to the community and that measures must be in place to ensure client satisfaction.

The capacity for the implementation of the technology must be determined before the technology is selected. This is done in terms of the number of households which have the requirements for the installation of the technology. The current status of each household in terms of income, current expenditure on energy, time and cost and the possibilities for businesses in the area once the technology has been implemented must be determined. This baseline is required to determine whether the technology will benefit the community and also whether the community can afford to adopt the technology.

It is important that the technology be sustainable in the long term. The ownership of the product of the project must be identified at this stage.

The benefits of the specific technology to the population must be determined and information about these benefits must be communicated to the population. The use of the technology must also be explained to the population and a determination must be made of the interest in the technology. The closer the technology to be implemented is to what is currently being used, the higher the chance that the community will adopt it.

The measures and rating methods proposed from the case study are summarised in Table 7-5.

Table 7-5: Measures and rating method for adoption by community

Measure	Method of measurement	Rating method
Capacity determination	Has a detailed capacity determination been done in the area of deployment? Have household income, current expenditure on energy, current time spent on energy and possibilities for businesses been reviewed? Does the current analysis indicate long term sustainability of the technology? Is the ownership of the product of the project clearly defined?	Yes/No
Benefits determination	Have the benefits of the technology been determined? Do the benefits address the needs of the population?	Yes/No
Information distribution	Has information been distributed to the population regarding the use and benefits of the new technology? Did the population show an interest in adopting the new technology?	Yes/No

Measure	Method of measurement	Rating method
Adoption probability	How similar is the technology to that which is currently used by the population?	Very close; close but a change in mindset is required; completely different from what is currently used

7.2.5 Suitable sites ready for pilot studies

The definition of this factor, "suitable sites ready for pilot studies", is as follows: *pilot studies are necessary to demonstrate technology to decision makers.*

This factor was first identified in the focus group as "pilot study site selection issues" and was refined to the current wording during the first round of the Delphi study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The comments in the first round Delphi study also emphasised that this factor reinforces project acceptability and shows that a proper implementation process is being followed. The case study showed that the selection of pilot sites is very important and valuable.

Before the technology can be selected, it must be determined whether suitable sites are available for piloting the technology. The pilot sites must be selected in such a way that they will be accessible for demonstration purposes to the community.

The measures and rating methods proposed from the case study are summarised in Table 7-6.

Table 7-6: Measures and rating method for suitable sites ready for pilot studies

Measure	Method of measurement	Rating method
Selection of pilot sites	Have pilot sites already been selected for this technology?	Yes/No
	How many pilot sites have been selected?	Number
	Where have the pilot sites been selected?	In a public place; in a private place
	If the pilot site is under control of a private entity, is the proposed owner willing to allow demonstration at the site?	Yes/No
	Are any pilot sites already operational and ready for inspection?	Yes/No

7.2.6 Access to suitable sites can be secured

The definition of this factor, “access to suitable sites can be secured”, is as follows: *access for implementers to sites where the technology can be implemented must be secured up front.*

This factor was identified during the first round of the Delphi study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The case study showed that for access to suitable sites the following must be in place: determine priorities of population; set implementation targets; identify site criteria; and identify sites.

Securing access to suitable sites for implementation of the technology will be dependant on the priorities of the population and whether the technology contributes to those priorities.

Realistic and achievable implementation targets must be set in the implementation plan. Any technology-specific site requirements must be documented in the implementation plan. For example, for a biogas plant, access to water and location of the cowshed close to the kitchen is required.

The measures and rating methods proposed from the case study are summarised in Table 7-7.

Table 7-7: Measures and rating method for access to suitable sites can be secured

Measure	Method of measurement	Rating method
Determine priorities of the population	Have the priorities of the population been determined? Does the technology address the priorities of the population?	Yes/No
Set implementation targets	Does an implementation plan exist? In how many sites is technology to be implemented in the first six months? In how many sites is technology to be implemented in the first year? How many sites will be in place after five years?	Yes/No Number (a large number is preferred)
Identify site criteria	Are there any limitations or special requirements for the implementation of the technology? Limitations can include installation of the technology within a certain distance from the dwelling. Special requirements can include the availability of water.	List of special requirements List of limitations

7.2.7 Economic development

The definition of this factor, “economic development”, is as follows: *economic development translates into (a) the community being able to pay for services and (b) economic sustainability.*

This factor was first identified in the focus group as “economic development (community eventually able to pay), economic sustainability” and was refined to the current wording during the first round of the Delphi study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The comments in the first round Delphi study also emphasised that, in the case of Africa, there is a higher premium on the benefit of the technology to the population and less emphasis on profit. The case study showed that income generation, cost and time saving and national income and savings all contribute to economic development.

Economic development can be achieved by job creation during the implementation of the new technology. Household income can also be improved if the cost for the new technology is lower than what is currently spent. The time spent by a household to collect fuel for energy can be spent in a productive way once the new technology is implemented.

At a national level renewable energy technologies can translate to income through the selling of carbon credits. Savings can also be made if the technology replaces an expensive resource, for example oil, which has to be imported and is subject to price fluctuations.

The measures and rating methods proposed from the case study are summarised in Table 7-8.

Table 7-8: Measures and rating method for economic development

Measure	Method of measurement	Rating method
Income generation	How many job opportunities will be created by implementing this technology?	Number (a higher number is preferred)
Domestic cost and time saving	How much time does a family currently spend on average per month to collect fuel for energy? How much money does a family currently spend on average per month for fuel for energy? How much time will the implementation of this technology save per month per family? How much money will a family save per month by implementing this technology? What is the initial installation cost of the technology?	Numbers (a higher number is preferred)
National income and saving	How many carbon credits will this project generate? Does this technology replace an energy source which is currently imported?	Number (a higher number is preferred) Yes/No

7.2.8 Availability of finance

The definition of this factor is as follows: *the determination of the required budget and the availability of finance for this budget are addressed here. The type of finance whether debt, equity or grant must also be taken into account.*

This factor was first identified in the focus group as "available budget – the finances to support a project" and was refined to the current wording during the first round of the Delphi study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The comments in the first round Delphi study also emphasised that the success of the technology (especially in poor areas) is dependant on the availability of funding at grassroots level. The case study showed that finance can be facilitated by implementing payment methods which are applicable for the households, as for example, bartering and that finance methods must be in place before the technology can be implemented on a large scale.

A financing plan must be in place before the technology is selected. The financing plan must address the question as to whether users can afford the initial investment required to implement the technology. If this is not the case, other measures must be investigated.

If users cannot afford the once off investment required to implement the technology, one of the methods to facilitate implementation is to adapt the technology to the environment so that users can supply material which is available but needs to be gathered, barter goods for the technology or provide labour for the implementation of the technology. An example of this is where farmers dig the holes required for biogas installations.

Financing schemes should be put in place before the technology is implemented. Financing schemes are however useless if the users will not be able to pay off the loans. It must therefore be determined whether users will be able to pay off loans, either by virtue of the income which they already receive, or because of the savings they make, or as a result of business opportunities or an environment more conducive to development becoming available to them when they use the new technology. These opportunities may be directly the result of using the new technology or indirectly as the time saved can be used productively, instead of gathering fuel. Also, if the technology, for example, provides lighting, they can be more productive for longer periods of the day.

The availability of donor funding can facilitate implementation of a new technology. It must nevertheless be clear from the outset what part of the implementation the donor funding will support, what is excluded from the support and also for how long the donor funding will be available.

Financial institutions should be approached up front to supply loans for the implementation of new renewable energy technologies if financing is required. It is important that allowance be made for households which have a seasonal income. The rates and payment periods should be negotiated on behalf of the users as especially users in rural areas do not have access to financing.

Government support of implementation of new renewable energy technologies is important and is consequently covered as a separate factor. In terms of financing however, it must be determined whether financial support for the technology will be forthcoming either in the form of subsidies or by the removal of duties and taxes.

The measures and rating methods proposed from the case study are summarised in Table 7-9.

Table 7-9: Measures and rating method for availability of finance

Measure	Method of measurement	Rating method
Financing plan	The financing plan must address the following aspects: Can the users afford the initial investment required for the technology in a once off payment?	Yes/ No
	If not, can the users contribute to the initial investment by means of providing materials that are freely available (such as rocks), by bartering goods or by providing labour for the implementation of the technology?	Materials can be supplied; goods can be bartered; labour can be supplied
	If financing is made available will the users be capable of paying off loans?	Yes, due to income which they receive; yes, due to the savings they make on other energy supply; yes, due to the business opportunities created by the technology; no
	Is donor funding available? If so for what part of the life cycle is the donor funding available?	Yes/ No To supply initial investment; to supply initial training; to support short term maintenance; to support long term maintenance
	Are financial institutions willing to provide loans for the initial investment required? Do loans make allowance for households with seasonal income? What rates and payment periods have been negotiated?	Yes/ No Yes/ No Numbers (lower rates and longer payment periods are preferred)
	Is government supporting the implementation of the technology? What percentage of the initial investment is the government supporting?	By providing subsidies for initial installations; by removing duties and taxes. Number (a high percentage is preferred)

7.2.9 Business management

The definition of this factor, “business management”, has been adapted as follows: *this relates to the performing organisation having the business management capacity and procedures in place to ensure that the implementation of technology can be done successfully.*

This factor was first identified in the focus group as “proper project management” and was refined to the current wording during the case study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The comments in the first round Delphi study also emphasised that the performing organisation determines the success or failure of the implementation of the technology. The case study showed which business management skills should be transferred, how the skills are to be transferred and what to do in the short term when the skills of the organisation are lacking.

Business management skills to be transferred include: market development; marketing; entrepreneurship; general management; personnel management; business development; price determination; financial management; organisational management.

Before the performing organisation is given the go-ahead to implement the new renewable energy technology, the capabilities in terms of business management of the performing organisation must first be determined. In some cases an existing organisation may be up-skilled to do the implementation. In other cases new organisations would need to be created.

In the case where an organisation must be up-skilled, the organisation may already have some of the business management skills required. For example, in Tanzania shop owners who already had successful businesses were tasked with rolling out solar technology (with limited success). The organisation may also have some of the technical skills required but will need to learn the business skills.

The method of skills transfer is important. Formal training may not be sufficient especially if the basic skills of the personnel of the organisation do not meet minimum standards. Ongoing mentoring and coaching is preferred. During the implementation phase the performing organisation can be supported with the required skills but for long term sustainability, the required skills will need to be transferred.

The measures and rating methods proposed from the case study are summarised in Table 7-10.

Table 7-10: Measures and rating method for business management

Measure	Method of measurement	Rating method
Determine current organisations in place	Are there currently organisations in place that can be tasked with implementing the new technology?	Yes/ No
	If not, are there organisations that have business management skills but in other applications?	Yes/ No
	If not, are there organisations with related technical skills?	Yes/ No
	Will a new performing organisation need to be created?	Yes/ No
Determine capabilities of the performing organisation	Does the performing organisation have skills and experience in the following areas of business management? • Market development • Marketing • Entrepreneurship • General management • Personnel management • Business development • Price determination • Project management (time, cost, quality) • Organisational management	Yes/ No
Business skills training	How will business skills be transferred to the performing organisation?	Formal training; informal hands on training; mentoring and coaching; do not know
	What interim measures will be put in place to compensate for lack of skills in the short term?	Performing organisation will be supported with business management; none

7.2.10 Financial capacity

The definition of this factor, "financial capacity", is as follows: *financial capacity refers to both the administrative capacity to manage finances and the ability to deliver, given the payment conditions.*

This factor was first identified in the focus group as "financial capacity" and remained as that wording during the case study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The comments in the first round Delphi study also emphasised that the performing organisation must exercise financial discipline when implementing the new technology. The case study showed that financial capacity for performing organisations can be problematic at the outset but that various methods can be used to alleviate the financial capacity required by the performing organisation.

Before the selection of a new technology it must be determined whether the performing organisation has the required administrative capacity to manage finances. If this administrative capacity is not in place, measures must be taken to address the administrative capacity.

Another important consideration about financial capacity of the performing organisation is the capital outlay required to implement the new technology. This capital outlay may be in terms of new equipment required to manufacture the technology, purchasing the components of the technology, purchasing the material for implementing the technology or infrastructure required to implement the technology. Lack of capital will hamper the ability of the performing organisation to deliver the new technology and so must be determined up front.

If the implementation of the technology will be hampered by the lack of capital, measures must be put in place which will alleviate the problem. These measures include the provision of subsidies or loans. Capital outlay can also be limited by clustering work.

The measures and rating methods proposed from the case study are summarised in Table 7-11.

Table 7-11: Measures and rating method for financial capacity

Measure	Method of measurement	Rating method
Financial capacity of the performing organisation	Does the performing organisation have the administrative capacity to manage finances? If no, how will this be addressed?	Yes/ No Formal training; coaching and mentoring; appointment of competent personnel; do not know
Capital outlay	What is the capital outlay required by the performing organisation?	Number (a lower number is preferred)
	Does the performing organisation have the financial resources for this capital outlay?	Yes/ No
	If not, are alternatives available to assist the performing organisation with capital outlay costs?	Subsidies; loans; none
	Can capital outlay be minimised by training the performing organisation to cluster work?	Yes/ No

7.2.11 Technological capacity

The definition of this factor, “technological capacity”, is as follows: *the technological capacity of the performing organisation means that the performing organisation has the correct technology necessary for implementation of the project at their disposal.*

This factor was first identified in the focus group as “capacity” and was refined to the current wording during the first round Delphi study pilot study. In the second round of the Delphi study, it was found that it was feasible to consider this factor during technology selection and that it is also highly important and highly desirable.

The comments in the first round Delphi study also emphasised that technical knowledge can be bought in from specialists and need not be developed in-house. The case study showed that technological capacity of the performing organisation is important over the long term as it is directly related to quality. Quality assurance must be enforced; regulation of performing organisations and the dictating of standards also contribute to quality installations. Client support is important both in terms of technical guarantees as well as after sales service. The technological capacity of the performing organisation is assured by training and technical backstopping when required.

Before technology selection, organisations must be identified which have the technological capability to implement the technology. In the short term, technical backstopping can be done but to ensure long term sustainability detailed training and refresher courses are required.

A quality plan must be in place before the selection of the technology. The body responsible for quality assurance must be clearly identified. The linking of financial incentives to the sustaining of quality is recommended. Regulation of the industry by certification of performing installations is one measure which can improve quality. Another measure is enforcing standards for the technology. During selection, technologies which can be installed by semi-skilled workers should be given preference. The quality plan must also address client support in both the short and the long term.

The measures and rating methods proposed from the case study are summarised in Table 7-12.

Table 7-12: Measures and rating method for technological capacity

Measure	Method of measurement	Rating method
Technological capacity of the performing organisation	Does the performing organisation have the technological capacity to implement the new technology?	Yes/ No
	If not, how will the technological capacity be assured? Manufacturing training Installation training Maintenance training Refresher courses Quality training Technical backstopping	Yes/ No
Quality plan	A quality plan must be in place that addresses the following:	
	Who is responsible for quality assurance?	Performing organisation; government agency; third party; do not know
	Is there a financial incentive coupled to quality?	Yes/ No
	Is there any regulation in place for the technology?	Certification of performing organisations; standards; none
	Can the technology be installed by semi-skilled workers	Yes/ No
	How will clients be supported? Technical guarantees After sales service	 Duration of guarantee Duration of after sales service

7.2.12 Government support

The definition of this factor, government support, is as follows: *Governmental support has been obtained for the technology.*

This factor was not explicitly defined in the focus group but lower level factors such as “regulatory financial incentive, tax regimes must be supportive” and “does it fit under national priorities” were identified. In the second round of the Delphi study, both factors were found to be feasible, desirable and important and were subsequently discarded as only feasible, highly desirable and highly important factors were finally considered.

The more generic factor of government support was however found to be important in Africa during the case studies; it was important in all eight cases investigated. In the first place, the government must be aware of the new technology and support its implementation. If the government is also prepared to assist in the implementation, success of implementation is further enhanced.

The measures and rating methods proposed from the case study are summarised in Table 7-13.

Table 7-13: Measures and rating method for government support

Measure	Method of measurement	Rating method
Acceptance by government	Is the government aware of the renewable energy technology which is being proposed?	Yes/ No
	Does the government support the renewable energy technology which is being proposed?	Yes/ No
Involvement of government	Is the government currently assisting or willing to assist the new technology with any of the following: • Energy policies • Energy legislation • Standards for the technology • Relief on taxes and/ or duties • Funding for the technology • Subsidies for the technology • Licensing of the technology	Yes/ No

7.2.13 Environmental benefits

The definition of this factor, "environmental benefits", is as follows: *the implementation of the technology will have a positive impact on the environment.*

This factor was not explicitly defined in the focus group but "environmental impact assessment" was identified. This was changed to "degree of environmental impact of the technology" during the pilot of the first round of the Delphi questionnaire. This factor scored feasible, highly desirable and important during the second round of Delphi but was discarded as only feasible, highly desirable and highly important factors were finally considered.

Environmental benefits were however found to be important in all eight cases investigated.

It is important that the environmental benefits of a technology be considered during technology selection. Environmental benefits may include: decrease in the release of greenhouse gasses; protection of fragile ecosystems; halting soil erosion; halting desertification; prevention of fresh water pollution.

The measures and rating methods proposed from the case study are summarised in Table 7-14.

Table 7-14: Measures and rating method for environmental benefits

Measure	Method of measurement	Rating method
Environmental benefits of the technology	What are the environmental benefits of the technology? • Decreases release of greenhouse gasses • Leads to protection of fragile ecosystems • Will contribute to halting soil erosion • Will contribute to halting desertification • Will prevent fresh water pollution	Yes/ No

7.3 Limitations of the study

This section addresses the limitations of this study specifically due to the small sample size of the Delphi study, the use of a different model for selection of factors in future similar Delphi studies, the use of variability coefficients and hierarchical clustering for further analysis of the case study data and the need for change management when selecting renewable energy technologies in Africa.

When conducting a Delphi study it is important to note that Delphis must not be confused with conventional quantitative surveys (Mullen, 2003). Linstone and Turoff (1978) state the a suitable minimum panel size is seven and also that accuracy decreases rapidly with smaller panel sizes and improves more slowly with larger numbers. This study had a panel size of seven which means that the minimum requirement was met. A larger panel size might have ensured that all thirteen factors finally identified during the case studies were identified during the Delphi study and might also have generated more factors. In the final analysis however, due to the triangulation of methods, the final result of the study was not compromised by achieving the minimum panel size.

The decision to use Likert scales for feasibility, desirability and importance for the rating of factors during the Delphi study can also be seen as a contentious issue. In the study participants were informed on the definitions of scales and the scales were based on those used by Jillson (1975). Other definitions for example technology, economy and acceptability could also have been used and should be investigated in future Delphi studies of this nature.

The case study data was analysed using simplistic pattern analysis. The answered obtained during the interviews and in the secondary data was compared to the factors identified during the Delphi study in a binary manner i.e. either there was evidence available or there was not. The case study data can be further analysed using variability coefficients and hierarchical clustering as this might produce a more in depth view on the data.

The issue of change management has not been addressed in this study as the study deals with the selection of technologies and not *per se* the implementation of these technologies. Change management is “a structured approach to transitioning individuals, teams, and organisations from a current state to a desired future state”, and includes both organisational change management processes and individual change management models (Lewis et al 2002). In terms of this study, the entity to be transitioned will be the community and the desired future state is successfully implemented renewable energy technologies. Some of the factors identified here as being important for technology selection will also need to be addressed in the change management plan during implementation.

7.4 Conclusion

Africa faces great challenges in the next few decades to reach a maintainable rate of positive economic growth. Energy is essential for economic development in Africa. Given the projected electrification levels which Africa is expected to reach by 2030, the current concerns about global warming and the need to meet the Millennium Development Goals for Africa, the implementation of renewable energy technologies is required.

The objective of this research was to develop a structured framework of factors which has been empirically validated and can be used for the selection of renewable energy technology alternatives in Africa to ensure long term sustainability of the application of these technologies.

The following four research methods were used to empirically develop the framework of factors: analysis of the theory, focus group, Delphi survey and case study.

The analysis of existing theory is a summary of the different types of renewable energy technologies available, a discussion of the challenges of renewable energy technologies in Africa and an examination of the different selection methodologies, factors and measures used in the selection of project, portfolios, programmes and technologies.

The focus group used the nominal group technique to identify 38 factors that need to be taken into account for the selection of renewable energy technologies in Africa and classified these factors into six categories.

The Delphi study was conducted over two rounds with the purpose of confirming and prioritising the factors identified during the focus group. The Delphi questionnaires were sent to experts (both academics and practitioners) in the field of renewable energy, with the emphasis on Africa.

In the first round, respondents were presented with the factors identified during the focus group and then asked to: comment on the classification of factors; comment on the description of factors; provide additional factors that were overlooked during the focus group; and provide a preliminary rating of the factors identified during the focus group in terms of feasibility, desirability and importance of considering these factors during the selection of renewable energy technologies in Africa. At the end of the first round Delphi the factors were regrouped into four categories.

In the second round of the Delphi study, the respondents were presented with a summary of the comments and ratings supplied in the first round and were then asked to supply new ratings in terms of feasibility, desirability and importance. The results were analysed. Eleven of the factors were rated by the experts to be feasible, highly desirable and highly important when selecting renewable energy technologies in Africa.

The eleven factors identified in the Delphi study were then used to generate the framework for the eight case studies which were conducted in the following three African countries: Rwanda; Tanzania and Malawi. The sources of evidence used included interviews, documentation and observation. The case studies confirmed that the eleven factors identified during the Delphi study are important for the selection of renewable energy technologies in Africa. Two additional factors were also found to be important and the wording of one of the factors was changed.

In conclusion, the thirteen most important factors that need to be considered for the selection of renewable energy technologies in Africa have been collated into a framework. The framework is contained in Appendix Q and can be used to select renewable energy technologies in Africa.

The framework can be used at various levels and by various organisations to select the most appropriate renewable energy technologies for implementation in Africa. The questions in the framework are answered for each competing technology. The technology that performs the best in terms of providing positive answers for all the questions can then be selected.

By using the framework proposed in this study, selection of renewable energy technologies can be done with the assurance that the most important factors for the successful implementation of these technologies have been taken into account.

The successful implementation of renewable energy technologies in Africa will lead to the improvement of the lives of the population in Africa, will increase their productivity and quality of life, and will contribute towards the alleviation of poverty and the empowerment of women and children. African children who have sustainable access to energy will be better educated and thus be better future leaders.

7.5 Contributions and Recommendations

In this section some practical suggestions and recommendations for future research are made.

7.5.1 Contributions to practice

The main contribution to practice is the list of factors together with measures for these factors which is contained in Appendix Q of this study. A renewable energy practitioner, whether from an NGO, government agency or other agency, can use this list of factors to ensure that an holistic approach is followed when choosing between renewable energy technologies in Africa. The factors can be used in any comparative selection methodology.

This study consulted the opinions of experts in the field of renewable energy technology selection in Africa during the focus group and Delphi study. The findings of the focus group and Delphi study were confirmed during the eight case studies in three African countries. Considering factors the factors identified in this study when selecting renewable energy technologies in Africa will increase the long term success rate of these technologies.

7.5.2 Contributions to theory

This study contributes to the theory in that a better understanding of what it takes to ensure technological success in rural Africa has been defined and collected in a comprehensive, holistic framework of factors.

The framework of factors and how to measure factors during project/technology selection have been determined and these factors can now be further debated by academics and practitioners alike.

7.5.3 Recommendations for practice

A lack of skills is very evident in Africa. The uses and sources of energy are not adequately addressed in basic education. School curricula should be updated to address alternate energy technologies to raise awareness. This will also encourage school leavers to follow technical career paths.

Technical career paths in Africa should be encouraged by ensuring that school leavers have the correct level of mathematics and science to pursue these careers; by providing funding for students to continue their studies in technical areas and by establishing technical colleges and universities in areas where these are lacking.

Selection of renewable energy technologies in Africa should not be done based solely on the economic or environmental benefits of the technology but should take into account the framework of factors described in this study.

Involving the community in Africa before implementation of a technology is of paramount importance. The community must understand the benefits and uses of renewable energy technology before any implementation is planned.

The availability of finance will hamper the best planned implementation if not addressed at the outset. The population will not invest in new technology which is not affordable. If the choice is between food and technology, food will win.

Education and training of implementing organisations is of great importance to ensure the long term sustainability of renewable energy technologies. Badly implemented technologies give renewable energy technologies a bad name and hamper progress for future implementations.

Renewable energy technologies which have been successfully implemented elsewhere, even in other developing countries, will not necessarily be successfully implemented in Africa. There is a need to adapt the technologies for the specific environment in which they will be used.

Quality of installations and of technology is of utmost importance as disgruntled users will quickly revert to traditional methods if the application of the technology is not properly maintained and supported.

7.5.4 Recommendations for future research

This study has produced an empirically tested framework of factors for the selection of renewable energy technologies in Africa. The following work is recommended to improve the framework and make it more user-friendly:

The proposed framework of factors should be used in a pilot project to make a selection of a renewable energy technology in Africa to ensure that all the factors are clearly described and that the suggested measures address the needs of a framework.

In the pilot project the framework of factors should be implemented into one of the selection methods discussed in Chapter 3. The analytical hierarchy process or analytical network process is recommended because of the ease of use of these methods.

Weights must be assigned to the different factors. Research will be required to determine whether the weights will be applicable in all scenarios or whether the weights are application specific. It may also be found that during implementation in a similar environment, use can be made of the same weights but this will need to be confirmed by future research.

The proposed framework of factors includes measures for each factor. These measures must be confirmed by future research. It is recommended that the opinion of experts be gathered using the Delphi method to confirm the measures. Several case studies will then be required to confirm the measures.

This research has touched on the various stakeholders who are involved in the implementation of renewable energy projects in Africa. Further research is required to confirm whether the list of stakeholders identified here is exhaustive.

Note: The appendixes of this study are not in the bound copy but can be accessed at: http://phd-thesis.wikispaces.com/. Please create an account and request membership.