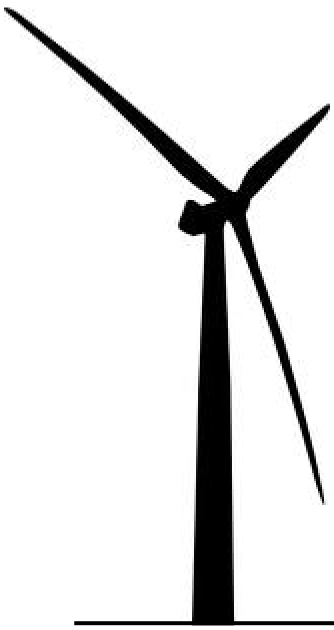

Small Wind Turbines in Kenya

An analysis with Strategic Niche Management

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Context of this report

This report is part of the fulfilments of the master program of ‘Sustainable Energy Technology (SET)’ of the Faculty of Applied Sciences at Delft University of Technology. The thesis falls within the ‘Energy and Society’ track of the Faculty of Technology, Policy and Management (TPM). This specialization studies the economical, societal, market and policy aspects of (energy) innovations in society.

The graduation committee consists of:

Dr. Wim Ravesteijn	Chairman; Associate Professor at the Department of Technology Dynamics & Sustainable Development (TIDO) at TPM
Dr. Linda Kamp	First supervisor; Assistant Professor at the Department of Technology Dynamics & Sustainable Development (TIDO) at TPM
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Abstract

Rural electrification has been a long-standing goal in Kenya, but there is still a long way to go with only 4% rural access to electricity. On top of that, if electricity is available, it is most commonly delivered by the grid, which suffers from power failures and growing costs. Therefore, there lies a large potential in small wind turbines (SWT) for the rural electrification of Kenya in areas endowed with sufficient wind resources.

The research analyses the status of the SWT sector by using Strategic Niche Management and the Multi-Level Perspective as its theoretical frameworks. It studies how the innovation is influenced by factors at three levels: the exogenous 'landscape'; the dominant way of doing things or 'regime'; and the 'niche', the level where the innovation emerges and develops. Furthermore, this research includes some new aspects to better adapt to the particular case of SWTs in the Kenyan context. The results of this analysis serve as input for developing strategy recommendations for all niche practitioners and for a start-up company, RIWIK, in particular.

This research finds that the obstacles for sector growth go much beyond the low public awareness and high upfront cost of small wind turbines. It are the underlying dynamic niche developments that are at the root of the preliminary state of the sector. In addition, the external environment shows to have a large influence on the sector. At one hand, niche upscaling benefits from the tensions in the regime. On the other hand, up-scaling suffers from several landscape factors such as corruption, socio-economic factors and social beliefs. Last, the analysis proves useful for outlining practical guidelines for all stakeholders, and for fine-tuning and underpinning the business approach of a start-up company.

This thesis also suggests possible ways in which the theory and methodology could be enhanced.

Key words: Small Wind Turbines, Kenya, Strategic Niche Management, Multi-Level Perspective, operational tool

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List of Abbreviations

AC	Alternating Current
BoP	Bottom of Pyramid
BHEL	Bobs Harries Engineering Ltd
CBO	Community Based Organisation
DANIDA	Danish International Development Agency
DC	Direct Current
ERC	Energy Regulatory Commission – Kenya
GoK	Government of Kenya
FI	Financial institution
GTZ	German Technical Cooperation
GVEP	Global Village Energy Partnership
HSG	Help Self Group
IGA	Income generating activities
JICA	Japan International Cooperation Agency
JKUAT	Jomo Kenyatta University of Agriculture and Technology – Kenya
KEBS	Kenya Bureau of Standards
KenGen	Kenya Generating Power Company Limited
KEREA	Kenya Renewable Energy Association
KES	Kenyan Shilling
KPLC	Kenya Power and Lighting Company Limited
MF	Micro-Franchise
MFI	Micro-Finance Institution
MLP	Multi-level Perspective
MoE	Ministry of Energy – Kenya
NGO	Non-Government Organisation
PV	Photovoltaic
RE	Renewable Energy
REA	Rural Electrification Authority – Kenya
SACCO	Saving and Credit Co-operative Organisation
SME	Small and Medium Enterprises
SNM	Strategic Niche Management
SWT	Small Wind Turbine
UN	United Nations
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organisation
UoN	University of Nairobi – Kenya
USD	United States Dollars

Exchange rate

All financial terms are given in the Kenyan currency (Kenyan Shillings –KES). The exchange rate as at

20 March 2012: KES 100 ~ 0.93 EUR

1. Introduction

1.1 Introduction

Energy services and appropriate energy technologies are vital for the social and economic development of Kenya. However, only 4 % of the 30 million rural inhabitants have access to any kind of electricity. In these regions, energy needs are met by polluting and unhealthy energy sources such as traditional biomass (wood fuel and charcoal) and fossil fuels (e.g. kerosene). Besides that, if electricity is available, it is most commonly delivered to the grid, which suffers from power cuts and growing cost (Kiplagat, Wang, & Li, 2011).

Because of the country's favourable wind regimes, small wind turbines are a relevant option to electrify rural areas with sufficient wind resources. This option is especially attractive for regions where the grid is not present. The technology is available in a whole range of sizes and can fulfil rural energy needs at all levels of society. Smaller wind systems (<1kW) are suitable for household usage, small businesses and farmers whereas larger systems (>1kW) are more appropriate for electrifying institutions and village mini grids (Berges, 2007).

Nevertheless, despite the fact that small wind turbines (SWTs) have been available in Kenya for more than 10 years and the stringent need for rural electricity, the SWT sector is still limited to few companies and pilot projects. As a result, there are only a limited number of small wind turbines installed in Kenya, of which a significant amount of them are malfunctioning. Besides the technical barriers, there are various social, institutional, cultural and economic issues that are at the root of the slow coming and difficult adoption of small wind systems in Kenya.

The objective of this thesis is to study how the small wind turbine sector has developed in Kenya, the main barriers for the technology and how these barriers could be overcome. Ultimately, this thesis aims to provide strategy recommendations to the involved actors. It also gives practical guidelines to RIWIK, a start-up company from Delft University of Technology that aims to enter the field of small wind turbines. Last, this thesis aims to provide insights in the applicability of the theoretical frameworks for this purpose.

1.2 Start-up Company 'RIWIK'

Started as a Delft Technical University study project, RIWIK aims to introduce SWTs in rural Kenya by providing local craftsmen with the necessary components for building small wind turbines. This local entrepreneur produces the turbines and his customers are people in his community ('local for local').

RIWIK will select these local entrepreneurs, train and certify them and supply them with the components to sell wind turbines. Part of these components are purchased, the most critical ones are produced by RIWIK themselves. The company will guide this process of recruiting and managing the local entrepreneurs, carry out quality control and support them in their daily business.

RIWIK has already initiated a small pilot and as a result, now has its first production unit running. The company aims to expand their business to 250 production units spread over Kenya within 10 years, with an installed base of over 50.000 small wind turbines. They will start operations in the beginning of 2012.

1.3 Theoretical background

The success of an upcoming technology is not only determined by its technical potential, the social environment surrounding the technology is at least as important. 'Innovation Sciences' studies technological development and how it is embedded in society. The innovation frameworks used in this thesis are Strategic Niche Management and the Multi-Level Perspective. The motivation for using these frameworks is given in section 2.1.

The framework of Strategic Niche Management (SNM) is proposed to study the experimental introduction of sustainable innovations in society. SNM uses the concept of creating niches, 'protected environments', to ensure development of the innovation. The SNM framework entails three internal niche processes: the voicing and shaping of expectations, the network formation, and the learning processes. The interaction between these three processes influences the potential success of the novel technology in society (Raven, 2005).

The Multi-Level Perspective (MLP) adds two levels that also influence the development process of the niche and its dynamics. The socio-technical landscape (macro level) entails the events and developments in an exogenous environment; it influences the lower levels but cannot itself be influenced by single actors. Situated below the landscape, the socio-technical regime (meso level) is the set of rules that are embedded in a dominant technology and social network, that guide technological development within and between firms (Mourik & Raven, 2006). The niche is the lowest level (micro level) where novelties emerge.

Investigating and analysing the SWT niche by the framework of Strategic Niche Management will provide the required insights how to reinforce the niche, and this way support regime breakthrough.

1.4 Problem statement

Practical problem

From section 1.1, it became clear that despite of the small wind turbine potential in Kenya, the adoption has been slow coming. At present, there are several publications on the small wind turbine sector (Osawa & Otieno, 2004; Ngondi, 2009) and the Kenyan wind energy sector as a whole (Kirai & Shah, 2009; Ngondi & Makanga, 2010; Ogana, 1987; IBRD, 1993). However, these articles and reports present rather limited information on the SWT sector and many aspects are thus still unexplored. For instance, none of these studies have provided adequate insights in the size and quality of the niche, and the external factors influencing niche development. Furthermore, they do not give a proper overview of who is active in the field of small wind turbines and what has been done up to now.

For this reason, it is essential to thoroughly research the development process of SWTs in Kenya. These insights will provide all actors with an enhanced understanding of the sector composition, and the constraints and opportunities for upscaling. This in turn can help them improve their SWT activities and boost the sector as a whole.

Secondly, as described in section 1.2, RIWIK aims to enter the small wind turbine sector. Although much effort has been put into identifying an appropriate business model, it has been developed without full knowledge of the composition and functioning of the SWT sector. In order to reach scale, RIWIK must fine-tune and underpin its business approach (Fugers & de Jong, 2011). Full insights in the SWT sector and external factors influencing its development will enable the company to improve on the business model and identify a feasible upscaling strategy.

Theoretical problem

For analysing the dissemination of SWTs in rural Kenya, the Strategic Niche Management will provide a helping framework. Through the development of a protected market niche, this sustainable energy technology can be successfully implemented. However, the SNM framework has been developed to support the breakthrough of disruptive innovations into the regime of a developed country. For instance, the SNM framework has been applied for analysing fuel cell vehicles in the UK (Lane, 2002), biogas in the Netherlands and Denmark (Raven, 2005) and PV in Japan and the USA (Shum & Watanabe, 2007). During recent years, the SNM framework has been more and more used for studying sustainable innovations in the context of developing countries (van Eijck, 2006; Byrne, 2009; Verbong, Christiaen, Raven, & Balkema, 2010; Rehman, et al., 2010; Jolly, 2010; Jandl, 2010).

Moreover, the Strategic Niche Management has been primarily used for the historical analysis of an innovation in society. Less effort has been taken to apply the framework as an operational tool for moving the sector forwards. For instance, several case studies have translated the results of their case study to sector guidelines, but these pieces of advice were rather limited (van Eijck, 2006) or were concentrated on policy guidelines (van der Laak, Raven, & Verbong, 2007). The interest in this field is growing. For instance, Raven, van den Bosch and Weterings (2010) are taking the first steps towards developing a managerial perspective by developing a competence kit for niche practitioners.

This thesis will study the current developments in Kenyan SWT sector, with the purpose of translating the results of the analysis into guidelines for all niche actors and one company in specific. As far as the author is aware, this has not been done before and as a result, there is a need for more experience in this field. Therefore, the main theoretical problem that will be dealt with is the practical application of Strategic Niche Management for a case in Kenya, a developing country.

1.5 Research design

1.5.1 Research objectives

The goal of this study is threefold. First, it aims to provide insights in the current development process of SWTs in rural Kenya using the framework of Strategic Niche Management. From these understandings, the thesis aims to generate practical guidelines for SWT stakeholders on how to improve the quality of the niche processes and this way move the sector forwards. Recommendations will be given to all actors (policy makers, NGOs, companies and research institutes), since it requires joint efforts to effectively implement upscaling of the niche.

Secondly, the aim of this thesis is to take it one step further towards operationalization of SNM as a tool for a company actor in particular. The developments in and around the field of SWTs are complex, a factor that has significantly contributed to the limited dissemination of wind-based decentralized electrification in rural Kenya. This knowledge and insights will enable the evaluation of the viability of the RIWIK business approach. Furthermore, the aim of this study is to offer guidance to the company what it should focus on in order to successfully operate in the Kenyan context.

Thirdly, this research aims to provide useful insights into the applicability of the SNM framework in Kenya, a developing country. On top of that, this investigation will offer guidelines to foster the activities of practitioners and RIWIK in particular, thus this thesis research also aims to demonstrate the usefulness of SNM as an operational tool.

1.5.2 Research questions

Given the problem statement and research objective, the main research question can now be formulated as:

How can upscaling of the small wind turbine sector in Kenya be realized?

To answer this research question, following sub questions are addressed:

1. What does the SWT sector look like, in terms of technology and stakeholder composition?
2. How is the niche functioning and developing?
3. What is the influence of the landscape and regime on the niche development?
4. What recommendations can be given to all stakeholders to improve the likelihood of niche upscaling?
5. What kind of insights can be gained that are relevant for RIWIK, and which practical guidelines can be given to enhance their business approach?
6. What lessons can be learnt from using the Strategic Niche Management in the Kenyan context as an operational tool, and how should the framework be modified?

1.6 Research methodology

Scope

In Kenya, wind energy is used for powering wind pumps, small wind turbines and medium to large wind turbines. This research focuses on the development of small wind turbines for electricity generation, for battery charging and powering small grids.

Two kinds of small wind turbines exist in Kenya: the horizontal axis rotors and the vertical axis rotors. The vast majority of wind turbines in the country are horizontal wind turbines. This thesis only focuses on this turbine type. Although no strict definition of small wind turbines exists in literature, systems with a rated power output of 10kW or less are mostly considered *small*. For this reason, this thesis research studies horizontal axis wind turbines with a power rating up until 10kW.

Furthermore, this study analyses the development of the entire horizontal axis SWT sector. This includes both locally manufactured and imported turbines.

Data sources

This research consisted of a preparation and finalization period in the Netherlands, and a three month field trip in Kenya. The following data sources were used: literature, interviews, and a questionnaire with university students and observation.

Literature sources predominantly entailed reports, journal articles, local newspapers and actor internet sites. This data source was used for gaining quantitative information, primarily for the Multi-Level Perspective and partly the niche description.

The relevant literature on the Kenyan small wind turbine sector is rather scarce and of insufficient quality. For this reason, studying the SWT sector itself was primarily done by taking open-ended, semi-structured interviews with 42 niche and regime actors (Appendix F). SNM interview questions focused on deriving the network composition and size, the perception and vision on SWTs and what has been learnt up to now by the different actors. The interviews also included questions for finding out the dynamic interaction between the three levels of the multi-level perspective. The initial interviewees were identified from literature as key sector actors. These contacts led to further interviewees ('snowball-method'). Since some actors are located in remote areas that were too difficult or time-consuming to reach, these interviews were done by phone calls and via email. Besides that, the SWT sector has global linkages with foreign research institutes and SWT suppliers; also these interviews were performed via Skype and email.

Next to that, the process of information gathering also resulted into valuable insights (Appendix B). These entail culturally and socially related observations as well as observations on direct SWT sector barriers and developments. Additional information was also gained through a questionnaire with 11 students from Jomo Kenyatta University of Technology (JKUAT). The results of this questionnaire focused on the absence of human resources in the SWT sector (Appendix C).

1.7 Document structure

Chapter 2 of this master thesis is dedicated to the theory, and presents the theoretical frameworks used for answering the research questions: the strategic niche management and multi-level perspective.

The following three chapters combine to the *analysis phase*, in which the internal and external niche status and developments are analysed. Chapter 3 describes the SWT niche itself including the technological aspects, stakeholders, development path and different SWT types that are now on the Kenyan market. Chapter 3 predominantly gives factual data to provide enough insights to grasp the content of chapter 4. Chapter 4 then assesses the sector development by analysing the state of the current niche and the three internal niche processes of Strategic Niche Management. Chapter 5 then puts the SWT sector in the broader view by applying the Multi-Level Perspective.

The following two chapters, 6 and 7, will bring the results of the analysis into practice by providing solutions for the current difficulties the sector is facing. Chapter 6 discusses the strategic directions for all sector actors. Chapter 7 then goes one step further, and provides specific guidelines for RIWIK, a newly entered sector participant. By comparing its current strategies and business approach with the results from the analysis phase, recommendations are developed for strategy optimization. Chapter 8 is devoted to the thesis conclusions, discussion and recommendations.

Appendix A presents several guidelines for other researchers that aim to study innovations in the Kenyan context based on the author's personal experiences. Following this, Appendix B discusses the author's observations during the field research, whereas Appendix C presents the results of the questionnaire. Next, Appendix D tabulates the contact details of several relevant interviewees. Appendix E then gives insights in the estimates of the sector size. Lastly, all transcriptions of the 42 interviews with the niche and regime informants can be found in Appendix F.

Figure 1 shows the breakdown of the chapters.

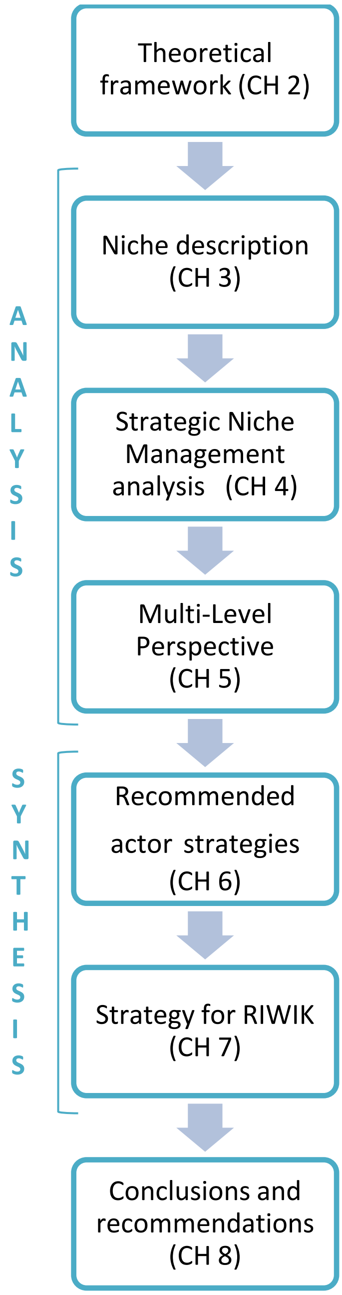

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Figure 1: Breakdown of chapters indicating where each sub question is treated

2. Theoretical framework

2.1 Introduction

This chapter discusses the theoretical framework used to answer the research questions as stated in section 1.5. The approaches of Strategic niche management (SNM) and Multi-level Perspective (MLP) will constitute the analytical frame for this thesis. These theoretical concepts are developed to study innovations by analysing both technology and society aspects. This is because the success of an innovation is not only determined by its technical potential, the societal environment has proven to be at least as important. Many technologies have failed due to their inability to adjust to society.

To gain full understanding of the factors that drive and hinder the widespread dissemination of small wind turbines in rural Kenya, the approach of Strategic Niche Management will firstly be applied to analyse the *internal aspects* of the sector development. This analytical method is specifically developed to study the introduction and development of new technologies through societal experiments in a niche, 'an incubation room' for radical innovations. Therefore it is considered appropriate for the evaluation of the case of SWTs in rural Kenya. Section 2.2 elaborates on the theoretical principles of the SNM approach and discusses the key processes on which the niche will be analysed.

The analysis in this thesis is complemented by studying the broader environment of the niche, the *external aspects*. The Multi-Level Perspective seems to be suitable for this purpose, since it takes into account the influence on the exogenous developments and the embedded technologies on the technology development. Section 2.3 discusses the three levels of the Multi-Level Perspective and their reciprocal interaction.

Following this, section 2.4 explains how these frameworks will be combined and adapted to fit the purpose of this study. This chapter ends with a summary of the theoretical concepts and their operationalization in section 2.5.

2.2 Strategic Niche Management

The introduction and upscaling of a new technology is a complex and difficult process. Even though the innovation might have improved characteristics compared to the established technologies, that does not guarantee it to be commercially successful (Raven, 2005). For example, low awareness might prevent users from adopting the new technology. Furthermore, in the beginning, a radical innovation might not be completely developed and might be too expensive. Also inadequate government regulations and the lack of infrastructure can hold back the introduction of a new technology (Mourik & Raven, 2006).

Strategic Niche Management was developed as a model to deal with these difficulties and this way facilitate the introduction and upscaling of a new sustainable technology in society. This approach originated from insights from evolutionary innovation economics. (Caniëls & Romijn, 2008) It can be used as a research tool to answer the question why a certain innovation trajectory was a success or a failure (van der Laak, Raven, & Verbong, 2007). Besides SNM for *ex-post analysis* (studying historical cases), it is also used as a policy tool (Caniëls & Romijn, 2006). This type of *ex-ante analysis* aims to steer the technology development in a certain direction. Moreover, Caniëls and Romijn (2006) provide insights in the use of SNM as a practical tool ('how to do it') for practitioners to encourage and improve niche processes.

Strategic Niche Management is based on the development of *niches*, which can be seen as the incubation room or protective system surrounding the new technology. In the niche, the innovation can grow and develop until it is strong enough to move from pilot and demonstration stage to widespread use. This protected environment is necessary during the transition period, because the emerging technology has to compete with the existing technologies which are technologically and economically superior to the innovation (Geels & Schot, 2007). These established technologies are part of large social networks, the *regimes*, which have certain rules such as price/performance ratio, user preferences or regulatory requirements (Raven, 2005).

2.2.1 The role of experiments in niche development

In Strategic Niche Management, societal experiments are put forward for the development of niches (Raven, 2005). This development can be thought of as two levels that are progressing simultaneously: the level of projects (experiments) in local practices and the overall niche level (Figure 2). Experiments gradually emerge into a niche that shares cognitive, formal and normative rules (Schot & Geels, 2008).

The role of experiments in this process is explained as follows. As stated above, a common difficulty of new technologies is their initially low technological and economic performance compared to existing technologies that already benefited from years of R&D and real-life experiences. Niche technologies therefore require further improvements through experimenting in real life circumstances. They also provide new insights in the technology potential, on the level of functionality and performance. Because of these improvements and enhanced understanding, the initial technology barriers can be tackled. The process of experimenting hence enables the effective implementation process of the new technology and its societal embedding (Verbong, Mourik, & Raven, 2006).

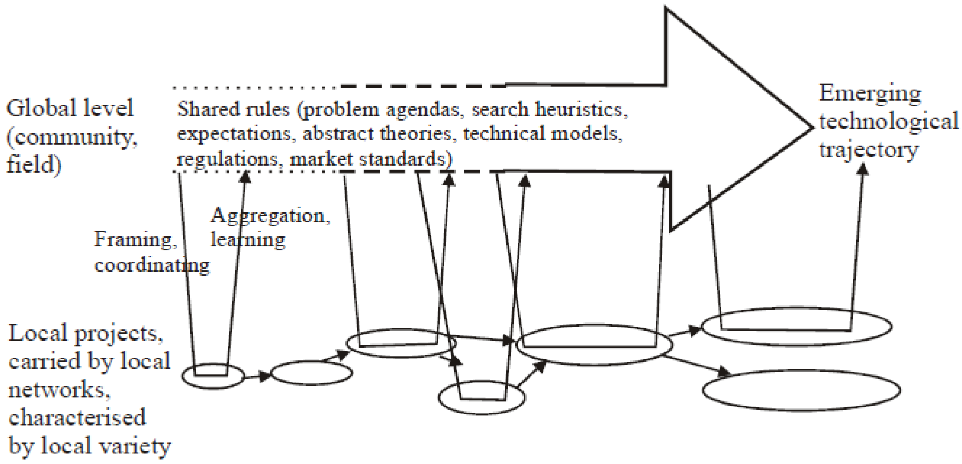

Figure 2: Local projects aggregating into a global niche level – from Geels & Raven (2006) in (Mourik & Raven, 2006)

There exist different kinds of experiments, characterised by the increasing level of knowledge and features necessary to introduce the innovation in society. Hoogma (2000) in Raven (2005) distinguishes following four types of experiment that occur in succession when introducing an innovation in society:

1. **Explorative experiments:** experiments to assess on user preferences, identify the most promising possibilities and decide on the design of future experiments. This type of experimenting is valuable at the first stages of the technology when there are still many uncertainties.
2. **Pilot experiments:** experiments to raise public and industrial awareness, examine the feasibility of the innovation in new environments and encourage policy making.
3. **Demonstration experiments**: experiments to demonstrate the benefits of the technology to potential users.
4. **Replication or dissemination experiments**: experiments to spread the tested technology and methods on a large scale by repeating successful earlier experiments. The aim of these experiments is to learn about applications, viability and acceptability by testing in other environments.

2.2.2 Niche development stages

Experimental projects add up to a technological niche that may grow into a market niche. In turn, a well-developed market niche can next take over the regime or become part of it. This subsection explains the different steps of this trajectory.

From technological to market niche

A *technological niche* emerges from continuous experimentation. At that moment, researchers, innovators and producers are getting involved and generally push the technology instead of responding to user demands. These actors join the niche predominantly because of the expectations of future markets. They start sharing expectations, lessons, ideas, strategies etc. The technological niche is characterised by some kind of protection, in the form of government tax exemptions, R&D commitments by firms, or prospective users' willingness to participate in experiments on an unpaid basis. At this stage, the technology is unable to compete with the dominant technologies and has only been able to gain a small market share. The protection thus enables experimenting without economic competition from the established technologies and outside the rules of the dominant regime. This way, the niche participants have the opportunity to interact and learn about the new technology which can then result in the user's articulation of a clear demand for the innovation (Raven, 2005; Smith & Raven, 2011; Caniëls & Romijn, 2008).

When at a certain moment, the researchers, technology suppliers and users have gained and shared sufficient knowledge, the technological niche develops into a *market niche*. At this stage, users start recognizing the value and benefits of the innovation. Furthermore, the technology is then attractive in terms of performance, functionality and cost over the established technologies. The technology is hence competitive enough so it can sustain itself commercially (Raven, 2005; Caniëls & Romijn, 2008).

Based on the transition from technological to market niche, Raven (2005) goes one step further by distinguishing four types of niches depending on their level of protection (e.g. subsidies, regulatory exemptions) and stabilization[1]. Figure 3 depicts the different niche types in four quadrants.

The four types are explained as follows:

1. **Technological niches** represent the phase of early experimental introduction of the innovation; there are only few experiments and actors rarely interact to share knowledge

[1] Stability of the niche is accomplished by its rules and the extent in which it provides structure to local practices

[2] With simple, locally manufactured SWTs there are often no controls that allow it to start, or the turbine starts

and experiences. These niches are defined by their low stability and high protection. Niche participants have high expectations.

2. **Regular market niches** are characterised by their high stability and low protection. This type of niche occurs during the later phases of experimental introduction; protection is not needed anymore since at least some users benefit from the technology.
3. **Dedicated market niches** have low levels of stability and protection. In this niche, users choose the technology despite the many uncertainties (low stability) because of curiosity, their advantages, or because no other option is available.
4. **Protected market niches** have a higher level of stabilization (more certainty, more experiments) but protection levels are still high. This could possibly be explained by the fact that protection at this stage is no longer temporary since it has become part of the system.

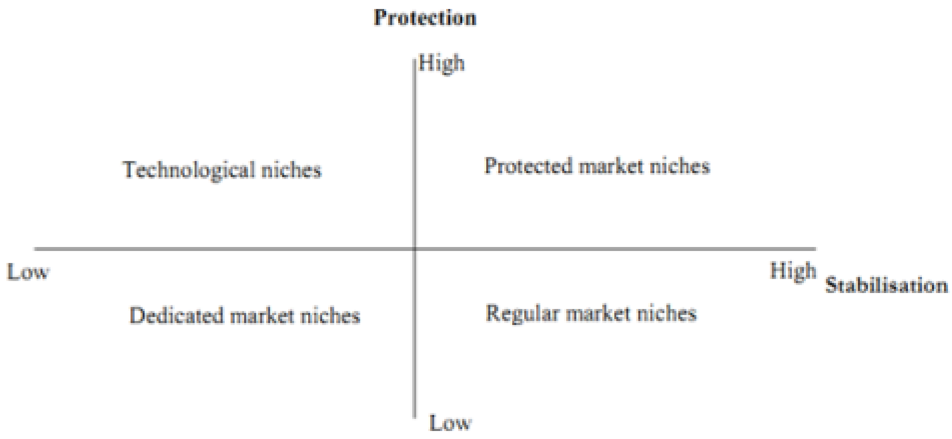

Figure 3: Four types of niche distinguished by their level of protection and stabilization – adapted from (Raven, 2005)

From niche to regime

Technological niche may move towards market niches, which in turn can eventually lead to the development of a new regime or become part of it. The trajectory from niche to regime is depicted in Figure 4. It presents the so-called process of cosmopolitanization as defined by Deuten (2003) in Raven (2005). The four phases within cosmopolitanization are distinguished by means of their stability and structuration.

In the *local phase*, a group of heterogeneous, independent actors create their own rules for the execution of their own experiments. There is no cooperation between the different actors, and hence also no shared set of rules. When the niche moves towards the *inter-local phase*, the actors transfer knowledge and expectations, and rules become more collective among different experiments. In the t*rans-local phase*, the knowledge and rules are more established and increasingly shared, e.g. standards are being developed based on the combined knowledge of the different actors. At the *cosmopolitan phase,* the niche has culminated into a regime. The rules are established which structure the local practices.

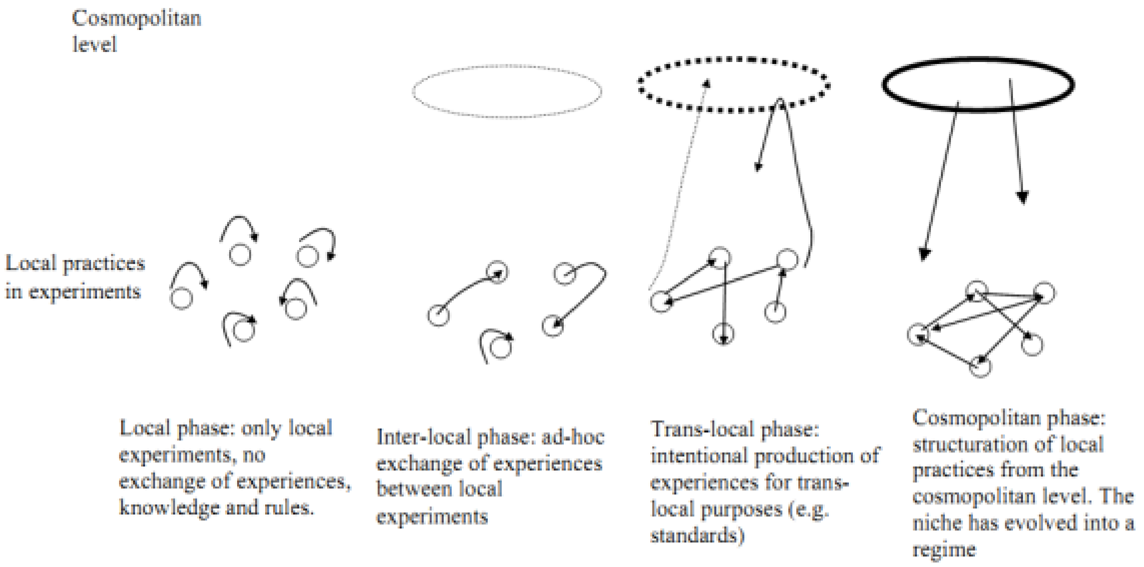

Figure 4: Emerging level of niches to culmination in regime in relation to local practices in experiments (Raven, 2005)

Niche development stages in the context of developing countries

The development path of a technological niche to a market niche and finally into a regime shift generally follows the lower level stages of Figure 5. This situation assumes a well-established, fully developed regime where market niches can break through by improved practices and increased market share. In case of energy transitions within the developing country context, the process of niche development into a regime can follow different pathways. Rather than acting as a technology that replaces the regime, the niche innovation can also become the regime at locations where the dominant technologies do not exist (grid is not present) or do not well serve that specific region (e.g. unreliable electricity). In this case, rather than replacing the power regime, niche technologies develop into an alternative power regime. This pattern is visualized Figure 5 (top level) (Verbong, Christiaen, Raven, & Balkema, 2010).

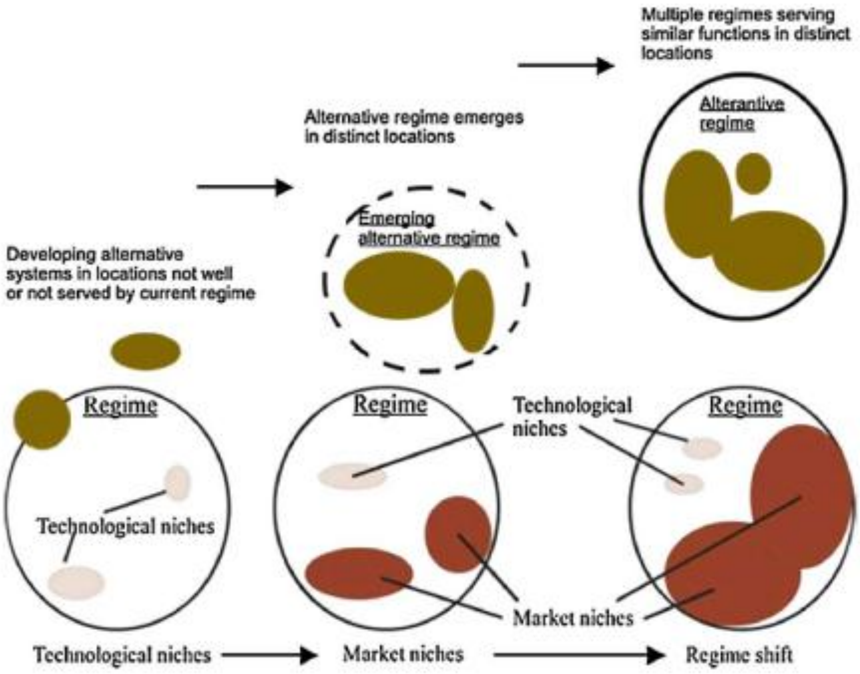

Figure 5: Alternative niche development patterns for developing countries where the power regime does not exist at various geographical regions (Verbong, Christiaen, Raven, & Balkema, 2010)

2.2.3 Niche processes

Above explanations have showed that the transition of new technologies is a complicated and gradual process. It goes through subsequent steps of knowledge development and sharing, structuration, stabilization and protection. Strategic Niche Management aims to contribute to this process by gaining insights and developing guidelines to encourage niche development.

According to Schot (1994) in Raven (2005), three internal niche processes are important when studying the niche development: the voicing and shaping of expectations, network formation and learning processes. These niche processes are closely interdependent and influence each other. The niche processes and their dynamics are discussed in succession:

Voicing and shaping of expectations

Expectations play an important role in the niche development. For instance, they provide direction to the innovation development, influence design choices and attract actors to join (van der Laak, Raven, & Verbong, 2007).

In the early niche stages, participants join the niche by investing effort, money and time because they have expectations of the future success. At that moment, actors have broad and unclear expectations about the technology and different visions of its future (van der Laak, Raven, &

Verbong, 2007). During time, expectations change because of external (e.g. regime and landscape factors – see section 2.3) and internal circumstances (e.g. results from experiments) (Raven, 2005).

This is depicted in Figure 6, where expectations are distinguished at three levels: 1) the micro level, expectations resulting from the niche 2) the macro level, which is related to developments in society (external circumstances) and 3) the meso level, which are the resulting expectations and visions at niche level.

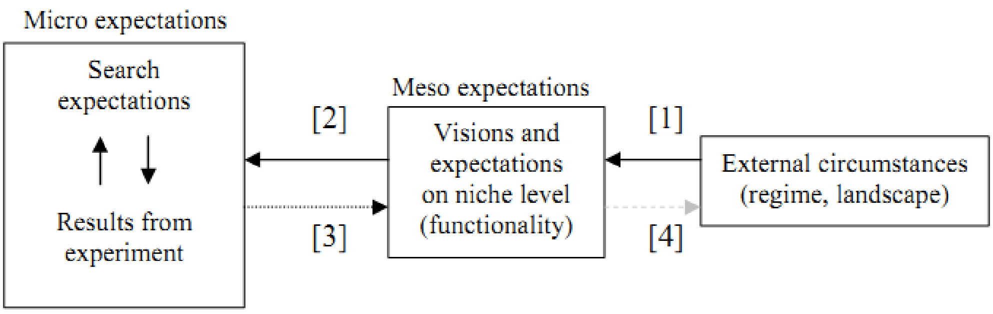

Figure 6: Influences on niche expectations (Raven, 2005)

With [1] External circumstances change visions at niche level

[2] Changing meso expectations lead to different experimental designs

[3] Results from experiments change expectations at niche level

[4] Changing visions and expectation at niche level change external circumstances

According to Hoogma et.al (2002) in Schot & Geels (2008), expectations contribute to successful niche development if they become be more robust (shared by more actors), more specific (give guidance) and have a higher quality (the expectations are validated from the on-going experiments).

Network formation

In the beginning of the niche development, the social network is still small, fragile and there are limited resources available. More experimentation attracts more network actors to join, including producers, users, government authorities, non-governmental organisations, societal groups etc. (Raven, 2005). These actor networks are essential for niche development since they sustain development, enable learning, carry expectations and express new technology requirements and demands. More participants also enable the provision of sufficient resources (money, expertise) to support niche development (van der Laak, Raven, & Verbong, 2007).

Practitioners consider two characteristics when analysing the actor network. First, the *network composition* is an essential factor. A good network requires a heterogeneous group of actors with different interests and roles. For instance, it should include new firms that have no strong ties with the regime to introduce the innovation. Also users should be actively involved to increase the learning experiences and supporting organisations are necessary to gain assistance (Raven, 2005).

Secondly, the network should be *aligned.* This characteristic refers to the degree to which actors' vision, expectations and strategies are in line with the niche development. This alignment can be achieved through regular interaction and co-operation between the different actors (van der Laak, Raven, & Verbong, 2007).

Learning processes

The third niche process comprises the learning, which refers to the range of processes through which actors articulate relevant technological aspects, markets and other characteristics (Wiskerke & Ploeg, 2004). Learning influences the niche by affecting the expectations and aligning them, attracting actors etc. Furthermore, a good learning process is reflexive and focuses on many aspects (van der Laak, Raven, & Verbong, 2007). Hoogma et al. (2002) gives five aspects of learning in Wiskerke & Ploeg (2004):

1. **Technical development and infrastructure:** What are the design specifications, required complementary technology and infrastructure?
2. **Development of user context:** What are the end-user characteristics, their requirements and the meanings they attach to a new technology and the barriers they encounter when using the innovation?
3. **Societal and environmental impact**: What is the innovation's impact on safety, energy and the environment?
4. **Industrial development**: Which production and maintenance network is needed to broaden dissemination?
5. **Government policy and regulatory framework**: What are the institutional structures and legislation relevant for the technology introduction? How should the government act and what incentives should they provide to encourage adoption?

As previously mentioned, an important aspect in the niche development is interaction with users. Hoogma (2000) in Raven (2005) gives two types of learning depending on the relation with the end-users: first order learning and second order learning. First order learning refers to learning about the innovation's effectiveness in achieving pre-defined goals. It is directed on gathering facts and data. On the other hand, second order learning aims to learn about the underlying norms and values of the new technology. This type of learning enables changes in assumptions and cognitive frames, and has a larger contribution to niche development compared to first-order learning (Schot & Geels, 2008).

Interactions between the different niche processes

Figure 7 presents the interactions between the different niche processes. As can be observed, the improving quality of the niche processes is an iterative process. When actors have positive expectations on the innovation development, they will join the network and invest resources in experimenting with the new technology. The results from experiments lead to learning experiences that in turn change expectations. When the technology performs well, the expectations will grow stronger and will become increasingly shared by the different actors. Expectations might also change due to external circumstances at regime or landscape level (Raven, 2005). Stronger expectations will in turn enable more resources to become available. On the basis of these renewed expectations, more actors become involved in the network and this in turn changes the design of experiments.

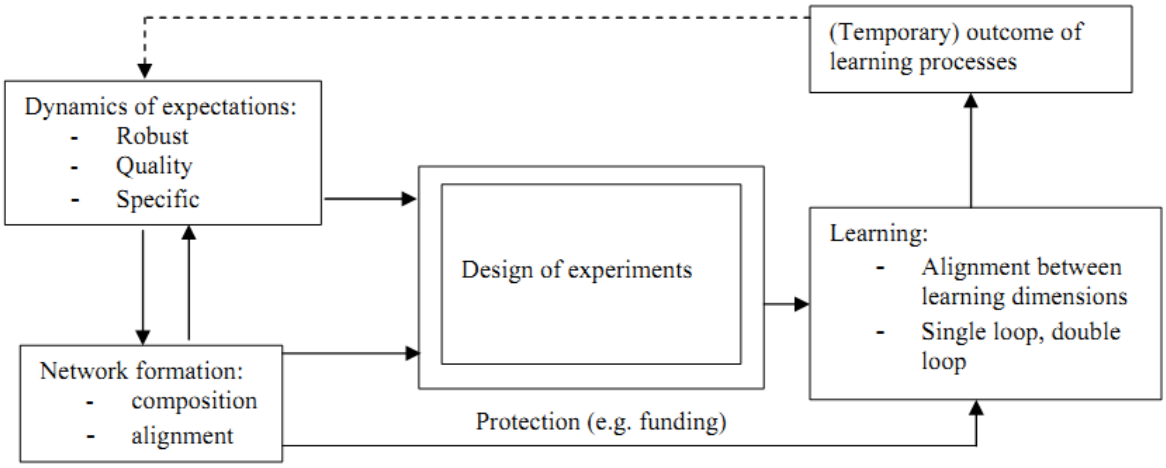

Figure 7: Niche dynamics in relation to the design of experiments (Raven, 2005)

2.3 Multi-Level Perspective

The previous section has introduced the concept of niches. They can be placed in a broader context, the Multi-Level Perspective. This model divides the social system into three different levels: 1) the exogenous socio-technical landscape (macro level); 2) the socio-technical regime (meso level), which are locked in technologies that are stabilized and 3) the niche (micro level), where radical innovations emerge (Figure 8). These levels present heterogeneous configurations of increasing stability (Geels, 2005a).

The model originated from the finding that a transition, which is defined as a regime shift, is not solely the result of the dynamics of the niche. It is also a consequence of the interactions between the three levels (Raven, 2005). The MLP framework was proposed for understanding the complexity of sustainability transitions by taking into account the multi-dimensional dynamics of socio-technical change (Geels, 2010).

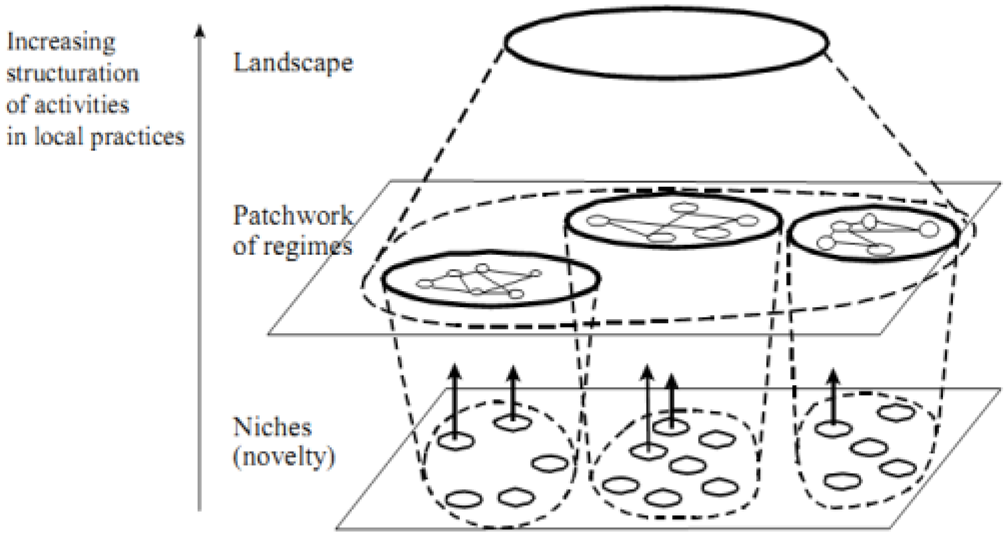

Figure 8: The three levels of the Multi-Level Perspective (Geels, 2005a)

2.3.1 The levels of the MLP

The three analytical levels and their main characteristics are as follows:

Socio-technical landscape

The landscape consists of the deep structural trends that are not directly part of the regimes and niches, but they do influence them. Factors at this level include amongst others demographic, macro-economic (e.g. oil prices, economic growth), cultural and infrastructural developments, scarcity of raw materials, factories, highways, societal values and norms, political coalitions and environmental problems. The landscape level has the slowest dynamics; these trends usually run relatively slow and are hard to change. However, this level also includes unexpected events such as wars and oil price fluctuations that have an abrupt impact on the regime and niche (Geels & Schot, 2007).

These external factors exert influence on the micro and meso developments and hence determine the barriers and drivers of a radical innovation. The regime and niche actors cannot influence the landscape in the short run (Geels, 2002).

Socio-technical regime

Established technologies are part of a wider social system called the socio-technical regime or system. Rip and Kemp (1998) in Raven (2005) define the socio-technological regime as a relatively stable configuration of technologies, institutions, behaviours, practices and networks that determine the production and use of the embedded technologies.

According to Geels (2005a), the socio-technological regime consists of three interlinked elements: a network of actors and social groups, the rules that guide the activity of these actors and the technical and material elements of the established technologies.

The *actors and social groups* include the users, public authorities, societal groups, suppliers, scientists, financial institutions etc. These networks produce and maintain the elements and interconnections within the regime. Actors within a specific group share the same vision, perception and routines; these may vary between the different networks. During time, the actors' role, interest and the activity within the regime can change (Geels, 2005a; Geels & Schot, 2007). The activities of the different actors are guided by the *rules of the regime*. These are for example regulations, standards, laws, mind sets and beliefs, behavioural norms, etc. (Geels, 2005a). These rules determine how the embedded technologies are used, produced and regulated. They form a kind of shared structure that steer actor behaviour but does not determine it. Rules can change over time and they exist because the different social groups support and reproduce them (Raven, 2005). The third element consists of *the material and technical elements* of the embedded technologies. In case of the electricity regime, these include the generation plants, grid lines, resources etc. (Geels & Schot, 2007).

These three elements provide stability and structure to the regime. The evolution and long availability of the embedded technologies cause them to be well *aligned* with the established regime and its rules. The more aligned, the harder it is for niche technologies to emerge (Raven, 2005). The regime itself is quite stable and there is generally a resistance to change for new technologies. This is because existing technologies are 'locked-in' or path dependent. For example, the incumbent actors have their own interests and want to keep their position in the market. Also regulations, standards and existing infrastructure lock-in the embedded regime technologies (Verbong & Geels, 2007).

Niche

The niche is the breeding place for new technologies to emerge. These new technologies are often developed to solve the problems of the dominant regime (Geels, 2005b).

The niche has a similar kind of structure as the regime, but it is different in size and stability. Whereas the regime networks are large and stable, niche networks are rather small and unstable. (Geels & Schot, 2007). The niche actors are generally regime outsiders or fringe actors (Geels & Schot, 2007), and join the niche because they hope the innovation will eventually be used by regime actors or replace the regime (Geels, 2005b). Niche networks also share sets of rules that steer the activities within the niche. While the rules in the regime are stable and well-articulated, the rules in the niche are unstable and are still being created. Thirdly, contrary to the embedded regime technologies, there exist many uncertainties on the development of the innovation (Geels & Schot, 2007).

Because of its weak structuration (low stability and high uncertainties), the niche can easily be influenced by the regime and landscape. Moreover, upscaling of niche technologies is generally difficult because the innovation mismatches with the dominant regime and diverges from the existing rules (Raven, 2005).

2.3.2 Multi-level interactions

The development of an innovation is significantly influenced by the interaction between the three levels, which is visualized in Figure 9. As mentioned above, the room for niches in the regime is directly related to the stability within the regime. The dominant regime has an aversion against niche developments; the more stable the regime, the stronger the resistance for new technologies to emerge.

The regime stability can however change because of its own dynamics. Geels (2002) in (Geels & Schot, 2007) distinguishes 7 dimensions in the sociotechnical regime: technology, user practices and markets, symbolic meaning of technology, infrastructure, industry structure, policy and techno-scientific knowledge. These dimensions are interconnected and evolve simultaneously. They however also have their own internal dynamics. This may result in tensions and uncertainties which weaken the linkages between the dimensions, destabilize the regime and lead to possibilities for change. This is represented by the shorter diverging arrows in the figure below.

The landscape is presented with long arrows to show its regular on-going incremental nature (Geels, 2002). Landscape developments can either reinforce or pressurize the regime. When the landscape strengthens the regime, it will diminish the incentive for a transition to take place. On the other hand, when landscape changes develop or enlarge regime problems and hence exert pressure, it will destabilize the regime. These disruptive influences are referred to as *top-down* pressures (Geels & Schot, 2007).

At niche level, the technology is being developed quite randomly. There are many uncertainties and the efforts to develop and upscale the technology go in all directions. This is presented by the small arrows in different directions in Figure 9. Through experimenting the niche can develop internal momentum through improved price/performance, support from powerful actors, increasing functionality of the innovation etc. New technologies can have a symbiotic relationship with the regime if it enhances the regime actors to solve problems and improve performance. Niche innovations can also be competitive with the existing regime, with the goal of overthrowing it. In this case, niche momentum creates *bottom-up* pressure on the regime and destabilizes it. This process will enable a transformation to take place (Geels & Schot, 2007).

The downward arrows to the niche level show that perceptions of niche actors, the design of experiments and the size of the network are influenced by broader regime and landscape developments. For example, when the regime actors do not expect that problems are solvable with the current technologies, they can decide to support and possibly participate in the niche by giving them access to resources and knowledge. (Geels & Schot, 2007)

When the interactions between the levels are aligned they reinforce each other. This process depends on the timing and the nature of multi-level interactions (Geels & Schot, 2007). This offers windows of opportunity for the radical innovation at niche level to breakthrough in the dominant regime. It can replace the regime or become part of it.

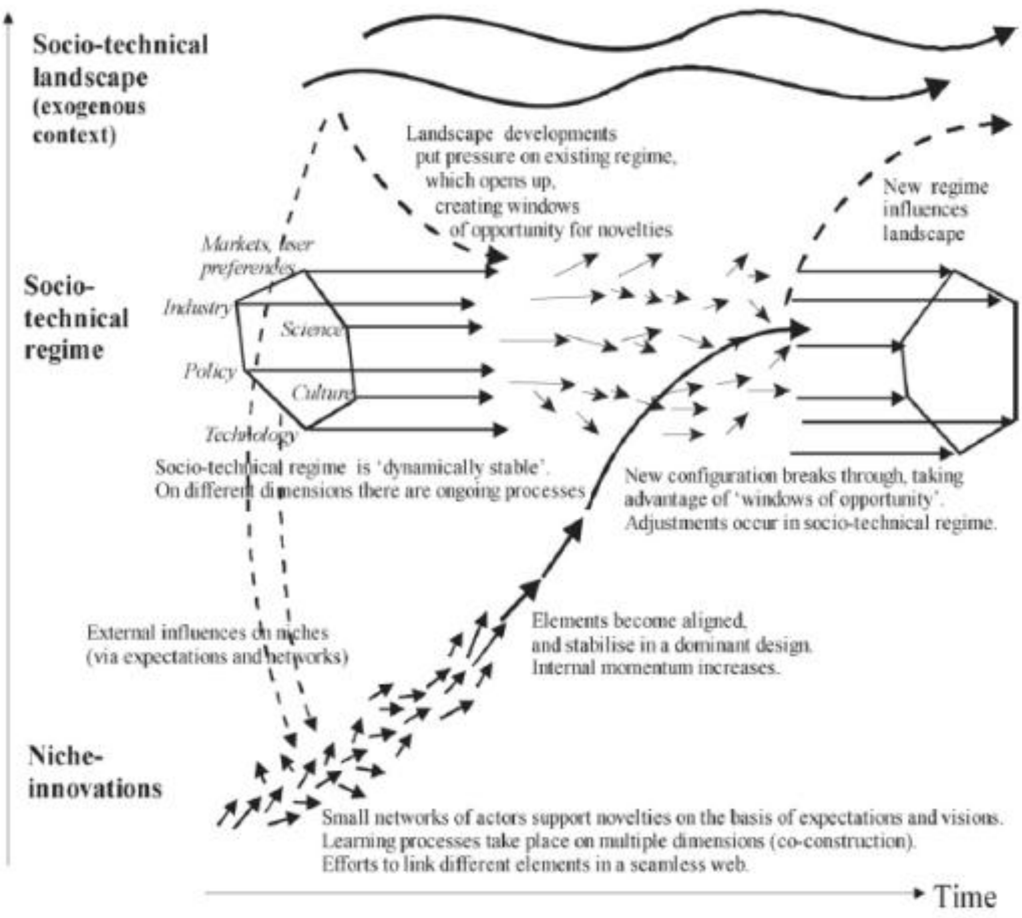

Figure 9: Multi-Level perspective on transition (Geels & Schot, 2007)

2.4 Operationalization of the frameworks

The previous sections presented the theoretical background for this research. This section explains the conceptual framework with the purpose of analysing the diffusion of SWTs in Kenya based on the frameworks of SNM and MLP. Figure 10 depicts the integrated approach for analysing the Kenyan SWT sector.

2.4.1 Strategic Niche Management

First, this thesis research closely investigates the niche itself through the three niche processes of Strategic Niche Management. This analysis is carried out in chapter 4. Because the niche entails both commercial activities as all kinds of experiments, 'niche activities' will be used as an umbrella term. It is explained below how the SNM framework will be used, and how it will be modified.

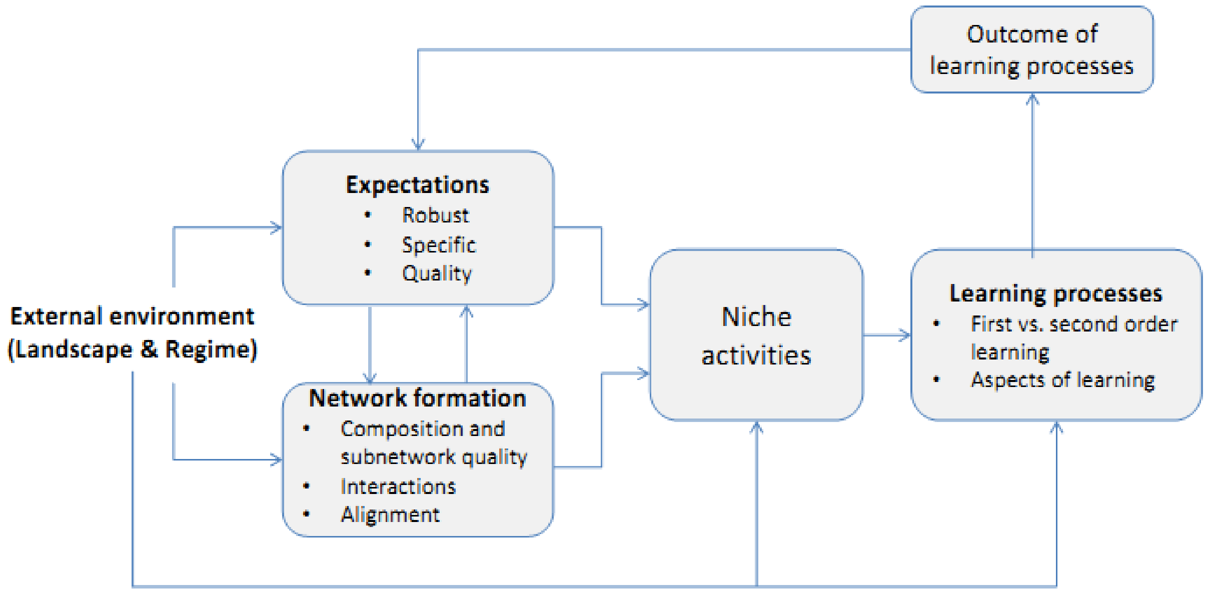

Figure 10: Dynamic interactions between niche processes and the external environment (adapted from Raven, 2005)

The three processes will be evaluated on:

Voicing and shaping of expectations

This thesis will look at both the influences on expectations and the expectations itself. First, the influencing factors will be analysed by dividing them into two categories:

- *Exogenous developments*, which entails all developments that are external to the niche. These include landscape and regime factors and changes, as described in section 2.2.3. In addition, the development of other niches can positively or negatively influence the development path of the SWT sector. This category therefore also entails the rise of other niches.
- *Endogenous developments*, which entails changed expectations through learning experiences and network composition. It considers the actual size of the niche, since the larger the sector the better the expectations (more awareness and confidence in technology).

This division is made to increase insight in the origin of the expectations: 'to which degree the expectations are influenced by the niche development itself or by the environment the niche is situated in?'

Second, rather than solely evaluating the expectations of the niche actors as being done in traditional SNM studies (section 2.2.3), the expectations of desired niche participants will also be considered.

This additional analysis will reflect the degree to which it is necessary to voice expectations through awareness/promotion campaigns, an important factor to take into account when developing the guidelines. The expectations will hence be evaluated on:

- *Internal expectations*: analyse whether the expectations of the current stakeholders are robust, specific and of high quality.
- *External expectations*: analyse the awareness and confidence level of the desired key niche participants.

Network formation

Section 2.2.3 introduced two aspects on which a niche network is usually evaluated on in SNM studies: composition and alignment. This thesis includes several additions to match the framework to the Kenyan context. The network formation will be analysed on following four factors:

- *Network composition*

  Before evaluating the completeness, one must first consider what the desired network composition should be for successful niche upscaling in the Kenyan context. This is because the ideal network composition is different in this case than in the context of developed countries, where SNM studies have been usually applied for. The first step of the network analysis will therefore be giving answer to the desired composition. On the basis of this ideal, it will be investigated to which degree the network is complete.

- *Quality of the sub networks*

  Apart from network size and the actors' roles, the performance of the sub networks in this experimentation process is at least as important. The quality of the sub networks determines the overall quality of the network. Depending on the interest of the involved actors and the external circumstances, the participants might research, develop products and deliver services below their potential. Increasing quality of the actors' performance raises the likelihood for success since it increases expectations and confidence and enables better learning. Where possible, this thesis will identify the quality of the sub networks.

- *Network interactions*

  The goals of networking and interacting are manifold: sharing of learning experiences and know-how, co-ordinate expectations and experiments, reduce risks etc. (Mourik & Raven, 2006). This thesis will investigate how and to which degree the network actors are interacting. Furthermore, actors are in the position to increase the network size as well by developing partnerships to attract desired niche actors to the network (e.g. university graduates, financial institutions). This study will pinpoint whether active niche participants are in the process of developing such partnerships.

- *Network alignment*
  This thesis discusses the network alignment itself (are the goals shared?) and the factors influencing network alignment: regulatory alignment, presence of an umbrella organisation, network stability and the degree to which actors collaborate.

Summarizing, for analysing the network formation this thesis will be adjusted to the Kenyan context by putting focus on the desired network composition and the quality of the sub networks. Next to that, similarly to the SNM theory presented in section 2.2.3, this thesis will investigate on the network interactions and network alignment.

Learning processes
The evaluation of this process will entail the lessons learnt, and also discusses who has learnt them (is their collaborative learning?). Next to that, the analysis of the learning processes will study to which extent actors have developed first and second order learning experiences. The theory in section 2.2.3 explained that Hoogma (2002) in Raven (2005) distinguishes 5 aspects of learning. The learning factors in this thesis will be analysed on following 8 aspects:

1) Technical development
2) Wind potential and analysis
3) Infrastructure
4) Industrial development
5) Social and environmental impact
6) Development of the user context
7) Appropriate business models
8) Government policy and regulatory framework

Comparing this list of learning experiences with the one presented in section 2.2.3, it can first be observed that two learning factors are added: ‘wind potential and analysis’ and ‘appropriate business models’. These additions are made to match the framework to the case of SWTs in Kenya. Furthermore, ‘Technical development’ and ‘Infrastructure’ will be treated separately in this thesis for clarity reasons.

2.4.2 Multi-Level Perspective

The landscape and regime developments have its influence on the niche development in two different ways.

First, as explained in section 2.3, the landscape and regime development influence the development of the niche. A destabilized or non-present regime offers windows of opportunity for niche breakthrough. Regime destabilization originates from pressurizing landscape factors and internal regime tensions. The room for SWTs hence depends on the strengths and weaknesses of the regime, by offering room for upscaling. Next to that, when a niche expands and builds up momentum, it can also exert influence on the regime through bottom-up forces.

In addition, the landscape and regime developments can also influence niche development by affecting the internal niche processes and the niche activities itself. This is represented in Figure 10.

- *Expectations*: e.g. a global movement towards green can increase the expectations on a sustainable technology. Also a failing regime can increase expectations; it creates more confidence among the actors and public that it can gain scale.
- *Network*: the landscape can influence the network, through cultural aspects and social factors that may influence actors to join the niche or to collaborate. These for example include a social resistance for collaborating, and corruption, which inhibit entrepreneurship and the performance of the niche participants.
- *Learning*: landscape factors such as education level and cultural aspects may also influence the niche through learning.
- *Niche activities*: the environment in which a niche emerges can influence the niche activities itself. For instance, landscape factors such as infrastructure, raw material supply and informal markets affects the total product cost (e.g. increased transportation costs, import taxes, transaction costs).

2.5 Summary

The development of a new technology is affected by the internal developments and external circumstances, which will in this thesis be respectively analysed by applying the framework of Strategic Niche Management and the Multi-Level Perspective.

Strategic Niche Management

Strategic Niche Management studies the experimental introduction of sustainable technologies by the development of niches. A niche can be defined as a protected space outside the competition of the established technologies, which are embedded in socio-technical regime. The regime holds barriers for innovations to breakthrough.

A niche is formed by the aggregation of societal experiments. In the initial stages, the technology finds itself within a technological niche, which is a space protected by the rules of the regime by subsidies or regulatory exemptions. A technological niche can evolve into a market niche, a space where (some) users start to recognize the values of the innovation. Depending on the level of protection and stabilization within the niche, there exist three types of market niches: a) regular market niches, in which users benefit from the technology; b) dedicated market niches, in which users use the technology because of curiosity or because there is no other option available and; c) protected market niches, where protection has become part of the system. The market niche can next develop into the regime, by overthrowing it or becoming part of it.

To study the niche and develop guidelines for encouraging its breakthrough, practitioners have proposed three niche processes which are dynamically interrelated: voicing and shaping of expectations, network formation and learning processes. The likelihood for niche breakthrough rises with increasing quality of the three niche processes.

Multi-level Perspective

Apart from the internal niche developments, the upscaling of the new technology also depends on external circumstances that create windows of opportunity. These external circumstances can also affect the niche upscaling directly. The Multi-level Perspective analyses the external environment by distinguishing three levels; the niche is the breeding place for new technologies to emerge, the regime is the common way of doing things and the landscape is the external environment in which the regime and niche developments take place. The dynamics between these three levels influence the ability of the niche innovation to breakthrough. This process depends on the timing and the nature of multi-level interactions.

Operationalization

To study the niche and develop guidelines for encouraging its breakthrough, the niche will first be analysed on the three niche processes of Strategic Niche Management (chapter 4):

- *Expectations*: exogenous and endogenous developments influencing the expectations; internal expectations (robustness, specificity, quality); external expectations.
- *Network formation*: network composition and quality; interactions; network alignment
- *Learning processes*: learning at eight different dimensions, first order learning (learning on facts and data) versus second order learning (learning about the cognitive frames and assumptions).

The Multi-Level Perspective in chapter 5 will then analyse the dynamic effects of the three MLP levels and its influence on the SWT niche by studying:

- the influence of regime strength and weaknesses on niche upscaling: are there windows of opportunity?
- the influence of the landscape and regime on the three niche processes and niche activities.
- the effect of the niche on the upper two levels.

3. Niche description

In order to gain full understanding of the SWT niche development and its dynamics (chapter 4), several aspects need to be discussed first. This chapter aims to provide an overview of the current SWT sector and its development up to now, including the technological aspects, stakeholders and market potential. This chapter presents the factual data, and is based on *global* SWT knowledge, hence not necessarily known by the Kenyan actors. The actual sector analysis follows in chapter 4.

This chapter first introduces the technology basics and possible uses in section 3.1. Next, it gives insights into Kenya's wind resources and the necessity of appropriate wind data and turbine siting for realizing full SWT potential (section 3.2). The third section presents the development of the Kenyan wind energy sector, which consists of wind pumps, small wind turbines and large wind turbines. This full overview is given as the sector growth is closely connected to the development of wind mills and large wind turbines. The fourth section elaborates on the present SWT network by describing the different actors. Following this, section 3.5 gives an overview of the types of small wind turbines that are currently on the Kenyan market. This chapter ends with a summary in section 3.6.

3.1 Technology description

This section introduces the technological background of a small wind system. The working principle, power output and their possible applications are successively explained. The aim of this section is to provide the basic technological insights to increase the understanding of the successive chapters and appendices.

3.1.1 Working principle

This section provides an overview of the SWT working principle and components. One should note that below description is kept general, since small wind turbines exist in many sizes and variants, all dependent on who's producing them and what they are meant for.

This section also briefly sketches the different design options of each of the components. An important note in this respect is that despite the fact that SWTs are conceptually simple, the total design is rather complex. This is because each component influences the behaviour and efficiency of the other individual components (Probst, Martínez, Elizondo, & Monroy).

A wind turbine typically consists of a frame, the central part of the turbine on which the blades, tail and generator are assembled. The frame is mounted on the tower. The wind turbine is connected to several electronic components. The components' function and turbine working principle are as following:

Blades

The blades convert wind energy into a rotational force. Three bladed rotors are most widespread. Generally speaking, two-blade turbines rotate faster and more efficient, but they are more susceptible to fatigue. Multi-blade design (>3 blades) rotors are less preferred to 3 bladed rotors, because the blades rotate slower and thus less power is extracted from the wind (Bartmann & Fink, 2009). A number of materials can be used for making the blades including wood, PVC, metal and fibreglass (Berges, 2007).

Tail

The tail is used to steer the turbine into the wind to achieve maximum power. Professional turbine designs include a furling mechanism to protect the turbine against very strong winds (Bartmann & Fink, 2009).

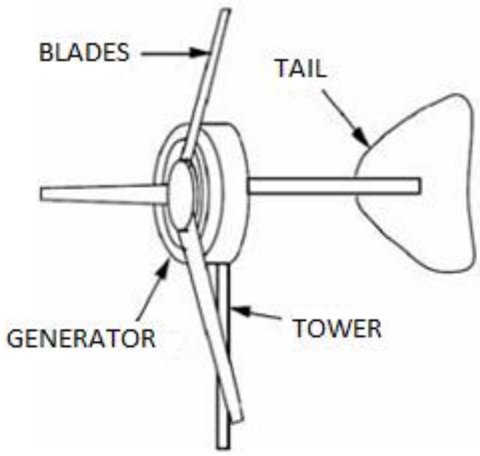

Figure 11: SWT components - adapted from (Dunnett, Khennas, & Piggott, 2001)

Generator

The generator converts the mechanical energy from the turning blades into electrical energy. Various types of generators can be coupled to rotating wind turbines: DC and AC types, with permanent magnets or electrical field excitation, induction generators and generators modified for electricity production (e.g. vehicle alternator, bicycle dynamo, induction motor) (Bartmann & Fink, 2009).

Tower

The turbine tower is needed to elevate the blades to the required height. The height generally varies between 10-20m (Dunnett, Khennas, & Piggott, 2001), which is usually achieved by a tube or lattice construction, either freestanding or guyed (Bartmann & Fink, 2009).

Electronics

The majority of wind turbine generators produce a non-standard alternating current (AC). Since the current has to be stored in a battery bank, an exclusively DC device, the **rectifier** is therefore required to convert the alternator voltage (AC) to suit the battery voltage (DC). The generated electricity is fed into **batteries**, which allows the system to provide power at low or non-existent winds.

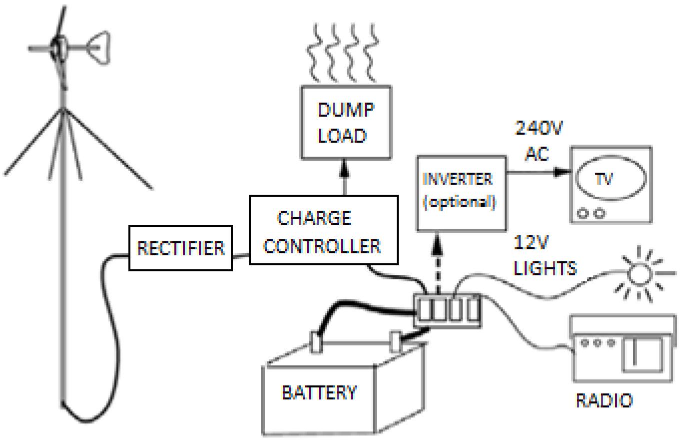

Figure 12: SWT with electrical components - adapted from (Dunnett, Khennas, & Piggott, 2001)

The **charge controller** has two functions. First, it ensures that the battery cannot be overcharged by dumping power to the **dump load** when the batteries are full. This prevents damage to the battery bank. A charge controller is also necessary to protect the turbine against over-rotation, as it keeps up the resistance in the generator when the batteries are fully charged.

Lastly, an **inverter** is used when the end-user wants AC power, for example for powering a television and a refrigerator.

3.1.2 The power in the wind

Figure 13 depicts a typical power graph of a locally produced small wind turbine of 300W rated power. Although these graphs greatly vary per turbine type – the difference between the power graph of a Jua Kali turbine and imported turbine is huge – it gives insight in the importance of being in a suitable, windy area. The power output (P) is coupled to the wind speed (V) according to following relation: $P \sim V^3$ (Manwell, McGowan, & Rogers, 2002). Therefore, as the wind speed doubles, eight times more power is generated by the wind power system. For the wind system that fits below power curve, the power output is 50W at 5m/s, but if the speed doubles to 10m/s, it generates 250W.

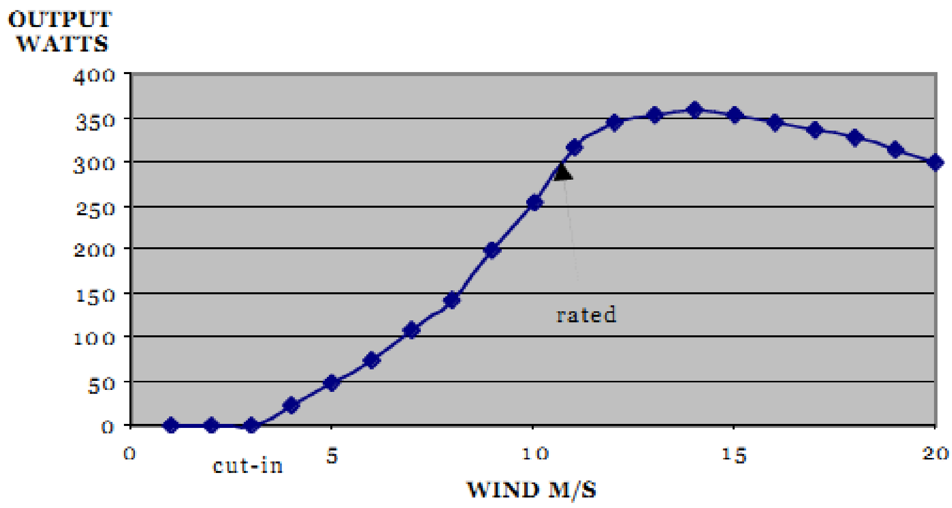

Figure 13: Power graph of 400W turbine (Dunnett, Khennas, & Piggott, 2001)

When the wind speed is high enough to overcome friction, the controls allow the rotor to turn and thus producing a very small amount of power[2]. This speed, at which the turbine starts to generate power, is referred to as the *cut-in wind speed.* The power output increases rapidly as the wind speed rises. When the turbine reaches rated wind speed, it produces the maximum power capacity it was designed for, the *rated power*. If the wind speed increases further and reaches the *cut-out speed*, the system shuts down the turbine to prevent damage (Manwell, McGowan, & Rogers, 2002).

Wind turbines are commonly defined by their rated power. This number is used to compare different wind turbines to each other, or to for example solar panels. However, this number does not give insight in the actual power production, since it does not tell at what wind speed the wind turbine generates that rated power. Since small wind turbines are usually applied in relatively low wind regimes, the cut-in speed and power at low winds are much more crucial to take into account. This information can however only be retrieved from power curve charts supplied by the manufacturer (Bartmann & Fink, 2009).

[2] With simple, locally manufactured SWTs there are often no controls that allow it to start, or the turbine starts when friction is overcome (Bartmann & Fink, 2009)

Since the rated power is a more convenient number to present the performance data and compare the turbine sizes, this figure will therefore be used in this report. Nevertheless, one should remember it does not tell a lot about the total power production.

3.1.3 Applications

Small wind turbines can provide electricity to some of Kenya's rural areas. Large structures inhibit wind flows and decrease power output, and thus wind systems are not effective in the built environment (urban areas) (Dunnett, Khennas, & Piggott, 2001). Small wind turbines can be used as a stand-alone system, a hybrid system (wind-solar or wind-diesel) or for feeding electricity into a micro grid. Furthermore, they are available in a very wide range of sizes, varying from 50W to 10kW. Depending on the amount of power produced, different applications are possible. A small wind turbine can be designed for both 240V alternating current for AC power use (e.g. refrigerator) or at 12V direct current for battery charging or lighting (see Figure 12) (Dunnett, Khennas, & Piggott, 2001).

Smaller wind systems (<1kW) can for example serve electrical power to *households*, who require modern energy for lighting, TV, charging devices etc. Table 1 gives a typical load demand of a rural small household. As can be observed from the table, the total energy demand in this case is 260Wh, which means that this household has a constant power demand of 260W for one hour a day.

Table 1: Typical Kenyan household energy demand (GVEP International)

Component	Power (W)	Time (Hrs / day)	Energy (Wh)
Phone charger	1	60	60
TV	75	1	75
Lighting	25	5	125
Energy requirement per day			260

Furthermore, *existing small businesses* such as carpenters, restaurants and retail shops could use electricity for lighting and operating electrical devices (e.g. refrigerator, electrical tailor machine, welding machine). For this user group, electricity allows them to increase productivity. An SWT system would in this case be an investment that can be recovered later on (GVEP International).

Besides that, small wind turbines have the potential to *create new businesses*. An energy kiosk operator could for example sell power to small businesses that require electricity to operate equipment or machinery. With the rising mobile phone penetration, a SWT based phone charging station is another potentially profitable venture. The same holds for a LED Lamp Charging shop or a business that provides TV services to those rural households without a TV (GVEP International).

Larger wind systems (>1kW) can be used as stand-alone system or connecting it to a microgrid. SWTs can bring modern energy to institutions (e.g. school, hospital) and larger businesses (e.g. Safari park). With the untapped potential for rural ICT, electricity from wind systems could also provide business opportunities for delivering ICT services. On top of that, off-grid electricity systems such as SWTs allow telecom providers to reach remote locations to increase their mobile coverage (Interview 11). Lastly, small wind systems offer possibilities to power rural communities, by for example feeding into a microgrid and delivering power to the individual households and small businesses (Osawa & Otieno, 2004; UNIDO; Craftskills, 2011)

3.2 Wind potential in Kenya

3.2.1 Wind resources

Wind is a result of the unequal heating of the earth by the sun. Different climate zones have different pressure levels, and wind moves from higher to lower pressure areas. Furthermore, the wind direction and speed are influenced by other factors such as the rotation of the earth, local topographical features and the terrain roughness (Ngondi & Makanga, 2010). Kenya is located within the equatorial region, which generally does not result in strong winds. However, there are significant winds in Kenya due to the country's topographical features and varying height levels in addition to its many lakes. Thus despite the fact that wind is far less uniformly distributed than solar, many areas do possess significant wind potential (Kiplagat, Wang, & Li, 2011).

So far, two wind maps of Kenya have been developed to demonstrate the different wind regimes in Kenya: a 2003 Wind Energy Atlas based on wind data (at 10m) of the Meteorological Department (Ottichilo et al.), and the 2007 SWERA wind map (at 50m), which was derived from satellite models (Theuri, 2008). To give an impression of the Kenyan wind regime, below figure shows the SWERA map, which is more accurate than the Wind Atlas (Interview 10). Since the SWERA map shows a satellite model of wind speeds at 50m height and the SWT height is considerably less (10-20m), Figure 14 shows an adjusted legend (Fugers, 2011). The wind map shows that the north-western region of Kenya has the highest wind speeds. The central, coast and south-western regions are also endowed with sufficient wind resource for small wind turbines. The latter regions are also densely populated, which means that there is a sufficient market potential for the development of an SWT sector of considerable size (Kiplagat, Wang, & Li, 2011).

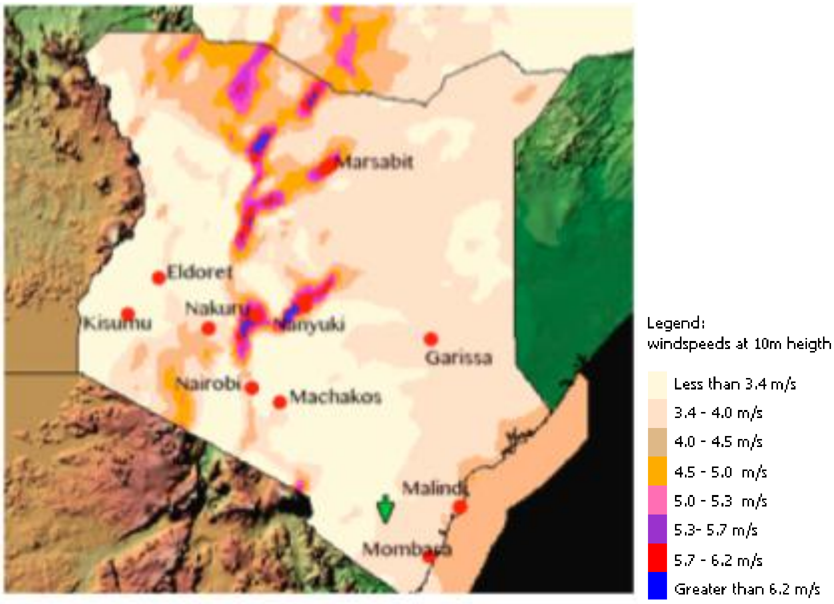

Figure 14: SWERA Wind map adjusted to 10m height (Fugers, 2011)

3.2.2 Wind data and turbine siting

It is crucial to evaluate the availability of wind before installing a wind system since only then one can judge on its viability to generate power at a certain location. For this reason, wind data is one of the most essential pieces of information for the dissemination of SWTs in Kenya (Osawa & Otieno, 2004). The economic viability of wind systems at a certain wind speed largely depends on the wind system cost and its envisioned application. Whereas some small wind turbines are commercially attractive from average wind speeds from 4 m/s, some only become viable at wind speeds from 7-8m/s (Dunnett, Khennas, & Piggott, 2001; Bartmann & Fink, 2009; Interview 4, 37, 40).

Besides that, wind data is also required for the design and sizing of a small wind turbine for a specific location. For these purposes, one must have more data than only average wind speeds. The wind speed distribution, variation of the wind speed during the year and variation of the wind speed during the day are other parameters needed to select the right wind system and battery size (Manwell, McGowan, & Rogers, 2002).

It must be noted that wind speeds may greatly vary within the same area or locality. They are for example heavily affected by its surroundings. Trees, buildings and other structures impart turbulence in the air, which in turn lowers the turbine output and increases the stresses on the wind system. The prevailing wind direction is for this reason another important parameter to take into account, since wind turbines are best placed upwind of these nearby structures. Mounting a turbine on a roof also downgrades the potential because the building creates turbulence. Obviously, wind speeds also heavily depend on the tower height, since they significantly rise as the distance above the ground increases. Siting the wind turbine correctly (out in the open and preferably on higher grounds) is therefore another essential step for realizing the full potential of the wind system: out in the open and free of obstacles (Bartmann & Fink, 2009).

3.3 History of SWTs in Kenya

This section discusses the history of small wind turbines in Kenya. Since the development of the sector went hand in hand with wind pumps and medium and large wind turbines, these are also included in this overview.

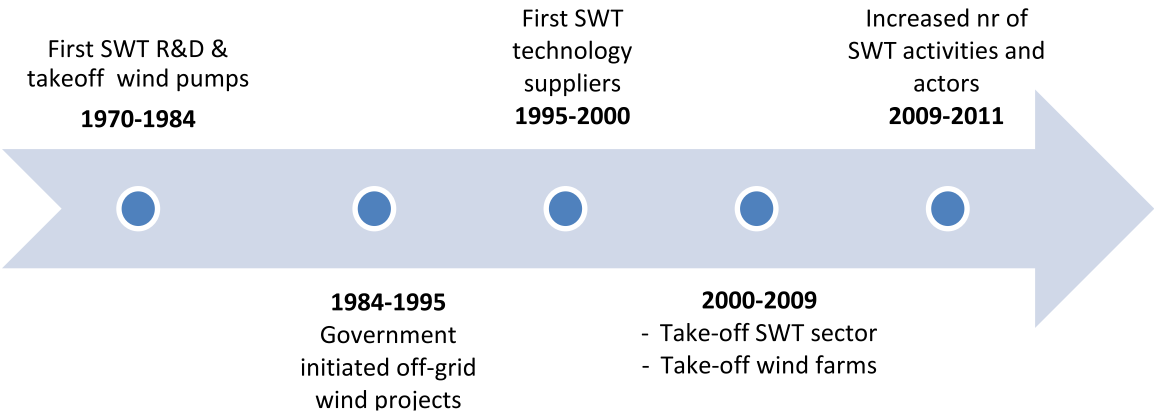

Figure 15: Development of SWTs in Kenya

Wind energy has a long history in Kenya. Wind pumps were first used over 100 years ago. Back then, it were primarily European colonisers who imported the turbines. During 1960s, when oil became available, most windmills were replaced by diesel engines. Since the oil crisis in the 70ties, there has been a renewed interest in wind pumps. Nonetheless, because of the lack of local knowledge and spare parts, Kenya encountered many difficulties establishing a wind energy sector. Over the years, there have been numerous feasibility studies, pilot projects and wind system ventures to demonstrate and re-introduce wind energy in Kenya. Most of these projects were initiated by donor agencies with help of western expats and were focused on both water pumping and electricity generation. Lack of proper coordination, inaccurate data, financial problems and low technical knowledge inhibited the establishment of a small wind energy sector. However, the feasibility studies did lead to some awareness of wind energy potential and wind energy technology in Kenya (Ogana, 1987). Bob Harries Engineering Ltd (BHEL) was the country’s first successful wind energy venture.

Since 1979, BHEL has been manufacturing and installing their Kijito wind pumps all around the country, mainly in the remote areas of Kenya (Harries, 2002).

The first wind turbines projects were carried out in the beginning of the 80ies. It entailed medium wind turbines for powering two off-grid communities. These projects both failed due to lack of attention and maintenance. In 1993, a third off-grid project was established from foreign donations (KenGen, 2012).

It took until the end of the nineties for the small wind turbine sector to take off. Established importers of energy systems (e.g. PV, battery systems) started extending their product range to small wind turbines (Interview 40). Furthermore, the first small SWT local manufacturer, Craftskills, was established in 1999 (Interview 5). WinAfrique entered the field in 2001, as the first dealer solely focusing on small wind turbines (Interview 11).

Several experiments followed in the successive years, primarily carried out by national and international universities. Although these experiments were limited to one attempt or pilot, it increased knowledge in technology development, usage and the feasibility of large scale application. The number of SWT dealers significantly increased.

In 2005, the installed capacity was estimated at 80-100 small wind turbines (total of 50kW), a total of 750kW large wind turbines and 300-350 windmills (Mutimba, 2005). As the popularity for wind energy increased, Jua Kali[3] also began experimenting with small wind systems. For some of them, it remained an experiment, whereas others were able to venture a small SWT business (Interview 22, 28, 30, 35 and 36).

The government awareness and interest in wind energy has been steadily growing over the last years, mainly due to rising oil costs, surging energy demand and the need to address global warming. Therefore, the Ministry of Energy developed wind maps in 2003 and 2007 (see above - Figure 14) to increase commercial grid wind energy interest (Kirai & Shah, 2009). Together with other incentives such as feed-in tariffs, the wind farm sector has seen a steady rise over the last few years, with one wind farm completed and several other projects in process (Table 2).

[3] Jua Kali is the local name given to people who work as a carpenter, welder, electrician or car mechanic. It literally means “hot sun” in Swahili, and refers to the rough, under open air working conditions of these artisans. (Daniels, 2010)

Table 2: Projected wind farm projects (Kiplagat, Wang, & Li, 2011)

Project	Capacity (MW)	Estimated commissioning date
Ngong 3 (KENGEN)	14	July 2012
Lake Turkana (IPP)	300	July 2013
Osiwo wind (IPP)	50	July 2013
Aeolus (IPP)	60	July 2013

Since 2009, the number of experiments, research programs and overall attention for small wind turbines went up, partly due to the positive wind energy attention for the wind farm projects. Universities have increased their wind research, non-profits are running support programs and more and more companies are getting involved. In 2009, Kenya has also known its first conference for small wind turbines, with a majority of attendants from Kenyan R&D institutes and NGOs (RISO DTU, 2009). At the moment, two local manufacturers are being set up (WindGen), and one business oriented non-profit has recently been established (Access:Energy). Several others have the ambition to start their own local SWT manufacturing (Interview 16, 32).

The exact number of pilots, wind turbines installed or technology suppliers is unknown, since there is no central registration and hence no database. However, estimates were made based on the information from the interviews and an internet research. Appendix E presents the approach for estimating the number of turbines installed and shows it most probably varies between 500 and 1000 systems.

3.4 Stakeholders

There are various parties involved in the SWT development and implementation in Kenya. This section discusses the different stakeholders involved in this process and how they contribute(d) to sector development. Note that various actors only participated in the SWT sector for a one-time study or experiment, and that also several SWT commercial actors have terminated their activities in the field of SWTs. Despite the extensive field and literature study, it should also be noted that this image of the SWT sector composition and size is not complete due to research limitations (research time frame and experienced difficulties to attain information). This section describes the stakeholders according to four groups: the technology suppliers, the local NGO and development organisations, the research institutes and the national government, which are depicted in Figure 16. This figure also depicts the current SWT user groups, and which type of technology supplier serves them. Note that these user groups do not include all possible target markets as discussed in section 3.1.3. Since section 3.5 will elaborate on this, this section is limited to the description of the four above mentioned stakeholder groups.

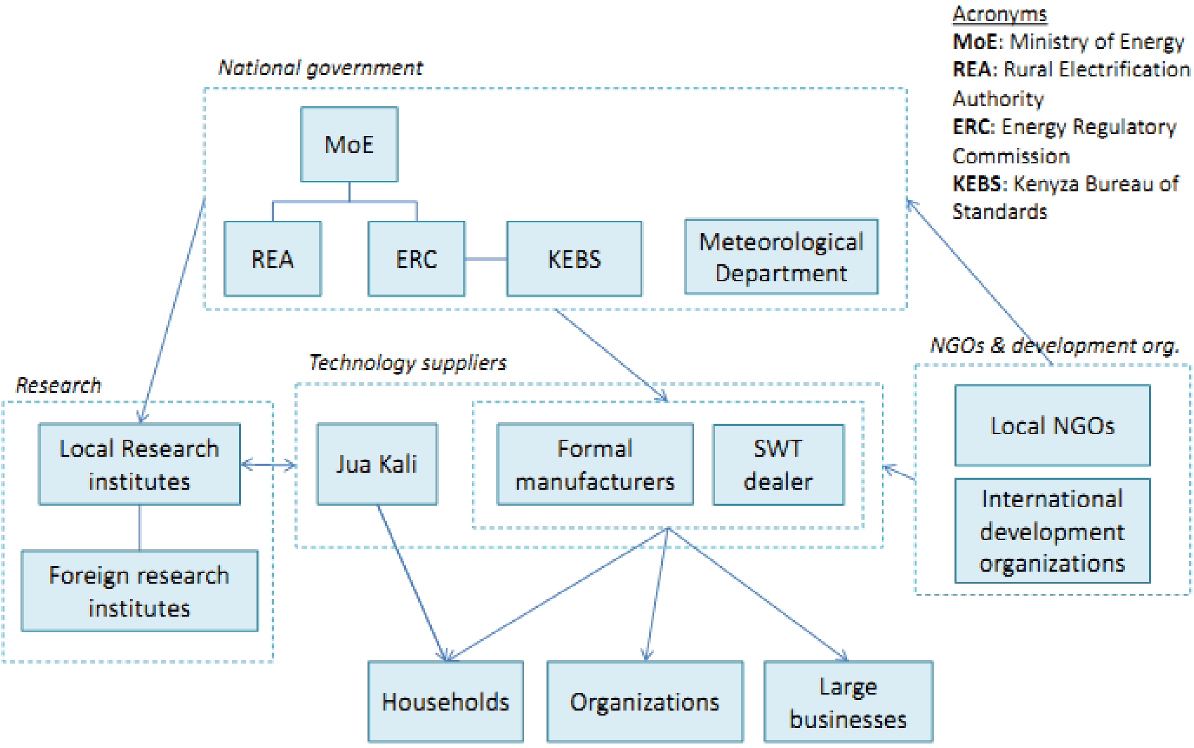

Figure 16: Overview of the present SWT network

3.4.1 Technology suppliers

The Kenyan SWT providers are very diverse, and they can roughly be divided in three groups: small wind turbines are being locally produced by both Jua Kali and formal enterprises. The third group consists of the various companies offering imported small wind turbines. Before elaborating on these different types of providers, some background on the Kenyan types of enterprises is required for gaining sufficient insights to fully understand section 3.5 of this chapter and the Strategic Niche Management analysis in the following chapter. A general description of the three groups is presented afterwards. Section 3.5 will elaborate on their turbine designs and market.

Kenya's economies

Kenya has two main economies: the formal and informal sector. The **formal sector** is the part of the economy that is registered, taxed and monitored by the government. Generally speaking, it comprises of the country's large scale industries and this sector receives some kind of government protection. The **informal sector** is commonly referred to as Kenya's second economy, and consists of all small, local entrepreneurs that work as artisans, vendors, mechanics, welders, carpenters and electricians. Unlike the formal economy, the informal enterprises receive minimal regulation or protection from the government (Orwa, 2007).

The history of this division goes back to the beginning of the British Colonisation in the late 19th century. While the British colonists dominated the formal industry, Africans were perceived as second-class workmen. In 1963, Kenya gained independence and a new national government was set. In the following years, the informal sector grown and capacity was increased within, particularly in the auto repair, metalwork and carpentry industries. The formal sector also grew stronger, particularly by increased activity by Indian entrepreneurs and to a lesser extent by Africans themselves. With the liberalization of the Kenyan economy in the late 1980s, borders were opened and high quality goods increasingly entered the country. The local production industries were unable to compete with imported finished goods on price and quality. As a result, formal local production weakened and import products took up an important position as the standard in the formal sector (Daniels, 2010).

Despite the many efforts to formalize the informal sector, the majority of the Kenyan population earns their living in this sector. According to an Economic Survey in 2002, 74.2% of the country's labour force works in informal enterprises. The sector however only accounts for 18.4% of Kenya's GDP (Orwa, 2007). Furthermore, the sector contributes over 90% of the new jobs created annually (Daniels, 2010).

Today, the part of the formal sector that supplies goods to the Kenyan market continues to thrive on imported goods. The informal delivery of goods goes through the Jua Kali, which are the informal artisans who engage in their production. Jua Kali artisans predominantly use manual labour and handmade tools to produce low cost goods that fit the market. They often work under materials constraints as they do not have access to all types and sizes of materials. Furthermore, Jua Kali have difficulties with regards to scaling up. Today Kenya's informal sector continues to thrive despite being ignored by public institutions and officials (Daniels, 2010).

Jua Kali

There are various Jua Kali throughout the country that have engaged themselves in the design, manufacturing and in some cases sales of small wind turbines. Primarily welders, electricians and car mechanics have been involved. This research revealed that Jua Kali initiated their SWT activities more than 13 years ago. Furthermore, 8 individual cases were found of Jua Kali having independently designed a small wind system from locally available, often scrap materials. Whereas for some of them it remained an experiment, others have tried or realized to turn their SWT activities into a business (Interview 22, 28, 30, 35, 36, 38, 40).

SWT manufacturers

Small wind turbines are being locally produced by formal SWT manufacturers. There are currently only two manufacturers in Kenya: Craftskills and WindGen. Craftskills was set up more than 10 years ago (2000) by a Kenyan (Interview 5), WindGen was recently founded (2011) by foreigners (Interview 12). Both companies design, manufacture and sell consumer scale wind turbines to businesses, households and institutions throughout Kenya. They operate from the capital Nairobi, and their wind systems are especially designed for the Kenyan market with maximal use of locally available materials.

Next to its wind pump activities, Bobs Harries Engineering Ltd (BHEL) also explored the possibilities of wind power generation for battery charging in 2007, with the idea of turning it into a business (Interview 4).

This actor group is growing at this moment, with various people being in the process of establishing a business in the sales of locally manufactured small wind turbines or the manufacturing equipment itself. Access:Energy has made more progress in this respect (Interview 16, 24, 26, 41). This research has also revealed that there have been several enthusiasts involved in the design and development of small wind turbines in prospect of future business opportunities (Interview 37, Interview 41).

SWT dealers

SWTs are widely developed and produced outside the Kenyan borders. Therefore there are a range of distributors of mass fabricated turbines in Kenya that import and sell wind turbines, and that are all located in the cities (predominantly Nairobi). As far as the author is aware, there are two Kenyan firms that have a strong focus on imported small wind systems: WinAfrique (2001) and EAWEL (2011) (Interview 11; EAWEL, 2011). Next to that, there are a range of SWT dealers that have a different primary focus, e.g. solar systems, batteries and water systems. It are primarily importers of solar systems who complement their energy product offerings with wind turbines. As they generally generate more income by for example solar system sales, less attention is paid to the SWT promotion and sales. It must be noted that the SWT activity strongly depends on the dealer itself. Despite their secondary focus, some of these enterprises have been able to sell up to 70 wind systems, whereas others just mention the turbines on their website but hardly make any sales (Interview 40).

The SWT dealers import their wind turbines from their foreign suppliers. These manufacturers produce the turbines on a large scale. A whole range of companies from all around the world distribute their products to the Kenyan market. The majority of dealers sell products from USA suppliers Southwest Wind Power and Bergey Wind Power (Chloride Exide, 2012; Davis and Shirtliff, 2012; Interview 11, 40).

3.4.2 Local NGOs and international development organisations

Next to the technology suppliers, local NGOs and international development organisations are also playing a major role in the SWT sector development. They have been involved in the sector for following activities:

- **Knowledge diffusion role**, developing reports stating the status of the SWT sector: GTZ, UNDP, ESDA (Kirai & Shah, 2009; Mutimba, 2005; Osawa & Otieno, 2004).
- **Experimentation** to investigate the feasibility of small wind turbines for electricity generation: SASOL, HSHC (van Dorst, 2010; Buntsma & Fugers, 2009).
- **SWT Jua Kali support** activities (technical and business): Access:Energy, Equator Fuel Stove, GVEP (Interview 15, 24, 26).
- **Funding** of SWT pilots, SWT entrepreneurs and local academic SWT research by International development organisation: JICA, DANIDA (Interview 4, 11, 33).
- **Renewable energy sector development** (now being established) by providing business and technical support, provide consultancy and access to capital etc.: UNIDO (Centre for Excellence) and the World Bank (Climate Innovation Center) (Climate Innovation Center, 2010; Interview 39).

3.4.3 Research institutes

Apart from the above described technology suppliers and non-profit actors, also Kenyan and foreign universities have contributed to sector development by a variety of research activities. Note that the Kenyan universities have been consistently engaged in the sector, whereas the foreign universities were involved in one time experiments.

- **University of Nairobi (UoN)**

The University of Nairobi already established an SWT research program in the seventies (Interview 10). UoN has also been involved in a community experiment with locally manufactured turbines (Interview 9), and now provides wind energy courses (Interview 7).

- **Jomo Kenyatta University of Agriculture and Technology (JKUAT)**

JKUAT has been involved in wind energy assessments and a demonstration pilot in 2003 (RISO DTU, 2009). Apart from wind energy teaching, JKUAT is establishing a program to develop or improve on renewable energy technologies including small wind turbines. JKUAT's goal is to produce designs that can be locally built, maintained and repaired by rural Jua Kali (Interview 33).

- **Foreign universities**

Involved in feasibility studies and experiments together with local partners (private, public and non-profit), e.g. Technology University of Denmark, Pennsylvania State University, Delft University of Technology and Eindhoven University of Technology (Interview 20, 22, 31).

- **Wind resource assessment institutes**

Involved in improving the knowledge of the Kenyan wind resources; the main stakeholders in this respect are the Regional Centre for Mapping of Resources for Development (Kenyan) and RISO DTU (Danish research institute).

3.4.4 National Government

The fourth important stakeholder group consists of several national government departments. First, the Ministry of Energy (MoE) is responsible for the energy policy and development. The MoE has also been involved in wind resource assessment. To stimulate the wind farm sector, the MoE has recently begun to collect wind data at 53 locations throughout the country that are selected for having favourable conditions for installing wind farms. Furthermore, the MoE also has an oversight role over the Rural Electrification Agency and the Energy Regulatory Commission (SREP, 2011).

The Rural Electrification Agency (REA) is charged with the mandate of electrifying rural Kenya, by either grid extension or off grid projects. They are also responsible for the promotion of renewable energy technologies. In 2010, they provided two schools with a wind– solar hybrid system as part of their off-grid electrification program. REA will also collaborate in the renewable energy R&D program of JKUAT (see above). Three staff members of REA will take upon the task of transferring this knowledge to the Jua Kali (Interview 18).

The Energy Regulatory Commission (ERC) is Kenya's energy regulator. ERC's Renewable Energy Department is responsible for preparing an indicative energy plan for renewable energies and assisting the Ministry of Energy to develop regulations for all forms of renewable energy. Next to setting the regulations, the ERC is also responsible for their compliance (Interview 14). For energy related standards, they cooperate with the Kenya Bureau of Standards (KEBS); when there is regulation attached to the KEBS standards, the ERC enforces them (Interview 6). Lastly, the Meteorological department is responsible for measuring wind speeds at their 33 stations located across the country. Interested parties can buy these wind data sets (Appendix B.3; Interview 9, 10).

3.5 Small wind turbines on the Kenyan market

Kenya has a whole range of small wind turbines on its off-grid electricity market. Each type of small wind turbine on the Kenyan market has its own characteristics (power output, cost, lifetime, etc.) and hence also its own market. For example, small wind turbines exist ranging from 50W – 10kW power output (see section 1.6) and from ca. KES 50.000 to several million Shillings (Interview 18, 29).

This section sketches an image of the different turbine categories available based on which group is producing or supplying the turbines. Among the first group one can find the Jua Kali type of turbines. The second group consists of the locally produced turbines by formal enterprises, and as part of university and charity projects. Thirdly, the imported turbines and suppliers are discussed. For each category, the turbine technology, performance and cost characteristics and market aspects are presented. This section ends with an overview of all turbine categories.

A general note with regards to the local manufacturing of small wind turbines is the lack of skills and knowledge often results in the production of unreliable turbines. While enthusiastic individuals with a sufficient engineering background may be capable of designing and manufacturing a working functional wind turbine, its performance is generally low because the actual turbine design, construction and operation of the system should be done with great care (Probst, Martínez, Elizondo, & Monroy).

3.5.1 Informal manufacturing

The makers of these turbines are predominantly Jua Kali (or for instance Access:Energy for training Jua Kali), who produce in the cities or rural areas. As previously mentioned, the informal sector is not monitored or registered by the government, and there is hardly any data about the SWT activity in this sector. For this reason, there is no track record of the amount of these turbines on the Kenyan market. Below information is retrieved from the interviews (Interview 15, 21, 26, 27, 29, 34, 36).

The Jua Kali sector is known for its copy behaviour: they copy designs from imported goods, books and catalogues, or from other artisans. This research revealed that some of the Jua Kali use their own creativity for building the turbines (trial and error), whereas others gained the required knowledge from the internet or from books.

Figure 17: 3 bladed Jua Kali SWT with metal blades, mounted on roof top (Ngondi, 2009)

Figure 18: 5 bladed Jua Kali SWT with metal blades, mounted on tree (Ngondi, 2009)

Technology

Jua Kali build turbines using a variety of cheap and locally available materials (e.g. scrap materials, spare car parts etc.):

For the blades, Jua Kali use wood, steel or even recycled fan blades. Depending on the quality of production, the wood and steel blades have potential to perform well. However, as is the case with the 'fan blade' choice, Jua Kali often use ready blade-shaped structure rather than developing the blades themselves as this is a difficult production step for un-experienced people.

The generators are generally old machines that are modified for electricity production. Because of its low cost and widespread availability, a popular option is converting an old *car alternator* to a wind turbine. However, the performance of this generator is quite low, because of the high power and friction losses, and due to the bad performance at wind fluctuations. Also *bicycle dynamos* in combination with bicycle wheels are used by several Jua Kali. In this design, the rotating bicycle wheel spins the dynamo to produce electrical output. Similar to the vehicle alternators, this generator type is cheap but produces low power outputs at low efficiency. Lastly*, self-built magnetic alternators* are in the Jua Kali designs. This type of generator is more advanced and costly than the previous Jua Kali alternatives. As a result, higher power outputs and better efficiency are possible when built well (Bartmann & Fink, 2009).

Jua Kali place the turbine on a variety of constructions. Not only tube or lattice constructions are common, some Jua Kali also place their turbines on trees or mount them on rooftops (Figure 17 and Figure 18). As explained in section 3.2.2, mounting the turbine on rooftops is detrimental for its performance. Old car batteries are a common option for electricity storage. Generally, Jua Kali turbines lack (appropriate) electronic components and do not include more advanced methods such as a furling mechanism.

Performance and cost

The Jua Kali turbines are generally available at very low cost, and are built with the materials available. These turbines are designed to produce power at the lowest cost possible. High power and friction losses are common and so is their bad performance at wind fluctuations. These turbines deliver power outputs between 30 and 300W. However, their power output at low wind speeds is generally low and the turbine is often placed in unfavourable locations. For this reason, low energy production is characteristic for this type of small wind turbine.

Market and business approach

The market for this Jua Kali turbine is primarily the rural households and farmers with low energy demands and low income levels. They are encouraged to buy the turbine because they know the Jua Kali directly or indirectly. The Jua Kali do not offer formal sector guarantees such as a maintenance contract or warrantee. Furthermore, the Jua Kali do not perform wind measurements to assess the SWT viability at a certain location.

3.5.2 Formal manufacturing

Locally registered SWT manufacturers produce turbines in this category. Also universities and several non-profit projects that are involved in locally built small wind turbines develop this kind of systems. An estimated 120 to 150 turbines are installed throughout Kenya of this category. This number is based on the sales of Craftskills, WindGen, and locally built turbines for one-off projects (Appendix E).

Figure 20: Hugh Piggott turbine for powering community (Mehta & Mehta, 2011)

Figure 19: Craftskills SWT powering an off-grid home (Craftskills, 2010)

Technology

The most popular design in this category is the open source turbine of Hugh Piggott. This design is used in many developing countries for the local production of small wind turbines (Dunnett, Khennas, & Piggott, 2001). Its 3 blades are made of wood, and the tube tower is guyed to give support. The Hugh Piggott turbine uses a Permanent Magnet Axial Flux (PMAF) generator, a type of permanent magnet generator (PMG), which uses permanent magnets, and is based on the fact that a changing magnetic field through a copper wire will induce a flux or electrical current (Bartmann & Fink, 2009). This PMG configuration is the most widely used technology for SWTs below 2kW, since they start producing power in low winds and at relatively high efficiency (Berges, 2007). Other advantages are its simplicity and accessibility, and the fact that it can be made of basic materials (Dunnett, Khennas, & Piggott, 2001).

However, this design also has several disadvantages. First, the energy losses are considerable at high winds: ca. 5% is lost at low winds with up to 50% at high wind speeds. Another disadvantage is the usage of permanent magnets. To limit the generator size and weight, the majority of the small wind turbines consist of the strongest magnet type available: neodymium magnets. Because of world scarcity, these generators are very sensitive to price fluctuations and they must always be imported (Berges, 2007).

The primary reason for the worldwide success of this design is the fact that it is a proven technology. As far as the author is aware, all actors (businesses, universities and non-profits) in this category started their SWT activities with a Hugh Piggott based design, possibly with some minor adjustments. Craftskills has been active long enough to make some adjustments to the design; their Windcruisers use imported fibreglass blades and modified induction motors as generator (Craftskills, 2011).

Performance and cost

The locally built formal wind turbines are made especially for the Kenyan market, and as much as possible produced from local materials. The cost is a critical design criterion, but so is the performance and turbine quality. For this reason, these turbines are available in a variety of sizes at medium cost and reasonable efficiency. For the smaller sizes (150W-300W), prices range between KES 100.000 and KES 200.000 (Turbine, tower and electronics). Turbines of ca. 1kW rated power are available for a total cost of KES 280.000– 350.000. For power outputs of around 3kW, which is the maximum size that can mostly be found installed, turbine prices rise up to KES 800.000 (Craftskills Ltd, 2010; Interview 5, 12).

Market and business approach

The market for these turbines is very diverse. The smaller (and cheaper) wind turbines can be used for applications with modest power demands such as small homes and businesses. The larger types of turbines are applicable for households with larger power demands (e.g. wealthy urban individuals for holiday home), institutions, community projects and larger businesses. Up to now, this type of turbine has been sold to households and farmers, and in a lesser extent to schools, businesses and community groups (Interview 5, 12, 20).

Local manufacturer Craftskills primarily finds its customers through a mouth to mouth approach, in which new customers are often connected to existing end-users, and after-sales services are not provided. Craftskills builds its turbines on customer demand. On the other hand, WindGen aims to standardize its products and build more on a regular basis. The two companies do not routinely perform wind measurements as standard before installing a wind turbine: WindGen only does it after customer request, whereas Craftskills investigate on the topography and vegetation and recommends its future customers to monitor the wind speeds themselves by using an anemometer (Interview 5, 12).

3.5.3 Imported turbines

The imported turbines are offered by the wholesalers or resellers. One of Kenya's largest SWT dealers has sold ca. 70 small wind turbines, whereas other dealers have only made few sales. All in total, it is estimated that there are between 280 – 560 imported small wind turbines on the Kenyan market (Appendix E).

Figure 22: Bergey wins turbine (Bergey Windpower, 2012)

Figure 21: Southwest Wind Power (Chloride Exide, 2012)

Technology

These turbines are mass scale produced, and the vast majority is 3 bladed. The blades are most commonly fibreglass blades, and the frame is mounted on (guyed) tubes or lattice structures. As is the case with the locally built turbines (formal sector manufacturing), the PMG generator is very frequently used, especially for turbines smaller than 2kW. For higher sizes of small wind turbines, induction generators are more often applied (Berges, 2007).

Performance and cost

The imported turbines are not specifically developed for the Kenyan market. The imported turbines are available in a large variety of sizes, from as small as 200W to 10kW. The cost of these turbines varies greatly. Generally speaking, these turbines are better and more reliable than their locally built variants, but they are much more costly (GVEP International). Prices can easily go up by a factor of 1.5-2 (Chloride Exide, 2012, Davis and Shirtliff, 2012; Interview 11, 40).

It must be said that there is a trend towards offering cheap turbines on the Kenyan market, which even the established SWT importers are planning to embark on. A significant part of the Kenyan manufacturers is shifting towards offering turbines from China that are low in price and in quality (note that this is not the case for all Chinese turbines – there are also reliable Chinese turbines on the market). Others are considering the import of second hand small wind. Also these turbines are much cheaper than their new variant, but their lifetime is considerably lower (Interview 5, 11, 31, 38, 39, 40).

Market and business approach

The SWT dealers generally offer more expensive products than the local manufacturers. There are several reasons for the high cost of imported turbines. The first is the transportation costs, since these turbines need to come from abroad. Second, the established foreign companies manufacture turbines for the Western market, and do not adjust their design for it to suit in the Kenyan context. Logically, manufacturing is also more expensive in the Western countries due to higher labour costs and overheads (Khennas & Dunnett, 2008). As a result, the vast majority of the SWT dealers have been providing turbines to a niche market of wealthy individuals and corporate customers, such as telecommunications companies and hotels. All dealers operate from the cities (predominantly from capital Nairobi), and they mainly target the urban individuals and businesses (Interview 11, 28, 40).

As mentioned above, for a large portion of the SWT dealers the wind systems are part of their product portfolio but are not their main focus. Contrary to companies such as WinAfrique and EAWEL, these dealers do not actively promote their SWT products. What’s more, some businesses only buy the product from the foreign suppliers after they have received an inquiry (Interview 39, 40).

As far as the author is aware, at least some dealers carry out wind monitoring before putting up a turbine, as the respondents from this group (company and end-user) confirmed to do so (Interview 11, 40, 42).

3.5.4 Overview

Below table gives an overview of the characteristics of the different SWT types on the Kenyan market. For clarity, the Chinese and second hand turbines in the 'imported turbines' category (see above) are excluded from this overview.

Table 3: Characteristics of Jua Kali, formally manufactured and imported turbines

Aspect	Informal manufacturing	Local manufacturing	Imported turbines
Production	(Very) small scale Local scrap/ spare parts	Small scale local (quality) materials	Mass scale
Power	20-300W	200W – 10kW	200W-10kW
Efficiency	Very low	Medium	High
Cost	Very low – low	Medium	High
Quality	Low	Medium	Reliable and well-tested
Repair and maintenance	Can be locally repaired (spare parts available)	Can be locally repaired Spare parts available	Local skills and spare parts may not be available

The local production of small wind turbines by Jua Kali is cheaper than any other alternatives, but in general these products also lack quality, are less efficient and produce less power. The Jua Kali turbines however do work well for the rural population, since the quality, size and price of the products are matched to consumer needs and budgets. Despite the fact that Jua Kali use local materials, availability of spare parts might be an issue since they are forced to work under material constraints. Lastly, due to their strong customer relationships (poor – middle class), Jua Kali are able to target a part of the population that is not reached by any of the Nairobi-based companies.

The local production of small wind turbines by formal enterprises is cheaper than imported machines. Local manufacturers design their products for matching in the Kenyan context, taking into account the needs of the end-users and to the conditions under which they are expected to operate (energy solution based on factors such as the local availability of skills and materials, wind resource and energy demand). Also local maintenance and repair skills together with the availability of spare parts are benefits of these domestically produced systems.

Lastly, the imported turbines are produced by reputable foreign suppliers and are generally well-tested and reliable and more efficient. Their main disadvantages are the high cost, lack of spare parts and missing local knowledge about the working of these turbines.

3.6 Summary

A small wind turbine generally consists of the following basic components: a variable number of blades, a tail, a tower, a generator and electronic components for feeding electricity into a battery bank. Although SWTs are conceptually simple, the design and manufacturing of the total system is quite complex. Small wind turbines are available in a wide range of sizes up to 10kW. They can be used for isolated electrification and for powering mini-grids. They could serve electrical power to individual households, small businesses, institutions, larger businesses and communities.

The Kenyan coastal, central, south-western and northern areas are endowed with sufficient wind resources for small wind turbines. SWT sector development is possible at these locations. Seasonal and daily climate variations have a critical impact on the technical and economic aspects of small wind turbines. Despite it being one of the most essential pieces of information for the dissemination of SWTs in Kenya, wind data in Kenya is scarce. Furthermore, since siting of the turbine can also make a big difference within the same area; it should be placed high and out in the open.

Wind energy research was initiated in the seventies. Despite the various feasibility studies and wind assessments in the following decades, it took until the late nineties for them to become commercial. SWT activities significantly increased the last decade. It is estimated that there are to date 500-1000 installed SWTs. Various actors participated in the SWT sector during the last 10 years, including:

- A few formal companies and various Jua Kali in local manufacturing
- Various import companies and their foreign suppliers
- Local NGOs using small wind energy systems in their power supply projects; active involvement in experiments
- International co-operation institutions supporting the sector with funding, status reports and business development support services
- Local and foreign universities and research institutes involved in wind analysis, SWT R&D and experiments

- National government: Ministry of Energy (primarily wind resource assessment), ERC (initiation of policy development), REA (use of SWTs in pilot projects) and Meteorological Department (wind monitoring)

There are three types of SWTs on the Kenyan market: Jua Kali made turbines, formal manufactured turbines and imported turbines. The local production of small wind turbines by Jua Kali is cheaper than any other alternative, but in general these turbines are made with low quality materials and insufficient knowledge. As a result, these turbines generally lack quality and efficiency. The main target group is the rural poor. Secondly, the local production of small wind turbines by formal enterprises targets the more prosperous households, businesses and institutions. The majority of these turbines are based on the open-source design of Hugh Piggott. These turbines are cheaper than imported machines and benefit from the availability of local materials and spare parts. They are however less reliable than the imported ones. Thirdly, the imported turbines are produced by reputable foreign suppliers and are generally well-tested, reliable and more efficient. The main disadvantages are the high cost, lack of spare parts and missing local knowledge about the operation of these turbines. Due to this high cost, the target market consists of only wealthy households, institutions and businesses.

4. Strategic Niche Management analysis

Whereas the previous chapter elaborated on the technology and stakeholder composition of the SWT sector (factual data), this chapter extensively analyses the niche by means of the three dynamic niche processes. The most commonly stated obstacles for sector upscaling are the lack of public awareness and high upfront costs. This chapter aims to disclose how the actors are resolving these issues, and present deeper insights into other internal developments that are influencing the diffusion of SWTs in rural Kenya.

For analysing the niche, information is primarily derived from the interviews in Appendix F, and in a lesser extent from personal experiences (Appendix B), a questionnaire amongst Kenyan university students (Appendix C) and literature resources. Section 4.1 first places the Kenyan SWT sector in the context of strategic niche management. The three niche processes are discussed successively (section 4.2 - 4.4). Section 4.5 concludes on the content of this chapter.

4.1 Current state of development

The field of small wind turbines is relatively underdeveloped in Kenya. As mentioned in section 3.3 and 3.3, relatively few SWTs have been installed in Kenya in a period of 12 years (ca. 500-1000). Furthermore, only a few retailers are actively selling imported turbines, and just recently a second local manufacturer has entered the market. Next to that, rural Jua Kali have been involved in the sector, and so have national and international research institutes and development organisations. There has been a notable increased SWT activity in the last two years, and various respondents are in the process of initiating or upscaling their actions in the field of small wind turbines (sales and support activities).

The technology was developed in a technological niche outside of Kenya. Global linkages have enabled a knowledge flow to the Kenyan actors, which has been at the root of the SWT niche. From the moment the technology was introduced, commercial activities already began by formal manufacturers and importers. These were quickly followed by rural Jua Kali that started copying the SWT design. In parallel, some actors have also been involved in altering the turbine design to fit into the Kenyan context whereas others have come up with new designs.

In traditional SNM literature, experiments emerge into a technological niche that in turn gradually grows into a market niche. But in the last ten years, the SWT sector entailed a mixture of different experiments taking place at the same time (explorative experiments, pilot experiments, demonstration experiments and replication). Whereas many of the commercial actors skipped the experimentation phase, the NGOs and research institutes experimented to learn about the technical design, user preferences, new markets, technology meaning etc. A lot of focus has also been on finding suitable approaches for new niche markets, particularly community groups. The development of the Kenyan SWT niche is thus by a rather un*traditional, non-linear* trajectory of accumulating experiments and niche developments. The step from demonstration to replication / dissemination has not yet been made, since there is still no large scale production and sales.

A large part of the aforementioned experiments were not continued and some commercial activities also stopped. The main barriers have been: corruption, changed expectations (discouraging results), different expectations amongst the involved actors, and lack of financial resources (Interview 4, 20, 32, 33). For donor projects in particular, the lack of ownership was also sometimes a reason for turbine breakdown (RISO DTU, 2009; Interview 4, 38). And finally, the lack of human resources in the form of in-house capacity and local skills for maintenance and repair has left many of the Kenyan SWTs non-working (RISO DTU, 2009; Interview 5, 39). Apart from these issues in upscaling experiments and commercial activities, there have also been two other main barriers that prevent sector growth: lack of public awareness and high upfront costs. The following section will shed light on the underlying characteristics and developments that hinder sector upscaling.

Considering the four niche types as described in section 2.2.2, the current SWT niche can be thought of as a dedicated market niche. This is because stability is rather low. In addition, apart from the VAT and import exemption on imported turbines, niche protection does not exist. Users choose for the technology, predominantly because no other suitable option is available or because of its advantages compared to other technologies.

Furthermore, as will be elaborated on in section 4.3, the SWT activities are characterised by a lack of sharing knowledge and experiences. There have been collaborations, but these were mainly one-time events. Next to that, many current stakeholders are unaware of the existence of other actors and do not know about previous experiments. However, there have been some improvements during recent years due to network events and an increased amount of sector status reports (although limited). Therefore, the niche is considered to be in the inter-local phase (second phase of cosmopolitanisation). Actors realize there is a need for intentional production of experiences for SWT research, and regulations such as licenses and standards are going to be developed in the coming years (Interview 14). It is therefore expected that if current developments continue, the niche will move to the trans-local phase in several years' time.

4.2 Voicing and shaping of expectations

Expectations are determined by external influences (exogenous developments), and the other two niche processes (endogenous developments). In the upscaling of the niche, internal expectations contribute if they are shared by all actors, if they are specific with respect to technological, economic and social aspects, and if they are supported by facts. The voicing of expectations is important to couple the different expectations and to attract potential investors, partners and users to join the niche (external expectations).

4.2.1 Influences

Exogenous developments

Expectations about SWTs in Kenya are influenced by a whole range of factors that are external to niche development: the upcoming of similar niches, foreign SWT expectations and landscape/regime factors. The landscape and regime developments are elaborated on in the following chapter (chapter 5); this section solely discusses their effect on expectations.

As previously mentioned in section 3.3, the availability of other wind energy technologies is has been playing a large role in increased SWT production and adoption. Wind pumps and wind farms have stimulated formal actors to participate in the niche (Interview 5, 12, 19). This research revealed different stories about the motivation for informal actors to start experimenting with SWTs, e.g. the trial and error production by Jua Kali after recognizing the power in the wind by wind pumps or after seeing a documentary on TV (Interview 21, 27).

Also the global flourishing of SWTs has influenced the sector and has consequentially promoted to the Kenyan sector growth (Interview 5, 19). The first technology providers became active in the end of the nineties due to linkages with foreign SWT players (Interview 5, 40). Furthermore, when analysing the sector composition (section 3.3), it becomes apparent that various past and current initiatives involve or are set up by foreign parties. One could say that global SWT expectations are trickling down to the Kenyan sector.

Expectations on decentralized, sustainable energy systems are steadily increasing because of several severe regime unbalances: rising energy prices, bad state of the electricity system, oil dependency, and growing energy demand (section 5.3). Furthermore, familiarity with renewable energy systems is improving as well due the rising education levels and growing access to internet (= information). With the increasing media attention on climate change, rising energy shortage and increased RE initiatives, more and more Kenyans are gaining awareness on the need to shift towards clean energy (section 5.3).

Nonetheless, these influences are particularly stimulating the adoption of solar energy technologies. The familiarity on solar systems is large, since the technology has been introduced more than 25 years ago and more than 200.000 systems have been sold so far (Byrne, 2009). The awareness and popularity of PV systems has a negative effect on the development of the SWT sector. As PV systems have been applied more often, and the solar resources are more abundant than the Kenyan wind resources, many believe that the solar sector will dominate the SWT sector. On top of that, many even believe solar PV is the best (and sometimes only) option for green, off-grid electricity in Kenya. This way, the positive expectations on solar PV cast shadow on the SWT sector (Appendix C, Interview 19, 38).

Lack of government incentives on the level of awareness creation, policy development and financial support is negatively affecting expectations on SWTs (section 5.3).

Endogenous developments

Expectations are also affected by internal developments. For instance, the state of the network can affect the expectations, but also the outcome of learning experiences can influence the expectations.

First, the expectations are rising due to sector growth itself. This is since the more niche participants and the increased number of installed actors, the more SWT visibility (Interview 5, 18). However, due to a lack of a centralized database and inadequate reporting (Appendix B.4), it is not recorded anywhere who is actually involved. This absent knowledge on the size of the network and amount of turbines installed hinders the expectation that SWTs will be a success (Interview 8, 11, 14, 19).

Failed projects seriously affect expectations. Many of the installed turbines are malfunctioning or completely out of order, which in turn affect internal expectations. When the users realize that their wind turbine cannot deliver as promised, they spread word to the people in their environment and discourage them from buying a turbine (Interview 20, 33, 38). Also NGOs and research institutes that set up SWT experiments have experienced similar situations with low quality turbines (Interview 9, 39).

Learning experiences alter expectations. There have been distinct learning experiences on the Kenyan wind potential, possible applications of the technology, cost as major barrier for SWTs, the importance of wind monitoring etc. (section 4.4). However, these lessons should be more aligned in order to improve the quality of the expectations – they need to be shared in order to be successful.

4.2.2 Expectations

Previously described influences affect the expectations of the niche actors themselves and of the niche outsiders that should become part of the niche to realize upscaling. The current and desired network composition is described in section 4.3.1.

Internal expectations

The exogenous influences are positively affecting the confidence of the stakeholders in the innovation, since they are more and more realising the potential problems associated with the power regime. In addition, they recognize it is a suitable option in windy areas where the grid is not present. Also the rise of other wind energy technologies, especially wind farms, is having spill-over effects on actors' expectations (Interview 20, 22). These factors justify their SWT activities and hence strengthen expectations on the validation of SWTs in Kenya's energy mix. As a result, some companies that used to be less focused on SWTs are now increasing their efforts in this respect (Interview 19, 40).

On the other hand, during the last ten years, there has also been a shift in expectations among several actors due to unsatisfying results from experiments. The efficiency and cost effectiveness of turbine installations is not as positive as initially articulated by technology suppliers (Interview 4). They learnt that it requires a lot of time and effort to develop and commercialize a high quality, cheap SWT (section 4.4). As a result, some of these actors have left the sector to continue with other activities (e.g. wind farms) whereas others are now decreasing their focus on SWTs in the hope of increasing turnover in another sector (Interview 5, 28 ,38). Since the intensity of participation greatly varies between the different actors involved, the general expectations on SWT viability are not robust.

Furthermore, there is still a general belief that country's wind potential is quite limited (Interview 4, 37, 40). Because of the abundant solar resources and the advanced state of PV systems, many expect that small wind turbines will remain a niche market and play a relatively small role in the electrification of Kenya. For the majority of the SWT dealers, their primary business is PV systems and the vast majority of their efforts go into selling this energy product (section 3.4.1). It can therefore be assumed that these dealers believe more in solar PV than in small wind.

In general, actors share the expectation that the future of small wind turbines is bright if the prices go down. Especially the imported systems are deemed to be too expensive (Interview 3, 11, 13, 24 and 40). Furthermore, everyone involved expects that SWTs can fulfil its functions (environmentally benign and able to provide a continuous supply of electricity) if installed in windy areas (e.g.

interview 5, 15, 18, 19, 22). The fact that people are now identifying the possibilities for participation and are more and more investing in the sector (see above), shows that the confidence in the technology and its market potential is growing. However, there is no clear expectation on the most appropriate dominant design, appropriate business strategy or required partnerships in this respect. The expectations are hence not specific enough.

Furthermore, actors have learnt about the country's wind resources and their close relation to SWT cost, since the price/kWh depends on turbine efficiency, its cost, and on the available wind resources (section 4.4.2). At the moment, the expectations about the viability of SWTs in terms of average wind speed are diverse; some believe the system becomes economically attractive at average wind speeds of 4m/s, whereas other would only target customers in 7-8m/s regions. This expectation originates from different lessons the actors had with different technologies at different locations. Overall, there are mixed expectations about the cost effectiveness of SWTs (Interview 4, 5, 9, 10, 14, 18, 33, 37).

Established actors have also learnt about the need for a better supply chain and production network with more skilled people in the rural areas. With the upcoming of the SWT Jua Kali sector, there are expectations on the benefits and potential of engaging this actor group, for manufacturing, sales and repair (Interview 18, 33, 39, 40, 41).

In addition, some actors have developed a sceptical attitude towards locally built turbines, because these are of lower quality when compared to their imported variants (Interview 7, 20).

Regarding the users, the ones involved in failed SWTs have lost confidence in the technology. Also researchers and non-profit actors have stopped their activities after having experienced a failure (RISO DTU, 2009; Interview 20, 22, 28, 35, 37).

External expectations

This section analyses the expectations of the desired niche participants. In general, it can be said that awareness and expectations on small wind turbines are low. Furthermore, when considering green off-grid technologies, the expectations are primarily focussed on solar PV (Interview 19, 22, 37). Nevertheless, especially due to the several external influences (more wind energy visibility and regime tensions), the external expectations are improving. On the other hand, failed SWT projects and lack of these governmental incentives are preventing new actors from joining the niche (Ngondi & Makanga, 2010).

External expectations can be divided on the level of the public (for SWT purchase and SWT venturing), the regulatory and state institutions and the financial institutions (investors and financers):

Potential users

The current situation shows that awareness about small wind turbines is still very low. The general population, especially in the rural areas, does not know about the technology nor are they aware about its functionality and long-term economic benefits. This is largest with people living far away from the cities, and whose experiences are limited to traditional energy sources[4].

Next to that, a large part of the Kenyan population has a depending attitude towards development organisations and the Kenyan government (section 5.1.6). They expect local NGOs to provide them with electricity, or hope the government will expand the grid to their villages. As a result, a part of the population is resistant to purchasing SWTs themselves because they expect it will be provided to them (Interview 19, 38). Next to that, users are not keen on buying Kenya-made projects, since they are regarded being inferior (Interview 7, 38). Thus apart from the need for articulating expectations through awareness generation, it is also important to provide high quality products and to articulate the expectation of a quality product with reliable aftersales service to the potential customers.

However, primarily because of regime tensions, non-users are slowly starting to recognize the potential value of SWTs. The current users of electricity from diesel generators or grid connection believe that renewable off-grid systems have several comparative advantages, such as the reduction of power cuts (in case of grid power) and the long-term financial benefits (in case of diesel generators, due to rising cost of oil). Rural users of traditional energy sources also often prefer electricity provision and expect it to make a difference in their lives (see section 5.2.3 – electricity opens up a range of new services, such as charging mobile phones and powering TV).

Potential entrepreneurs

Not only is the previously described lack of awareness a crucial aspect for attracting more users, it is also one of the key barriers for the relatively small sector size in terms of low private sector activity (section 4.3.1). Only very few have seen the potential of SWTs as a commercially viable enterprise, because this market has not been proven (Interview 18, 24).

Two types of 'unfamiliarity' can be distinguished: the technology itself is not known, nor is there a thorough understanding of its market. Low technology awareness implies that most people are not familiar with the cost/performance ratio, its functionality etc. Low market awareness can be

[4] (Interview 5, 8 10, 12, 13, 14, 24, 25, 26, 29, 33, 36, 37, 38, 40, 41)

explained as follows: small wind systems are particularly attractive in rural, windy regions with primarily low to middle income households. Furthermore, wind systems are available from ca. 300W, a somewhat large power output. For this reason, many seem to believe there is hardly a market for SWTs. As an example, according to some respondents, there are very few people that have such large power needs and that can afford a system of this size. This is one of the key reasons why the city-based private sector does not seem to recognize the market potential for high capital products such as SWTs (Appendix C; Interview 19, 33, 37, 38, 40).

National government

Negative experiences with non-working or malfunctioning wind turbines has been one of the key reasons for the Kenyan government and public not to show any interest in the sector for years. In the end of the eighties, the Kenyan government had installed two medium size off-grid wind projects. In a short period of time, these projects for powering communities with off-grid wind (medium size) collapsed, because of improper installation in one case, and lack of maintenance skills in the second case. Therefore, the government lost their belief in off-grid wind (Interview 18).

For years, public authorities were unaware about the socio-economic and technical advantages of (off-grid) wind turbines, nor did they had insight in the country's wind potential as a whole. With the sector growth and increasing knowledge on the wind potential, the Kenyan policy makers gained expectations these last years. Positive feedback from experiments enabled this shift in expectations, through amongst others UNIDO and REA (Interview 18, 39).

It should also be noted that whereas institutional awareness as a whole has grown, the overall government expectation of small wind turbines is still limited. During the research, it became clear that within relevant government organisations, there are employees that are not knowledgeable about the SWT sector, nor are they aware about their department's role in the niche (Appendix B.5; Interview 18, 40).

Local governments

Government expectations at local level are also important since they are important to include in the network (section 4.3.1). An interview with a local government official showed he has good expectations of SWTs due to the area's high wind speeds. Nonetheless, despite the various SWTs in that region, the officer was completely unaware about the sector and whether or not there were turbines installed in his region (Interview 25). No direct conclusions can be drawn from this since this observation comes from one source. Nonetheless, taking into account the overall low awareness levels, it can be assumed that there is also need for voicing of expectations at the local government level.

Financial institutions

The SWT market is almost non-existent and there is thus no proof of market. As a result, financial investors have low expectations on SWTs as a commercial success, i.e. generating returns. The financial institutions include formal financial service providers (banks, investment firms) and non-bank financial institutions (MFIs, SACCOs[5]). Financial institutions are cautious to support SWT entrepreneurial activities since they do not seem to recognize the commercial opportunities as there are so few installed turbines. Financial institutions also fear lending money for buying small wind systems, because they do not trust the technology. When the product fails, the financial institutions fear that the end-users will default on paying back the loan. Moreover, small wind turbines are generally imported. Therefore, when the RE product breaks down, it is expensive to repair them since for example spare parts have to be shipped and the local maintenance knowledge is not available (Interview 9, 12, 15, 40, 41).

4.2.3 Conclusions

The expectations of niche actors and outsiders are positively influenced by favourable landscape developments and increased regime tensions. Also the flourishing of other wind energy niches and global interest in small wind turbines stimulates the sector and so does the SWT growing sector itself. On the negative side, the lack of government incentives and out-of-order turbines are the main factors that hinder a positive attitude towards small wind turbines. Furthermore, the success of the solar PV market in Kenya is negatively influencing the expectations on small wind turbines.

The expectations of the niche actors are diverse. Whereas some are increasing SWT efforts due to positive regime influences, some have gained adverse expectations due to negative outcome of SWT projects. There are also diverse expectations on the SWT viability in terms of average wind speed, and there is no clear expectation on the most appropriate dominant design, suitable business strategy or required partnerships to realize upscaling. There are some shared expectations with regards to the necessity to decrease cost, the positive impact of small wind turbines, and the fact that there is some market potential. Furthermore, actors are increasingly acknowledging the potential of rural SWT craftsmen for production, sales and repair.

[5] SACCO stands for Savings and Credit Cooperative Organisation. In Kenya, it is a widespread type of micro-finance, in which an organized group of people save money in a pool from which they can get financing(Kariuki & Rai, 2010).

With regards to external expectations:

- Potential users are unaware of SWT technology, but this is slowly improving. The dependent attitude towards aid and government organisations hinders SWT purchase. Locally manufactured products are regarded as inferior to imports.
- There is a rather negative expectation with regards to the technical and business potential of SWTs. This hinders the desire of technology suppliers and supporting actors to join the niche.
- Government expectations used to be low due to negative outcomes from experiments. They have now gained expectations on SWTs due to wind farm developments, but this expectation is not shared amongst all the officials of the relevant government departments.
- One case showed that at local government level, the expectations on SWTs are high because of high wind speeds at that specific location.
- Financial investors have low expectations on SWTs as a commercial success, because the market has not yet been proven.

These diverse external expectations demonstrate the need to voice expectations through awareness creation and on the delivery of high quality goods and services.

4.3 Network formation

Niche networks are considered good when they are heterogeneous, regularly interact and perform well. Such network is able to increase expectations, improve learning experiences, attract resources and interest more actors to join. This section analyses the niche on its network. First, the niche is analysed on its composition, which includes sector completeness, what kind of role the actors fulfil and the quality of their performances. In addition to this, the niche is studied on the linkages between the different actors, which are crucial for shaping expectations and increasing the quality of the learning experiences. The network is largely influenced by the expectations presented in the previous section. Also social and cultural factors (landscape- section 5.1.6) influence the network formation.

Section 4.3.1 discusses the SWT network composition and quality of operations. The following section describes the collaborations and linkages between all actors. Section 4.3.3 explains the alignment of the network.

4.3.1 Composition and quality

Section 4.2 explained the necessity of a complete network that involves all necessary actors. This section analyses the niche on its composition, and hence on whether all necessary actor groups are present. These 'required' actor groups are gathered from literature. For instance, Geels (2005a) states that a good network should include technology producers, researchers, finance and capital institutions, supply chain, users, societal groups and public authorities. This list is completed by co-operatives, NGOs and end-user finance actors; social groups that also need to be present according to the actor's learning experiences (section 4.4).

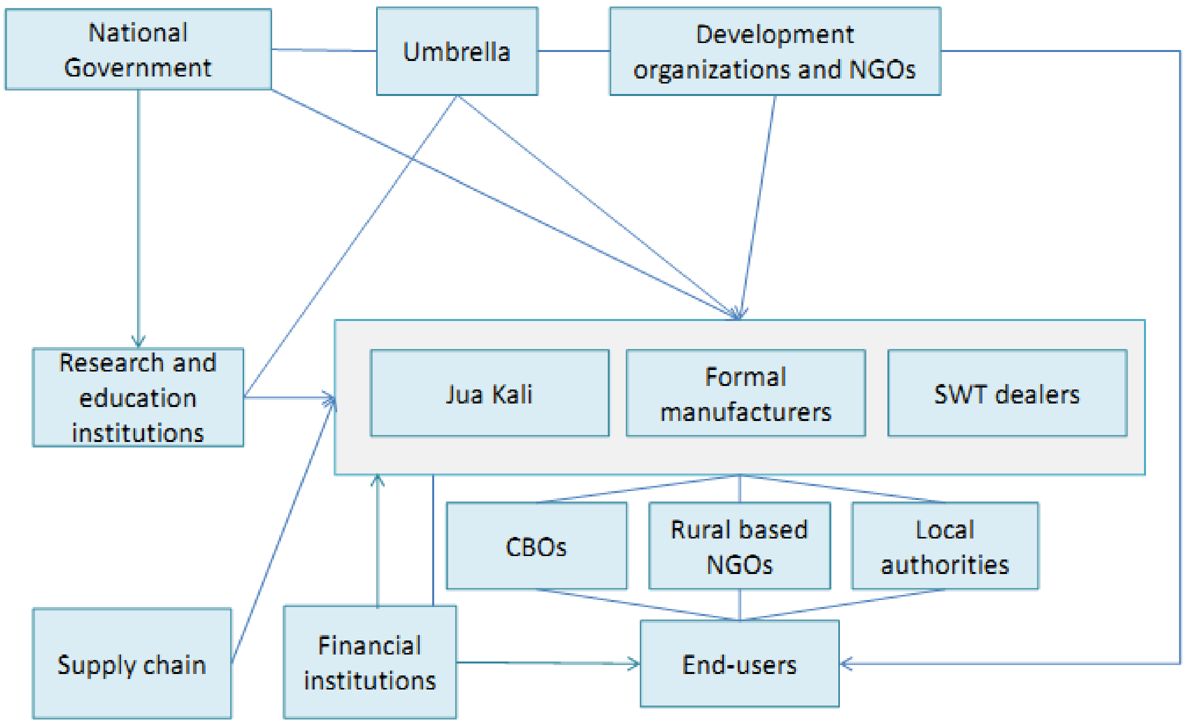

Figure 23: Ideal SWT network

The descriptions of all actor groups below first explain why the certain actor group should participate in the network. This section also reflects on the number of actors within each group, since niche upscaling largely depends on the amount of actors with different roles and interests. For instance, a small producer network limits the supply and hence the amount of users, government participation etc. Next to that, where relevant, this section also discusses the issues that affect the quality of the different social groups; inadequate focus or overall poor performance diminishes actors' role in the SWT network, and can even have a detrimental effect on the other niche processes. Lastly, this section does not only provide information on the actual state of the network composition and quality. It also aims to provide the underlying reasons for the size and quality of the actor groups and their impact on the niche.

1) Jua Kali

Jua Kali actors are necessary as producers since they are able to serve markets that others do not.

Composition

Evidence has been found on the involvement of various Jua Kali that acted as individual entrepreneurs. The size of this actor group is unclear, since there is no centralized database of any kind[6] (Interview 18, 19). As explained in section 3.4.1, for some of these Jua Kali, SWTs remained an experiment, whereas others have managed to turn their SWT activities into a business. For large scale dissemination of Jua Kali type turbines, more Jua Kali are needed.

Quality

In general, these Jua Kali are not able to produce and sell large amounts of turbines because of the many difficulties they experience in this process: lack of knowledge, difficulty to acquire all needed materials, lack of finance, low marketing knowledge (Interview 22, 28, 30, 31, 35, 36). Since they do not take wind measurements and in general produce inferior turbines due to the lack of knowledge and information, this sometimes results in malfunctioning Jua Kali turbines (Interview 7, 35). This in turn damages the overall expectations of SWTs (section 4.1). For large scale dissemination of Jua Kali type turbines, their individual performance has to increase.

2) Formal manufacturers

Local production at formal level is attractive for reducing product price, increasing the design suitability in the Kenyan context and the availability of spare parts (section 3.5.4).

Composition

There are only two active formal manufacturers: Craftskills (Kenyan producer) and the most recent manufacturing entrant WindGen (foreign party). Several interviewees also mentioned their ambitions in the field of SWTs (Interview 16, 24); they seem to start recognizing the possibilities by the developments described in section 4.2.1.

A first issue in the current lack of a dedicated formal SWT sector is the low awareness; only the ones that understand the technology and recognize the market possibilities will be stimulated to start a business. Besides that, there are several societal and cultural factors that influence the number of

[6] the cases found in this research were found by coincidence or through intermediates

SWT entrepreneurs: starting an energy business requires innovation, risk-taking and strong entrepreneurial beliefs. These factors are barely present in Kenya's formal sector, which is partly due to its colonial inheritance (section 5.1.6). Next to that, the country's corruptive and bureaucratic nature also impedes people from engaging or venturing into a new business, and so does the low access to start-up or growth finance and political uncertainties (Appendix B). The overall low interest in local SWT production can also be explained by Kenya's weak manufacturing culture (section 5.1.5).

The aforementioned factors also inhibit established 'dedicated' SWT manufacturers from upscaling. There are various issues preventing their growth, of which the most important are: lack of growth finance for technical and marketing purposes, inadequate regulatory environment and lack of skilled staff members (Interview 5, 12, 15, 31).

Quality

Evidence has been found on the production of low quality turbines by the actors from this group. Local wind measurements are not standard. Introducing this aspect could enhance the SWT performance. Another problem is the lack of engineering knowledge and skills (Interview 5, 7, 9, 12).

3) SWT dealers

Apart from locally manufactured turbines, SWT dealers could also be part of the technology supply mix.

Composition

There are quite a number of dealers, but the intensity of participation in the SWT network varies substantially. Amongst these technology suppliers, there are only two actors that predominantly focus on SWTs (section 3.4.1). This is because the vast majority does not recognize the opportunities for SWTs; they do not know how to tap into that market, and prefer the security of generating income through the sales of other (more popular) products (Interview 40). The amount of focused SWT suppliers is low because of the difficulties and risks associated with putting a new kind of product on the market (see previous subsection).

Quality

There are a considerable amount of dealers that offer wind systems but do not focus on it. There is also a trend towards cheap, low quality imports from China which ruin small wind turbines' reputation. As a result of these factors, many of these dealers underperform (Interview 5, 12, 18, 31, 39, 42). According to several respondents, the companies' technicians do not know how to properly install, maintain and repair the systems. Some believe these companies are more interested in making the sale rather than serving the customer, whereas others refer to the sector's lack of recruiting and retaining skilled staff members (Interview 12, 39). Whatever the reason may be, the low SWT focus is leading to low quality installations, which in turn affects the general expectations about small wind systems (section 4.1).

Lastly, as mentioned in section 3.2, local wind measurements are often necessary to guarantee the performance of small wind systems. Whereas the majority of companies perform standard wind monitoring for a short period of time before installation, some of them leave it upon the customers themselves to assess the viability of an SWT at a specific site (Interview 11, 28, 40).

4) Research and education institutions

A good network requires research and education institutions for improving the SWT technology, its applicability and the knowledge of the Kenyan wind resources. Next to that, these institutions fulfil a valuable role in developing engineering competencies and strengthening local technical skills. One of the responsibilities of research institutes is to disseminate knowledge gained from research by, for instance, publications and network events.

Composition

Up to now, there are only two Kenyan universities involved in SWT sector for teaching, researching and experimenting: University of Nairobi and JKUAT. Local training institutes and polytechnics are Kenya's practical educational institutes. A large part of these graduates end up working in the rural areas, within a company or as technical Jua Kali. These educational institutes do not offer courses or training programs on small wind turbines (Interview 38), and should hence become part of the network.

Quality

For both universities, the area of practical experimentation and implementation appears to be a problem, because they lack the financial resources to turn their ideas into practice and actually experiment with the technology. Lack of government funding for SWT research is identified as a barrier for the limited SWT research (Interview 9, 18, 33). Furthermore, whereas UoN has carried out practical experimentation with for instance local SWT production, JKUAT has up to now mostly focused on the theoretical research and analysis of imported SWTs (Interview 7, 10, 31, 34). It should be noted that JKUAT is now establishing an extensive research program on the development of locally produced SWTs by Jua Kali (Interview 34); it is thus expected that JKUAT's practical contribution to the sector will significantly increase in the future.

The JKUAT network event of 2009 (RISO DTU, 2009) demonstrates that this actor group is taking efforts to spread SWT knowledge. Unfortunately, no similar events have taken place afterwards and there are few academic SWT publications (Interview 13, 32). Next to that, this research revealed an incident of plagiarism of a recent status report, where information was copied from a report published 5 years earlier. This implies the circulation of out-dated information, which detriments learning processes and shaping of high quality expectations (Appendix B.1).

This actor group also has a large role in enhancing the engineering capacity of the SWT sector. Apart from the relatively low research focus, the university teaching program lacks practical courses and does not inform students on the industry itself and its market potential. These graduates often end up working with large companies or government organisations (Appendix C; Interview 7, 9, 11, 13, 18, 33).

5) Development organisations and NGOs

These actors could contribute to the SWT sector in a variety of ways; through funding, experimenting, acting as local sales agents, vocational training etc.

Composition

Several Kenyan NGOs and development organisations are involved in the SWT business since it is intertwined with foci such as poverty reduction, health and climate change (see section 3.4.2 for overview). These parties have fulfilled a knowledge diffusion role (SWT status reports), carried out or funded SWT pilot and demonstration projects and promoted the technology amongst government officials (Kirai & Shah, 2009; GVEP International; Berges, 2007; Interview 4, 33, 39). Other non-profits have taken efforts to support SWT entrepreneurs for local production, both informal and formal parties (Interview 15, 24). And now recently an SWT organisation was established that aims to train Jua Kali in building and selling micro wind turbines from local materials (Interview 26). Other initiatives are now being set up for enhancing technical RE skills at all levels of the value chain, and supporting RE entrepreneurs (Climate Innovation Center, 2010; Interview 5, 39).

One could therefore conclude the non-profit sector has been playing a large role in the SWT sector upscaling. However, many of these organisations are not active anymore in the field of SWTs. Furthermore, with its strong local networks in the most remote areas, the SWT sector could benefit even more from increased NGO efforts to reach rural households and communities. For instance, on the subject of market research, raising local awareness, assisting with the distribution of SWTs and training local technical and sales capacity (Gradl & Knobloch, 2011).

Quality

Individual performances should also be improved to realize full SWT potential. This research revealed incidents or corruptive practices among non-profit organisations. In one case, an entire experiment failed due to malpractices of a local NGO (Interview 24, 39). Next to that, similar to the plagiarism activities of local research institutes, evidence has been found of local NGOs that are spreading incorrect or out-dated information about the sector which in turn distorts the voicing and shaping of expectations (Appendix B.1).

6) Co-operatives

In order to target community groups and low income households, several SWT actors have learnt about the necessity of alternative business models and partnerships (section 4.4.6). An appropriate SWT actor group in this respect is co-operatives. According to the International Cooperative Alliance (2004) in (Gunga, 2007) a cooperative is defined as "…an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly owned and democratically controlled enterprise". Co-operatives or Community Based Organisations are widely used in Kenya to facilitate access to the rural markets. These bodies can be used as a partner for the distribution and sale of SWTs, gain local awareness and even organize the management and payments for SWT group purchase.

Composition

Community based organisations have been part of the SWT network in primarily research projects of NGOs and research institutes (Interview 20, 39). Since no real efforts have been taken to tap into these low to middle income markets, technology suppliers do not cooperate with these organisations. However, there is now an increased interest in attracting this actor group in the SWT network (Interview 11, 26).

7) Supply chain

An adequate supply chain consists of local technical and sales people for the processes of maintenance, repair, sales and installation become complicated and costly. A complete network consists of local partners for fulfilling these functions. These local partners may include mentioned aforementioned actor groups 'NGOs', 'CBOs' and 'financial institutions', but could also consist of local technical companies or rural Jua Kali. Apart from human resources, a high quality supply chain for local SWT production also has to consist of the suppliers of materials, components and machinery.

Composition

Regarding the human resources, Nairobi-based suppliers lack technical expertise and sales forces in the proximity of the end-users. This creates a weakness that affects the cost of SWTs and their sustainability (section 4.4.4).

Regarding the material supply, this is no problem for SWT dealers, since they have a range of foreign suppliers to buy products from. Furthermore, raw materials are also available for SWT production in the cities, where these material resources are widely available through established companies. These are primarily wholesalers, with the majority of raw materials being imported. Especially magnets are difficult to retrieve and local SWT production would hence benefit from Kenya-based magnet suppliers (Interview 7, 12). Overall, the material resources for local SWT production are reasonably well, but some parts do need to be imported.

This is contrary the material and equipment availability in Kenya's rural areas. SWT Jua Kali respondents encounter many difficulties on retrieving the right material resources such as electronic parts, magnets and a drill press. To support the local rural production of SWTs by local craftsmen, the supply of equipment and material should be improved (Interview 21, 27, 29).

8) Financial institutions

Financial institutions should be part of the network for two reasons. First, there is a large group of potential users that cannot afford the initial investment of SWTs, but could do so with financial support. They could play a major role in increasing the SWT awareness by educating the public, and at the same time offer the new customers a loan for purchasing such system. Furthermore, financial institutions are also crucial for informal and formal businesses financing (start-up and growth capital) (Interview 13, 15, 18, 20, 22).

Composition

As explained in section 4.2.2, financial institutions seem to be ignorant or lack confidence in wind systems because of the low market size. Financial institutions are therefore missing in the SWT network for end-user financing, which indirectly limits the market size of SWTs (Interview 15, 22).

Even more than for SWT end-users, the Jua Kali entrepreneurs find it very difficult to get access to finance. According to the interviewees, lacking financing mechanisms are the number one barrier for the Jua Kali to turn their SWT R&D into a real business, or upscale their existing SWT business for it to generate enough income (Interview 15, 35, 37). Lack of finance is a common problem in Kenya to start a formal business. In general, it is very challenging to receive a loan for a start-up because banks do not trust formal companies without a credit history. Since the SWT sector is still small, this challenge only increases. When observing the spectrum, formal financial institutions cannot see the commercial opportunities because there are so few installed SWTs (Interview 12, 15).

Nonetheless, it should be noted that the last years, the finance climate has been improving with the rising number of investors that are willing to support renewable energy companies with start-up and/or growth capital (Interview 38).

9) National government

Actors have learnt about the desired role of national authorities by introducing standards, subsidy schemes, end-user financing, research funds, licensing, adjusted tax regulations and national awareness campaigns (section 4.4.8),

Composition

The government's role in the SWT sector is relatively small. First, the government misses full insights in the SWT sector because of the lack of data and statistics (Interview 8, 19, 30). Although the SWT sector is in an early stage, this absence creates the perception that it hardly exists. This in turn results in low government participation. Government departments are not aware of the SWT industry and/or are not urged to put efforts in setting appropriate policies.

For instance, KEBS will initiate the standardization process for locally produced small wind turbines when the market grows, and the number of local manufacturers increases to three businesses (Interview 6). Furthermore, the responsible government bodies are not motivated to set a duty exemption for SWT magnets, since they have various applications. It is therefore difficult and time-consuming for customs officers to assess what they will be used for, and whether or not taxes have to be paid. As long as the local SWT manufacturing sector remains small, no incentives will be taken to set this regulation (Interview 14). The same holds for the licensing of SWT technicians. The ERC has learnt about the fact that many SWT dealers underperform since they are not specialized in wind systems (Interview 14). Therefore, ERC will is in the process of introducing a license for SWTs to ensure there is compliance with the laws. An SWT company will then only be allowed to run its business when they employ a licensed technician. However, ERC gives priority to more established sectors to set such regulations (Interview 14). Lastly, the MoE has also indicated to not actively spread information to gain public awareness, since it does not want to raise demand as long as there is insufficient supply (Interview 19).

Another large issue with regards to the government's role is the lack of wind data. SWT actors have learnt the data of the Meteorological Department are inadequate and unaffordable (section 4.4.2), and that they would greatly benefit from more, better and cheaper wind data sets. However, this is not the case predominantly because of the fact that this institution is self-funding, and wind monitoring has been done in an inefficient and expensive way (Interview 10).

Nevertheless, the MoE is now increasing its role in wind monitoring and is currently measuring wind speeds across the country for wind farms that is indirectly also beneficial for the small wind turbines (Interview 19). Besides that, REA initiated two SWT demonstration projects and only wants to increase its future role by increased experiments and cooperating in training local SWT Jua Kali in collaboration with local university JKUAT (Interview 18).

It can therefore be concluded that the government's role is increasing, and it is expected to become even larger with the growing SWT sector. Nonetheless, because of the relatively slow pace in developing regulations and the bureaucratic and corrupt nature of the Kenyan government, it is expected that SWT regulations will not be introduced anytime soon. Besides that, actors believe that even though regulations might be set, corruption will continue to cause that existing practices do not meet the standards of official policies (Interview 4, 12, 17, 33).

10) Local authorities

Local authorities should be part of the network. When targeting rural households, local authorities are especially must to work with since they have substantial impact on the local opinions. Especially when targeting communities as a whole by means of mini-grids, local regulations become important and collaborations with local government offices are needed (Interview 18, 22).

Composition

District officers and local chiefs are hardly part of the SWT network. They have only been involved in charity and research projects of NGOs and universities (Interview 20, 39).

11) Umbrella organisations

Umbrella organisations could fulfil a valuable role in the SWT sector by increasing linkages between the different stakeholders (e.g. knowledge exchange) and potentially lobbying to the government[7]. Such association could also greatly contribute to promoting better business and could play a key role in spreading outcomes and insights to a wider community to gain overall expectations (Interview 11, 37).

Composition

No societal groups have found to be currently involved in the SWT network, despite of the former efforts taken to set up such platform. According to Osawa and Otieno (2004), the East African Wind Energy Association (EAWEA) was established in 2003 as an SWT platform. Besides that, Kirai & Shah (2009) reported on the existence on the Kenya Wind Industry Association (KWIA). None of the

[7] No lobbying efforts have been done up to now as far as the author is aware (Interview 14)

interviewees knew about these organisations and also an internet research did not reveal any additional information.

KEREA is the main Kenyan Renewable Energy platform. This umbrella has upon until now predominantly focused on solar energy, because of limited funding and unattractiveness for others to join (Interview 37). Nevertheless, KEREA has a crucial role in the wind energy upscaling attempt of 2006 (see section 4.3.2). Lack of funding prevented the program from being launched (Interview 37). Up to now, no other platform or societal group was set up to fulfil this important role.

However, Kenyan actors are part of international network organisations. Some Kenyan SWT manufacturers are part of Wind Empowerment, a global R&D platform for the development of locally built small wind turbines (Wind Empowerement, 2011). Another interviewee responded to be part of AREA (Africa Renewable Energy Alliance), a network in which the members share experiences about introducing energy technologies in African countries (Interview 26).

4.3.2 Interactions

Collaborations directly influence network alignment and the sharing of learning experiences. Partnerships are also needed in order to attract new participants to the network. This section discusses to what extent actors have collaborated or linked up, and what it means for sector development.

A first perquisite for collaboration is that actors know of each other's existence. This is far from the case for Kenyan SWT actors. None of the interviewees had a proper view of the SWT sector and its main actors because of the lack of central database (e.g. on website, report, publication) or an umbrella (Appendix B.5; Interview 11, 18, 19, 26). This strongly inhibits the process of network alignment and the sharing of learning experiences (Appendix B.4; Interview 26). Apart from the low awareness of the active niche participants, another difficulty for linking up appears to be the general fear of collaboration amongst Kenyans. Especially Kenyan companies believe that collaborating with other for-profit actors will reduce their market share and profits (Appendix C; Interview 10, 24).

There have been collaborations between local universities and one company. These were however onetime events. Research institutes do not fully collaborate for research purposes, mainly because of above described fact that many Kenyan universities are more focused on teaching than on researching and innovating (section 4.3.1). As a result, students do not find their way to the SWT sector. With the absence of engineering competence, the sector would greatly benefit from these private-academic partnerships to increase student's awareness and facilitate their sector employability. Next to that, partnerships with universities and R&D institutions would benefit the optimization of the technology (Interview 5, 11, 30).

There have also been collaborations with foreign universities, which have enabled the flow of technical knowledge about small wind systems for local production. Kenyan research institutes and companies selected designs and scientific knowledge developed in the western world. Product optimization still takes place outside the Kenyan borders, by actors' memberships in international platforms. NGOs primarily fulfil a support function rather than carrying out actual projects. As far as the author is aware, collaborations between NGOs and companies were also onetime events (Interview 31, 39).

On the level of product design and optimization, the connection between SWT suppliers and their customers is weak, because mainly all formal companies are located in Nairobi (Interview 5, 11, 12, and 40). Established feedback channels are rare. Linkages are also missing between the foreign suppliers and SWT dealers regarding user feedback.

Next to that, some formal companies have been able to establish linkages with rural Jua Kali as part of their supply chain (maintenance and repair) but the majority does not collaborate with this group of suppliers (Interview 5, 11, 12, 40).

Apart from these missing linkages, actors should also put efforts into establishing partnerships with actors that are net yet in the network: financial institutions for end-user financing, CBOs and local authorities and local training institutes and polytechnics. It should be noted that several newly entered SWT companies are investigating on possible interesting partnerships with these actor groups (Interview 12, 26).

Regarding the sector collaborations as a whole, in 2006, there has been one real attempt to upscale the Kenyan small wind energy sector by private actor collaborations (BHEL and Craftskills) and KEREA, a renewable energy umbrella organisation. Inability to retrieve funding ended these sector upscaling plans. The actors did not decide to continue collaborating in another form, because of unaligned expectations and overall approach. Next to that, a network event was organized by Risø DTU and JKUAT in 2009. It brought Kenyan and foreign experts in the area of low cost wind energy technologies for developing countries. Although these two events could have exerted a larger influence on SWT sector growth by continuing these efforts, they have been valuable in the exchange of learning experiences and overall network alignment (Interview 13, 32).

4.3.3 Network alignment

Network alignment refers to the degree to which the actors in the network share the same vision, goals and strategies. This subsection describes the network alignment, by first discussing the factors influencing the alignment process and next elaborating to what extent the network is aligned.

Factors influencing alignment

As mentioned above, there have been various collaborations between different network actors (technology suppliers, NGOs, international and national research institutes, but these were mostly onetime events. The outcome of SWT projects caused many actors to stop their activities, for instance because it resulted into altered expectation with regards to cost effectiveness, the complexity to of local SWT production, etc. So although there sometimes was a shared long term vision, no cases have been found on continuing partnerships (Interview 4, 20, 26, 33). The network alignment is hence inhibited by lack of network stability.

Collaborative learning enhances the network alignment, because the same learning experiences result in similar strategies. The sharing of learning experiences is nevertheless inhibited due to missing linkages: user- supplier, SWT dealer-foreign supplier, universities- NGOs – companies, etc. There also seem to be a resistant attitude of several actors to share learning experiences (Appendix B.2; Interview 10, 12; section 5.1.6). Considering the Jua Kali, the complete lack of support and interactions between these group members inhibit sharing of learning experiences to realize an efficient, cost-effective SWT design (Interview 21, 27, 29, 34, 36). Furthermore, development organisation and research institutes have carried out experiments for learning. Formal SWT enterprises deliver the systems for these experiments, but it is unclear whether these are effectively transferred. And if so, it is not certain how companies use these learning experiences to improve their SWT activities.

Lack of regulatory alignments through e.g. licenses and standards are also detrimental for network alignment. Actors have learnt about the need for the government to take an active role in the SWT sector, by developing laws, standards, code of practices etc. (section 4.4.8). Several respondents have acknowledged their 'fear' of government organisation, despite their importance in this process. The government has a bad reputation due to corruption and bureaucracy. As a result, individual actors do not seem to trust government and would rather avoid them than interact with them (Interview 7, 12, 38). This inhibits the development of appropriate policies, and hence affects network alignment.

In this respect, an SWT association would also contribute to sector growth by lobbying to encourage government actors to set an appropriate legal framework, and assist them in the actual policy formulation. An umbrella could also help set a certain goal with regards to SWT technology and market development, and act as a platform for collaborative learning. As mentioned in section 4.3.1, there is no SWT umbrella organisation at this moment, which inhibits network alignment (Interview 37).

The network event in 2009 of RISO DTU is the only clear event that has contributed to sharing of learning experiences (Interview 15, 31) and hence network alignment.

However, on a global level, the Wind Empowerment platform aims to align global SWT research and strategies of global SWT parties for the local manufacturing. With some Kenyan parties taking part in this platform (WindEmpowerment, 2012), it is expected that this global alignment will have positive effects on the development of the Kenyan SWT niche.

Network goals and strategies

The overall network alignment is rather poor because of above described factors. There are some shared goals and strategies; that is offering SWTs at a lower price and the aim to expand the supply chain. However, because every actor has specific perceptions and expectations, their strategies also differ:

The SWT dealers have different expectations on how the price can effectively be reduced. As a result, they also have different strategies. Some aim to move from importing premium products toward second hand SWTs (Interview 11) whereas others have higher expectations on the business potential of lower quality, Chinese systems (Interview 41). Others have negative expectations of both options and even consider it as a real threat for the industry, since the lifetime and quality of these options are deemed to be considerably lower (Interview 3, 5, 18, 38).

Furthermore, there are also misalignments with regards to target markets; whereas research institutes and NGOs primarily investigate on SWTs for poor niche markets, the commercial formal actors aim the more wealthy end-users (Interview 11, 20, 28, 39, 40).

Several actors in the field of local SWT production expect the sector to grow if the design is adjusted to the Kenyan context: available at lower cost with a better performance at low wind speeds (Interview 4, 5, 12). Other newcomers believe it comes down to an altered business approach, that it is a matter of properly tapping into the right market: e.g. by providing SWTs to community groups, the pursuing of large-scale production to bring the costs down or by applying alternative marketing methods (Interview 26). Another strategy is decentralized production (Interview 16, 24).

Due to positive learning experiences with Jua Kali, several existing actors and new entrants are now setting up initiatives for encouraging the Jua Kali network (Interview 12, 24, 26, 33, 39).

4.3.4 Conclusions

The required actor network for successful niche upscaling is rather complex. Instead of one group of technology suppliers, there are three groups that offer different kind of products to different kind of users. Contrary to developed countries, the Kenyan SWT sector requires CBOs, local authorities, financial institutions for end-user financing and NGOs to realize niche upscaling. In general, the total network is rather small due to low SWT awareness.

Besides network composition, also quality is important when analysing the network. Conclusions per actor group are as follows: none of the technology supplier groups functions how they ideally should, each of them for different reasons. There are especially few formal SWT manufacturers. None of the actor groups has been able to reach scale, each for different reasons that are both internal (e.g. attitude) and external (e.g. lack of finance, lack of regulatory environment). Furthermore, cases have been found in all groups of actors that perform below standards.

Local universities have been involved in the sector for a long time. However, their theoretical focus and lack of (correct) publications limit their effectiveness of their contribution to the niche. Practical training institutes are not part of the network, but they should to develop human resources. Furthermore, non-profit organisations are represented well, although many efforts were one-time events. In addition, non-profits could also contribute to niche upscaling as local sales agents. Some non-profit organisations have an adverse effect on sector upscaling because of corruption.

In addition, co-operatives, financial institutions and local authorities are missing in the network. Furthermore, the material supply chain is especially problematic for Jua Kali, whereas the formal companies are hindered by an absent distribution and service network. The GoK is aware of the need for policies, but has not yet introduced them. At the moment, the GoK contributes to niche upscaling by wind monitoring and SWT pilots, although it could increase efforts on both aspects. Last, there lies a great potential for an SWT umbrella organisation. Stakeholders now only take part in global networks.

Linkages between the different actors should increase for network alignment and attract niche participants. These linkages are hindered by the fact that stakeholders do not know of each other's existence. There have been several collaborations for onetime experiments. There also has been one collaborative attempt to upscale the small wind energy sector and one network event. However, overall, collaborations should increase for enhanced feedback collection, and for niche participation of university graduates, Jua Kali, financial institutions, CBOs, local authorities and practical educational institutes.

Network alignment is low due to the instability of the network, missing linkages for collaborative learning, lack of regulatory alignment and lack of an umbrella organisation. There has been one event up to now in order to increase shared learning. As a result of these factors, the network is not aligned and strategies largely differ.

4.4 Learning processes

Learning processes are considered to be of high quality when actors learn on multiple dimensions, and about both the facts as the cognitive frames and assumptions (first and second order learning). Apart from the learning experiences themselves, the knowledge and information transfer is very important is this respect; learning experiences should be shared amongst all actors.

This section discusses the learning experiences of the involved actors. It should be stressed that these learning experiences are not shared by all actors because of the reasons explained in section 4.3.3. Furthermore, observations showed that various actors are not that focused on learning or find the concept of learning difficult to grasp (Appendix B.7).

4.4.1 Technical development

Following lessons in the area of technical design are distinguished according to the different types of technology suppliers.

Formal production design

As mentioned in section 4.1, the knowledge for the local 'formal' production of SWTs comes from abroad. The majority of actors have selected the Hugh Piggott design. Since it does not take into account the Kenyan context (wind regime, cost and materials), the actors have learnt that it should be optimized. However, learning often did not go beyond the observation that optimization is required (Interview 4, 20, 22).

Moreover, actors generally lack insight in what it takes to accomplish better product performance. Nevertheless, several cases have been reported from actors that researched on how to improve the Hugh Piggott design or have actually come up with a totally different configuration. These actors have tried to make improvements based on better design choices, in particular regarding blade design, materials and generator (Interview 5, 41). Nevertheless, as far as the author is aware, there is no factual data yet on whether these adjustments are actually improvements, in terms of efficiency, cost, life time or cut-in speed. Next to that, the most recent SWT entrants are also using a (slightly altered) Hugh Piggott design (Interview 12, 26). One could therefore state that despite the general awareness, there is a need for improving the Hugh Piggott design or shift to a totally other design in order to deliver a better product and target a wider audience. Furthermore, no suitable alternative has emerged up to now nor is there a proper understanding of what influences SWT performance and how to test it.

All actors have a strong focus on the turbine's economic efficiency, and this has resulted into following interesting insights: the actors have learnt that the tower, copper wire and magnets are the most expensive SWT parts (Interview 7, 12). Furthermore, actors have learnt about the influence of the price fluctuations of certain foreign raw materials. Especially the permanent magnets are relevant in this context. Magnets used to be much cheaper, and particularly the permanent magnet prices have known sudden rise these last years (Interview 7, 12). The instability of the price makes it difficult for SWT researchers and developers to come up with a suitable design. Hence actors are aware of the need for design alterations in order to low costs, but there are yet no clear results on that matter.

A general learning experience has been on the necessity for large-scale production to decrease cost. A consequence of low public awareness is the low amount of sales. Local production is done on a small scale which means that price advantages are not taking place, nor is there enough income to do R&D (Harries, Guyo, Muchunku, & Berges, 2009; Interview 4, 12, 20, 37).

Lastly, it should be noted that SWT R&D for this type of turbine is continuing worldwide, amongst others by the participants in the Wind Empowerment platform. Thus also on a global level actors have learnt on the necessity for better SWT design, and Kenyan SWT actors might adopt these (Wind Empowerement, 2011).

Jua Kali design

Also no dominant design emerged in the low cost, low power SWT category. The lack of knowledge and limited financial resources limit Jua Kali's ability to successfully experiment and come up with a suitable design (Interview 21, 27, 29, 34, 36). Since there are no linkages between these different actors, they have only been able to learn from their own learning experiences (trial and error). A professional attempt for such a turbine has recently been made by Access:Energy and several real-life experiments have also been carried out. This organisation is set up by educated Westerners that brought along technical knowledge, and as far as the author is aware, they are the first to have professionally analysed their SWTs by producing power curves. Since Access:Energy is still in pilot phase, there is still no full clarity on the suitability of this design (Interview 26).

In general, the most important design requirement for these turbines is cost. Actors have learnt about the range of low cost materials to produce a turbine with. Nevertheless, it is unclear what the best material choice and configuration is. In addition, the actors lack insights to what level low cost compromises performance. Furthermore, there is no clarity on the performance/cost ratio and product life time (Interview 21, 26, 27, 29, 34, 36).

Last, several actors have also learnt that it is possible for Jua Kali to construct the Hugh Piggott design, but that it requires quite some efforts (Interview 24, 26, 32).

Imported SWT design

Learning on cost has also been the case for the imported turbines. The SWT dealers acknowledge the high product price, and the fact that it limits the potential market size (Interview 11, 28, 40). Since feedback mechanisms between foreign suppliers and Kenyan dealers are missing, the foreign companies are not aware how the product should be altered for it to fit more in the Kenyan context. Kenyan actors have also not yet learnt what effective measures to take in order to reduce product price. Some are importing Chinese (low-quality) designs, whereas others are considering the import of second hand turbines for this purpose (Interview 4, 11, 38, 40).

4.4.2 Wind potential and analysis

Actors have recently learnt about the Kenyan wind potential through two wind measurement campaigns by the MoE: the 2003 Wind Atlas from Meteorological data, and the 2008 SWERA map from geospatial mapping. These maps have shown there is wind in Kenya (Interview 10). Nevertheless, despite these gigantic improvements the last decade, there is still a lack of detailed knowledge about the Kenyan wind resources (Interview 9, 13, 18, 26, 38).

Next to that, actors have learnt about the extent to which local wind speeds affect the power output. There is however a large diversity amongst the individual suppliers. Jua Kali have a limited understanding about the exact relation between wind speed and power output due to lack of understanding (Fugers, 2011; Interview 15, 21, 35). The formal actors have more experience in this respect and have learnt about the necessity of wind data. They consider the unavailability of accurate, affordable and well-organized wind data a major barrier for the development of SWTs because the generated power is directly dependent on the wind speed (Appendix B.4; Interview 5, 7, 9, 38, 40).

An important aspect of learning entails the need of gathering knowledge on wind data analysis and interpreting them. Note that all active formal niche participants have learnt about the importance of wind data, but they do not all carry out wind measurements at a specific site due to the high costs associated (Interview 5, 12, 37).

4.4.3 Infrastructure

The city based formal companies have learnt about the need for better road infrastructure to upscale their business. Kenya's underdeveloped infrastructure has shown to be an important factor for the total end-user cost because of the higher installation costs. Respondents identified serious price increases: some companies have to charge an additional 20%, others an extra 50.000KES-100.000KES depending on the distances (Interview 4, 5, 7, 11, 12, 13, 40).

4.4.4 Industrial development

This learning aspect entails the distribution network, maintenance and repair network, and the production network needed to broaden dissemination.

Distribution network

Actors have learnt about the city-based[8] companies' necessity of an enhanced distribution network. Now all the technical expertise, technology suppliers and sales force is located in Nairobi area, which pushes the product cost. This immediately affects the product price. Next to that, the fact that these companies are far away from their customers makes it difficult to effectively target them.

The presence of local sales agents would increase local awareness and enhances trust in the company and product. This is due to the importance of personal networks in the Kenyan society (preference for buying a product from a community member, family member or acquaintance). Some actors also believe that decentralized formal production would be a viable option to bring the product to the people and decrease the cost (Harries, Guyo, Muchunku, & Berges, 2009; Interview 16, 37, 39).

Maintenance and repair network

Actors have learnt about the importance of product maintenance for SWT sustainability. Regular services increases product life time and avoid high replacement costs. Next to that, product breakdown leads to bad publicity (Interview 11, 20, 23, 35, 39). Despite these lessons, maintenance contracts are not standard (Interview 5, 40), amongst others because of Kenya's poor maintenance

[8] The vast majority of companies is located in Nairobi; several cases have been found of Mombasa and Kisumu based SWT suppliers

culture (see section 5.1.6; Interview 20). From these lessons, actors have recognized the need for a local technical support network to increase after-sales services.

According to several respondents, local technical capacity is required to decrease the cost of installation, maintenance and repair. Next to that, the presence of local technical skills would increase user's attention to maintenance and repair; when the company is far away, users are less able to find their way to the company for after-sales services. For this reason, various actors have recognized the need for the development of appropriate local capacity installation and after-sales services to this way maximising technical sustainability and increasing market penetration (Interview 7, 18, 19, 37, 39).

Production network

Regarding the production network, SWT dealers have learnt about the diversity of foreign suppliers to buy the products from. Due to the increasing global interest in small wind systems, the Kenyan RE dealers are putting SWTs on the market, and they have a wide range of dealers to import their turbines from (Interview 11, 28, 40). Regarding the local formal production, all actors have learnt that the size of this network should increase. The advantages of local production have been shown in terms of lower price, availability of spare parts and local maintenance knowledge (Interview 5, 15, 37).

Next to that, development aid and university actors have recognized the need for strengthening the Jua Kali production network. Rather than enhancing Jua Kali skills for maintenance, some actors believe a Jua Kali production network would benefit the SWT sector since they match the quality of their products to rural consumer budget and needs. The fact that Jua Kali fabricate the products close to their customers enhances local awareness and trust. Next to that, SWT price and installation cost would considerably drop. Several existing actors and new entrants are now setting up initiatives for encouraging the Jua Kali network. For instance, by developing a product that can be manufactured by Jua Kali or training Jua Kali artisans for turbine production (Interview 33, 39, 41).

4.4.5 Social and environmental impact

The development of small wind energy impacts the Kenyan society on a wide range of socio-economic and environmental aspects.

The Kenyan SWT activities and in particular the donor projects have shown that small wind systems have a large social impact. Schools have for instance proven to benefit from SWT electricity by the development of morning/evening classes and access to computer as a modern education method.

Actors have also learnt that electricity enables ICT and TV services, which in turn provides access to information to the most remote communities. Living conditions have been proven to increase by better lighting and kerosene cost reduction. Besides that, in some cases, SWTs have shown to save time since they allow for battery charging at home instead of at a (long) walking distance (RISO DTU, 2009; Berges, 2007; Interview 5, 11, 20, and 39)

Moreover, pilot projects of non-profits and universities have also shown that electricity from SWTs enables the use of electric tools and equipment and thereby enhances productivity and revenues of many small businesses such as welders, carpenters and tailors (Interview 22, 39). If the grid is not available and the wind resource is good, some experiments have learnt that the energy produced by SWTs is cheaper than other off-grid alternatives such as PV[9] and diesel generators, especially if the fuel supply is far-off (Interview 5). Actors have also learnt about the health benefits of introducing green electricity; the utilization of traditional energy sources such as kerosene for lightning have shown to be significantly decreased with the introduction of an SWT (Berges, 2007; UNIDO, 2011).

Furthermore, small wind systems positively impact the environment. With its zero emissions, small wind turbines have also proven to contribute to the reduction of carbon emissions through biomass and fossil fuels (UNIDO; Interview 5, 22). Moreover, small wind turbines produce some noise contrary to the silent grid (Dunnett, Khennas, & Piggott, 2001). However, when compared to the most frequent off-grid alternative diesel generators they are far quieter. None of the respondents have indicated these impacts as a concern or barrier for small wind system in Kenya. The same holds for the possible visual impacts of small wind turbines (Dunnett, Khennas, & Piggott, 2001). With its 10m height, small wind turbines are a landmark in its surroundings. However, none of the interviewees argue this being a negative impact.

4.4.6 Development of user context

Lessons from technology suppliers

Target customers

Different producer groups have learnt about different application domains for a small wind turbine. First, Jua Kali turbines are considerably cheap and their target market has shown to be rural middle-class households and small farmers. Their (envisioned) end-users are primarily the people from their communities (Interview 21, 27, 29, 34, 36).

[9] Note that this statement is based on respondents' experiences with SWTs in the last decade and do not necessarily take into account the current falling PV panel prices.

On the contrary, most formal companies have experience with larger and more costly turbines for wealthy individuals, telecom companies and other businesses such as hotels. In a lesser extent, they provided farmers and institutions (schools, hospitals) with a wind turbine. These companies have also sold units to NGOs, universities and churches for their pilot projects. Apart from own usage for powering their rural property, a part of these turbines are used in experiments or charity projects (see below) (Interview 5, 11, 12, 28, 40).

Next to households, institutions and large businesses, small wind turbines have the potential to provide electricity to community groups, small businesses and individuals who can purchase a turbine with a financial arrangement (e.g. MFI, SACCO loan). All together, these target groups form a large market for SWT companies, but the vast majority of formal actors has not tapped into it yet (Interview 22, 26, 40).

Meaning of the technology

The number one reason for turbine purchase has shown to be the unavailability of the grid, and low confidence it will reach them any time soon (Interview 23, 35). In a much lesser extent, small wind turbines were acquired as money saver on the KPLC bill, or as back-up option for the grid (Interview 1, 9, 22). Furthermore, small wind turbines are predominantly used for electricity, but some cases have been reported on their use as water pumping devices. In that case, the electricity from a turbine is used to power a pump (Interview 12).

Because of the lack of company-customer interactions, many SWT suppliers do not get feedback on consumer perception on the technology, the extent to which it fulfils their needs and the impact it has (Interview 4, 11, 41). More user involvement would allow for product optimization based on technical aspects, economic and societal aspects (first-order and second-order learning).

Education of customers

Actors have learnt on the necessity to educate end-users on the usage and maintenance of the technology, since the majority of Kenyans are unfamiliar with the technology. The conservative attitude of rural people is problematic as well (Interview 19, 22). This is especially the case for remote rural villages where education levels are often poor. Experiments have shown that without education and training of customers, they are not able to manage the wind energy system leading to technical failures. For example, a standard method in Kenya for extending the charge in a battery is pricking it with nails. Without end-user education, also SWT users would be tempted to extend battery operation in this way (Interview 5, 12, 20, and 40).

Marketing

Valuable lessons have been learnt on effective promotion methods in order to gain awareness and increase customer base. It has been learnt that the most effective way to find new clients is by means of demonstrations, hence increasing visibility of a working SWT (Interview 5, 9, 12, 22). Despite the fact that actors learnt about the need for large scale marketing campaigns, there have been few lessons on which marketing method is most appropriate. For niche upscaling, awareness creation is crucial, but the actors have not yet invested in extensive marketing because of the associated high cost (Interview 5, 40). The lack of appropriate marketing methods appears to be an important reason why current customer base generally does not include rural households, small businesses and community groups.

Jua Kali find their customers through extensive personal networking (Interview 21, 35). Also they have reported on the difficulty of finding customers and lack of resources for marketing (Interview 15, 29).

Lessons from NGOs and research institutes

NGOs and research institutes have learnt about the use of SWTs for powering communities through a mini-grid or battery charging point. These experiments focused on extensive monitoring of user experiences, impact on living conditions and employment creation (Interview 4, 20, 24, 33, and 39). Focus was thus more on the users (second-order learning) than on the technical aspects (first-order learning).

Interesting lessons were learnt about the complexity of community group customers. The delivery of energy services has proven to be much more than technology functioning: "*the people dimension is crucial.*" (RISO DTU, 2009). The actors have learnt that the real challenge lies with the social rather than the technical aspects. Community projects are vulnerable to corruption and lack of ownership. They also require community participation by for instance taking part in the decision process: the entire community has to agree. Appropriate education and awareness creation is required for everyone to understand the technical, financial and business aspects. On top of that, a suitable management model has proven to be crucial for sustainability: who will take responsibility for what, which management structure is suitable, how will the SWT finance be arranged? (RISO DTU, 2009; Interview 4, 20, 26, 38, 39).

Community electrification also requires the involvement of local governments and village chiefs, since they have a strong influence on the SWT acceptance. Whereas a positive opinion encourages willingness to buy/adopt a turbine, negative local government official can break the project. Also these actors have limited awareness on SWTs and should therefore be educated on the SWT technology and functionality (RISO DTU, 2009; Interview 19, 20, 23, 39).

4.4.7 Appropriate business models

As mentioned above, actors have (fragmentally) learnt about the required key partners, need for distribution channels, possible target markets etc. However, they have not yet learnt how to incorporate this into an appropriate business model. Furthermore, all commercial formal actors are located in the cities (predominantly Nairobi) and have a rather conservative business model. They sell their products from the city, and in the best case they have local technicians in the rural areas. However, for increasing their target market, they could also consider selling electricity, leasing wind turbines etc.

Actors have hence not yet learnt about the best business model, and in particular, they do not know which integrated approach can create and sustain access and delivery of SWT electricity services to the poor people.

At the moment, actors are developing innovative plans and strategies that combine into a new kind of business model (Interview 16, 26). Executing these plans will shed light on which business models do and do not work in the rural Kenyan SWT context.

4.4.8 Government policy and regulatory framework

All SWT businesses and many other network actors identify the lack of regulatory framework and institutional support to be a major constraint for sector growth. First of all, actors have learnt that the need for a long-term perspective for small wind turbines. Several respondents mentioned the need for a stable SWT policy, since regular changes have a discouraging effect for actors to continue their SWT participation and for new stakeholders to join (Interview 12, 32, 33).

Each of the respondents identified low public awareness and high up-front investments as hindrances for SWT breakthrough (e.g. Interview 8, 9, 12, 13, 37, 40). The government is in the position to increase awareness by setting up a public campaign and by other ways of promotion. As previously mentioned, REA is mandated to promote renewable off-grid power generation systems. Despite their recent SWT activities in light of this responsibility, actors believe more should be done (Interview 13, 18, 30, 31, 33) For instance, REA requires more funding to continue its activities in the field of SWTs (Interview 18). Furthermore, there are no policies to encourage the investment of the private sector, communities and households in small-scale wind for off-grid electricity supply. Actors believe that end-user subsidy or tax arrangements would be a great help to stimulate adoption (Interview 13, 40). In addition, actors have identified the need for the government to allocate resources into capacity building and SWT research (Interview 9, 13, 18, 37).

There also have been valuable learning experiences about the need for adequate wind data (section 4.4.1). In an effort to retrieve wind data sets, several actors have approached the Meteorological Department to retrieve data sets. However, these appeared to be too expensive, rather scarce and inadequate. Therefore, the respondents believe that the national government should put more efforts in wind monitoring and spread them at low (or no) cost (Interview 18, 33, 38, 40).

As mentioned above, magnets are a crucial component of many locally manufactured turbines. Since these are not produced in Kenya, they have to be imported. There is however no duty exemption on imported magnets, whereas imported wind turbines do benefit from a tax reduction. According to some actors, tax reduction incentives for imported magnets, and possibly other necessary components or equipment, should be provided by public authorities to stimulate local manufacturing of SWTs (Interview 4, 12).

There have also been learning experiences on the need for SWT standards. These are necessary to assure the performance of products that are put on the Kenyan market. In order to sell SWTs, importers require a quality mark of the Kenyan Bureau of Standards (KEBS). Usually, a standardization mark is also mandatory for locally manufactured products. There are however no national standards for locally manufactured turbines because of the limited market size (Interview 6, 9, 12, 33).

It should lastly be noted that many actors are not fully familiar with the regulation for small wind turbines. Certainly the Jua Kali are unaware: section 3.4.1 explained their position in Kenyan society, and how this group of people falls outside the realm of government regulation and protection (Interview 21, 34, 37). Various respondents of all stakeholders groups were unable to provide details on the SWT regulations, and they were particularly not aware of the underlying reasons for the inadequate policy framework (e.g. Interview 5, 26, 41). This means that there is a lot of uncertainty about regulations, standards and their future developments.

4.4.9 Conclusions

With over ten years of Kenyan SWT experience, actors have learnt a lot about the technological, economic, regulatory, societal and environmental aspects of SWTs. However, these learning experiences are only shared to a limited extent due to lack of linkages between all actors, lack of feedback channels, no platform for sharing information and resistance to sharing lessons.

Generally speaking, it can be said that much of the second-order learning was developed by non-profit and research actors, who more focused on the people dimension, social structures, technology impacts etc. This learning led to important lessons regarding other niche markets and the key elements of what an appropriate business model should entail. The private sector, for its part, is more focused on obvious markets and develops first-order learning experiences, especially about the technology and economic aspects. The learning experiences in the informal sector are relatively limited, and mostly focus on the techno-economic aspects.

Lessons have been learnt on following aspects:

Technical development

Regarding the SWT technology, no dominant design has yet emerged in any of the three categories. The formal SWT manufacturing sector learnt lessons on the need for a better SWT design. Actors have learnt on the need for design alterations in order to low costs, but there are yet no clear results on that matter. Large scale production is needed to achieve price reductions.

Few lessons have been learnt on a suitable SWT Jua Kali design. Cost is an important design criterion, and actors have learnt about appropriate cheap materials. These lessons are not collectively learnt because of missing linkages.

The foreign suppliers of SWTs have not yet learnt on the need to alter the SWT in the Kenyan context, or how to realize cost reductions because of the lack of feedback channels. Overall, more technical lessons should be learnt.

Wind potential and analysis

Actors have recently learnt about the Kenyan wind potential through MoE wind maps. However, more detailed wind monitoring is required to enhance knowledge on areas that are favourable for SWTs. Jua Kali actors have limited insights about the exact relation between wind speed and power output due to lack of physical understanding and own wind monitoring. The formal actors have more experience in this respect, and have learnt about the necessity of wind data and the need for detailed analysis.

Infrastructure

Nairobi-based companies have learnt about the need for a better road infrastructure to decrease the total cost of a turbine.

Industrial development

Formal actors have learnt about the need for an enhanced distribution network with more local sales agents. They have also recognized the need for a local technical support network, to increase the after-sales services and bring the costs down.

Regarding the production network, SWT dealers have learnt about the diversity of foreign suppliers to buy the products from. The local manufacturers have learnt that the size of this network should increase. Next to that, development aid and university actors have learnt about the potential of Jua Kali to produce SWTs.

Social and environmental Impact

Actors have learnt about the environmental and health impacts of SWTs. Furthermore, it are especially the non-profit projects for pilot or demonstration purposes that have resulted into lessons about the social impact of the technology.

Development of user context

The SWT actors have gained different learning experiences with regards to the development of user context. Actors have learnt about the diverse target markets and the need for end-user education. They have gained a shallow understanding of the meaning of the technology because of the lack of feedback channels. There have been learning experiences on appropriate marketing methods, but these should be expanded on. Only non-profit actors and universities have learnt about community groups as market segment. This target market has much potential to generate impact and increase SWT penetration. It however also requires appropriate partnerships and community ownership models.

Appropriate business models

With all commercial actors having rather conservative business strategies, learning experiences are missing on appropriate business models.

Government policy and regulatory framework

SWT actors have learnt about the necessity for a better government regulatory framework and institutional support for sector growth, particularly on the levels of public awareness campaign, tax and subsidy arrangements for end-users, SWT standardization, affordable wind data and tax incentives for imported raw materials. Few actors have full knowledge of the underlying reasons of the (lack of) SWT policy, and current developments in this respect.

4.5 Conclusions

First, conclusions can be drawn regarding the state and development path of the niche. It is following an untraditional trajectory, since it is characterised by a mixture of technological experimenting and commercial activities. This is mainly due to the global SWT activities and its linkages to the Kenyan sector. Furthermore, despite of the fact that experiments are still taking place, the current SWT niche can be considered to be a dedicated market niche that is in the inter-local phase. The niche has not yet reached the replication phase. Furthermore, a large part of the experiments were not continued and some commercial activities also stopped. The main barriers for entrance from an end-user point of view are the lack of awareness and high upfront costs. The underlying characteristics and developments that influence sector upscaling were explained through the evaluation of the three internal niche processes.

First, regarding the niche expectations, we can conclude that they are positively influenced by favourable landscape developments, increasing regime tensions and the flourishing of other wind energy niches. On the negative side, lack of government incentives and out-of-order turbines are the main factors that inhibit confidence in the technology. As a result of learning and above influences, the expectations of niche actors have changed. But even though they have improved, there is evidence that expectations have not yet converged, are not at all specific and are of low quality. Furthermore, the external expectations are improving on the level of awareness and overall realization there is a need to shift to RE decentralized technologies. However, the external expectations are still quite negative because the market has not been proven and because of the bad image of non-working turbines. Social and cultural factors also play an inhibiting role, especially in product purchase and on the level of SWT entrepreneurship. These negative external expectations demonstrate the need to voice expectations through awareness creation, a strong government vision and on the delivery of high quality goods and services.

Before conclusions could be drawn on the completeness of the network, the required network composition had to be investigated. It can be concluded that the required actor network for successful niche upscaling is rather complex. The SWT niche has three different supplier groups, and needs a large variety of actor groups due to the complexity of operating in the Kenyan society. When analysing the completeness, one can say that the network misses some crucial actor groups: CBOs, local authorities, financial institutions, rural supply chain, practical educational institutes and an SWT umbrella. And last but not least, active user involvement seems to be lacking.

Regarding the extent to which the niche participants contribute to the network and the number of actors per sub network, it can be concluded that there is a lot of room for improvement. All technology supplier groups underperform and have not yet reached scale yet in terms of SWTs installed. Universities, NGOs and the GoK participate in the network, but the intensity and quality of participation should increase. Furthermore, interaction amongst these actors is inadequately facilitated despite recent improvements. A problem is that actors do not know of each other's existence, and that many of the collaborations were of short duration. Current niche participants should establish linkages with actors of groups that are not yet in the network, and should enhance interactions with current niche participants for network alignment. Network alignment is now low due to the instability of the network, missing linkages, lack of regulatory alignment and lack of Kenyan SWT umbrella. Interactions would also benefit shared learning. Now, learning experiences are only shared to a limited extent due to lack of linkages between all actors, lack of feedback channels and user involvement, no platform and the resistance to sharing lessons. Furthermore, this research shows that various actors are not that focused on learning or find the concept of learning difficult to grasp.

Commercial actors have primarily learnt at first-order level, whereas research institutes and NGOs have gained most lessons through second-order learning. Furthermore, learning is characterised by a parallel trajectory were different applications are investigated at the same time. NGOs and research institutes focused on the poor, companies put focus on the ones who can easily afford a turbine. Various lessons have been learnt on the technical side regarding the need for technological improvement, but this has not yet resulted into a dominant design in any of the three technology supplier groups. Formal actors have learnt about the Kenyan wind potential, the necessity of wind data and the need for detailed analysis, whereas informal actors have no exact understanding of this. Furthermore, lessons have been learnt on the need for better infrastructure. Lessons were also developed on the need and possibilities to optimize the distribution network, production network and maintenance network, and about the potential of Jua Kali in all three networks. Learning experiences have taken place on the user context, but these are very fragmented and have not been turned into appropriate design or business approach changes. Overall, learning experiences are missing on appropriate business models to tap into the SWT market. Lastly, SWT actors have learnt about the necessity for a better government regulatory framework and institutional support for sector growth, but they have not yet learnt how to change it. An overall conclusion with regards to the learning processes is that even though lessons have been learnt on many aspects, these learning experiences have not yet resulted in effective solutions or their implementation.

5. Multi-Level Perspective

The breakthrough of the SWT niche is dependent on the interaction between the processes at the different levels of the MLP. Top-down landscape pressure and bottom-up niche pressure can create tensions on the regime level. Destabilization of the regime creates windows of opportunity for the niche innovation to break through. Also the landscape itself can directly influence the niche through for instance social, cultural and infrastructural factors. This chapter analyses the developments at the different levels and describes its dynamics.

The information discussed in this chapter comes from a combination of the interviews (Appendix F) and the literature study. The influencing factors and how they (indirectly) affect the niche development are gathered from the interviews. The quantitative data is predominantly retrieved from literature sources.

Section 5.1 presents the external factors (landscape) that influence the regime and niche, whereas section 5.2 deals with the regime developments. The niche has been extensively dealt with in the previous chapter, and will therefore not specifically be elaborated on in this chapter. The interactions between the three levels are presented in section 5.3. This chapter ends with a conclusion in section 5.4.

5.1 Socio-technical landscape

The development and implementation of off-grid wind turbines is driven by several landscape factors that are outside the sphere of influence of the regime and niche actors. This external context includes both long term developments and abrupt events, and can exert positive and negative influences on the lower levels. This section describes the landscape by providing factual information; the landscape's influences on the regime and niche level are dealt with in section 5.3.

5.1.1 Environmental issues

Climate change has a significant influence on Kenya's and energy and economic situation. In 18 years (1990-2008), temperature has experienced a rise of 1.77% and rainfall is reduced with 5.2% (Kirai, 2009). As a result, the water levels and hydro dams are depleting and the available hydropower and hence grid electricity is reduced. Climate change is also at the root of the increased floods and droughts. These extreme events have major socio-economic consequences and are a key factor for Kenya's declined economic growth (SEI, 2009).

Together with the increasing power demand and the scarcity of fossil fuels, climate change is also at the root of the worldwide increased environmentalism. As a result, there is globally a lot of focus on green technologies. This global movement towards green is tripling down to Kenya in various ways. The Kenyan government and public are gaining environmental awareness through increased media attention and international climate conferences. Also international organisations such as the United Nations and The World Bank are encouraging Kenya for a transition towards a green economy by various programs (Omar & Lagat, 2011; Kirai, 2009). Western donor money is also more and more given to 'green projects' through the NGO sector.

5.1.2 An economy out of balance

There are several external shocks and internal developments that are heavily pressurizing the country's economic situation and energy problems.

First, Kenya's population is massively expanding (Figure 24). In the last 40 years, the population has quadrupled from ca. 11 million people in 1970 to an estimate of 41 million in 2011 (Trading Economics, 2011). If these growth numbers continue, the population will reach 85 million in 2050. This population growth rate is amongst the highest in the world, and can be attributed to high fertility and longer life expectancy due to better health conditions (Fengler, 2010). Kenya's growing population has major consequences for the energy demand, since it is a key driver for the rising energy consumption.

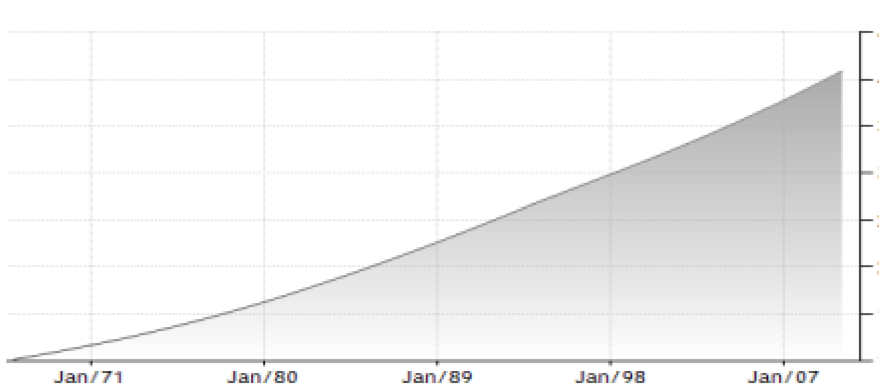

Figure 24: Total population of Kenya (Trading Economics, 2011)

Next to that, global oil prices have drastically increased the last decade (Figure 25) due to oil scarcity, rising demand and geopolitical instability. Moreover, the on-going crisis in the Middle East and North Africa has driven up the price of crude oil even more with a 37.4% increase in the first 9 months of 2011 (The World Bank & Australian AID, 2011). Kenya is highly reliant on oil for transportation, power generation, aviation etc. (Kiplagat, Wang, & Li, 2011). Its economy is therefore more and more imbalanced due to these escalating oil prices. Currently, the top four oil export products do not even earn enough to pay for the oil imports. This heavy reliance on oil makes the country very vulnerable, in terms of energy security and foreign exchange drain (The World Bank & Australian AID, 2011).

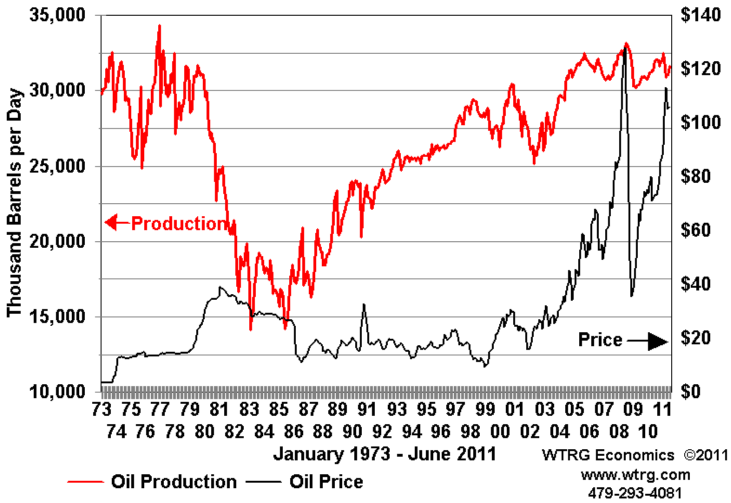

Figure 25: Global crude oil price history (WTRG, 2011)

This increased global oil price is having a major influence on the economy due to Kenya's heavy reliance on oil. Also the droughts in the Horn of Africa, rising costs of electricity, Euro crisis, increased currency volatility and higher international food prices are putting the economy under pressure. Figure 26 visualizes these factors and their influence on the depreciating of the Kenya Shilling and decline of Kenya's economy.

So after an economic dip after the post-election chaos in 2008, the economy is again under pressure. However, despite of these current challenges, Kenya is still experiencing a GDP growth rate of over 4% (The World Bank & Australian AID, 2011). Besides that, wealth levels keep rising and the Kenya's middle class continues to rise (Broere, 2012). Furthermore, the economy of Kenya is still the largest by GDP in the East and Central Africa region. Its advanced industrial and agricultural sectors underpin Kenya's economic growth numbers. Another key driver has been the mobile phone sector (section 5.1.3).

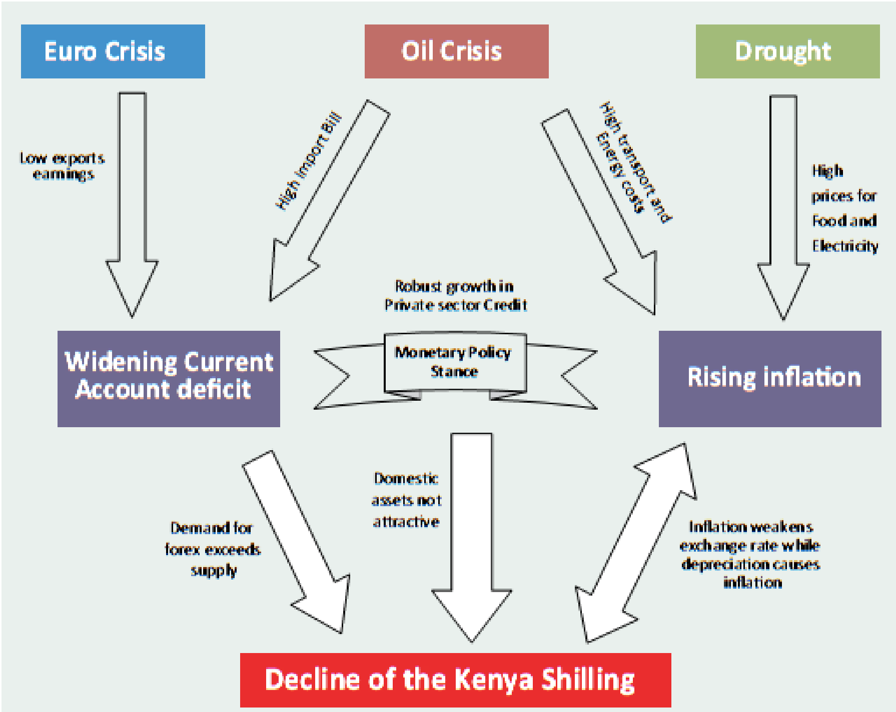

Figure 26: Kenya's weakening economy (The World Bank & Australian AID, 2011)

5.1.3 Socio-economic conditions

Poverty

Despite the economic improvements, Kenya remains a low-income country with a GDP per capita of US$ 772 (The World Bank & Australian AID, 2011). In spite of the large amount of development aid organisations and government incentives for improving the poverty level, 48% of the population is living in poverty. Especially a large part of the rural population is unable to meet its daily needs such as food, water, healthcare and education. (IFAD, 2011).

Formal and informal markets

Closely related to poverty is the Kenyan division between the formal and informal markets. This concept was already partly introduced in section 3.4.1 and section 4.2.2. In Kenya, the majority of the working population earns it money in the informal sector. They lack rights, land and education. Furthermore, there is a causal relationship between the informal sector and poverty, with average incomes and living conditions being much lower in the informal economy (Orwa, 2007).

In addition, the informal economy is characterised by a lack of formal financing mechanisms such as banks and investors. They have to rely on informal mechanisms built on personal relationships and social networks to organize contract enforcement and payments. In the best case, they can get access to MFIs or SACCOs (Kariuki & Rai, 2010).

Education

The Kenyan education system faces several challenges that have effect on technology acceptance and the availability of human resources in Kenyan society. Firstly, education levels are quite low, especially in the remote areas. As a result, new technologies are regarded as strange and are viewed with scepticism.

Next to that, human resource development is quite low. The educational institutes are characterised by serious shortages or lack of essential resources and facilities. This has its effect on the practical oriented educational institutes (polytechnics and technical training institutes) and on the universities (Makori, 2005). Moreover, Kenyan universities are characterised by their theoretical orientation. There is a focus on memorization rather than really understanding the content. Students learn from books and have limited practical, hands-on experience. Consequently, this creates people who are incapable of producing knowledge that matches their own social, economic and physical environments. Another key characteristic of the Kenyan education system is that it lacks an integrative dialogue amongst all stakeholders in the field. This creates a mismatch between the needs of the industry and the teaching programs of the educational institutes (Mwangi).

Fortunately, improvements are being made, especially with regards to increasing literacy and overall quality of education (African Economic Outlook, 2011).

5.1.4 The ICT revolution

Another landscape factor is the growing penetration of mobile phones and the internet, due to the growing popularity of smart phones and social network applications. There are now over 25.3 million mobile phone subscriptions in Kenya which is more than the number of adults the country counts. This ICT penetration means that information is becoming more available and public awareness is growing, even in the rural areas.

Besides that, as described in section 5.1.2, the telecom sector is a key driver for the economic growth. It has generated a set of innovations regarding saving accounts. For example, the majority of the mobile phones are now linked to bank accounts. As a result, financial services are becoming available to the previously unbanked part of the population. Next to that, the rise of electronic gadgets in Kenya's rural areas is also pushing the (rural) demand for electricity, since these devices have to be charged (The World Bank & Australian AID, 2011).

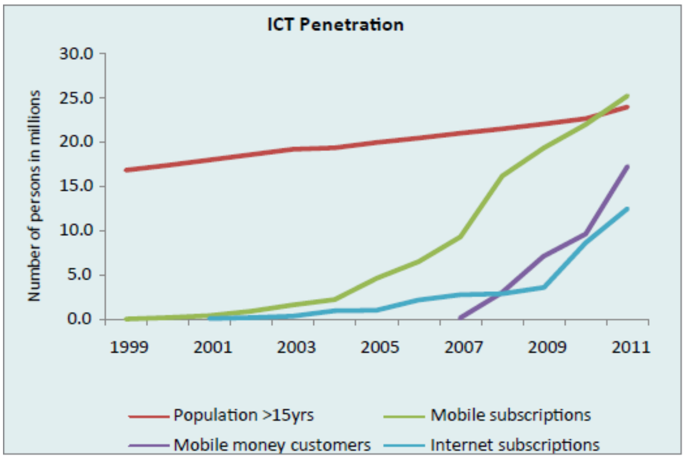

Figure 27: ICT penetration in Kenya (The World Bank & Australian AID, 2011)

5.1.5 Natural resources and infrastructural limitations

Kenya's natural resources are of significant influence for the regime and niche developments. First, where the country used to be endowed with sufficient water resources to produce a significant amount of hydropower, this is significantly decreasing due to the changing environmental conditions (Vision 2030, 2007). Another resource aspect entails the availability of raw materials for the local production. Kenya lacks many of these resources and therefore has to import them. The increased global demand for raw materials has in turn impact on the prices of these materials (Berges, 2007).

Furthermore, Kenya's road network is relatively underdeveloped. Due to unequal population densities – the population is heavily concentrated in the southern half of the country – the road network is clustered in the dense areas along the Mombasa-Nairobi-Kisumu connection (Figure 28). Furthermore, a significant part of the roads are of poor quality (AICD, 2010). These insufficiencies hold back the productivity of companies and the overall economy. At the moment, progress is being made; the government has taken steps to improve capital budget for improving the road infrastructure (AICD, 2010) and are attracting Chinese investments for this purpose (Moskou, 2011).

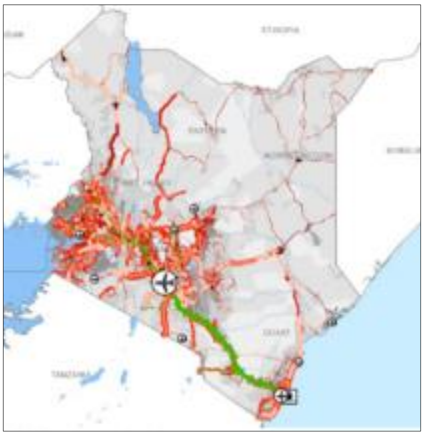

Figure 28: the road infrastructure of Kenya (AICD, 2010)

5.1.6 The social and cultural environment

There are various social factors and cultural beliefs engrained in Kenyan society that influence the development and adoption of new technologies and the willingness to bring these to the market. Several of these factors are a result of the colonisation period followed by half a century of development aid. Kenya has been colonised since the 18th century, and especially the British colonisation, until 1963, has left a deep footprint on today's society. Other influences include the country's social context (poverty and life expectancy) and education system.

Conservative attitude

The colonists have brought technology into the country and took overall control. As a result, Kenyans stopped innovating and owning it themselves. Ndegwah (2011) gives insight into this situation:

> *'Colonial racism had succeeded in alienating many Africans from their own culture'. Most missionaries (even though, in some cases, without intentional and deliberate malice) ignored any possibility for a dialogue and demonized African cultures, because they regarded everything the African did or thought as evil.*

Today, 40 years after Kenya's independence, a critical and innovating attitude is still missing. This problem can be partially attributed to the curriculum of most Kenyan colleges and universities, where students are taught to learn by heart as opposed to invent and innovate (section 5.1.3 and Interview 38).

Resistance to new technologies

Not only does Kenya suffer from a conservative attitude with regards to innovating, there also is a general lack of consumer and social acceptance of new technologies. Especially in the distant, poor areas villagers tend to be resistant to change. This can be attributed to the short-term focus of many rural Kenyans (Hofstede, 2005), which is caused low life expectancy and high poverty levels (section 5.1.3). Furthermore, technology is often seen as alien, which further drives the preference for traditional energy. This rather conservative attitude is a consequence of inadequate information and lack of awareness (Painuly, 2001).

Dependency syndrome

Kenya also suffers from a 'Dependency Syndrome' (Mathaai, 2009), in which Kenyans are over-reliant on aid and government support. The foundation for this over-reliance seems to be laid during colonialism, and has been sustained through Western donor agencies in the successive years. As a result, Kenyans seem to think that new technologies are things that are provided to them by the government or by aid workers rather than something they create on their own (The Lemelson MIT Program, 2003). In addition, this dependency attitude is strengthened by Kenya's high power distance, traditionalism and lack of individual initiative, which are some of the cultural dimensions described in Hofstede (2005) and Trompenaars (1999).

'Self-employment equals failure'

Even though the importance of entrepreneurship as a driver for growth has been acknowledged by the government, the general perception towards self-employment is rather negative. Despite the country's high unemployment rates (section 5.1.3). Kenyans prefer a 'white collar-job' within a large company or government organisation (Appendix C; Interview 30, 38). This mentality, in which people prefer office work as opposed to manual work or self-employment, was created during colonisation. White-collar employment received highest status, and only the ones without education would consider self-employment because they had no choice. Entrepreneurship was strongly associated to the poor and uneducated which were generally part of Kenya's informal sector (Daniels, 2010).

Despite recent improvements, the same mind-set is still present in today's society and Kenyan graduates are still attracted to formal employment despite the low employment opportunities. This can partially be attributed to Kenya's higher education environment. The curriculum of most colleges and universities is concentrated on preparing graduates to be employment seekers instead of employment creators (Maina). Also in their later careers most of them do not opt for self-employment, because of the white-collar mentality and the security of a fixed job. So paradoxically, the educated people who generally come from a higher income family and have more access to start-up capital have the best entrepreneurial profile, but are least attracted to self-employment.

Corruption

Corruption is recognized as the single most important obstacle for the economic and social development of Kenya, and it is affecting all sectors and levels of society (Anassi, 2004). For example, resources are being diverted to dishonest individuals instead of the hardworking. As a result, the people and businesses that are able to contribute to economic growth are hindered (Maina et. al, 2000). Corruption also impedes people to engage or venture into a new business. Well-connected individuals are for example much more likely to access government funds or permits (Transparancy International Kenya, 2008). Tenders do not always go to the best proposal, but to the one that in the right circle or patrimonial system. As Ngunjiri (2010) quotes: *"Personal relations represent a kind of social capital in scarce supply* - Bezerra, 1994*"*. Entrepreneurial activity is also affected by corruption on economic level, such as taxes, access to resources and access to information which are all vulnerable to corruption (Ngunjiri, 2010).

Since the demise of the Kanu regime in 2002 and especially after the establishment of the new constitution of 2009, corruption has significantly reduced (KNBS, 2009). However, fraud is still ingrained in Kenyan society, and still commonly occurs in both the public and private sector. Furthermore, the government remains its bad reputation regarding corruption. As a result, people do not trust the government, and would rather avoid government officials than collaborate with them (Interview 17).

Lack of high-quality manufacturing culture

In Kenya, the majority of the Kenyan products that are locally produced are manufactured by the informal sector. In general, the Kenyan public does not attach much value to quality. Jua Kali goods are therefore mostly of inferior quality, since focus is put on developing products that people can afford (Daniels, 2010). Another reason for the low emphasis on quality is the country's lack of indigenous manufacturing industries. The manufacturing sector accounts for only 14% of the GDP. As a result, a real manufacturing culture is missing and specialized labour hardly exists. (Trading Economics, 2011) As a result, people regard locally produced products as inferior to products from abroad (Interview 18, 20). Closely related to this is Kenya's high reliance on cheap imports (e.g. from China), which is ruining the country's manufacturing sector. This is, if products are predominantly imported, there is no little incentive to develop the technical knowhow to innovate and produce products themselves (Interview 38).

Resistance to knowledge sharing

The practice of knowledge and data sharing does not exist in Kenya's formal sector. Whereas informal entrepreneurs take on apprentices to share their knowledge and skills, Kenya's formal entrepreneurs generally lack the sense of working together. It suffers from a secretive attitude wherein no one dares to share knowledge or data. This is because from the moment that certain data is valuable to someone else, it offers power and money (Interview 10, 12, 38).

5.2 Socio-technical regime

A regime can be described as the dominant way of doing things. This section should give answer to following question: “how much room does the regime provide for the development of the SWT sector?” It thus analyses the regime relevant for the breakthrough of small wind turbines in Kenya. Because of poor wind resources in the urban areas (section 3.1.3), focus is put on the dominant energy sources in the rural areas.

Describing the Kenyan energy regime is complex since there is not one prevailing technology. The demand and use of energy is based on geographical location (rural vs. urban areas) as well as the type of activity and economic condition. The majority of the rural household energy needs in Kenya are met by traditional energy sources such as wood fuel and kerosene. Electricity access is limited outside the cities, but if present it is predominantly provided by the grid and in a lesser extent by off-grid diesel generators.

There are several developments going on in the Kenyan energy regime. First, there is transition taking place from traditional energy sources (e.g. biomass, kerosene) to modern forms of energy (e.g. LPG, electricity) (Ngigi, 2008). Small-scale wind turbines can support this transition being an attractive option for rural electrification at places where the grid is not present. Besides that, if present, the power regime suffers from several issues, which provides room for replacements by SWTs. There is also a push for transformational change towards reduced environmental impacts by increasing the use of renewable energy sources. Also this transformation offers chances for clean small wind turbines (SREP, 2011).

Section 5.2.1 describes the situation of the traditional energy sources and explains the factors influencing the transition from domestic energy sources to modern sources of energy. Next, section 5.2.2 elaborates on the dominant forms of electricity in Kenya’s rural areas, the actual power regime. It addresses the persistent and emerging problems associated with these energy sources, as well as the factors that contribute to regime stability. Section 5.2.3 then discusses the perception of the end-users on the dominant energy sources. Last, section 5.2.4 presents the role of the national government in this respect. Below text already partially reveals the landscape factors that influence the developments within the energy regime. A full overview of these level interactions follows in section 5.3.

5.2.1 The transition from traditional to modern energy sources

Traditional energy sources play a key role in the energy supply of Kenya. Like many other developing countries, the majority of the population is dependent on biomass sources such as firewood and charcoal for cooking (SREP, 2011). Biomass especially meets the energy needs of the rural poor. This biomass overreliance poses several serious problems. For instance, biomass suffers from a supply/ demand deficit of close to 60 %. Next to that, its usage has severe negative impacts on the environment (deforestation and degradation of rangelands), climate (CO2 emissions) and the population (health effects). On top of that, deforestation largely contributes to the diminishing water levels at rivers and dams, which in turn affect the national grid instability and power outages (see section 5.2.2).

Apart from biomass, kerosene is also commonly used. About 92% of all households use kerosene, for lighting (Kiplagat, Wang, & Li, 2011). One of the main reasons for its effective diffusion in the rural areas is its elaborate supply and distribution chain (Karekezi, 2009). Due to the increasing global oil prices and the high environmental impacts, the use of this fuel is heavily under pressure (Byokola, Lema, Kristjansdottir, & Lineikro, 2009).

These problems are at the root of the shift towards sustainable, modern sources of energy. However, the current access to modern energy services for the majority of the population is not only low; it is also key barrier to the development of the rural areas. In terms of energy use for cooking, a gradual transition is taking place towards modern biogas technologies and LPG, and in a lesser extent towards electricity. There is also a gradual transition going on towards electricity for lighting and other possibilities that it offers (battery charging, television viewing etc.). Electricity is only available to a limited extent in rural areas (Ngigi, 2008). To date, electricity only accounts for 10% of the national energy consumption (Kiplagat, Wang, & Li, 2011).

In this transition from traditional to modern energy sources, a pathway is followed towards low greenhouse emissions by using renewable energy sources, because of pressure through climate change and global movement towards green. Both governments and development organisations are setting up initiatives and programs towards achieving a more green economy (SREP, 2011), which is in turn creating RE awareness.

The next section discusses the availability and state of electricity in Kenya's rural areas.

5.2.2 The dominant forms of electricity

The dominant forms of electricity in Kenya's rural areas are the grid, and to a lesser extent off-grid diesel generators. The grid coverage is currently 18% at national level, with an estimated 4% access in the rural areas and 51% in the urban areas (AICD, 2010). Figure 29 depicts the Kenyan grid network. In areas outside the reach of the electricity grid, thermal diesel generators operated by the Kenyan Power company KPLC are most commonly applied. Standalone diesel generators are also used in Kenya by institutes such as NGOs, hotels and schools (Ngigi, 2008). The popularity of other decentralized power generation niche technologies are also gaining prominence; primarily solar systems, with over 30,000 solar systems sold annually (Kiplagat, Wang, & Li, 2011).

Figure 29: Grid network in 2009 (Mohammad, 2009)

A first overall pressure related to electricity is its growing demand due to population and economic growth. Both the individual consumption as amount of electricity consumers is rising. Figure 30 presents this trend. The current electricity demand is 7775GWh, which is projected to rise to ca. 100.000GWh in 2030.

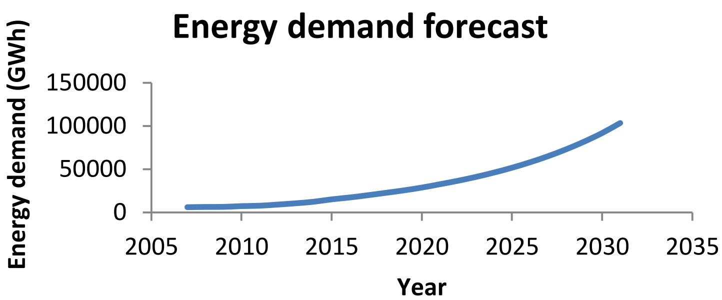

Figure 30: Energy demand forecast in Kenya (adapted from SREP, 2011)

As mentioned above, the two dominant electricity sources are the national grid and diesel generators. Note that these are not only prevailing with regards to their actual penetration; these technologies are also dominant with regards to the public perception and government strategy (section 5.2.3 and 5.2.4). The developments and problems with the national grid and diesel generators are as follows:

Grid electricity

Kenya Electricity Generating Company Limited (KenGen) is the national power generation company, and provides over 70% of Kenya's electricity. Close to 30% of the power is delivered by the six Independent Power producers, and is entirely generated by thermal fossil. The Kenya Power and Lighting Company (KPLC) is the national power utility and holds monopoly on the electricity distribution. The Rural Electrification Authority (REA) is responsible for rural grid extension and the installation of off-grid electricity projects. The grid power comes from are hydro power (50%), thermal (34%) and in a less extent from geothermal, cogeneration and large scale wind (SREP, 2011).

Coverage

As mentioned above, the grid coverage is very low in the rural areas, which is the main drawback of this energy source. This is because in remote areas, it is often impractical and unprofitable for the government to build long and expensive transmission lines to connect the many scattered villages. For this reason, grid extension is very costly and happens at slow pace.

Capacity

As a solution for the supply/ demand gap, the government of Kenya puts emphasis on increasing the centralized electricity production (section 5.2.4). The total effective grid capacity is 1302 MW (excluding isolated power systems). To meet the demands in 2015, the grid capacity has to almost double to 2500MW (SREP, 2011). The grid is thus facing a major challenge to close this gap. The majority of the electricity is generated by hydropower, with over 50% of the effective installed capacity being hydro-electricity. Recurrent droughts due to climate change are depleting the water levels at the hydro-dams. Thus, Kenya's main share of power is heavily pressurized whereas the energy consumption continues to rise (Kiplagat, Wang, & Li, 2011).

Power cuts

The electricity deficit makes the national grid also very vulnerable to power cuts. Figure 31 shows the power cut frequency that Kenyan households and retailers experience (Lighting Africa, 2008). Shutdowns are very frequent due to power shortages and extreme weather conditions, such as an overload of rain or wind damaging the grid lines (Interview 1). To keep control of the situation, power rationing is often introduced in dry periods (KPLC, 2011). Since the drought related problems are expected to get worse, power cut frequency and its severity is projected to increase. On top of that, the weak transmission and distribution network is another major cause of power cuts (Interview 2; SREP, 2011). Besides that, vandalism is also an obstacle for the power grid sector. Destroyed power lines are very common as Kenyans lack sense of ownership (Interview 1).

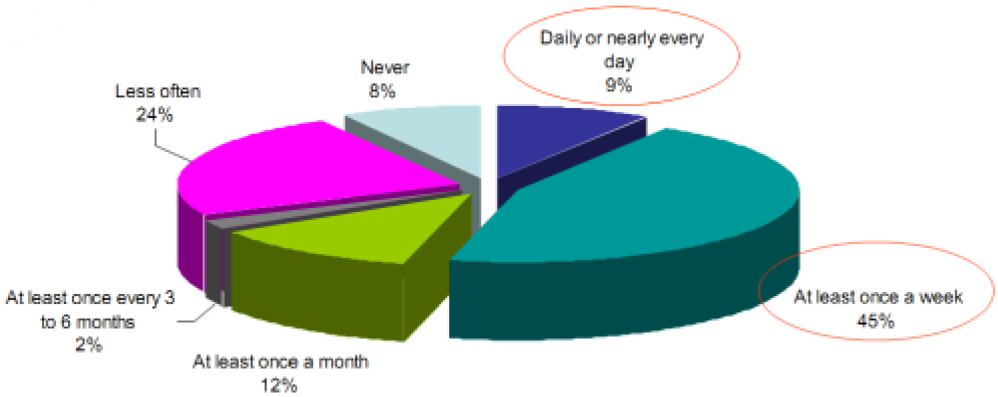

Figure 31: Power cut frequency (Lighting Africa, 2008)

Cost of electricity

When the grid is available[10], this power option is often preferred to off-grid electricity systems due to the lower initial investments. However, the operational costs are gradually rising as Kenya's critical power supply situation is pushing the price of electricity. Next to that, due to the dwindling hydro-energy, the Kenya is shifting towards fossil based thermal generation for providing power to the grid. This generation mode requires large quantities of oil. Because of the steep price increase of petroleum, the electricity price is put under even more pressure (Kentv, 2011).

Diesel generators

Although diesel generators only fill a small part of the electricity needs, they are the most common way for off-grid electricity generation. They are used as a back-up option during power cuts and for electrifying communities or institutions that are far away from the grid. First, the majority of the government's off-grid projects are using diesel generators; they deliver 1.2% to the total KPLC electricity (SREP, 2011). Kenya also has a large number of diesel generators that are privately owned by institutions, companies and wealthy individuals (Byokola, Lema, Kristjansdottir, & Lineikro, 2009).

[10] When a transformer is within 600m distance, it is possible to get connected to the grid. The cost of household connection starts at approximately 35.000Ksh (SREP, 2011). In this case, the initial investments are lower than purchasing a stand-alone system. This is not true when no transformer is present. The customer is then forced to pay for the transformer himself, which costs a minimum of 300.000Ksh (Interview 2)

Diesel generators are preferred to its off-grid alternatives because of the low initial investment, modularity and ease of installation. However, the operating costs are fairly expensive and are only expected to rise due to the increasing global oil prices. Another major drawback is the environmental contamination due to greenhouse emissions of diesel generators. The health risks associated with diesel use form the third main issue with diesel generators (Ngigi, 2008).

5.2.3 Public perception on current and new energy alternatives

Above sections have shown the problems associated with the dominant traditional and modern energy sources. This subsection presents the perception and role of the Kenyan population, since they exert a large influence on the adoption of alternative energy technologies.

As aforementioned, the vast majority of the Kenyan population lacks access to electricity and uses traditional energy sources for cooking, lighting and heating. Electrical energy can offer many possibilities (e.g. battery charging, ICT, refrigeration) and it can significantly contribute to overall development (Kirubi, Jacobson, Kammen, & Mills, 2009). Nevertheless, the shift towards all modern (and hence more costly) forms of electricity knows several major barriers: the high poverty levels, short-term mindedness and high resistance to change prevent their adoption (Ngigi, 2008).

Figure 32 shows the perception of consumers on the quality, reliability and accuracy of the energy services and products. Renewable energy has the highest consumer satisfaction, followed by petroleum, biomass and grid electricity being lowest. Customers' perception hence favours renewable energies, and thus offers chances for the SWT sector. The low satisfaction of KPLC customers can be explained by recalling the problems the electricity sector is facing (Section 5.2.2): grid users are hindered by the frequent power cuts and the rising cost of electricity. Furthermore, getting connected in the first place is often not possible due to the long distance to a transformer. Moreover, the rising fuel prices are affecting customers' satisfaction of diesel generators (KIPPRA, 2010).

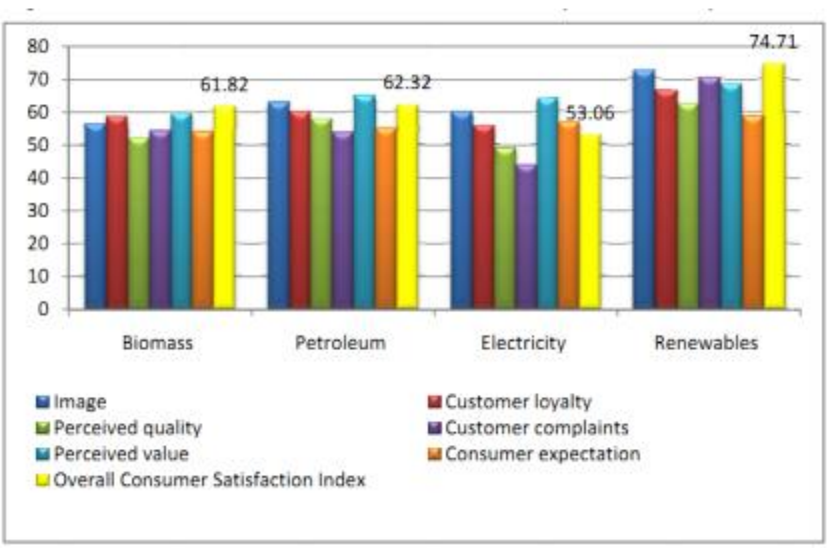

Figure 32: Consumer Satisfaction Index (KIPPRA, 2010)

Nevertheless, the Kenyan public, especially the rural villagers living far away from the cities, often believe that they can only get access to electricity by connecting to the national grid:

> *"In some areas, it is very difficult to convince the community of the benefits of a renewable energy solution. People tend to believe electricity can only come from the grid. Since diesel generators are quite common in rural Kenya, people seem to be most sceptical about renewable energy systems."* (Interview 18)

Furthermore, as is the case with the non-users, the resistance to change and short term mindedness inhibit the shift of the common electricity sources to renewable energy. Because a large part of the Kenyan population lives by the day, it is more logic to spread the costs even though renewable energy systems are cheaper in the long run (Interview 14). This makes it harder to introduce renewable energy systems to non-users with a need for electricity, especially the less-educated and poorer ones. This part of the population will favour the grid (or diesel generators) above renewable energies. Furthermore, the current users of these common electricity alternatives will rather stick to it than making the shift towards renewables.

Lastly, interviewees have also shown that corruption makes it hard to introduce new energy systems. Situations have been identified wherein systems have been sabotaged by villager leadership since it prevented them from earning through the malpractice of overcharging their community members for the fuel costs (Interview 4).

5.2.4 Policy environment

The government takes up a special role within the energy sector and SWT sector in specific. Based on the landscape influences and the state of the regime, it sets its policies. The government can also take up a role within the niche network. As mentioned in section 3.4, the government has recently set up 2 pilots through the REA. This section analyses the role of the government in the regime context, by discussing its ambitions and strategies for improving and encouraging Kenya's energy sector.

Ambitions

The Ministry of Energy is responsible for the development and implementation of energy policies. It also has an oversight role over the government electricity companies and institutions, including KPLC, REA, KenGen and the energy regulatory commission ERC. The MoE strives to reach several notable ambitions:

Transition from traditional to modern energy sources

Set up in 2008, Vision 2030 is the government's strategy to turn Kenya into a middle-income country with high quality of life by 2030. This strategy focuses to realize the UN Millennium Development Goals (MDGs) and elimination of poverty. Since electricity is a pillar to reduce energy poverty, this strategy dictates that every Kenyan citizen must have access to electricity by 2030 (Vision 2030, 2007). On top of that, Kenya is suffering heavily from climate change effects. Deforestation is a direct consequence of the heavy biomass reliance, and is estimated to account for about 20% of Green House Gas emissions. Avoided deforestation has thus potential for climate mitigation (Gaye, 2007). For these reasons, the government is pushing the shift from traditional energy usage (biomass and kerosene) to green electricity.

Economic growth

To become the "globally competitive and prosperous country with a high quality of life by 2030" as stated in Vision 2030, Kenya needs to grow its economy. Therefore, major efforts are put into encouraging its industries and attracting foreign investment. Increasing energy supply and diversification of sources in order to provide reliable and affordable energy is recognized to be vital to reach these goals (SREP, 2011).

Strategy

To realize these goals, the Kenyan government is pursuing following strategy:

Increase grid capacity

The MoE is putting priority on growing the Kenyan electricity industry, by increasing capacity and by increasing connectivity especially in the rural areas. As a result, most efforts and resources are put into increasing the grid electricity capacity (Appendix B.6). Geothermal, wind and nuclear energy are the most favourable power generation options that are now being looked at (Kiplagat, Wang, & Li, 2011). Furthermore, some believe that the MoE support the grid electricity sector instead of the off-grid sector because the Kenyan government has a majority share in the country's largest electricity companies KenGen and KPLC (Interview 4, 5, 27).

Expand rural electrification

Kenya has its Rural Electrification Program running since 1973. Despite the large efforts in increasing the rural connectivity, (Rural Electrification Authority, 2007), KPLC only had 133.000 rural customers in 2008 (Kirai, 2009). For this reason, several measures have been put in place to increase rural access to electricity. First, the government is subsidizing grid connections, and offers a STIMA loan for those that cannot afford the initial investments of getting connected to the grid (Interview 2).

Next to that, as mentioned above, the MoE aims to increase connectivity in the rural areas, by grid expansion and off-grid electricity projects. Established under the Electricity Act of 2006, REA is responsible for reaching these objectives (

Table 4). The initial objective was to connect 200.000 new rural customers each year (Rural Electrification Authority, 2007). Later on, this ambition was recognized to be unfeasible and was adjusted to 120.000 new connections each year. However, due to lack of financial resources and the high costs of grid expansion and off-grid projects, the Kenyan government has not been even able to achieve these newly stated ambitions (Interview 2). Next to that, regime actors themselves believe that the GoK alone will not be able to achieve 100 % connectivity in 2030 as stated in Vision 2030, due to these high costs and many remote communities (Interview 1, 18).

Table 4: Rural electricity access and connectivity levels (Rural Electrification Agency, 2008)

Phase	Period	Access Level	Proportion of Rural Population with Electricity	Projected Number of Rural Electricity Customers	Cumulative Additional Power Demand (MW)**
	2008	63%	10%	750,000*	
Phase I	2008-2012	100%	22%	1,400,000	325
Phase II	2013-2022	100%	65%	5,050,000	2,150
Phase III	2023-2030	100%	100%	9,060,000	4,155

Adopt renewable energies

Since the first national energy policy of 2004, renewable energy measures are undertaken to promote their use (Kiplagat, Wang, & Li, 2011). Renewable energy sources have really gained importance in the government's energy plans since the enactment of Kenya's Energy Act 2006. This is because the Kenyan government has recognized renewable energies to be vital to combat climate change, diversify national power sources and guarantee energy security. Furthermore, they are pushed towards green by the global environmentalism and external influence by its development partners.

For this reason, the Kenyan government has set several renewable energy policies. The MoE primarily concentrates on supporting renewable energy sources to provide electricity to the national grid. Amongst others, they have set a Feed-In Tariff for renewables and are setting up a Green Energy Facility to lend funds to viable on-grid renewable energy projects (SREP, 2011). For off-grid technologies, the GoK is pushing the RE supply by a variety of measures, including promotion through REA, zero rating import duties, standardization, policy development etc.

SWT policy

Above subsections explained the goals of the GoK and the strategies they are pursuing to reach these objectives. This subsection specifically elaborates on the SWT policy.

SWTs can play an important role in realizing the goals of the GoK. This hence offers opportunities for small wind turbines. However, most focus is on increasing pushing the development of the solar (Interview 2, 18). The government incentives for SWTs only consist of:

- Zero import duty for small wind turbines (Interview 11)
- Installation of wind masts and data loggers for data collection to attract more wind farm investors; these data sets are also valuable for the SWT sector (Interview 18, 19)

However, as explained in section 4.3.1, the government plans to increase its role in the SWT sector in the near future by introducing appropriate policies, including standards and licenses (Interview 19).

5.3 Influence of landscape and regime on niche upscaling

This section describes the interactions between the three different levels of the MLP, with as goal to shed light on the room for the upscaling of the SWT niche. It answers the question: "What is the influence of the landscape and regime on the niche development?" The niche can be influenced by the upper levels in two different ways. First, a destabilized or non-present regime offers windows of opportunity for niche breakthrough. Regime destabilization originates from pressurizing landscape factors and internal regime tensions. Secondly, the landscape and regime developments can also influence the niche development by affecting the niche processes. This section first presents the developments in the regime and possibilities for alignment with the SWT niche (Figure 33 – green circle developments). After this, the direct upper level influences on the niche are presented (Figure 33 – blue circle developments).

Lastly, as section 2.2 explained, the bottom-up niche forces can influence the regime. These forces are stronger when a niche expands and its success magnifies. As Figure 33 shows (red circle developments), this process takes place when the niche elements become aligned and internal momentum increases. In the case of SWTs, no clear evidence has been found of the niche influencing the regime. This is because the SWT niche is still a fragmented set of actors and activities. Lack of alignment is inhibiting the niche to gain momentum. This is indicated in Figure 33 by the dashed red circle.

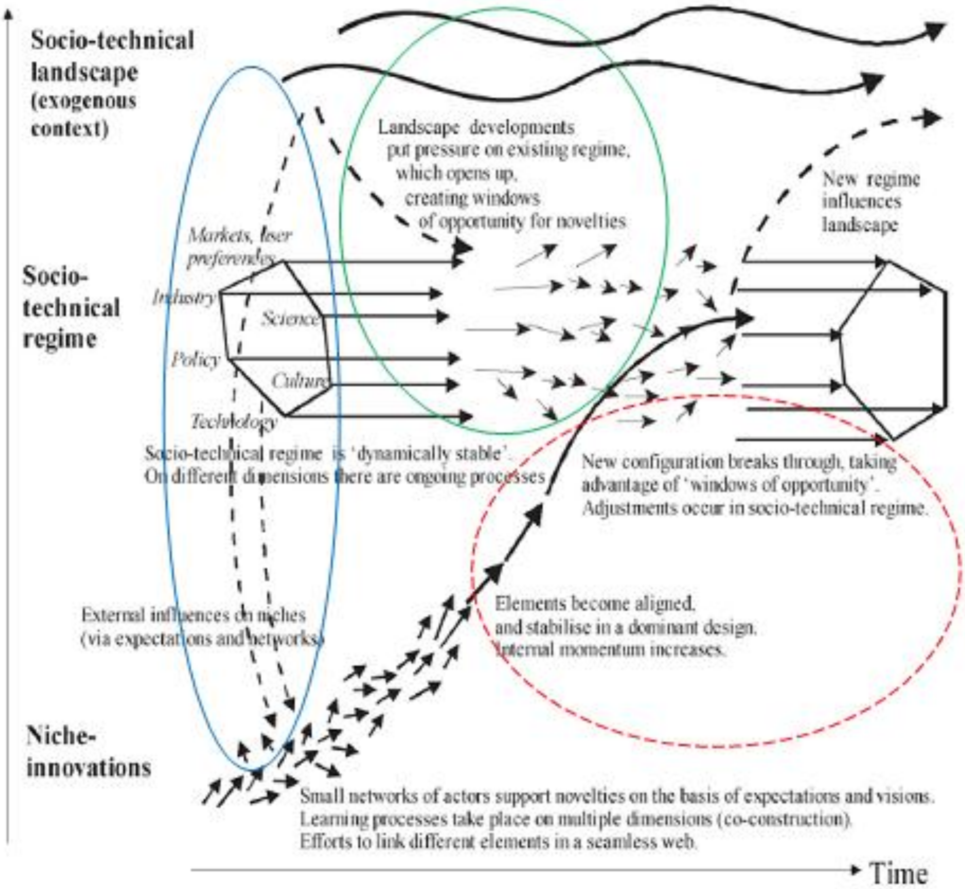

Figure 33: Niche influences by landscape and regime (adapted from Geels and Schot, 2007)

Regime strengths and weaknesses; and their effect on niche development

This subsection discusses the energy regime in the rural areas and the developments taking place due to landscape influences and internal tensions. The content of this subsection is already partly explained in the previous section (section 5.2) to put the regime description in its context. This subsection aims to present the landscape influences and resulting effects and the regime as a means to highlight the barriers and chances for SWTs.

Possibilities for SWTs in areas that are not connected to the grid

With the transition from traditional to modern energy sources, there is a need for increased access to electricity (Interview 4). This modernization is taking place due to various weaknesses of the traditional energy sources: detrimental health effects, environmental impacts, increased fuel prices and a supply/ demand deficit (Kirai, 2009). The traditional energy sources also limit the socio-economic development of the country (Ngigi, 2008). As a means to decrease poverty levels and improve living conditions of the rural villagers, the government is executing a strategy to push increased electricity access. Climate change problems, UN push and global movement towards RE alternatives is also at the root of this government strategy (Interview 2, 19). Next to that, these factors are also influencing the programs of (international) development organisations (SREP, 2011).

The user perspective on this transition is mixed. At one side, the high poverty levels, short-term mindedness and high resistance to change prevent the adoption of new technologies. On the other hand, there is a distinct need in rural villages for electricity access, due to increased penetration of electronic gadgets and rising wealth levels of the rural middle class (Interview 5).

The grid could be a good option for increasing electricity access in the rural areas. However, extension of the network is going too slow. On many locations the grid is not available and will not be available in the foreseeable near future due to the high cost of grid extension (Interview 1, 2, 18). On top of that, more grid consumers also require increased grid capacity. This is already a major issue at the moment; rising population and increased purchase power (especially amongst middle class) are at the root of Kenya's growing energy consumption. The current installed grid capacity does not suffice to cover the growing demand and this weakens the position of the grid electricity sector within the current regime. Climate change is an immediate cause of Kenya's inadequate energy supply, since decreased rainfall limits the available hydropower. Furthermore, with its weak transmission and distribution system, the grid is also very vulnerable to extreme weather conditions, such as an overload of rain or wind damaging the grid lines. The growing electricity-deficit and vulnerability of the grid network lead to frequent power cuts. Together with the rising cost of oil, the electricity-deficit is pushing the electricity prices (SREP, 2011).

These problems related to centralized electricity production and grid expansion make decentralized generation a very practical option to support this transition. Diesel generators are now most commonly used as back-up and off-grid power generation option. However, they are becoming less attractive by the day because of the rising cost of oil and detrimental health effects. All together, these factors are pushing the shift towards decentralized energy alternatives (Kiplagat, Wang, & Li, 2011). The global movement towards green is another driver for this shift. The public is gaining awareness on the necessity of adopting green technologies, which is stimulating niche technologies such as small wind turbines.

In conclusion, there is room for green niche technologies to upscale in regions where the grid is not present. In areas endowed with sufficient wind resources, decentralized small wind can play a large role in this respect.

Possibilities for SWTs in grid connected areas

There could also be an important role for alternative sources of electricity such as SWTs in grid connected areas. User preferences disrupt this regime technology with its frequent power cuts and rising operating costs. Users of decentralized renewable energies are more satisfied than grid and diesel generator consumers (section 5.2.3). And as mentioned above, due to landscape influences, there is an increased trend towards RE technologies. In areas where the grid is available, there is therefore some room for SWTs as a back-up option or as money-saver on the KPLC bill

However, the Kenyan culture is decreasing the opportunities for alternative niche technologies such as small wind. People are rather sceptical to new technologies. Furthermore, due to relatively low income levels and short-term mindedness, grid power and diesel generators are preferred to off-grid renewable energy because of their lower upfront investment. These user preferences are primarily due to low income levels, a day by day attitude and low awareness on the alternatives. Also corruption has proven to contribute to regime stability (Interview 3, 12).

Various landscape factors are however destabilizing the rigidity of the regime with regards to the end-user. As people in the most distant areas are gaining access to information through mobile technologies and education levels are improving, they gain awareness and lose scepticism on the alternatives (Interview 4).

GoK strategies and their influence on SWT niche development

The government is an important player in the energy regime and opportunities for SWT upscaling. In theory, there are many landscape factors that push the GoK to actively stimulate SWTs. A key driver of regulation is the need to comply with international limits and trend towards green. As a result, the

MoE regulation has pronounced emphasis on renewable energy sources. But more importantly, the Ministry of Energy has recognized this need to shift towards alternative energy sources by its severe energy-deficit situation, wherein demand overweighs supply for all available sources of energy (biomass, petroleum and electricity) (SREP, 2011). The country is exploiting its own energy sources and is highly dependent on imports. What's more, oil dependency is now one of the main reasons for Kenya's economic crisis, together with the climate change induced droughts (The World Bank & Australian AID, 2011). This reinforces the GoK's need to accelerate towards non-fossil based domestic power generation (SREP, 2011).

As a solution for these problems, the GoK could decide to actively encourage the adoption of green decentralized energy generation by means of amongst other SWTs. However, the GoK is not following this strategy. Up to now, the MoE emphasized increased grid capacity, grid extension and stand-alone diesel generators as a solution to eradicate energy poverty in the rural areas. And although renewable energies are an important part of the new energy law, focus is predominantly on green grid-connected energy generation. However, policies have recently been set and are still being expanded for several off-grid renewable energies: small hydro and solar PV and solar thermal (Interview 8, 14, 19). With regards to small wind turbines, few government incentives have been set. Overall, the government momentarily acts more as a barrier than a facilitator for the SWT sector (Interview 4, 7, 12, 32).

Direct external influences on the niche

Previous subsection explained how the landscape influences the regime which in turn creates windows of opportunities for the SWT niche, but also puts barriers on its development. Regime developments also positively influence niche actor expectations by amongst others regime weaknesses, global movement towards green and increased access to information (Interview 11, 12, 25, 26).

However, there are also various landscape factors that negatively influence the emerging of a niche. First, the undeveloped infrastructure poses a challenge for Nairobi-based SWT entrepreneurs to distribute their products to the remote areas, which in turn pushes the product cost (Harries 2002; Interview 4, 11, 40). The lack of raw materials of a consistent quality also significantly hinder the manufacturing and maintenance operations for the local manufacturing of SWTs. Local SWT producers are especially hindered by the price fluctuations of some critical raw materials that have to be imported, including steel and magnets (Harries, Guyo, Muchunku, & Berges, 2009; Interview 7, 8, 12, 32, 33).

The socio-economic conditions also have a major impact on the sector. First, as explained in chapter 3 and 4, the division between the formal and informal sector plays a large role in the network composition and niche markets reached. The informal technology suppliers reach informal customers; the formal companies serve formal end-users (see section 3.5). The informal financing system also affects the niche activities, since transaction costs are higher and more complicated when formal businesses want to offer products to informal customers. Furthermore, poverty levels hinder the market size of SWTs. Another socio-economic indicator in this respect is education. Low educational standards limit the understanding and hence acceptance of small wind turbines. Furthermore, low educational quality hinders SWT human resources at all levels of the value chain (Interview 18, 20, 39).

Moreover, section 5.1.5 presented various social and cultural factors that are characteristic for Kenya. These elements externally influence niche development by expectations and networks. These interactions are presented in Figure 34. The top level represent the landscape factors and the lower level the consequences at niche level.

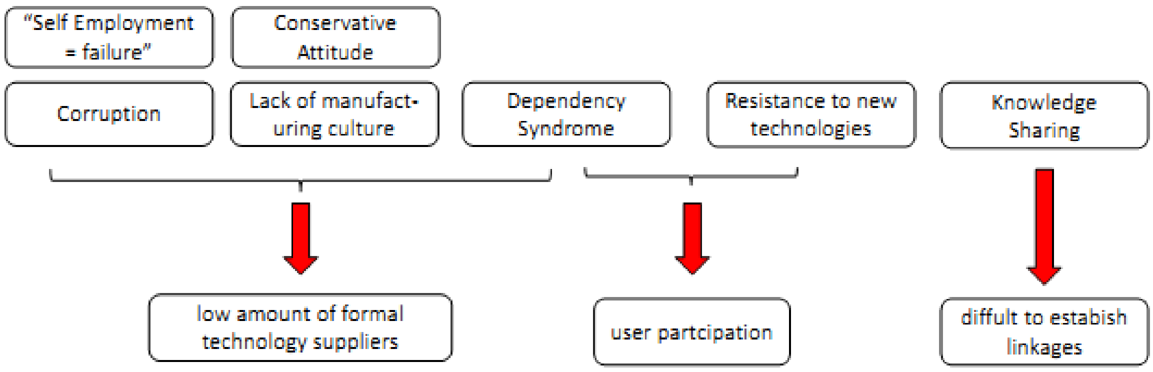

Figure 34: Social and cultural landscape factors influencing niche processes

First, for the development of new technologies and its widespread dissemination, Kenya requires innovative solutions and entrepreneurs to put these products in the market. Corruption has proven to inhibit entrepreneurship and projects to take off (Interview 4, 18, 20, 24, 38). The same holds for the relative conservative attitude, Dependency Syndrome and negative perception on entrepreneurship (Appendix C; Interview 12, 14, 18, 21, 24, 26, 38). These four factors directly influence the low amount of formal SWT entrepreneurs, which was described in Section 4.2. There is especially a shortage in formal manufacturers, due to the increased risks and lack of manufacturing culture (Appendix C; Interview 18, 26, 41)

On top of that, network linkages are more difficult to establish due to the general resistance to share knowledge and experiences (section 4.3.2) (Appendix B.2; Interview 10, 24, 26, 38). The Dependency Syndrome does not only inhibit entrepreneurship, it also creates a passive attitude towards purchasing products. Last factors in this respect are the overall resistance to new technologies and relatively high poverty levels. That are landscape factors that strengthen established technologies and this way prevents innovations (Interview 14, 19, 20, 30).

5.4 Conclusions

The landscape and regime developments influence the niche in two distinct ways. First, the energy regime offers opportunities for the SWT niche since it is de-aligned by landscape influences in a number of ways. There is a transition taking place from traditional to modern energy sources (including electricity). The GoK and development organisations are pushing this transition because of their negative environmental impacts, the rising oil price, the need to eradicate energy poverty and the global movement towards green. The growing penetration of ICT and overall improving socio-economic conditions are also pushing this development since it causes an increased need for electricity in the rural areas. Rural villagers are more and more open to electricity. Where there used to be a large resistance to new technologies, this is now improving due to increased media attention and access to information. Because of the many difficulties encountered with expanding the grid lines and increasing capacity, decentralized energy options are very viable alternatives. Furthermore, diesel generators are losing attractiveness due to the rising oil price, the associated environmental issues and the global movement towards green. As a result, there is much room for rural electrification by REs such as small wind.

Climate change, increasing oil price, insecurity of supply, growing population and increasing wealth are the most important developments that put pressure on the grid. As a result of these factors, the national grid is hindered by capacity problems, power cuts and increasing electricity prices. User preferences are important in this respect. The image of REs is improving because of better education levels, more access to information through ICT and the trend towards green. Thus in areas where the grid is available, there is some room for SWTs as back-up option, as money-saver on the KPLC bill or as sustainable alternative.

The Government of Kenya is aware of the environmental issues of the current energy sources and of the need for increased rural electrification. Its position towards off-grid renewable energies is increasing, especially towards solar PV, with appropriate policies and incentives. However, very little is being done for SWT policy development. Plans are now being developed to improve on that.

Apart from creating windows of opportunity for the niche, the landscape and regime developments are influencing the SWT niche directly. First, regime issues and landscape factors such as environmental problems are increasing the expectations on off-grid green energy solutions.

But particularly the direct influences of the landscape on the niche impact the niche. Inadequate infrastructure inhibits niche development, since it pushes the product price through higher installation costs. Furthermore, lack of raw materials complicates local SWT manufacturing. Also the division between formal and informal economies is complicating niche activities: commercial formal actors focus on customers from the formal economy, whereas Jua Kali deliver products to informal customers. On top of that, poverty limits the overall market size. Furthermore, low educational standards limit the understanding and hence acceptance of SWTs. In addition, the inferior quality of the education system hinders the SWT human resources at all levels of the value chain.

But especially social and cultural factors have influence on the niche processes. Corruption, the Dependency Syndrome, an anti-entrepreneurial mind-set and the rather conservative attitude complicate the set-up of SWT activities and its upscaling. Locally manufactured turbines are considered to be of less quality, which makes it difficult to upscaling of this subsector. The resistance to new technologies, poverty level, and dependent attitude also inhibit the purchase of SWTs.

Lastly, as far as known, the niche has not yet gained sufficient momentum to put pressure on the regime.

6. Recommended actor strategies

6.1 Introduction

The previous three chapters have analysed the SWT sector in depth, by studying its status and composition, the internal dynamic processes and the external environment in which the niche is emerging. This analysis has given insights in the complexity of the issues that hinder sector upscaling. Although these challenges are great, they are not insurmountable. This chapter is meant to provide practical pieces of advice on how to overcome some of these issues. This proposition targets all practitioners in the field of small wind turbines, since everyone involved can make a change. In addition, sector development can only be realized through the combined efforts of all actor groups. Although it is unrealistic to assume that all stakeholders will immediately and all together follow the proposed guidelines, the content should prove useful since each effort is one step forward in the upscaling of SWTs in rural Kenya.

Furthermore, this chapter is meant to give direction to the sector upscaling. However, for taking these ideas forward, below set of guidelines still has to be translated into an action plan that also discusses the 'when', 'where' and 'how' of the proposed strategy. This chapter thus acts as the basis of such action plan. In addition, these guidelines might be the foundation for a stakeholder meeting where the next steps can be organized and where actors can get involved in taking those steps. As RIWIK was closely involved in the process of this thesis, the company has a deep understanding in the sector composition and complexities of upscaling. With this information, RIWIK is in the ideal position to take the lead in initiating such stakeholder meeting.

Lastly, this chapter asserts various essential strategies for realizing sector growth, but it should be noted that these are non-exhaustive. The guidelines showcased below are limited to addressing the most critical issues arising from the analysis phase.

Section 6.2 starts with guidelines on the niche level and entails advice for three of the key actor groups involved: the formal companies, non-profit actors and universities. The other sections of this chapter propose pieces of advice for each separate actor group. Although this comes with a certain repetition, such division enables a more targeted and effective set of guidelines. Guidelines for the formal companies, Jua Kali, research institutes and non-profit organisations, and the Government of

Kenya are discussed in succession in section 6-3 to 6.6. Section 6.7 concludes on the content of this chapter.

6.2 General guidelines

The pieces of advice presented in this section are meant for three specific actor groups: the formal companies, non-profit actors and universities that are active in the field of SWTs. Jua Kali can for instance take part in any of the below propositions, but it is not likely for them to take the lead in any of below events.

Before presenting the guidelines, one general note should be made to everyone involved (also Jua Kali): a lot is going on at the moment with regards to renewable energy deployment in Kenya and many initiatives are being established. Therefore, it is recommended for stakeholders to take part in the following existing initiatives: the World Bank's Climate Innovation Center and UNIDO's Center of Excellence (section 3.4.2). These provide excellent opportunities for actors to take part in, since it offers possibilities for human resource development, access to capital, collaborative R&D etc.

The guidelines at niche level are as follows:

Set up network events and congresses for exchanging knowhow and increasing collaborations
This research has demonstrated that actors do not know each other, which is one of the reasons why they do not interact. The network event of RISO DTU in 2009 has proven to be valuable for the sector (section 4.3.2). For this reason, it is highly recommended to continue the efforts in this respect by for instance regularly organizing network meetings and congresses. These initiatives create possibilities to share lessons and increase multidisciplinary collaboration. Anyone can take the lead in initiating such events, although it is most obvious for a non-profit actor or university to take upon that role.

Collaborative mind-set
Apart from the lack of knowing each other, the fear of collaboration appears to be another factor inhibiting sector development (section 4.3.2). However, partnering can make sense in the Kenyan SWT context since it can create value for all co-operating parties. It allows for co-development, attracting resources, sharing the risks of R&D, getting access to new knowledge or skills and accessing new markets (de Man, 2004). Especially in such an early sector stage that still requires better know-how, products and resources, increasing the collaboration ties would benefit the involved parties, and the sector as a whole. The author hereby aims to encourage all SWT actors to adopt the mind-set of collaboration and realize the benefits it can bring.

Lobby for enhanced GoK participation

Up to now, the Kenyan SWT actors have done limited efforts in lobbying to the Kenyan government, which inhibits its participation in the network (section 4.3.1). As the research has shown, the GoK is not keen on collaborating: they lack confidence in SWTs because of the small sector size (section 4.2.2). Therefore, lobbying should be a key activity, in which the actors demonstrate the potential and benefits of small wind turbines to the MoE and voice their wishes regarding policy establishment.

SWT promotion and awareness creation in order to increase expectations

The low awareness and confidence in SWTs has shown to be a major barrier for SWTs. Therefore, promotion is very important to create awareness amongst the public and attract more actors to the network. A website that informs about SWTs, past projects and the Kenyan wind potential, as well local demonstration sites and a media campaign would be very good promotion tools to surmount these barriers (section 4.4.6).

Establish an SWT umbrella for knowledge exchanging, lobbying and SWT promotion

Above guidelines are focused on promotion, sharing knowledge research coordination and the need for lobbying. An umbrella could play a major role in this respect, as it could cover all of these aspects. An umbrella could give a single clear voice that represents all actors to the Kenyan government. Next to that, such organisation could initiate aforementioned collaborative SWT promotion campaigns. As it would bring together the actors, an umbrella would also act as place for exchanging knowhow and best practices. The initiative for such umbrella can be taken by leading companies, but also by NGOs and research institutes could take upon that role.

Create learning opportunities, and search for solutions

The analysis has shown that there is a need for enhanced learning. Although actors have learnt about a range of topics, focus in this stage should be put on developing solutions for the observed lessons learnt (section 4.4.9).

Furthermore, for everyone involved in commercial activities or experiments, there lies great potential in learning from end-user feedback. It is important to thereby not only learn from a technical perspective, but also from cultural patterns and consumer preferences. In addition, NGOs, companies and universities should build in feedback loops in their operations to collect information from staff members and local partners.

Last, it is to not only learn from Kenyan experiences, but to also learn from the gained experiences of others. For instance, through evaluating similar technologies in the Kenyan context (e.g. solar community powering) or learning from SWT activities in other similar countries, where the niche is in a more developed phase (e.g. Mongolia - Batchelor, Scott, Daoqi, & Bagen, 1999). When an innovative business model is introduced, also consider to learn from businesses with a similar approach.

Create sense of ownership for guaranteeing project and sector sustainability

The niche analysis has shed light on the negative effects of the welfare mentality, in which products are given away (section 4.2.2 and 5.3). It creates a dependent attitude, and the lack of sense of ownership results in poor product maintenance. This in turn leads to malfunctioning turbines and damages the overall image of small wind turbines. To counteract these negative effects, it is advised for all actors to carefully consider the impact of donating products for experiments. Companies in particular should also be careful to sell products to charity actors who aim to donate them as part of their development program, as that creates market disorder.

6.3 Company guidelines

Obviously, technology suppliers play a central role in the sector development. This section elaborates on the guidelines for formal companies; the recommendations for Jua Kali are presented in the following section. The benefits for companies to adopt these guidelines are quite straightforward, since following them will directly or indirectly lead to company upscaling.

'Start small, but think big'

This research has shown that SWT actors' lack of focus or lack of business attitude seriously hinders the SWT sector (section 4.2.1and 4.3.1). This attitude leads to malfunctioning turbines and limits the sales of the individual companies. So despite the fact that technology suppliers are serving a relatively poor target market, it is strongly recommended to think big in terms of production and sales. Such attitude will increase sales, enhance expectations and attract more resources and actors to the niche. Next to that, capturing economies of scale is an important aspect of decreasing product cost, which will in turn lead to an increased market range.

Think out of the box

Overall, actors should think out of the box when shaping expectations and developing strategies, since there are many possibilities for SWTs: technology, market and business wise.

For instance, with regards to target markets, it is advised to also *consider the rural poor* (poor households, small businesses, community groups). These market segments cumulate large numbers of potential clients, and create a high development impact. These target groups go hand in hand with innovative business models.

Furthermore, this analysis has shown that all commercial actors are now quite conservative in their business approach. This is despite the fact that there have been various learning experiences that demonstrate the need for altered business approaches in terms of supply chain, marketing, financing mechanisms, social village structures and partnerships (section 4.4.7). Furthermore, rather than selling the product, one could also decide to sell the electricity or lease turbines. To upscale their activities, SWT actors should evaluate their current business model, think out of the box and search for innovative ways on how to incorporate lessons learnt.

Develop public-private partnerships

It is strongly recommended to strengthen ties with the universities that are already active in the field of small wind turbines. First, despite the lessons learnt on socio-technical aspects, these have not yet led to an appropriate solution (dominant design) (section 4.4.1). Collaborative research would be a win-win situation in which both parties can exchange and create knowhow. Second, this research has shown that commercial actors lack human resources (section 4.3.1), and experience difficulties on finding skilled staff members. Such partnerships would be a good way to develop local expertise and guarantee sector inflow. In this respect, it is recommended for company actors that lack in-house capacity to take initiative in collaborating with educational institutes, through for instance internships and presentations. These types of initiatives would help increase SWT awareness amongst university students.

Enlarge SWT network by tapping into existing networks

For targeting the remote and/or less wealthy individuals, technology suppliers should tap into existing networks. This would enable the enlargement of the SWT sector. The presence of these new niche participants can help to increase local SWT awareness, enable end-user financing, enhance distribution channels and establish a service network. For this reason, it is advised to develop partnerships with following parties.

- Partnering with *local financing partners (MFI/ SACCO)* allow for end-user financing (section 4.3.1). Cost has proven to be a major issue for the dissemination of SWTs, especially since the sector lacks economic protection. A partnership for end-user financing allows a company to create its own protection measures.
- It is advised to link up with *local authorities*, from a regulatory point of view (what are the local regulations?) and from an expectations point of view. This is since local authorities can have a large influence on the local SWT perception (section 4.3.1).
- *Local NGOs* can play a role in raising local awareness, and possibly even in the development of local human resources.
- Identify the possibilities for connecting to *co-operatives* as a partner for distribution and co-organizing community projects (section 4.3.1).
- A better service network is a key for guaranteeing system reliability. Look for *local (SWT) Jua Kali* for system maintenance and repair (section 4.4.4)

Guarantee performance and system quality

This research has demonstrated the effect of poor quality wind turbines and insufficient power capacity on the sector upscaling (section 4.2.1). Companies should realize the huge negative impacts this has on the complete sector, and should hence put everything into place to guarantee technical reliability. Appropriate actions are:

- *Site assessment:* Always assess the viability of the site for product installation by observing the local environment. In addition, in case of uncertainties, perform local wind measurements. This is the most optimal way to guarantee the product performance at a specific location.
- *High quality equipment and installation:* the SWT should be robust, perform well and be of good quality, so that the risk of a breakdown is reduced and maintenance can be minimized.
- *End-user knowledge transfer:* Successful knowledge transfer on correct operation and maintenance is as important as the quality of the equipment itself in ensuring technological reliability. Where possible, provide your customers with wind energy training courses and/or a manual.

6.4 Jua Kali guidelines

Jua Kali actors are necessary as producers since they are able to serve markets that other do not. They should ideally have a central role in the network. However, their position in society makes it difficult to induce change on their own. Therefore, this section is limited to several basic, realistic pieces of advice.

Take part in existing initiatives

The main advice for SWT Jua Kali is to hook up to existing programs. Various formal actors are now in the process of establishing an initiative to support the SWT Jua Kali sector. For instance, this research discovered that formal actors are establishing a technical R&D program for optimizing Jua Kali turbines, training programs and equipment supply. Also Access:Energy and RIWIK (see chapter 7) are setting up business initiatives, which the Jua Kali can be part of, and there are NGOs that offer business support services to rural energy entrepreneurs. Appendix D presents a list of contact details of the representatives of these initiatives.

More tips:

- Do not work on SWT design and manufacturing on yourself: the combined insights of different Jua Kali technical professions is necessary for making a good turbine
- If possible, link up with other SWT Jua Kali for sharing know-how and experiment collaboratively
- Where possible, document on the learning experiences to make them tangible and distributable
- Try to learn on your customers' needs, rather than solely focusing on the technology
- Although it is difficult to deliver high quality products without adequate knowledge and a manual, it is highly advised to adopt a 'high quality' attitude, in which you try your best to deliver as good products as possible. That is to say, the product does not only depend on the used materials and design itself; the quality of manufacturing is at least as important.

6.5 Advice for research institutes & non-profit organisations

The active universities and non-profit organisations support the SWT sector in many ways. Especially the role of the non-profit actors is very diverse, from providing business support to carrying out SWT experiments themselves (section 3.3). Although the specific role of these two actor groups largely varies, the recommendations are very similar and are therefore discussed together in this section.

Following these guidelines will increase the actors' impact on the SWT sector:

Link up with technology suppliers and provide support

Sections 6.3 and 6.4 have presented the guidelines for the technology suppliers. Some of this advice entailed collaborations with universities and non-profits, and thus indirectly show how these two actor groups can effectively contribute to SWT upscaling. Apart from technology development, there lies great potential for universities and non-profits in supporting technology suppliers with developing new modes of value creation (Gradl & Knobloch, 2011). Obviously, it is recommended to be open and pro-active in establishing these collaborations.

Develop SWT capacity for improving human resources

Lack of human resources has shown to be a key barrier of sector growth (section 4.3.1). Educational efforts should be focused on capacity building of the technical and business development skills, at all levels of the value chain. One should develop expertise at university level and educate the local people for installing, maintaining and, if possible, producing and selling small wind turbines. Universities could play a role in this by adjusting their educational efforts to the needs of the market. Rather than solely focusing on theory, it is advisable to include practical modules. In addition, it is highly recommended to teach students the business side of SWTs (the current players, business potential etc.). Also local NGOs could initiate training programs for developing local capacity, for instance for maintenance and repair.

Publish up-to-date information for shaping high-quality expectations

The circulation of out-dated SWT sector information and lack of database is detrimental for sector upscaling (section 4.2.1). Therefore, it is highly recommended for both actor groups to increase efforts in distributing up-to-date and correct information, since this will largely contribute to shaping high quality expectations.

6.6 Recommendations for the national government

Appropriate policy measures at national government level can have a significant impact on the Kenyan SWT sector. The Government of Kenya is in the position to remove several critical barriers to the widespread deployment of SWTs, and it can play a pro-active role in coordinating sector development. The establishment of policies would also enhance the overall expectations (section 4.2.2).

As explained in section 5.2, the country faces critical challenges related to its energy sector. Actively supporting the SWT sector would contribute to one of their main goals: to increase access to modern energy services in Kenya's rural areas. Up to now, one of the main reasons for low GoK participation has been the ignorance about the SWT sector. The author hopes that this thesis provides policy makers with better insights in the SWT sector status ('proof of market'), its problems but also the benefits of increased SWT deployment.

This thesis has shed light on the internal and external aspects of niche development. The GoK is in the position to enable change at both levels, although one must realize the external environment factors are much more challenging to improve on. The main advice for improving the external niche influences (section 5.1) is to first create a better business environment through improved infrastructure, increased political stability, decreased corruption, good access to information and 'entrepreneurship sensitization'. Next to that, the GoK should focus on improving the conditions for local manufacturing, by for instance improving the supply of raw materials.

Before presenting the direct SWT policy guidelines to the Kenyan Ministry of Energy and the government organisations it controls, several general recommendations must be given. First, continuing government commitment is a perquisite for success, since SWT upscaling requires a consistent and long term regulation (section 4.4.8). Second, although some officials are well aware of the SWT sector, these are far outnumbered (section 4.2.2). Therefore, it is important to raise awareness and spread knowledge within all government departments and municipalities. Third, we have learnt that a lack of data hinders the development of appropriate policies, which indicates the need for sector monitoring (section 4.3.1). This will enable the central government to adjust their energy policy accordingly.

The most important guidelines for SWT policy measures are as follows:

Temporary niche protection through financial mechanisms

The analysis has shown that SWT cost is a major barrier for breakthrough (section 4.1). Flexible financial mechanisms should be set for both end-users and suppliers. For instance, subsidy arrangements for end-users would have a huge impact on increasing SWT demand. Another way to artificially reduce product price is by putting financial incentives in place such as import duty exemptions on SWT raw materials and tax exemptions. Next to that, we have seen that knowledge development is crucial to overcome SWT barriers, but that the main actors lack resources for technical R&D. Funding would be of great support. Next to technology support, the GoK should also support innovative business models that might otherwise not be profitable in the beginning.

Regulation measures for realizing regulatory alignment and increasing quality of performance

The analysis has shown the lack of SWT regulations that has its effects on network alignment (section 4.3.3). Furthermore, equipment standards and licensing are the best tools for increasing product quality and enable regulatory alignment (section 4.2.1).

Perform wind assessments at national level and distribute the data at low or no cost

Section 4.4.2 has explained the necessity for increased learning on the Kenyan wind resources, as there is a lack of high-quality and extensive wind maps and data sets. For this reason, the MoE is now monitoring at various places around the country to improve the information on the Kenyan wind resources. The MoE should continue its efforts in this respect and should make this data available to the relevant actors at low or at no cost.

Empower the informal SWT sector

The weak informal economy hinders Jua Kali operations. The government is in the best position to make a change on this level. First, as the informal financial environment is inadequate, focus should be put on improving informal financing mechanisms. This will enable informal end-users to purchase SWTs. Second, the development of microenterprises and Jua Kali innovations should be supported by means of product development aid and innovation hubs.

Remaining tips

As the previous sections explained, there is a need for SWT promotion and better human resources. Government information campaigns as well as top-down improvement on SWT educational programs would greatly benefit the SWT sector. Last, for improving expectations, it would be very beneficial for the GoK to set a policy goal for SWTs, for example: ‘To have 10.000 turbines installed by 2015’.

6.7 Conclusions

Whereas the previous chapters emphasized the complexity of niche upscaling, this chapter has informed stakeholders on how to deal with this complexity. It outlines practical solutions for directly and indirectly improving the quality of the three internal niche processes. This is expected to lead to sector upscaling.

It can be concluded that the niche processes can be improved by focussing on the niche level, *and* by inducing change at the local level. In addition, niche upscaling is not solely in the hands of the government or one niche manager. This chapter shows that everyone involved can significantly contribute to improving the three niche processes and niche protection, whatever its function is within the sector. Even more, the combined efforts of all actors is considered to be the most powerful catalyst for scaling up the niche.

7. Strategy for RIWIK

As a start-up from Delft University of Technology, RIWIK is now being established in Kenya. Their business concept was developed based on an internship experience of one of the founders, Bart Fugers. Together with fellow student Joppe Buntsma, he recognized the Jua Kali potential for building and selling small wind turbines, and the barriers the Jua Kali face in this respect. This experience was the basis of establishing RIWIK (Fugers, 2011). The company management includes former TU Delft student Bart Fugers, and two experienced managers, Eric de Jong and Hans Lipman. Although the set-up of the business has a two year history with frequent visits in Kenya, extensive market research and expert interviews, there is uncertainty about the suitability of the business concept in the Kenyan SWT context. In addition, there are various critical aspects that RIWIK has not yet considered or fully developed.

This chapter aims to put RIWIK in the broader Kenyan SWT context. Insights from the analysis will first be used to investigate the suitability of the business concept in the SWT sector (does it offer a solution for the sector blocking factors?). On top of that, the findings from the analysis are used to provide several practical guidelines for RIWIK in order to increase their chances of success.

Section 7.1 first elaborates on the RIWIK business concept by discussing its background and key principles. Section 7.2 then compares the RIWIK business concept with existing business models. This is valuable since a lot can be learnt from the experiences of others (see section 6.1). Following this, the business concept and results from the analysis are then put side by side. Section 7.3 discusses the two key factors that underline the RIWIK business concept, whereas section 7.4 discusses the room for improvement and corresponding guidelines. Note that all information regarding RIWIK's intentions and business concept are retrieved from internal company documents. Section 7.5 concludes on this chapter.

7.1 RIWIK business concept

In September 2009, two students from Delft University of Technology travelled to Kenya for an internship. The goal was to locally produce a small wind turbine for an NGO. However, once arrived, the NGO staff was less interested in the product and the technology background than expected. Therefore, the two students started partnering with Dalton Mathenge, a local welder that lives in Naro Moru. Dalton has been struggling on building an SWT himself: he had to travel to 5 different cities for getting the required materials and was missing some knowledge. With some technical support and by helping him to get the required materials, Dalton was able to independently build an 800W wind turbine. Up to now, Dalton has produced 3 turbines and sold them to people in his community.

This experience was the basis of establishing RIWIK (Rural Investment Wind Power in Kenya), a company that aims to support local entrepreneurs such as Dalton in building and selling wind turbines to their communities. RIWIK will select local entrepreneurs, train and certify them and sell the ‘small wind turbine kit’ to them, so they can start a production unit of small wind turbines with mainly local products. The local entrepreneur will thus produce the turbines and his customers are people in his community. The business concept is called 'local for local'. This means that the production units work for a relative small area, where they know their customers.

RIWIK is using a design in which the majority of required components are available in Kenya, and only a small portion has to be imported. It is a redesign from the open source Hugh Piggott wind turbine. The redesign makes the product more suitable for local production in Africa: simpler to produce, cheaper and hassle free for customers. The 24 DC, 800W rated turbine will cost approximately 200.000KES in total. For end-users who cannot afford the investment, a loan will be organized with a micro-finance or SACCO partner.

Apart from supplying the entrepreneurs with the wind turbine materials, RIWIK will also support them by providing technical trainings and a manual to produce and maintain the small wind turbines. Quality control is another key element. Below figure presents the RIWIK business model. RIWIK plans to grow within 10 years to 260 small, local production units spread over five regions in Kenya with an installed base of over 50.000 small wind turbines.

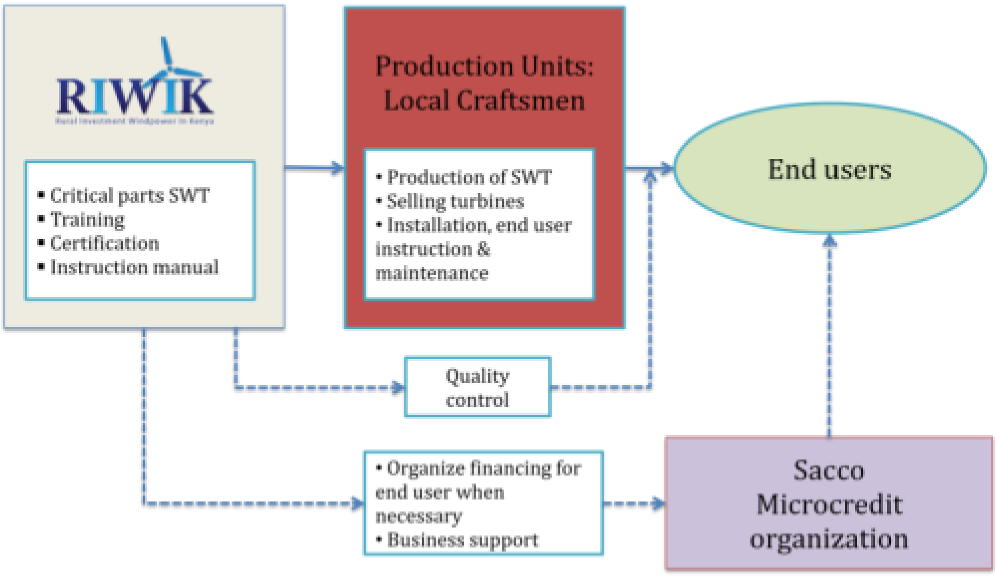

Figure 35: RIWIK Business Model (Fugers, 2011)

7.2 RIWIK as a micro-franchise company

As was explained in section 6.1, when an innovative business model is introduced, it is useful to also consider other businesses with a similar approach as a means of learning. A thorough analysis shows that RIWIK has many similarities with micro-franchise model, which is an adaption of the typical franchise concept to the Bottom of Pyramid (BOP) context. This subsection demonstrates the (micro-) franchise model and similarities with the RIWIK business model.

Principles of franchising

Micro-franchising is a business concept that uses basic franchising concepts. Franchising is the process of replicating proven businesses at another location following a set of systems and procedures. The franchisor owns the overall rights of the business and controls the macro-aspects of the company, e.g. brand, marketing, on-going training of the franchisees and optimizing the product and business model. The franchisees are independent entrepreneurs that join the company because of the proven business concept ('guaranteed success'). They are responsible for the micro-aspects, the day-to-day operations.

Micro-franchising and its benefits

Micro-franchising follows the same principles of franchising, but incorporates a strong social development component. This business model is gaining popularity in the development country context, and is regarded as an effective way for supporting SME businesses and delivering products to remote customers. The prefix 'micro' refers to the fact that it requires relatively little capital to start a franchisee business and the customers have lower income in comparison to traditional franchising. Furthermore, the micro-franchisees are often small (one or few employees), and lack the skills and financial resources to grow big on their own. Furthermore, franchise models at the BOP level normally adopt appropriate marketing methods and distribution models.

Figure 36: Micro-franchising characteristics (Dutheil & Chongo, 2010)

The strength of micro-franchising lies in the distinct benefits for both the franchisor as the franchisees. With such concept, the **franchisor** is able to achieve broader and more rapid market coverage, without having to be involved in the day-to-day operations. In developing countries, the local presence of sales forces (franchisees) is especially beneficial since it helps overcome community resistance to a new idea. Franchisee ownership also increases accountability and lessens the chance of bribery of fraud. Advantages for the **franchisee** are that the franchisor brings products, skills (training) and services that they would not have been able to realize themselves. Besides that, supply links are often poor in remote areas and are therefore difficult to achieve for an individual rural entrepreneur. The franchisor has also better negotiating power with suppliers, which allows micro-franchisees to benefit from operating at economies of scale. Contrary to individual entrepreneurs, the franchisor is able to provide loans to both franchisees as their customers. Besides that, failure risks are reduced because of the proven business concept and strong brand, and the franchisees do not have to focus on long-term strategies.

Lastly, the micro-franchise concept is characterised by a good learning culture within a franchise company due to the extensive linkages. Innovations and new practices that are developed by one franchisee can easily be applied throughout the entire franchisee network.

Comparison with RIWIK

Above characteristics and business model benefits are very similar to the RIWIK concept. Below table presents the similarities and differences with the micro-franchise (MF) company and RIWIK. As the table shows, RIWIK resembles the micro- franchise model in many ways. The key differences are as follows:

- **Licensing:** (micro-) franchising typically consists a licensing fee, 'the right to operate the franchise business', a financial return which RIWIK does not plan to include
- **Franchisee financing:** the micro-franchise concept is very often combined with an appropriate finance mechanism for the franchisee, which is not the case for RIWIK. It only plans to facilitate financing for the end-users.
- **SWT production:** RIWIK entails of a strong technical component, in which the franchisees should not only sell SWTs but they should also produce/assemble the turbine. Traditional micro-franchising sometimes does include a technical component (e.g. producing bio-oil), but that does not demand such high level of technical skills. This affects the franchisee selection, training and sensitivity to quality.
- **Product cost and target market:** whereas micro-franchising is usually aimed at target the BOP itself, RIWIK's product is more expensive and thus primarily targets more prosperous households, small business and institutions. In this sense, it is less 'micro' than a traditional micro-franchise.

Table 5: Comparison of RIWIK with the Micro-Franchise (MF) model

Model Characteristics	RIWIK	MF
General aspects		
Replication of small businesses at other location with proven business model	X	X
Company provides centralized services	X	X
Extensive Quality control system	X	X
Company delivers materials/products to entrepreneur	X	X
Entrepreneur produces end product	X	Dep.*
Entrepreneurs are carefully spread to avoid competition	X	X
Customers have low incomes ('micro')		X
Entrepreneurs		
Process of selecting and finding entrepreneurs	X	X
Technical training of entrepreneurs	X	Dep.*
Marketing/Sales training of entrepreneurs	X	X
A franchise contract, entailing the rights and duties of both parties	X	X
On-going training & assistance to entrepreneurs	X	X
An franchisee manual, with the description of procedures	X	X
Financial model		
Sell or license business approach		X
Facilitate loan for end-users	X	X
Financial arrangement for entrepreneur		X

* Dep.: dependent on the company

Micro-franchising in Kenya

Micro-franchising knows a distinct history in Kenya, with the first franchisor becoming operational over 10 years ago. Initial investment, product price and product type largely vary between the different Kenyan micro-franchises. Also, whereas some Kenyan micro-franchises are for-profit, others handle a non-profit approach. The most successful Kenyan examples include:

- **The Health Store Foundation** (non-profit): a network of micro pharmacies that sell drugs (The Health Store Foundation, 2006)
- **Honey Care Africa** (for-profit): a network of farmers that produce and sell honey (Honey Care Africa, 2005)
- **Coconut Farm** (for-profit): a network of franchisees that produce and sell coconut oil (Coast Coconut Farms, 2008)
- **Solar aid** (non-profit): a network of franchisees that sell solar lamps (Solar Aid)

7.3 Underlining the business model with insights from analysis

This section aims to underline the business model with insights from the niche analysis. RIWIK's key strengths based on the derived barriers and developments are as follows:

This section aims to underline the business model with insights from the niche analysis. RIWIK's key strengths based on the derived barriers and developments are as follows:

Supply chain

The niche analysis has shown the need for an extensive supply chain, in order to increase local awareness, reduce product price and guarantee turbine maintenance and repair. Furthermore, local agents are highly recommended since people want to rely on personal contacts instead of 'some factory in Nairobi' (section 4.3.1 and 4.4.4). RIWIK's local for local concept matches this stringent need; with rural craftsmen assembling and selling SWTs, they automatically realize such supply chain.

Customer base

A critical aspect for RIWIK's success is the ability to find Jua Kali that match the required profile; that is, someone that is technically skilled, studious and has a good relationship with its community. But even important, such RIWIK craftsmen must also be entrepreneurial and motivated for starting a production unit, a challenging concept, both technically as business wise. This study demonstrates the RIWIK feasibility in this respect. First, there are already various local craftsmen in Kenya that have built wind turbines, and some of them even have a small business going on (section 3.4.1). On top of that, several Kenyan universities and non-profits have also recognized the Jua Kali business potential for SWTs, and are now setting up R&D and training programs to support them. The SWT-Jua Kali link is strong (section 4.4.4). This greatly underpins the potential of local craftsmen to produce and sell small wind turbines independently.

Protection

Section 4.1 explained the SWT sector is as a dedicated market niche that lacks protection. Protection would enable to temporarily reduce the product price until the niche technology and business models are mature enough. The RIWIK business model provides a solution for this lack of protection: the company aims to introduce end-user financing mechanisms through innovative funding from micro-finance and SACCO partners in order to reach product diversification to the lower-end markets.

7.4 Guidelines

This section provides seven guidelines for RIWIK. These advices are different from the general company guidelines in chapter 6. This section takes it one step further towards offering specific guidance to RIWIK, what it should focus on in order to successfully operate in the Kenyan context. The guidelines below are thus focused on factors that are particularly relevant for the RIWIK business model and stage the company is in. Obviously, it is recommended for RIWIK to also look into the guidelines that are presented in the previous chapter.

This section pinpoints various critical issues of this concept based on insights from primarily the Strategic Niche Management analysis in chapter 4. The adduced crucial points are based on mismatches between the business model and these insights from the analysis phase. Guidelines are provided as a solution for these hindrances. Next to that, some guidelines originate from important aspects that RIWIK has considered but not yet fully developed.

As an input for developing these guidelines, various knowledgeable people were contacted in the field of micro-franchising, sustainable rural electrification, micro-entrepreneur financing mechanisms, Jua Kali associations etc. Appendix D presents an overview of these experts that were visited during the field trip in Kenya. Figure 37 visualizes the approach for developing the advices.

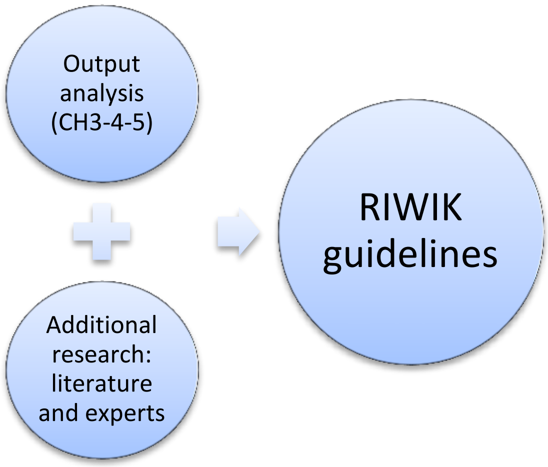

Figure 37: Method for developing guidelines

For confidentiality reasons, the public version on this part is limited to listing the seven guidelines:

1. Create a learning environment by means of demonstration experiments
2. Introduce feedback mechanisms as a means of quality control and learning
3. Introduce central marketing as means to strengthen brand identity and increase awareness
4. Expand target market with community groups
5. Establish strategic partnerships
6. Critical steps for establishing a successful franchisee network
7. Consider appropriate financing franchisee financing mechanisms

7.5 Conclusions

This chapter has shown that RIWK has many similarities with a micro-franchise company, with the main differences being the SWT production by the franchisees, the absence of licensing and franchisee financing, and the product cost. It can be concluded that this comparison results in interesting insights for developing guidelines for RIWIK.

This chapter also highlights that the results from the analysis enable the evaluation of a business model. First, it was possible to underpin the business concept of RIWIK. This concept has proven to have potential for the effective distribution of small wind turbines in rural Kenya, since it provides an answer for some of the main issues the SWT sector is facing. It introduces a protective measure and an effective supply chain, lowers the product cost and increases local awareness. Basing the business concept on local craftsmen appears to be logical, because there is already quite some SWT Jua Kali activity.

Secondly, for increasing the viability of the business, it was able to propose guidelines on the main features of SNM: learning, articulating expectations and network development. First, it is advised for RIWIK to create a learning environment through demonstration projects and feedback mechanisms. The latter is also advantageous for quality control. Second, RIWIK should put efforts in articulating expectations by central marketing efforts as a means to strengthen brand identity and increase awareness. Third, RIWIK's main efforts should be on developing a good network by establishing strategic partnerships, and by paying much attention to building the franchisee network. Last, in order to reach a large scale, it is recommended to also take into account the community groups as possible market segment, and to introduce appropriate franchisee financing mechanisms.

8. Conclusions and recommendations

This study has analysed the developments of SWTs in the order of 50W to 10kW for decentralized electrification in Kenya. The approaches of Strategic Niche Management and the Multi-level Perspective constituted the analytical frame for this thesis. This chapter concludes on the results of this research. It also discusses, reflects and recommends on the theoretical and methodological aspects of this study.

First, section 8.1 answers the main research question and the empirical sub questions that have been driving this research. This is followed by a reflection on the research process in section 8.2. Answer to the methodological/theoretical sub question is given in section 8.3 and 8.4. Section 8.3 first reflects on the methodology, which leads to several methodological recommendations. Section 8.4 then presents a theoretical discussion on the applied frameworks, and how these can possibly be enhanced. This chapter ends with recommendations for further research on the Kenyan SWT sector.

8.1 Conclusions

This section concludes on the key findings of this research. First, it briefly answers the main question that has been driving this research. It then provides an in depth answer to the main question by giving answer to the sub questions formulated in section 1.5.2.

The main research question was: **How can upscaling of the small wind turbine sector in Kenya be realized?**

The SWT sector has seen a long and cumbersome development trajectory, characterized by various one-time experiments, fragmented learning experiences, lack of focus and low quality products and services. To date, there is limited experience in the use of SWTs in Kenya. However the interest in the technology is significantly growing, motivated by the need to address energy poverty, the benefits of a shift to low emission development, flourishing of other wind niches, rising cost of oil and the growing demand for power. As a result of these factors, the SWT niche has gained momentum during recent years. For instance, more dedicated niche participants have entered the sector, the first steps towards network interactions have been taken and also the knowledge on the Kenyan wind resources has significantly improved.

To facilitate further upscaling, the Government of Kenya is in the process of developing policy measures with regards to standards, licenses and high quality wind data. Nonetheless, because of the relatively slow pace in creating and implementing regulations, it is expected that these will not be introduced anytime soon. In addition, there is more work to do by the government, since sector growth would also be encouraged by a better business environment and a well-designed financial support program.

However, niche upscaling is not solely in the hands of the government. Rather than standing aside, technology suppliers, research institutes and non-profit organisations can enable change themselves with targeted and joint efforts. First, collaborations and interactions between the different stakeholders can create much value for everyone involved. For example, it allows for co-development, attracting resources, joint lobbying and getting access to know-how. Moreover, upscaling can be enabled by network expansion through the development of key partnerships.

Furthermore, in the light of sector growth, it is essential for stakeholders to think big by having a clear idea of how the experiment or company can be scaled up. Other determining factors include quality control, capacity building and SWT promotion. In addition, technology and business innovation are key points for successful niche upscaling and it should take into account feedback from all relevant stakeholders. In this respect, there is a need for transforming the lessons learnt into appropriate solutions.

The combined efforts of all actors on these aspects are considered to be the most powerful catalyst for scaling up the niche.

Now answer is given to the empirical sub questions:

1) **What does the SWT sector look like, in terms of technology and stakeholder composition?**

Regarding the technology, the most important conclusion is that despite the fact that SWTs are conceptually simple and straightforward, the design and manufacturing of the total system is quite complex. Another key aspect is the need for assessing the wind resource and siting the turbine correctly, since the produced power is immediately related to the wind speed.

Furthermore, it can be concluded that the development of the SWT sector in Kenya has seen a long trajectory until it reached its current stakeholder composition. With the first R&D in the seventies, it took until the end of the nineties before commercial activities and practical experiments were set up. The last decade, the number of actors, experiments and commercial activities significantly rose. During these years, a diverse group of actors took part in the sector: a few formal companies and several Jua Kali in local manufacturing, various import companies, SWT enthusiasts, NGOs and developments organisations, and local and foreign universities. Furthermore, the national government has also started to play a role in the sector at the level of wind monitoring, pilots and policy (planning). Despite the diversity of this group of stakeholders, several of these actors have terminated their SWT activities. Nevertheless, since 2009 more dedicated actors entered the sector and there is increased government attention. Although no specific numbers are known, this research indicates that the number of installed small wind turbines is currently in the order of 500-1000.

Conclusions can also be drawn on the level where stakeholders and technology come together. A very important characteristic of the Kenyan SWT sector is the three supplier groups and the products they deliver to specific market segments. This distinction is made on the basis of imported and locally manufactured turbines, of which the latter can be subdivided into formal and informal sector manufacturing.

The local production of small wind turbines by Jua Kali is cheaper than any other alternative, but in general these turbines are made of low quality local materials and with insufficient knowledge. As a result, these turbines generally lack quality and efficiency. The main target group is the rural poor. It is estimated that this technology supplier group has installed the least amount of turbines.

The local production of small wind turbines by formal enterprises targets the more prosperous households, businesses and institutions. The majority of these turbines are based on the open-source design of Hugh Piggott. These turbines are cheaper than imported machines and benefit from the availability of local materials and spare parts, but are more error-prone than its imported variants.

These imported turbines are produced by reputable foreign suppliers and are generally well-tested, reliable and more efficient. The main disadvantages are the high cost, lack of spare parts and missing local knowledge about the operational aspects of these turbines. Due to the high cost of imported turbines, the target market consists of wealthy households, institutions and businesses. This actor group has contributed most to the amount of turbines installed.

2) How is the niche functioning and developing?

The case of SWTs in Kenya is characterised by its global linkages and resulting parallel trajectory of commercial activities and niche experiments. It can be defined as a dedicated market niche that is in the inter-local phase. Generally, lack of public awareness and high upfront costs are considered to be the main obstacles for sector growth. When investigating the underlying reasons for these barriers, it can be concluded that the niche development is rather complex since it entails a range of different aspects, developments, influences and actors that have an impact on the entire value chain.

This analysis showed that the expectations are influenced by exogenous and endogenous developments. The niche expectations are becoming more positive due to favourable landscape developments, increasing regime tensions and the flourishing of other wind energy niches. On the contrary, lack of government incentives and out-of-order turbines are the main factors that inhibit confidence in small wind turbines. Furthermore, the high confidence in the PV technology is hindering the expectations on SWTs. Even though expectations have improved through increased learning, there is evidence that they have only converged to a limited extent. In addition, there are not at all specific and are of low quality. Furthermore, the external expectations are improving with increased public attention and the articulation of the need to shift to RE technologies. However, the external expectations are still quite negative because the market has not yet been proven and because of the bad image of non-working turbines. Social and cultural landscape factors also play an inhibiting role, especially in the product purchase and on the level of SWT entrepreneurship.

In addition, the niche is characterised by a rather unstable network, as several actors have left the niche. The desired network composition is complex and extensive. Several actor groups are missing, of which the most important include: CBOs, local authorities, financial institutions, a rural supply chain, practical educational institutes and an SWT umbrella. In addition, user involvement is too low. Furthermore, various present actors lack SWT focus and/or underperform, which has its effect on the quality of products and services, information dissemination, human resources and establishment of adequate policies.

Interesting conclusions can be drawn when comparing the three technology supplier groups. Despite the benefits of locally produced turbines for better network formation, enhanced knowledge transfer and decreased product cost, these have not yet been realized. The formal manufacturing actor group is still very small in number of companies. There are more SWT Jua Kali, but this subsector is in an early development stage and many hurdles have to be overcome for this group to reach upscaling. In addition, there are many import companies but these have not contributed that much to sector upscaling, mainly due to lack of focus. Upscaling in number of turbines installed appears to be an issue for all three technology suppliers.

Moreover, interaction amongst these actors is inadequately facilitated despite recent improvements. There is a need for creating linkages with actors of groups that are not yet in the network. Niche upscaling would also benefit from enhanced interactions with current niche participants for network alignment. This is as network alignment is currently low due to an unstable network, missing linkages, lack of regulatory alignment and lack of an umbrella organisation.

Throughout the years, the niche actors learnt on various aspects, but these are fragmented due to lack of linkages, inadequate feedback channels, low user involvement and the resistance to share know-how and experiences. Furthermore, this research shows that various actors are not that focused on learning or they find the concept of learning difficult to grasp.

Interestingly, commercial actors have primarily developed first-order learning experiences. Their lessons are mainly on the technology and its economics. Furthermore, commercial actors are quite conservative in their approaches and business models. On the contrary, research institutes and NGOs have gained most lessons through second-order learning. In addition, they primarily investigated on small wind turbines for the rural poor and the socio-cultural implications of such product introduction. This learning led to important lessons regarding other market segments. It also shed light on the key elements of what an innovative, more appropriate business model should entail. Few lessons have been learnt on the SWT manufacturing by informal actors.

An overall conclusion with regards to the learning processes is that even though lessons have been learnt on many aspects, these experiences have not yet resulted in effective solutions or their implementation. Solutions need to be sought on the technical side for a dominant design to emerge. Even more importantly, as SWTs in Kenya are in market niche stage, it is crucial to learn about marketing and how to bundle lessons learnt into an appropriate business model. Last, there is a lack of learning on the user-side due to missing feedback mechanisms.

3) What is the influence of the landscape and regime on the niche development?

The landscape and regime developments influence the niche in two distinct ways. First, the energy regime offers opportunities for the SWT niche since it is de-aligned by landscape influences in a number of ways. There is a transition taking place from traditional to modern energy sources as a result of several landscape pressures: climate change, global movement towards green, rising oil price and the need to eradicate (energy) poverty. It especially causes the Government of Kenya and development organisations to push this transition. Furthermore, the rising need for electricity services and improved technology acceptance also contribute to this transition.

Because of the many difficulties encountered with expanding the grid lines and increasing capacity, decentralized energy options are very viable alternatives. Off-grid diesel generators (regime off-grid technology) are losing attractiveness due to rising oil prices and environmental issues. The regime therefore offers a lot of room for rural electrification by REs such as small wind.

Apart from diesel generators, the grid is the other power regime technology. There is pressure from the landscape on the grid through climate change, increased oil prices, insecurity of oil supply, growing population and increasing wealth. As a result, the national grid is hindered by capacity problems, power cuts and the rising costs of electricity. User preferences are important in this respect. The perception on REs is improving because of increased education levels, access to information through ICT and the trend towards green. Hence in areas where the grid is available, the regime offers room for SWTs as back-up option, as money-saver on the electricity bill or as sustainable alternative.

The Government of Kenya, an important regime player, is aware of the environmental issues of current energy sources and the need for increased rural electrification. Its position towards off-grid renewable energies is increasing (in particular towards solar PV) with appropriate policies and incentives. However, very little is being done for SWT policy development. Plans are being made to improve on that, but up to now, the GoK is more a blocking factor than a driver for small wind turbines.

Apart from creating windows of opportunity for the niche, the landscape and regime developments are influencing the SWT niche directly. First, regime issues and landscape factors such as environmental problems are increasing the expectations for off-grid green energy solutions. But especially the direct influences of the landscape on the niche impact the niche, primarily negatively. The niche activities are hindered by the costs associated with the inadequate infrastructure. Furthermore, lack of raw materials complicates local SWT manufacturing. The informal-formal sector division has its effect on technology suppliers and their market niches. Low educational quality affects the sector's human resources.

But especially social and cultural factors influence the niche processes. Corruption, the Dependency Syndrome, an anti-entrepreneurial mind-set and a rather conservative attitude complicate the set-up of SWT activities and their upscaling. People believe that locally manufactured turbines are inferior quality, which complicates the upscaling of these types of turbines. Lastly, the still existing resistance to new technologies, the high poverty levels and dependent attitude inhibit the purchase of SWTs.

4) **What recommendations can be given to all stakeholders to improve the likelihood of niche upscaling?**

This case highlights that all concerned actors, whether they be technology suppliers, NGOs, research institutes or public authorities, can significantly contribute to improve the three niche processes and niche protection. In addition, it can be concluded that enhancements can be made by focussing on the niche level, *and* by inducing change at the local level.

On the niche level, it is highly recommended to create network opportunities, lobby to the government, actively promote small wind turbines and set up an umbrella organisation. Furthermore, it is advisable for stakeholders to create learning opportunities, and to focus on searching for solutions.

At the local level, it is recommended for formal companies to put more focus on SWTs, dare to dream big and to think out of the box. It is not only necessary to improve on the technology; innovations on the business side are at least as important. There lies much potential to improve the network by developing key-partnerships and tapping into existing networks. In addition, it is absolutely necessary to put everything in place to ensure system quality. Furthermore, it is more likely for Jua Kali to realize success if they hook on to existing initiatives. Non-profit organisations and research institutions can have the largest impact by supporting the technology suppliers, develop the required human resources, and disseminate up-to-date information to the public. Last, the national government is in the position to change the internal and external aspects of niche development. Externally, improving the business environment would have major impacts. Internally, it is highly recommended to establish a consistent legal and institutional framework for SWTs.

Overall, the combined effort of all these actors is considered the most powerful catalyst for scaling up the niche.

5) **What kind of insights can be gained that are relevant for RIWIK, and which practical guidelines can be given to enhance their business approach?**

This case highlights that the results from the analysis enable the evaluation of a business model on its strengths and allow for identifying possible improvements.

First, this concept has the potential for effective distribution of small wind turbines in rural Kenya, since it provides an answer for some of the main issues the SWT sector is facing. It introduces a protective measure and an effective supply chain, lowers the product cost and increases local awareness. Basing the business concept on local craftsmen appears to be logical, because there is already quite some SWT Jua Kali activity.

Furthermore, the results of this analysis enable the identification of several critical success factors of RIWIK's business model and strategy. Guidelines can be proposed based on the main features of SNM. First, it is advised for RIWIK to create a learning environment through demonstration projects and feedback mechanisms. The latter is also advantageous for quality control. Second, RIWIK should put efforts in articulating expectations by central marketing efforts as a means to strengthen brand identity and increase awareness. Third, RIWIK's main efforts should be on developing a good network by establishing strategic partnerships, and by paying much attention to building the franchisee network. Last, it is recommended to also take into account the community groups as possible market segment, and to introduce appropriate franchisee financing mechanisms

8.2 Reflections on the field research

This section is dedicated to some reflections on the process of data gathering and analysis. Any field research is performed within boundaries and comes with certain challenges, and this thesis is no different. This is especially so in the context of developing countries, where things take longer and accessibility to information is low. This section provides insights in the research processes: "What went well? Which challenges occurred? How were these overcome?" The point here is to acknowledge the conditions in which this research has taken place, and how these have influenced the practical fieldwork. At the same time, the insights in the research process are meant to support the validity of the research conclusions.

Data gathering

As will not be new for anyone that has done research in a developing country, things go slower than conducting a study in a more developed country. For instance, I spent a lot of time on finding the key informants, arranging meetings and travelling to interviewees. However, contrary to what I anticipated on when planning the research, I did manage to gather a large amount of information during the three month field trip. Apart from online sources, I was able to pinpoint various actors by personal references. Although the reliance on personal references may have excluded some key informants, I was able to interview a diverse group of actors and I therefore perceive the total sum of information satisfactory for drawing research conclusions.

However, more time available would have allowed for interviewing additional informants outside Nairobi, such as end-users, local authorities and Jua Kali. Since I was restricted to using public transportation and travel distances being large, it was not possible to visit that many rural informants. Moreover, this made generalisation of these results a precarious task and I had to be careful on what to base the conclusions on.

Regarding the interview process, I had to take into account issues such as the language, culture and education level of the interviewees. The assistance of a local companion was of great help in this process. Furthermore, the topics of SNM appeared to be too vague for various interviewees. Converting the interview into more direct research questions resulted into valuable information.

Data analysis

As is the case with any piece of qualitative research, the data analysis proved to be complex and time-consuming. This subsection highlights the most significant issues in this process and explains how I tried to overcome these hurdles.

First, several literature sources formed a source of bias by providing incomplete, fragmented or even untrue information. Second, the information from interviewees was prone to errors as well. For instance, the factual data was mainly retrieved from interviews due to the lack of documentation on the SWT sector. As a result, there was a heavy reliance on interviewees' personal memories and the information they wanted to reveal. I also found examples of informants exaggerating and even lying. What is more, I had to take into account that interviewees sometimes answered questions based on what I wanted to know rather than what they believed was true.

For these reasons, I made a lot effort to deal with this bias by putting much attention on and time in the data analysis. First, I triangulated data as much as possible by using other data and I assessed the credibility of all given answers based on other available sources on the topic. Second, three Kenyan graduate students alternately accompanied me to a large part of the interviews. These students supported me in the interpretation of the given answers.

Last, where relevant, I questioned myself what an answer on a particular question reveals. For instance, with regards to the aspect of learning, how can the true learning experiences be exposed? Does the fact that an actor does not recognize it as a learning experience, he or she does not take it into account in future strategies or new experiments? Although I tried to be critical on the given answers, I must acknowledge this issue poses a limitation on the research results.

Having said this, I believe the combination of triangulation, a critical attitude and support of a local Kenyan were effective measures in the data analysis, and in turn enabled me to draw valid conclusions and do justice to the case.

8.3 Methodological reflections and recommendations

Recalling the goal of this research, this thesis aimed to generate practical guidelines for stakeholders in general and RIWIK in particular to move the sector and company forward. This way, it would also shed light on the applicability of the frameworks of SNM and MLP for this purpose (section 1.5.1). This section first discusses the analysis phase of this research. That is, the methodology and the adjustments that were introduced study the Kenyan SWT sector. After this, the section evaluates the thesis synthesis: "to what extent was this applied methodology useful for developing actor guidelines?” This reflection also leads to several methodological recommendations and suggestions for further research, which are presented in section 8.3.3.

8.3.1 Reflection on the analysis phase

This section discusses the theoretical framework that has been applied in this thesis. First, the framework of Strategic Niche Management is discussed followed by a reflection on the Multi-Level Perspective.

Strategic Niche Management

Changes were made in the analysis of each of the three niche processes. These adaptations are treated subsequently.

Voicing and shaping of expectations

Traditional SNM analyses the expectations of the niche actors (robustness, specificity, quality). In this thesis, following changes were made:

Exogenous and endogenous developments

The factors that influence the expectations were analysed regarding their exogenous and endogenous nature (section 4.2.1). This brought structure into the analysis, and provided insights to which degree the overall expectations can be influenced by niche actors themselves. This study also showed that the exogenous developments compromise of more than the landscape and regime. Section 4.2.1 demonstrated that the Kenyan SWT niche is being influenced on a positive way by the spill-over effects of other wind energy sectors: wind pumps and large swale wind turbines. On the other hand, the growing popularity of PV systems is casting a shadow on the SWT niche. This is as various regime and niche actors believe that solar PV will be dominant and SWTs will remain a niche.

Indicator: external expectations

The indicator ‘external expectations’ was added to this thesis. Describing this indicator provided understanding in the expectations of the desired niche actors: “are they aware about the technology, and if so, how do they perceive it?” This is turn demonstrated that there is a strong need to voice expectations in order to attract these desired niche actors into the network (section 4.2.2).

Network formation

This thesis was enriched with following two concepts for analysing the state of the network:

Defining the desired network composition

The first step in evaluating network completeness was to analyse which actor groups such network consists of. Especially in a developing country, where social structures, infrastructure, culture etc. are different, we have learnt it is critical to first define the ideal network and interactions before analysing its composition. Also the reason for required participation is different in developing countries. For instance, this research has shown that local authorities not only influence through regulations, but also as local influencer of technology perception (section 4.3.1). In conclusion, it became apparent that when investigating the network composition in a developing country such as Kenya, it is important to identify the desired network composition prior to executing the network analysis.

Indicator: quality of the sub networks

A wider scope on network formation by introducing the quality of the sub networks was useful. The network should not only be complete, the intensity of participation and quality of performance of its individual actor groups seemed to be as important as its actual composition. It appeared to be a main endogenous influence on internal and external expectations (section 4.2.1).

Learning processes

For analysing the learning processes, two factors were added to the list of Hoogma (2000):

Indicator: learning on the 'wind resources'

It was shown that lessons on the wind potential and wind data have a large impact on the Kenyan SWT sector. For instance, this lack of lessons results in uncertainties on the potential of SWTs, which in turn affects the expectations. On top of that, it has shown to hinder the operations of current suppliers (section 4.4.2). This learning point was thus useful to include in the analysis.

Indicator: learning on appropriate business models

This case has shown that actors have learned about a diverse range of aspects, but have not yet been able to translate these lessons into effective solutions. For upscaling from market niche to regime, there is especially need to bundle lessons learnt into an appropriate business model. Another business aspect that becomes important in market niche stage appeared to be marketing: "which marketing methods are most effective for increasing awareness and finding the customers?" (section 4.4.6 and 4.4.7).

Multi-Level Perspective

This thesis analysed the effect of the external environment on the niche development by means of the MLP framework. Taking into account the external environment proved very valuable for gaining deeper insights in the niche development and identifying the origin of certain niche problems. Apart from the materialistic elements, the socio-cultural factors and ingrained mind sets appeared to have a major influence on the development of the niche. It can therefore be concluded that a thorough analysis of the social practices and cultural behaviour is essential when studying the external environment in the case of a developing country.

Although the principle of MLP is relatively simple in theory, the analysis method appeared to be quite challenging to apply in practice. Obviously, this difficulty originates from the complexity of the case and the many factors influencing the sector. For example, when digging deeper into the lack of SWT entrepreneurs, it appeared that there are various multifaceted factors that are affecting the entrepreneurial behaviour in the Kenyan formal sector (e.g. culture, historical events and local practices). In order to bring more structure into this complex analysis, this thesis made a clear distinction between the direct and indirect influences of the landscape and regime on the niche development. This division is ought useful, and it may be valuable to apply as well in future case studies.

8.3.2 Reflection on the synthesis phase

All together, the analytical frameworks proved to be useful for the analysis, since they were able to demonstrate the complex, underlying factors that influence the Kenyan SWT sector. From this, the main barriers for SWT upscaling could be identified, which in turn led to strategy recommendations. But to which extent is this thesis useful for moving the sector and RIWIK forward?

First, the thesis content itself is deemed to be helpful for all sector actors. In itself, it acts as a document for spreading knowledge about all aspects of the SWT sector development. This information was largely unknown up to now (section 1.4). This thesis has shed light on who is active in the field of small wind turbines and what has been done so far. It provided understanding of the underlying reasons hindering breakthrough. Furthermore, writing down all the lessons has made this information tangible. Overall, such full insights are expected to enhance actors' understanding of the sector they are operating in. In turn, this may lead to more appropriate strategies, trigger partnerships and maybe even enhance expectations.

Furthermore, the proposed guidelines are distilled from the main issues of the SWT sector. It is useful since it captures the most critical factors and provides a straightforward solution. Even though these might not be that easy to realize in practice all at once, every effort is one step forward.

However, there is a weakness in the development of these actor strategies. Despite the fact that it is expected that all of these guidelines will contribute to niche development, it would have been an added value to have gained insight in the importance of an action for overall niche upscaling. For instance: "on which learning experiences do actors have to put most focus? Which kinds of actors are absolutely necessary to include in the network, and which are of less priority in the current niche stage?" A weighed analysis of the niche would enable the prioritization of the proposed actions and this way form a better basis for a sector action plan. Hence at first sight, it seems useful to introduce the SNM quantification for more targeted actions. Section 8.3.3 will go into detail on the possibilities for further research on SNM quantification.

Regarding RIWIK, an SWT actor that is making its first steps on becoming operational, this thesis has provided them with enhanced understanding of the composition and functioning of the SWT sector. Furthermore, the analysis allowed to underpin the current business model by identifying its key strengths. In addition, the results from the analysis enabled to pinpoint several critical issues of the RIWIK business concept. These in turn led to specific straightforward guidelines, which are expected to help the company forward in their future operations. However, to formulate a detailed strategy for RIWIK, it was necessary to collect additional information by means of expert interviews and literature resources. Thus in this case, the SNM analysis proved useful for pinpointing the strengths and several issues, but it also showed that detailed strategy formulation requires extra inputs.

8.3.3 Methodological recommendations

Above sub sections have reflected on the research methodology. This sub section translates the innovative factors into methodological recommendations for future case studies. It also expands on two methodological concepts that would be interesting to further research on.

Recommendations

It is recommended that future SNM case studies incorporate following enrichments:

Expectations

1) *Structure the origin of expectations*

To bring more structure into the analysis of the expectations, it is recommended to divide the origin of expectations into two categories: 'exogenous developments', all developments that are external to the niche (landscape, regime and the developments in other niches) and 'endogenous developments', which entails the influences of the other two niche processes (learning and network formation).

2) Add the indicator: external expectations

It is advisable to also analyse the 'external expectations', since it sheds light on the expectations of the desired niche actors. This in turn helps clarifying the network composition, as negative external expectations will complicate the process of network expansion.

Figure 38 visualizes the proposed total approach for studying the expectations in future SNM studies.

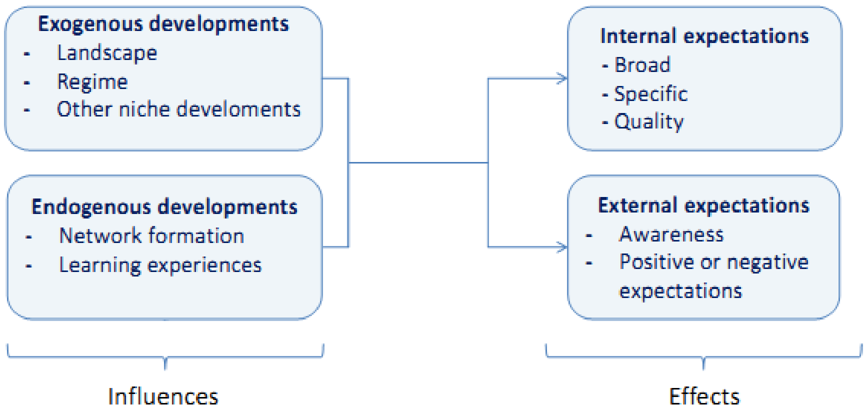

Figure 38: Proposed approach for analysing the expectations

Network

This thesis has shown the importance of defining the desired network composition and looking into the quality of the sub networks. The methodological recommendations are listed as follows:

1) Identify the desired network composition prior to the network analysis

Prior to analysing the network, it is recommended to identify the desired network composition and the function that each of the actor groups ideally should fulfil. This is especially relevant for studying networks in developing countries, as the ideal network composition can be totally different and more complex than for networks in developed countries.

2) Add the indicator: quality of the sub networks

Rather than solely studying the form of the network, it is advisable to also investigate on the network content by identifying the quality of performance of the different actor groups.

Learning

Two learning factors were added in this thesis case. These are also relevant to add in future studies in following cases:

1) When analysing renewable energy technology, which are dependent on the country's resources, it is relevant to learn on the availability of these resources (e.g. wind, solar).
2) It is advisable for researchers that are evaluating market niches to include lessons learnt on appropriate business models and marketing methods.

Multi-Level Perspective

When using the Multi-Level Perspective to study the external niche environment, it is advisable to make a division between the direct influences and indirect influences on the niche since it brings more structure into the analysis. The *direct influences* include the effect of the landscape and regime on the niche processes. Next to that, the stability of the regime can also influence the niche, by creating windows of opportunities in case of regime tensions. This type of impact on the niche is then referred to as *indirect influences*.

Further methodological research

Further methodological improvements are possible. Two areas that could be studied in more depth are:

Investigating the niche content

Recalling the analysis of the network formation, this thesis has also taken into account the quality of the sub networks. In contrary to the other network indicators that evaluated the *form* of network (broadness and interactions), this indicator investigated on the *content* of the network. With hindsight, it would have been interesting to also look into the content aspects of the other two niche processes. For instance, it is not only vital that the actors learn on multiple dimensions and share these learning experiences, it is also important that these lessons are correct. Learning experiences can be faulty when actors misinterpreted facts or have drawn the wrong conclusions from the niche activities. The same reasoning holds for the expectations. Faulty learning experiences immediately affect expectations, which in turn have its influence on future niche activities and network formation. The danger of evaluating the content is that it comes with certain subjectivity. How can the content be judged? What is wrong and what is right? For the network quality indicator, the extent to which actors contribute to the network or even counteract in some cases was triangulated through evidence from the interviews. To omit subjectivity on the quality of learning processes, comparing them to the lessons learnt from foreign SWT sectors would be an appropriate option.

In conclusion, the niche content is not an aspect of the current SNM framework. We have learnt that evaluating the content of the network proved useful (section 8.3.2), and that there lies potential in a similar approach for the other two niche processes.

SNM as an operational tool: the potential of quantification

As explained in section 8.3.2, SNM quantification could enrich the framework for using it as an operational tool. Pantoflet (2007) already did an attempt to quantify the processes of Strategic Niche Management to determine to which extent an experiment can be perceived as a success. Such similar approach could potentially make the SNM framework more suitable for practical applications. Assigning a sign or value to each of the indicators would increase insights in the importance and urgency of a potential action. Also adding a weighing factor would be a useful addition, since some indicators might be more important for niche development than others. For instance, in this thesis case, the participation of local authorities might be more important than the participation of co-operatives. Moreover, quantification would also shed light on the degree of niche development. This could be made possible by using ‘standard numbers’, in which the scores of each indicator and the total score are compared with a reference situation (in this case, e.g. the solar sector). Further research is necessary on the quantification of SNM and its appropriateness for using this method for operational purposes.

8.4 Further theoretical research

This research has shown that the case of SWTs in Kenya does not entirely match the theory. The first two subsections discuss the issues with regards to SNM and MLP and state why these need more attention in further research. After this, the last subsection presents the overlap between the theoretical frameworks and business model literature. These similarities could lead to interesting future research topics.

8.4.1 Strategic Niche Management

The influence of global developments on the niche

The traditional SNM literature describes the development of a technological niche into a market niche, which in turn can grow into the regime by increasing market share and applications (Schot & Geels, 2008). This research has shown that through the linkages with foreign research institutes, technology suppliers, development organisations and global platforms, the technological niche emerged outside Kenya. Whereas some actors remained experimenting with the technology to test and improve it, others immediately became commercial (market niche). The SWT niche still entails a mixture of experiments and commercial activities. It can thus be noted that because of the international SWT developments and linkages with the Kenyan sector, the niche is following an untraditional, non-linear trajectory (section 4.1). Next to that, it would be interesting to further research on the influence of international developments and linkages on the niche. An example of this would be to consider the effect of international network linkages for resource mobilization (development aid, international finance institutions) and the inflow of knowledge. Furthermore, attention could be paid on the influences that the local niche and its actors have on the global developments.

Competitive attitude may be counterproductive for niche upscaling

This research has indicated the lack of interactions in the Kenyan SWT sector. Furthermore, it also showed that even though the market for electricity is void in Kenya's rural areas (and hence competition does not really exist), commercial actors seem to feel the threat of competition, which hinders interactions (section 4.2.3). It would be interesting to investigate the effect of competition in the network formation, and especially how commercial actors perceive the influence of other companies entering the sector. One could say that in the niche phase, the number of actors and their size directly influences the entire niche, since the more activities, the more visibility and technology awareness (level of expectations – section 4.2.1). Increased expectations in turn would positively influence the individual performance of commercial actors. One could therefore question to which extent network collaborations between commercial actors is beneficial for increasing individual performance, and when the tipping point takes place. This tipping point would represent the saturation of the sector in number of suppliers, the moment at which the inflow of additional suppliers negatively affects the performance of the established players (e.g. in number of sales, profit margin). In addition, how do the commercial actors perceive the entering of new companies: do they recognize the benefits or believe it has impact on their performance of their company? In turn, how does this influence their willingness to collaborate, and (how) does this willingness change in time?

8.4.2 Multi-level perspective

The effect of similar niche developments on the studied niche

The MLP analysis takes the incumbent regime technologies and the landscape into account. However, a more advanced market niche that is growing into a regime can also be of large influence for technology and market development of other similar niches. This research suggests that the development of the more advanced PV niche negatively affects SWT development. The expectations of regime actors (and even some niche actors) are so focused on PV, that the willingness to look into other alternatives decreases (section 4.2, 5.2.4). An interesting addition to the MLP framework could hence be to look more closely into the development stages and speed of similar niche technologies, and how this affects the development of the studied niche.

Defining the regime: the risk of a too limited scope

This research showed that the regime for SWTs is quite complex because of the width of the regime. There is not one dominant technology. Depending on the location, energy needs, income, use, etc. other dominant energy sources prevail. Each dominant energy source has its own actors, but also its own infrastructure, rules and perception. Therefore, we can question what the actual regime is for SWTs, and what its boundaries are (section 5.2). Verbong (2011) has introduced the concept of creation of alternative regimes at geographical locations were the grid is not present. However, traditional energy sources fulfil partly the same functions as modern energy sources. This research has shown that there are SWT customers that solely or predominantly use the electricity for lighting (section 4.4.6). Furthermore, the energy policy, development programs and public acceptance on rural electrification is dependent on problematic state of the traditional energy sources (section 5.2 and 5.3). In case these differences in applications exist, it would be relevant to describe the regime for a particular market niche. Or at least, to also take into account the traditional energy sources when discussing a new kind of electricity in the rural areas of a developing country. In this process, it is advisable to investigate the function of SWTs for the particular case, by analysing what users use it for: as fuel switch (transition), or for new applications (development of alternative regime at places where the grid is not present)?

Transition to decentralized electrification may be temporary: there is no linear transition process

We have found that there are multiple simultaneous transitions taking place in the Kenyan energy sector: the shift from traditional to modern forms of energy, and from grey to green energy sources. There also appears to be a shift from centralized to decentralized energy options (solar, wind, hydro mini-grids, and biogas) (section 5.2). However, one could question whether this is actually a transition, and not just an intermediate solution. That is, despite the current trend to decentralized energy options, the ambition to connect all inhabitants to the grid still exists in Kenya (section 5.2.4). Furthermore, another aspect in this discussion is the question of how long decentralized electricity options are appropriate, since one must take into account the increasing aspirations of the public: with increasing wealth and a higher standard of living, the demand for higher capacity will most probably rise along. From the moment an SWT for instance does not deliver enough electricity anymore, and the grid has become available in that particular region, a customer might switch to centralized energy options rather than expanding its decentralized energy system.

8.4.3 The overlap between the applied theory and business model literature

During the research, the similarities between business model literature and MLP/SNM became apparent. The business model environment as described in Osterwalder & Pigneur (2010)- 'Trends, Macro-Economic forces, Branch forces and Market forces' - overlap with many of the aspects described in MLP and SNM. This is logical, as a 'niche experiment' is influenced by the same external factors as an entire niche. It would be interesting to look into these similarities and differences more closely, to give an answer to which extent the upscaling of the niche is different to the upscaling of an individual niche player.

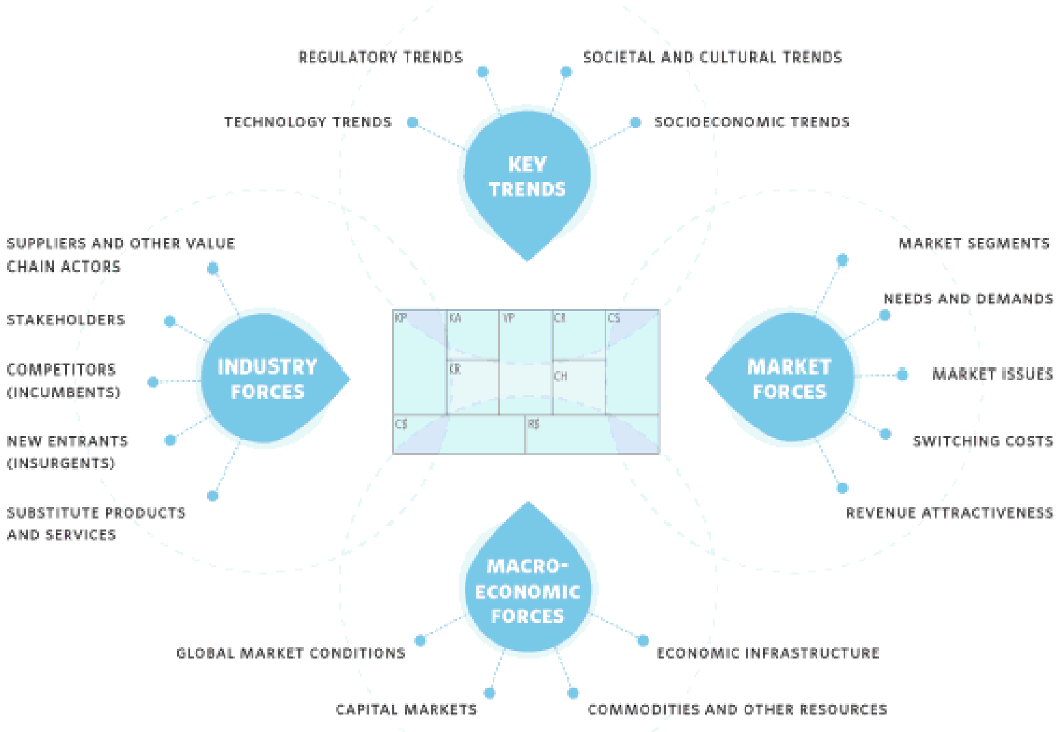

Figure 39: External factors of Osterwalder & Pigneur (2010)

Furthermore, section 8.4.1 and 8.4.2 identified issues for further research on the SNM and MLP framework. Business strategy literature could offer an appropriate starting point for looking deeper into some of these issues. For instance, section 8.4.1 discussed the need for enhancing the SNM framework by taking into account the counteractive effect of competition on the network. Competition within the same sector is an important aspect of business strategy literature, and would thus offer an interesting research start (Porter, 1998; Morris, Schindehutte, & Allen, 2005). The same holds for competition of substitute products. As explained in section 8.4.2, the MLP analysis only takes account the emerging of other niche technologies on the level of expectations. Business model literature does look into this by for instance classifying them as product substitutes (Osterwalder and Pigneur, 2010; Porter, 1998).

Other business model literature could also lead to interesting research topics. For example, network alignment is a key indicator of the SNM framework. It emerges when actors regularly interact and collaborate. Insights from business models state that in collaborative research and accessing external funds, there must be a certain similarity between actors' business models. For instance, Hummel, Slowinski, Matthews, & Gilmont (2010) state that similar value propositions increase the chances of collaboration and the quality of these partnerships. So especially in market niche phase, where commercial activities take place, business models could be a large influence on market niche development into a regime. It would be interesting to investigate the effect of business models on actor network development.

8.5 Further research on the Kenyan SWT sector

This research has analysed the status of the Kenyan small wind turbine sector as a whole. However, distinct differences were noted between the formal and informal supplier groups, with regards to their target market, government support, network, knowledge level and access to resources (section 3.3, 3.5.1, 4.3.1 and 4.4). Because of time limitations, logistical challenges and complete lack of literature resources on the SWT Jua Kali sector, the results of this research with regards to this actor group are rather limited. For this reason, it would be relevant to study this subsector in more detail. This would complement the results of this thesis work, and at the same time it would increase insights on the emergence of innovations within the Kenyan informal sector.

Moreover, experts in the field of SWTs declare the potential of locally produced turbines as a means to create a strong supply chain, build local capacity, knowledge transfer, decrease product cost and ability to adapt the system to the local circumstances (Khennas & Dunnett, 2008; section 3.5). However, this research has also confirmed on the disadvantages of local manufacturing. For instance, the raw material supply appears to be problematic. Furthermore, low quality equipment and lack of skills are a hindrance for sector growth by undermining the reputation of the technology (section 4.2.1 and 4.3.1). On the other hand, despite the higher quality of import systems, these have proven to be more expensive and are often poorly installed (section 3.5 and 4.3.1). For this reason, it would be interesting to compare the social, financial and environmental sustainability of import versus locally manufactured turbines.

The research did not include an economic analysis to evaluate whether the implementation of SWTs is economically feasible for electricity generation compared to local alternatives. This would have been time-consuming, mainly because of the diversity of SWTs on the Kenyan market, the variety of its alternatives and the complexity of wind analysis. Up to now, some researchers did such a study for one kind of turbine (Berges, 2007; van Dorst, 2010). A complete economic analysis would enhance insights on the viability of the niche upscaling, and the size to which it can grow.

However, as this research has demonstrated, it must be stressed that the uptake of SWTs is not only determined by the economic performance, a well-performing niche is at least as important. For the breakthrough of SWTs, it is crucial to develop a complete network, in which the actors are strongly linked and have shared and realistic expectations. Moreover, at an individual level, well-performing actors are considered a key. On top of that, it is of great importance to develop wide learning experiences and transfer these lessons into appropriate solutions. It is the combination of all these factors that will determine the development of the small wind turbine sector in Kenya, and to which degree it will be able to achieve its full potential.

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