Greening Kenyan Electricity Generation

An innovation system functions approach to the role of the CDM in the adoption of wind energy technologies in Kenya

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Contents

List of Abbreviations

BP: British Petroleum

CDM: Clean Development Mechanism

CER: Certified Emission Reduction

DGIS: Directorate General for International Cooperation

CO_2: Carbon Dioxide

EIA: Energy Information Administration

EU: European Union

ECN: The Netherlands Energy Research Centre

FiT: Feed in Tariff

GDP: Gross Domestic Product

GHG: Greenhouse Gas

ICT: Information and Communication Technologies

IEA: International Energy Agency

IPCC: Intergovernmental Panel on Climate Change

IVM: Institute for Environmental Studies JI Joint Implementation

LDC: Least Developed Countries

MDG: Millennium Development Goal

MoE: Ministry of Energy

PDD: Project Design Document

RET renewable energy technology

SWERA: Solar Wind Energy Resource Assessment

TIS technological innovation system

WTIS wind technological innovation system

UN united nations

UNEP united nations environmental program

UNFCCC united nation framework convention on Climate Change

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Summary

This study is part of a research project on ‘Greening the African Energy Ladder: The role of national polices and international aid” carried out in a cooperation between the Dutch Directorate General for International Cooperation (DGIS), The Netherlands Energy Research Center (ECN) and the Institute for Environmental Studies (IVM). The study takes an innovation system functions approach to investigate the dynamics around the adoption of wind energy in Kenya. Seven functions are used to characterize the evolution of adoption dynamics around wind energy in Kenya, these are: entrepreneurial activity, knowledge development and knowledge diffusion, guidance of the search, market formation, resource mobilization, and support of advocacy coalitions. The paper concludes that the trend patterns in the Kenyan wind technological innovation system (WTIS) are generally characterized by an increase in functional activity. The functions knowledge development, knowledge diffusion, market formation and support of advocacy coalitions show a clear increase in functional intensity. Resource mobilization and entrepreneurial activity are lagging behind. The positively developed functions are induced by institutional developments in the energy sector, the early activity of key individuals and developments in information and communication technologies. A lack of managerial skills among actors in the wind energy system, lack of capabilities for renewable energy infrastructure investment among finance institutions and uncertainties about power demand and sovereign guarantees are currently blocking the resource mobilization and entrepreneurial activity functions. Regarding the role of the Clean Development Mechanism in the evolution of the system, the thesis concludes that the CDM has only marginally influenced the evolution of the Kenyan WTIS.

1 Introduction

1.1 Climate change and access to energy

Over the past few years scholars have increasingly come to agree that climate change is influenced by anthropogenic Green House Gas (GHG) emissions (for example Solomon et al. 2007; Smith et al. 2009), and there is increasing consensus that the global community should take action to avoid or at the very least reduce the consequences of climate change. The International Panel on Climate Change (IPCC) estimates that the industrialized world will need to reduce emissions by 25% to 40% in 2020 and by 80% to90% in 2050 (relative to 1990 levels) in order to avoid the worst of climate change (in: Gupta et al. 2007, 776). Ideas around the scale of reducing emissions of GHGs differ, but many authors believe that considering the costs and risks of inaction, ambitious action to reduce greenhouse gas (GHG) emissions is economically rational (e.g. Stern et al. 2006; Burniaux et al. 2009).

While reducing GHGs is important to deal with the effects of climate change, increasing global access to energy is crucial to economic development (Toman and Jemelkova 2002) and crucial to progress in attaining the United Nation (UN) Millennium Development Goals (MDGs) (Dutta 2005; Matinga 2005). Access to electricity in sub-Saharan Africa is still a large problem, where an estimated 61% of the population does not have access to electricity (IEA, 2009). Efforts are made to stimulate access to electricity in developing countries are increasing and it is thought that in the decades ahead most of the growth in global energy demand will come from emerging countries (WRI 2009, 8). It is vital to make sure that the increase in energy demand resulting from this growth is met through climate friendly technologies, and developing country involvement is therefore crucial for climate change mitigation and adaptation (UNEP 2009, 79).

Interestingly, countries in sub-Saharan Africa possess abundant renewable energy resources, including solar wind, geothermal and biomass sources (Karekezi and Kithyoma 2002). To harness these resources however, technology is needed.

1.2 The Clean Development Mechanism

Some incentives exist to stimulate investment in renewable energy technology projects in developing countries. Probably the most well known example of such an incentive is the Clean Development Mechanism (CDM), one of the three emission trading mechanisms of the Kyoto protocol[1].

According to the United Nations Framework on Climate Change Cooperation (UNFCCC) “the CDM allows emission-reduction (or emission removal) projects in developing countries to earn certified emission reduction (CER) credits. These CERs can be traded and sold, and used by industrialized countries to a meet a part of their emission reduction targets under the Kyoto Protocol” (UNFCCC 2010a). In this way, the CDM aims to “stimulate sustainable development through technology transfer[2]” (UNFCCC 2010b), in a cost-effective way. According to recent estimates, around 1,000 CDM projects have been registered globally. These projects are now producing CERs that should amount to 2.7 billion tonnes of CO_2 equivalent emission reductions in the first commitment period of the Kyoto Protocol, 2008–2012 (UNFCCC 2010a).

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[1] The others being Joint Implementation and the International Emissions Trading Scheme

[2] The IPCC (1996) defined technology transfer as “the broad set of processes covering the flows of knowledge, experience, and equipment amongst different stakeholders such as governments, private sector entities, financial institutions, NGO’s and research/educational institutions”

The market on which CERs are traded is called the 'carbon market', and transaction value in this market grew 87% in 2008 to reach a total of $120 billion (UNEP 2009). The CDM accounts for about 13% of the transaction value on the global carbon market (UNEP, 2009).

It remains unclear to what extent the CDM is effective in stimulating technology transfer. Doronova (2009) points out that "the group of the literature covering issues of technology transfer in CDM is still immature, lacks theoretical grounding and rigorous empirical evidence" (2009; 144) and her study was pioneering in taking up this issue. As the end of the Kyoto protocol is approaching and a new Technology Mechanism will be drafted (UNFCCC, 2010c), studies on the role of the CDM in stimulating technology transfer are currently very valuable.

This thesis will contribute to research in this area[3], and research the influence of the CDM on adoption dynamics around renewable energy technologies in Kenya.

1.3 Country Context

Kenya is a country on the East coast of Africa with a population of approximately 39 million. The country is bordered by Uganda, Tanzania, Rwanda, Somalia and Sudan (Theuri, 2008). 21.1% of the population lives in cities, with an estimated 3.1 million in the capital Nairobi (UN, 2010). Kenya is East Africa's largest economy, with a GDP of around US $30 billion. The GDP per capita is however somewhat lower than most of its neighbours with $730 US in 2008 (UN 2010). The government is a parliamentary democracy modelled along a Westminster system of government with the president

[3] It should be noted here that the thesis does not place the technology transfer concept at the centre of analysis. However, as a number of functions in the innovation system functions approach are important to technology transfer, the thesis does contribute to research on the role of the CDM in technology transfer.

being the head of state. The official language is English, and the commercial language is Swahili. Nairobi harbours the regional head quarter of several bodies of the United Nations, and the global headquarters of the United Nations Environmental Program.

In the Kenyan energy mix biomass is currently the largest form of primary energy consumed, accounting for 68% of the total national primary energy supply (MoE 2010). It is often obtained unsustainably, which tends to deplete the natural resource base (Theuri, 2007). Kenya has an electrification rate of only 15%, but this is higher in cities where 51% of people have access to electricity (IEA 2009). Despite the current low electrification rate, demand for electricity is ever increasing mainly due to economic growth over the course of the 2000s and the increased use of electrical appliances (KPLC, 2009).

In 2007 the Kenyan government presented its current economic development plan, in which it aims to become a "prosperous middle-income nation by 2030" (NESC, 2007). The expansion of Kenyan energy production is vital if the country is to get onto a path of continuous economic development.

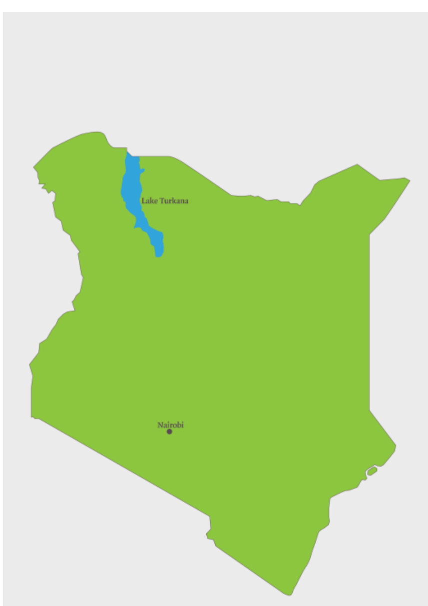

Figure 1: Kenya

1.4 Research Questions

This paper applies the 'technological innovation system functions' approach to investigate the adoption of renewable energy technologies in Kenya. The innovation system functions approach (for example: Jacobsson and Bergek 2004; Jacobsson and Bergek 2006, Bergek et al. 2008a; Bergek, Hekkert) is a recent theoretical development in the innovation systems approach, where the success of the development, diffusion and adoption of a new technology can be evaluated on the basis of a number of functions an 'innovation system' performs.

We hypothesize that the CDM plays (some) positive role in the development of the innovation system around renewable energy technologies by catalyzing the development of several system functions in the innovation system. An elaboration on the exact hypothesized role of the CDM in the development of system functions is presented in Chapter 2 and illustrated in figure 2 on page 23. The innovation system functions approach is particularly valuable when it is used to identify the mechanisms that stimulate or block the effective adoption of a particular technology.

In 2008, countries in Africa only accounted for 0.5 % of the total installed capacity for wind energy around the globe (WWEA, 2009). The figures on newly installed wind capacity do not show a radically different dynamic: 96, 1 % percent of new installations were in Europe, The US and Asia. Where Latin America could see its growth rate of new installations double in 2008, new installations in Africa constituted a constant 0,5% of the total new installations (WWEA, 2009; 11). Apparently there are some mechanisms at play that hamper the effective adoption of wind energy on the African continent, and to the best of our knowledge these mechanisms have not been researched taking an innovation system functions approach. This led to the decision to investigate the wind technological innovation system (which will be called the WTIS from now on) in Kenya. The research question therefore reads as follows:

What are the inducement and blocking mechanisms that determine and characterize the evolution of a WTIS in Kenya, and what has been the role of the CDM in this evolution?

To answer this question, the thesis will first discuss the innovation system functions approach. Chapter 2 will outline the approach, and will elaborate on the method used to study adoption dynamics in Kenya. Chapter 3 will outline the dynamics in the WTIS in Kenya between 1997 and 2010. This outline will be used to structure the analysis on the inducement and blocking mechanisms, and allows us to draw conclusions on the role of the CDM in the evolution of the WTIS in Chapter 4. Chapter 5 will briefly discuss the results, draw final conclusions and offer policy recommendations.

1.5 Aims

This thesis is an attempt to contribute to the literature in two main ways. First, it will be a modest contribution to technological innovation systems literature. Little work has been done on a technological innovation system functions approach in developing countries. Jacobsson and Bergek (2006) elaborate briefly on a functional approach to innovation systems in 'emerging' countries, taking Chile, Korea and Brazil as cases. To the best of our knowledge, no case studies employing a technological innovation system functions approach were conducted in sub-Saharan Africa. Secondly, the thesis will use the answer to the main question to make policy recommendations. These will hopefully –and again modestly- contribute to the literature on the adoption of RETs as well as on the future of the Clean Development Mechanism.

2 Theory and Method

2.1 The Innovation Systems Approach

Different ideas around the concept of innovation have developed since Christopher Freeman took the rise of Japan as a case to study dynamics of economic catch-up and coined the term innovation system (Freeman 1987). Freeman defined the “innovation system” as “the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies” (Freeman 1987). In general, scholars in the innovation systems approach use the concept of innovation in the tradition of Schumpeter where innovation “encompasses technological innovation as well as organizational, institutional and social innovation” (Horst Hanusch and Andreas Pyka 2005, 4).

Some scholars argue that in this tradition the concept of innovation can be interpreted in a broader sense than only the production of genuinely novel technologies or processes, and see innovation as “the attempt to try out new or improved products, processes or ways to do things” and is therefore an aspect of most if not all economic activities (e.g. Kline and Rosenberg 1986, Bell and Pavitt 1993). This also means that the term innovation may be used for changes that are new to the local context, even if the contribution to the global knowledge frontier is negligible. This allows using the concept of innovation beyond only high-tech and typically 'first world' activities and makes innovation system approaches to the adoption of technology “maybe as relevant in the developing part of the world as elsewhere” (Fagerberg, Srholec, and Verspagen, 2010, 1). In studying dynamics on wind energy adoption in Kenya, the application of wind energy technologies in a new context –with possible adaptations of the technology to the local context- will be regarded as innovation.

Scholars in innovation studies speak of an "innovation system" as the firms involved in the innovation process do not operate in a vacuum. Rather, they are "embedded through historical, social and economic ties to other economic units" (Narula 2003), and are thus part of a network of actors and institutions (Bergek, 2008a). Institutions in this sense are defined by North (1987) as the "humanly devised constraints that structure political, economic, and social interaction that consist of both informal constraints and formal rules" (North 1987).

Central to modern innovation systems theory is that innovation is "the result of an interactive process that involves many actors at the micro level", and that "next to market forces many of these interactions are governed by non-market institutions" (Soethe, Ter Weel, and Bart Verspagen 2009, 8). These interactive processes are influenced by landscape developments that contain highly heterogeneous factors such as "oil prices, economic growth, wars, emigration, broad political coalitions, cultural and normative values and environmental problems" (Geels 2002, 1260) and it is the dynamic interplay between changes in the 'background' of landscape developments and 'foreground' of micro-dynamics that either stimulates or blocks the innovation process. In this thesis this interplay between structural trends and micro-dynamics among actors, networks and institutions are at the centre of analysis. This thesis will study these dynamics taking a technological innovation system functions approach.

2.2 Technological Innovation System Functions

The first step Bergek (2008a) takes in outlining a technological innovation system research framework is to define a Technological Innovation System (TIS) as the level of analysis, which is seen as a "socio-technical system focused on the development, diffusion and use of a particular technology (in terms of knowledge, product or a set of products)" (Bergek, Hekkert, and Jacobsson 2007).

To study these systems, Bergek presents a scheme of analysis to assess a TIS performance (Bergek, Jacobsson, Carlsson, Lindmark and Rickne 2008a). In this scheme she asserts that in a technological innovation system a number of 'functions' need to positively develop for a technology to successfully diffuse. Structuring an analysis based on the performance of these functions can be a useful tool in thinking about innovation policy. The important functions that need to be fulfilled by actors, networks and institutions in an innovation system were identified through a meta-analysis of the innovation systems literature and later applied and empirically refined (Jacobsson and Bergek 2004; Bergek, Jacobsson, Carlsson, Lindmark, and Rickne 2008a; Bergek, Jacobsson, and Sandén 2008; Hekkert and Negro 2008; Negro and Hekkert 2009; Suurs 2009). The seven functions we use in this thesis are based on the work of Suurs (2009) who explicitly states that the proposed list of functions in his work can be used as a "check list of key activities that need to be present in any TIS that is to develop positively" (Suurs 2009, 52). Suurs (2009) uses seven functions in his analyses: *entrepreneurial activity*, *knowledge development*, *knowledge diffusion*, *guidance of the search*, *market formation*, *resource mobilization*, *and support of advocacy coalitions*. To maintain comparability of studies, the functions and function descriptions used in this thesis are heavily inspired by the functions used in Suurs (2009) and Suurs and Hekkert (2010). The descriptions of these functions can be found in the second column of Table 1.

Based on Jacobsson and Bergek (2006) this thesis asserts that a functional approach to innovation can be valuable in catch-up situations. In such contexts one will however have to be less restricted in thinking about what indicators to use to assess system performance. An open attitude to innovation indicators in developing countries is supported by Freeman and Soete (2009). One might remember, they say, how "the comparisons made in the 70s and 80s between the so-called socialist economies and the OECD countries ignored many of the substantial differences in definitions between R&D in the West and in the East. Today, it could be argued that there are similar major problems in making comparisons between the developed, emerging and other developing countries in comparing STI indicators" (Freeman and Soete 2009). In this thesis standard aggregate indicators like patent statistics and R&D spending are not used to assess system performance. Rather, we use a broad definition of innovation and look for indicators that can tell us something about dynamics around innovation and technology adoptionin a developing country context. The example event types that are used as indicators to assess system performance in Kenya can be found in the third column of Table 1.

Table 1: The Innovation System Functions

System function	Explanation	Example Event Types
F1. Entrepreneurial Activity	Entrepreneurs are at the core of a technological innovation system. This function represents the activity of entrepreneurs in taking up wind energy technologies in Kenya.	Start of wind power plants, increase/decrease in installed capacity
F2. Knowledge Development	This function represents the creation of new or country specific knowledge for the development of wind energy	Wind data collection, feasibility studies for wind sites; the creation of appropriate technology blueprints
F3. Knowledge Diffusion	This function represents the dynamics in access to information that is useful in adopting wind energy in Kenya	Workshops with dedicated support for wind energy developers, accessibility of country specific publications in wind sphere
F4. Guidance of the Search	This function represents the degree to which developers are guided toward making to make effective choices between possible technologies	Institutional formation around RETs and wind, explicit targets for wind energy or renewable energy
F5. Market Formation	This function represents the efforts to create or expand (niche) markets for wind technologies	Feed in tariffs for wind energy, tax exempts for wind technologies, price dynamics of wind turbines
F6. Resource Mobilization	This function represents dynamics in the availability of funds and human resources for wind project development.	Donor funds made available, wind technology specific resource funds, financial capability building
F7. Support from Advocacy Coalitions	This function represents dynamics in the extent to which wind energy solutions are supported over other solutions	Powerful individuals lobby for wind energy, expressed support of key opinion formers, increased media interest in wind energy

Another useful recent theoretical development has been the idea that in studying innovation systems it is possible to identify 'motors of innovation', which drive the development of an innovation system. The TIS approach is essentially a growth model based on the notion of cumulative causation (Jacobsson and Bergek 2004) where the cumulative causation concept points to the possibility of a TIS massively accelerating its pace of development when certain functions are positively developing. This is what can cause the rapid build-up of the system that is needed to accelerate the diffusion of sustainable energy technologies. Suurs (2009) calls the self-reinforcing dynamics between functions that stimulate rapid build up a 'motor of innovation' and similarly, this thesis will look at a possible establishment of a 'motor of adoption'; those self-reinforcing dynamics that rapidly accelerate the adoption of wind energy technologies in the Kenyan context.

If we extend the 'motor' metaphor, our hypothesis is that international initiatives like the CDM could be the 'catalysts' in a 'motor of adoption' that is developing around RETs in developing countries. The exact hypothesized role of the CDM on self reinforcing dynamics in a TIS are illustrated in figure 2.

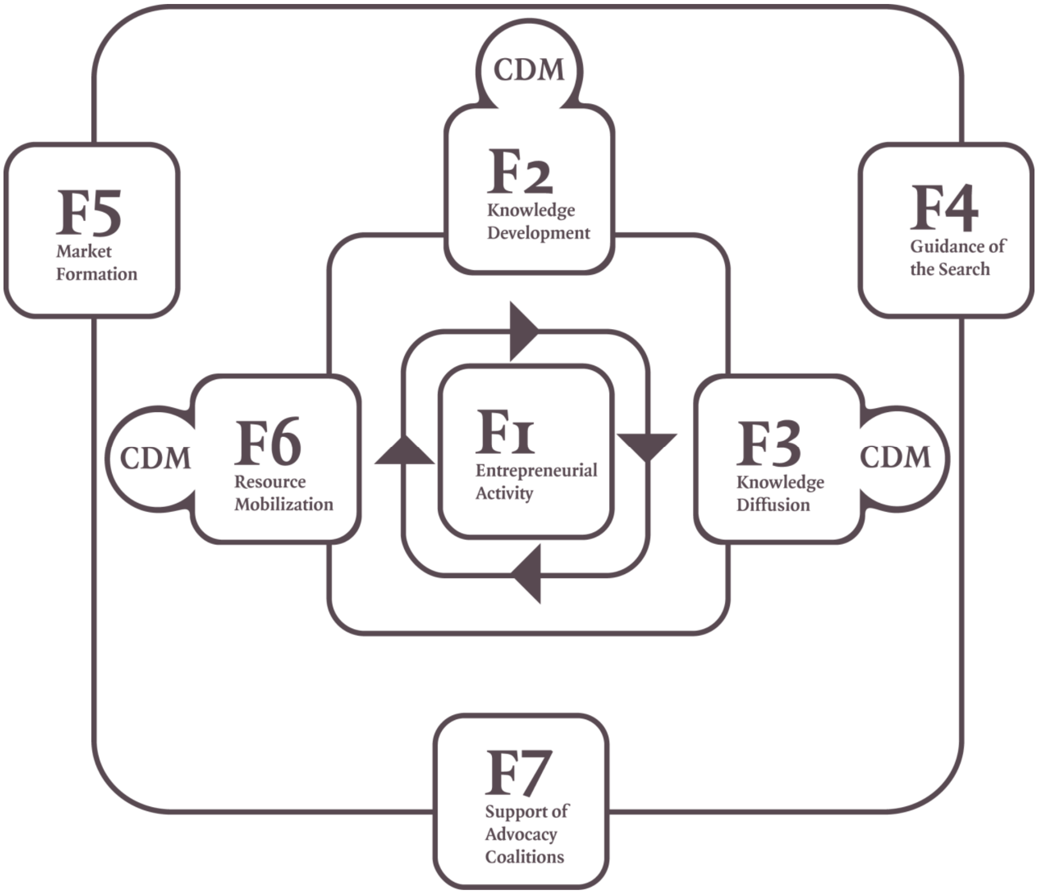

Figure 2: Hypothesized Influence on the CDM on TIS

In the middle square, the 'CDM catalyst' is expected to 'attach' to the knowledge diffusion function, and to stimulate both the entrance of actors and institutions that engage in resource mobilization to set up projects in Kenya. The CDM stimulates and facilitates this as CERs make a project economically more attractive and this could aid in convincing finance institutions of the financial viability of a project. These new actors urge institutions to create and disclose locally relevant knowledge about wind energy, and engage in the creation of locally relevant knowledge for their feasibility studies. These new resources and knowledge lead to entrepreneurial experimentation, which signifies that a TIS in a formative stage is positively developing. Together these dynamics are thought to increasingly lead to the "support of advocacy coalitions" for wind energy, which could in turn lead to institutional initiatives for "market creation". Then, the success of the CDM and wind energy technologies can contribute to the expectations that wind energy technologies will be an important energy solution in the future and a "guidance of the search" function is stimulated that would guide even more entrepreneurs into the WTIS.

2.3 Methodology

A central idea in innovation systems theory is that in order to explain the differences in innovation performance 'historical analysis (in a broad sense) plays a more important role than economic theory' (Soethe, Ter Weel, Verspagen 2009, 29). Researchers at Utrecht University have developed a method to approach the development of innovation system functions historically called 'event history analysis'. This method and varieties thereof have earlier been applied in innovation system functions analyses (e.g. Boon, 2008; Chappin, 2008; Negro et al., 2007; Negro et al., 2008 and Suurs 2009) and has proven to be a useful way to systematically analyze complex longitudinal data.

The event history analysis is based on the process approach "a world view that conceives of change processes as sequences of events. Based on the process approach, a TIS development will be approached as being a meaningful narrative with plots" (Suurs 2009). The basic idea in the method used is to construct a database of events that characterize the evolution of an innovation system. Then the idea is to label these events according to what functions are performed and write a narrative on how different functions were exactly performed. This allows the researcher to distil the inducement and blocking mechanisms that have caused these patterns to emerge. This thesis approaches the Kenyan situation in much the same way as Suurs' case studies were approached. The approach to data collection however, is somewhat different from these earlier studies.

Firstly, as electronic documentation is less evident in sub-Saharan Africa, it was impossible to take a bibliometrical approach in the time available for this thesis. Therefore, for this thesis a sample of key players in the Kenyan WTIS were identified during the first few days of the field work and interviews were set up with key players in different stakeholder categories. The distribution of interviews among stakeholder groups is illustrated in figure 3[4].

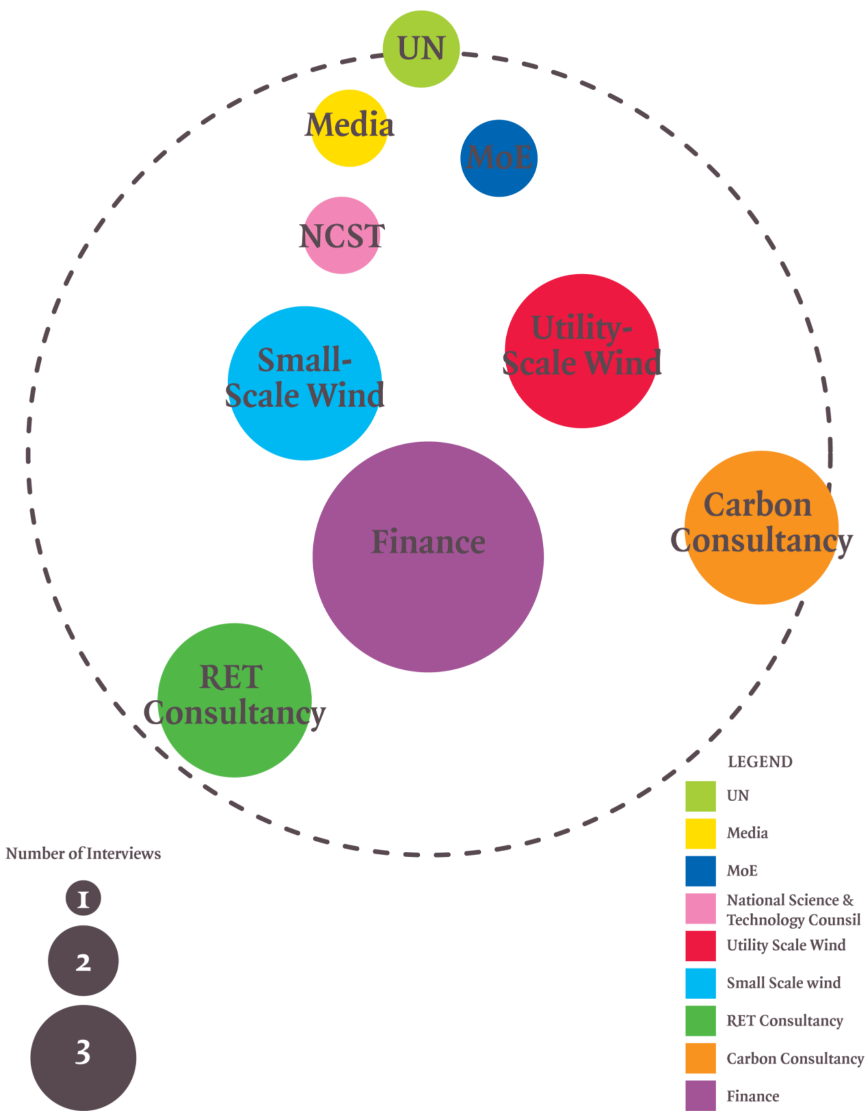

Figure 3: Distribution of Interviews among Stakeholders

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[4] The codes used to reference quotes from interviewees in Chapter 3 are based on this figure, and use an abbreviation of the colours used to signify stakeholders which interviewee made the statement (for example, interviewees in utility scale wind are called "Red 1" and "Red 2"and coded "R1" and "R2" while interviewees in finance are called "Purple 1..3" or coded "PRP1..3". An overview of interview codes in presented in Annex B.

Secondly, to identify if and when a 'motor of innovation' is starting to catch on Suurs argues it is useful to look at a graphical representation of system performance. He claimed that "for every system function, a different graph may be drawn. Together these graphs will provide an overview of how the various system functions develop in time. This way, they may indicate the effect of a motor of innovation" (Suurs, 2009). This means that if we know when a function becomes 'dynamic' i.e. the shape of the function is changing, we can take a look at the micro-dynamics at that time to make an attempt at establishing whether and what sort of 'cumulative causation' is taking place. Researchers from Utrecht (e.g. Negro et al. 2007, Negro and Hekkert, 2008 Hekkert & Negro, 2009 and Suurs, 2009) obtain such a graphical representation by doing a quantitative historical event analysis from bibliographical data they collected, counting the number of events that characterize the positive or negative developments of a function described in newspapers, academic journals and the like.

To get a graphical representation of a trend function from qualitative interviews the study borrows an idea used in system analysis software. When creating a system model in this software, in many cases one does not know the particular function of a flow within the model. While one does not specifically know the change of the function over time, if one knows approximately what the function should look like simulation software for systems analysis allows you to draw an approximation of the function to make the model work[5]. To be able to quickly identify important periods we asked the interviewees to sketch the trend lines for the different functions over time with a pencil in empty graph axes provided by the researcher. Then, the respondents were asked to explain the shape of the graph pointing out the key events that led to that function taking that particular shape. The researcher later scanned the different sketches into a

[5] For example in the "STELLA" software. See for example "Systems Thinking and the STELLA Software: Thinking, communicating, Learning and Acting More Effectively in the New Millennium" at http://www.iseesystems.com/resources/Articles/STELLA%20IST%20-%20Chapter%201.pdf

computer and put them all in one graph in an 'illustrator' program to identify the general trend patterns for a specific function. The idea appeared to be quite complex in execution as interviewees were not always sure how to interpret the functions or were unfamiliar with sketching the flow of functions. In the end, six of the fifteen interviewees agreed to sketch the functions, the results of which are presented in Annex A.

From the key events all the respondents pointed out in the interviews we constructed an event database. For every event the specific function it represents was attached to the event by labelling them with the 'function code' based on table 2 in this chapter on page 16 (and thus range from "[F1] Entrepreneurial Experimentation" to "[F7] "Support of Advocacy Coalitions"). Events can be either positive or negative for the development of a specific function; a negative influence of an event on a function was represented by a minus sign before the function code (e.g. [–F1]) and a positive development by the function code between brackets (e.g. [F1]). In this way, a quick glance on the number of positive or negative events provided insight into the functional patterns. The results of this analysis are integrated into an historical narrative presented in Chapter 3. The thesis distinguishes trend patterns and interaction patterns in Chapter 4.

3 The Evolution of a WTIS in Kenya

3.1 Introduction

This chapter presents the results of the stakeholder interviews conducted in Nairobi from May 20th to June 13th. At the end of this chapter, the reader should have a good understanding of the evolution of dynamics in the Kenyan WTIS. It is important to understand that the narratives were written after trend and interaction patterns were identified. The events described in the chapter are therefore not exhaustive, but are a selection of events mentioned in the interviews important for understanding the researcher's analysis of the trend and interaction patterns in the formation of the Kenyan WTIS.

3.2 A note on TIS definition

According to Bergek (2008a) "analysts face several choices when it comes to deciding the precise unit of analysis – or focus – of the study. The outcome of these choices determines what particular TIS is captured". In this respect, it should be noted that this thesis has chosen to focus the actors, networks and institutions around one "product group" (2008a; 412)(wind) which was useful to answer "the nature of the question raised" (2008a; 412) (adoption dynamics through the CDM). This has resulted in that the range of wind technologies this thesis takes up in its analysis is limited.

Broadly speaking, there are two types of wind energy technologies; mechanical and electrical: wind pumps use the kinetic energy from the wind mechanically to pump water, and wind turbines transform kinetic energy in the wind to electricity.

The analysis presented below is primarily concerned with the latter category of wind energy technologies. Electrical wind turbines vary in technological sophistication but have the same basic design. The design in wind turbine technology has been 'converging' over the past decades and currently, almost all commercial wind turbines are 'horizontal axis' machines with rotors using 2 or 3 airfoil blades (NYS, 2005). The rotor blades are fixed to a hub which is attached to a main shaft, which turns a generator normally with transmission through a gearbox- and thereby produces electricity. These kinds of electrical turbines come in different sizes and capacity. Utility scale turbines are usually used for bulk power delivery and sale electricity to the electricity grid. Industrial scale turbines are most often used in commercial/industrial and village power applications[6]. Micro systems and Small-scale systems are used for charging batteries, water pumping, small businesses, residential power, farm applications, remote communications stations and government facilities (NYS, 2005). An overview of this wind turbine categorization is provided in Table 2.

Table 2; Categorization of Wind Turbine Technologies

Size	**Categorization**
< 1kW	Micro systems
1kW - 50 kW	Small- scale systems
50 kW – 250 kW	Industrial- Scale
> 250 KW	Utility Scale

In the interviews it became clear that an analysis of wind energy technologies conducted in Nairobi would mainly be an analysis of "micro and small-scale systems", and "utility scale systems". This is reflected in the event database and the narratives, where the events mentioned by the interviewees were highly biased to these kinds of

[6] Because of the limited amount of electrical appliances used in developing countries, small-scale and micro-systems often also suffice for this purpose there

systems. The resulting analysis is therefore limited to explaining the dynamics around the adoption of these kinds of systems.

This is not to say that mechanical applications of wind energy are not important in agricultural settings in Kenya. Nearly all interviewees did briefly mention mechanical applications of wind energy as Kenya's first experience with wind technologies. Because this history helps in understanding how landscape developments have always been important in instigating technological change in the wind energy sphere in Kenya, early dynamics around these systems are include it in the prelude to the narratives.

3.3 Prelude: The oil crisis of the 1970s and the beginnings of liberalization

At the turn of the 20th century, wind energy was introduced in Kenya by European settlers. These windmills were mostly imported from Europe, and used primarily for lifting water in domestic and agricultural settings. With the rise of combustion engines, the popularity of these windmills weakened over the course of the century, and the windmills were often abandoned and replaced by diesel and petrol engines.

The attempt to restore some of these windmills started during the oil crisis of the 1970s. However, the country had become independent with Kenyatta as its first president (Reynolds, 2000) and the Kenyan Government at this time had installed severe import and foreign exchange restrictions. This made it impossible to bring in spare parts to restore the existing windmills or import a complete windmill. Against this background, the middle and late 1970s were characterized by a spirit of experimentation in wind energy [F1], where the goal was to come up with a cheap locally made alternative to the imported windmills (Ogana, 1986; 291). During the late 1970s early 1980s, multiple windmill projects were started [F1], but "most of these projects were quickly abandoned" (Ogana, 1986; 293). The failure of these projects are often attributed to premature field testing of prototypes [-F1], little international knowledge diffusion [-F3] and bad project planning and project management, mostly resulting in financial problems (e.g. Ogana; 1986). In this period expatriates with ideas to start wind energy projects in the 1980s were hampered by the fact that most foreign wind energy developers thought Kenya to be "too risky", and "too far away" (R1, 2010), and "when oil prices dropped so did interest in renewable energy" (LG, 2010) [-F7]. When Kenyatta was succeeded by the authoritarian leader Daniel Arap Moi in 1978 the country became characterized by high levels of corruption, and international interest in the country for economic development dropped. Under national and international pressure, parliament amended the constitution to allow more than one party in the early 1990s. The first democratic elections in Kenya in 25 years were won by Moi in 1993, and the government agreed to economic reforms urged by World Bank and IMF.

Interestingly, it is around this time when the history of 'industrial-scale' wind in Kenya begins. In 1994, a grant by the Belgium government [F6] was used to introduce three 200 kW wind electric turbines in Ngong hills just outside Nairobi, to run a grid fed two turbine system rated at 350kW [F1]. Only one turbine is still in use, and although Ngong hills is currently known to be a very good wind site, it becomes clear from interviews that 'when we did them [the Ngong Hills 1994 windmills], we did not have any feasibility study done. We just knew from experience that it was windy there' (R2, 2010) indicating that effective knowledge development initiatives were not yet in place [-F2]. The operational data and information available from Ngong Hills did however instigate "a lot of hope to future investments in wind" (Theuri, 2008) [F4, F6]. The organization of the power sector at this time however did not allow for entrepreneurs to enter the Kenyan wind energy market, as energy was handled in a state monopoly by the "Kenya Power and Lighting Company" (KPLC), which was at that time responsible for generation, transmission and distribution of electricity in Kenya. The institutional framework for independent energy production, thus also the market for independent electricity production using wind turbine technologies, was not yet in place [-F5].

3.4 Emerging institutional framework for independent power production (1997–2005).

Toward the end of the 1990s, a global trend toward liberalization was also having its effect in Kenya. The petroleum sub-sector in Kenya was fully liberalized in 1994, and a liberalization of the power sector followed in 1997. The electric law (the Electric Power Act number 11, 1997) led to the formation of the Kenya Power and Lighting Company, and the Kenya Electricity Generating Company. The main results of the law were a liberalization of the sector allowing both domestic and foreign equity participation though independent power producers (IPPs). Although these initiatives were not specifically aimed at renewable energy technologies or wind energy, there was now the possibility for independent entrepreneurs to install utility scale wind turbines to feed in to the Kenyan electricity grid [F5]. A restructuring of the roles of the key actors under the law meant that there were now clear roles for five types of key players in the sector - policy formulation and articulation though the Ministry of Energy (MoE), power transmission through KPLC, power generation by the state owned Kenya Electricity Generating Company (KenGen) as well as IPPS and control through the electricity Regulatory Board (ERB) (ERC, 2008). However, the first IPPs entering the domestic market were only thermal electricity producers IberAfrica and Westmond, which were in the years after followed by the IPPs orPower inc. and Tsavo power (R2, 2010) and used fossil fuels for their power generation. Kenya was at that time (similar to the current situation) mostly reliant on hydropower for electricity generation and the thermal generators were often set up in response to a shortage in electricity during droughts. Because of this, the "contracts for these thermal generators were often rigid, and the unit price of thermal electricity is relatively high" (R2, 2010). Entrepreneurial activity in the renewable energy sector was at this time virtually non-existent as power shortages and new contracts for IPPs were dealt with on an ad-hoc basis, which favoured entrepreneurs in the well-understood and well-developed thermal IPP sector [-F1].

Although the renewable hydropower was the country's main electricity source, it should be noted that during the late 1990s, there was very little political urgency for a sustainable energy system; the choice to have hydropower as providing the base-load of electricity was "purely economic" (YL, 2010). In the late 1990s and early 2000s, oil prices were only a fraction of what they were during the oil crisis in the 1970s, and the climate change debate was absent in the international political arena [-F4]. Environmental issues in general were however slowly entering the political agenda in Kenya, most probably because of the international discourse started by the Rio Declaration, the Kyoto summit, and later "the formulation of the Millennium Development Goals and the inclusion of the importance of energy in these goals in 2002" (MDGs) (LG, 2010). The MoE was expanded with a department of Renewable Energy following the merger of the former Biomass Energy Department with the Alternative Technologies Division formerly in Electric Power Department [F4] in 1998. One year later the National Environment Management Authority (NEMA) was established under the Environmental Management and Coordination Act (EMCA) No. 8 of 1999, "as the principal instrument of government in the implementation of all policies relating to the environment' (NEMA, 2010). One of the reasons why these early efforts in bringing the environment on the political agenda did not translate into activity around wind energy technologies was indicated by the interviewees to be the "formulation of Kenya's Least Cost Power Development Plan (LCPDP) in 2000" (PNK, 2010). The plan stipulates aims in expansion of electricity production for a period of 20 years. With regards to renewable energy, only geothermal was in this plan recognized as an important energy source for the future (Mbuthi, 2005), and in general the search for electricity sources was guided to generation using cheap fossil fuels like coal. This LCPDP was pointed out by one of the interviewees as having a negative effect on the 'guidance of the search' function [-F4], specifically pointing out that 'originally, we were not looking at wind' (PNK, 2010).

Wind energy, and at this time only micro and small-scale turbines for off-grid electricity production started their revival on the back of two information landscape developments: the rise of the internet and the rise of a telecommunication industry [F3]. The growing number of off-grid telecommunication towers was starting to create a niche market for cheap off-grid electricity solutions [F5]. Because of the increased possibility of finding the cheapest solution through internet searches [F3] hybrid systems of wind/diesel became an option as an electricity solution. This led to the formation of a Nairobi-based small-scale turbine reseller, seller and installer of US produced turbines for the Kenyan market (LB1, 2010) [F1]. At the same time, another Nairobi based entrepreneur made use of the knowledge on wind technology available on the internet [F3] to develop his own residential and small-scale turbines [F1]. The first installation of one of these locally produced turbines was in 2002, and after the MoE started promoting the development of wind-diesel hybrid systems for electricity generation [F4] in areas remote from the national grid (Kenyan Ministry of Energy, 2008), where public institutions like schools got tax exempts for the use of renewable energy, this stimulated the creation of a niche market [F5] for residential and micro-turbines. The design of this locally produced 'WindCruiser' turbine was improved with help of engineers from Jomo Kenyatta University of Agriculture and Technology and became the first patented Kenyan wind turbine in 2005 [F2]. It should be noted here that it was an individual entrepreneur that was making these entrepreneur/research institute links happening. Efforts in market creation by the MoE for wind turbines did not automatically lead to the creation of knowledge networks in the institutional sphere, but were taken up by a key individual to establish his own networks for knowledge development and diffusion [F2, F3].

Because many countries around the world were 'increasingly embracing the use of renewable energy' (MoE, 2003) the MoE hired a consultant to prepare the first 'wind energy resource atlas' for Kenya in 2002 [F2, F4]. Such initiatives to contribute to knowledge development and diffusion were largely made ad-hoc, and were inefficient. As one of the interviewees characterized the process: "there were a lot of problems getting accurate data, and at that time no electronic records were kept so it all had to be input manually. Its purpose at that time wasn't really for entrepreneurial use but just because every country should have a national wind atlas. 1000 copies or something were printed, most went to people who lost it or moved jobs, no electronic copy was kept. Also, the data might not be accurate" (OR1, 2010). The loose institutional structure around renewable energy could thus be said to hamper knowledge diffusion [-F3], and early entrepreneurial activity was hampered by the dubious quality of these knowledge creation efforts.

3.5 The perfect storm (2006- 2008)

The aforementioned sessional paper no. 4 also initiated the process of the creation of a new energy act in 2006, which was a consolidation of the 1997 Electric Power Act and the 2000 Petroleum Act, which was an important step toward a 'comprehensive' energy policy in Kenya. As a result of the act, which became operational in July 2007, the Electricity Regulatory Board became the Energy Regulatory Commission (ERC) a body that regulates the whole energy sector. Under the same act KETRACO was formed at a later stage in December 2008 as the body responsible for constructing, operating and maintaining all new high voltage electricity transmission lines of the Kenyan Electricity Grid. An outline of how energy industry relevant for wind energy has now taken shape is illustrated in Figure 4.

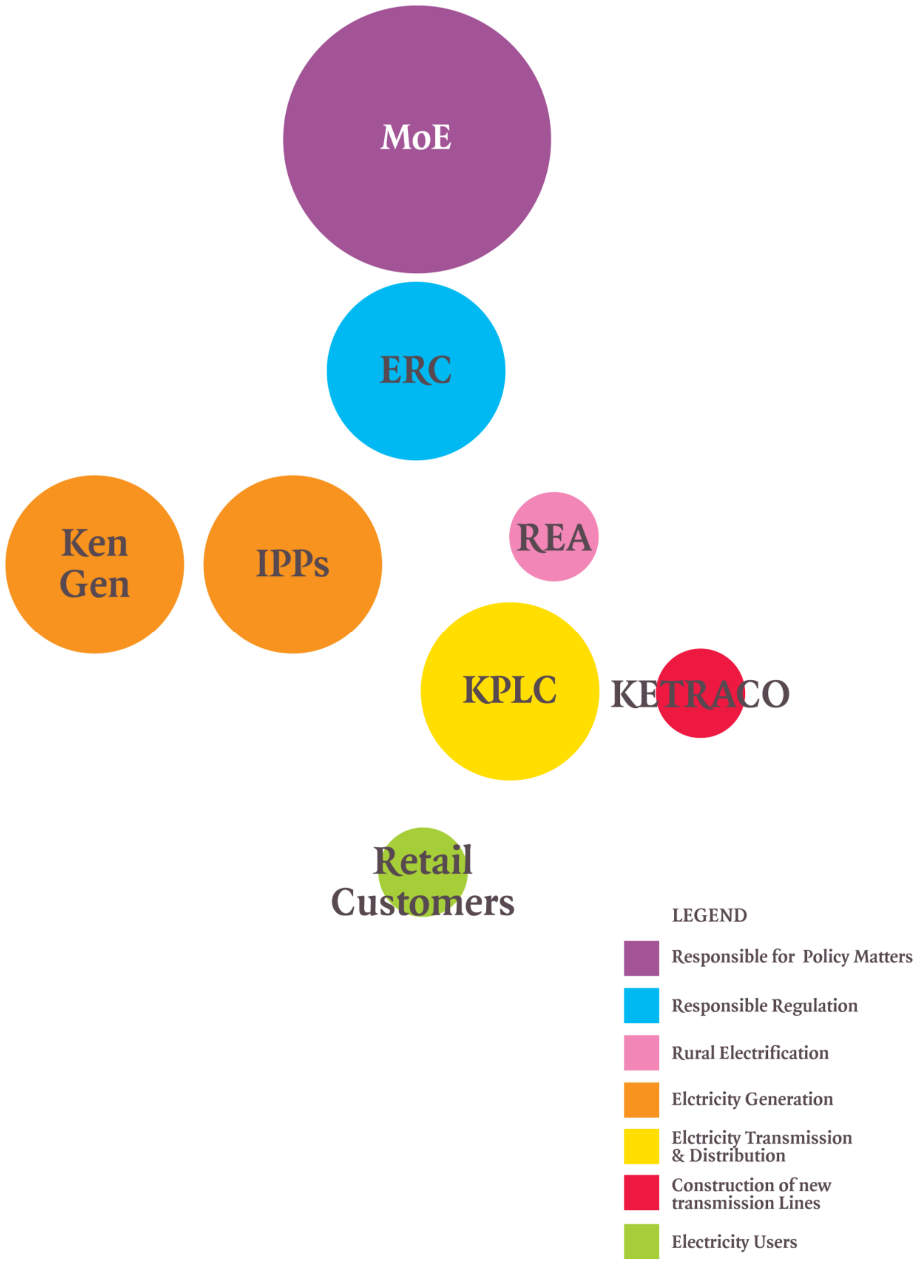

Figure 4: Institutional Arrangement of the Kenyan Energy Sector Relevant to the evolution of the WTIS

The act also explicitly states that there will be more emphasis on renewable energy including solar and wind (Theuri, 2008) [F4] and that the 'ministry shall promote the development and use of renewable energy technologies' (MoE, 2006; 100) [F5]. By formulating this act, the MoE influences the expectation of actors in the TIS, as renewable energy is now explicitly part of the national energy strategy. Rural electrification was given a new impetus by the policy through the formation of a rural electrification authority (REA) to promote development of rural electrification by more actors than KPLC, including private sector developers. From 2007 onward, the REA publishes tender notices for wind solutions for institutions like schools, guiding entrepreneurs to think about wind turbine solutions [F4] (DB, 2010) and again making a step in contributing to the creation of a niche markets [F5] for wind energy.

In 2007 the Kenyan National Economic and Social Council published the white paper "Vision 2030", which aims at transforming Kenya into an industrialized mid-income country by 2030. Energy is one of the foundations of the vision, as well is Science, Technology and Innovation. In the document it is stated that the government "stays committed to reforming the energy sector, including the continuous creation of a strong regulatory framework" (NESC, 2007). Science, Technology and Innovation are an important part of reaching future economic goals. Influenced by the focus on innovation in the Vision, the ministry of Higher Education and Science and Technology was created, which was to become responsible for fostering innovation in Kenya. The beginnings of the creation of an institutional framework for knowledge development and diffusion in wind energy technology are created here [F2, F3], but this has as of yet not had any clear results in stimulating these functions in the WTIS. Next to this, the vision was pointed out by nearly all interviewees as "very important in expectations about developments in energy demand' (PNK, 2010) [F4, F5]. Although 'wind power generation by IPPs' was part of the 'key projects to be implemented' in the energy section of the vision, one of the reasons why solar and wind were not directly factored in the nation energy planning matrix and the LCPDP was 'the scarcity of information and data that is critical in aiding decision making and planning' (Theuri, 2008) [-F2]. From 2007 onward, climate change was increasingly becoming part of the global discourse on energy. "Following mainstream politics", an interviewee from UN stated, "the UN in Nairobi also increasingly started to explore RET potential in Kenya" (LG, 210). To this end, a Solar and Wind Energy Resource Assessment project was started early 2007 by UNEP, Risoe, DLR, Practical Action, and the Ministry of Energy, financed by the Global Environmental Facility. They published a wind and solar energy resource map for everyone to download in May 2008, contributing to knowledge development for wind energy [F2], increasingly guiding entrepreneurs to think about wind as a source of energy in Kenya [F4].

It was in the period leading up to May 2008 when we would start to see what one of the interviewees described as '*the perfect storm*' for Kenyan interest in RETs and wind energy (LG, 2010). From early 2007 to mid 2008, commodity prices were going up at an unprecedented pace. All interviewees pointed out that in this period the increased frequency of droughts led to ever more heavy fluctuations in Kenyan electricity generation. In 2008 for example, the droughts in the three years before meant that the Masinga Dam, the main reservoir for the Seven Forks Hydropower Project received very little water inflow and this reduced capacity of power plants in the entire cascade by 18.4% (KPLC, 2009). In 2007, because of an ever increasing gap between supply and demand, KPLC had to bring in the thermal emergency power producer AGGREKO to be able to satisfy demand. Because the bill for this increased amount of thermal energy is placed at the customer by adding a 'fuel surcharge' to electricity prices, the discourse around electricity prices flared up in 2008. As an interviewee from the media put it, 'in 2008 consumers were really starting to get fed up with electricity prices' (YL, 2010) [F7]. The bad experiences with EPPs were not immediately a positive development for entrepreneurs in the wind energy sphere. Quite the contrary, a key opinion maker from a national newspaper stated that: "experiences with AGGREKO and thermal IPPS shaped my ideas around independent power producers negatively" (YL, 2010) [-F7]. What these price dynamics did do, was to open up the energy market for wind energy [F5] as the price of production at high quality sites would be far lower than the electricity prices with the fuel surcharge KPLC started to charge.

It was on the back of the problems with the continuity and price of a hydropower-intensive electricity mix that an initiative by Dutch entrepreneurs in Kenya, the Lake Turkana Wind Power[7] (LTWP) project could start expecting support from key individuals in the institutional sphere [F7]. According to multiple interviewees, this key project broke a lot of boundaries influencing the standardization of agreements and negotiations in wind energy development, and members of the LTWP consortium were stated to have greatly contributed to reducing transaction costs in wind energy development. An interviewee from LTWP formulated it as follows: "concerning contracts in wind energy, those were things [that] players in Kenya did not know much about. There we really brought in a lot of knowledge" (R1, 2010). Next to this, because the initiators of the project had experiences in other sectors in Kenya[8], they were familiar with investing in Kenya. This has probably influenced them in estimate risk differently than international actors, as it for example allowed them to make estimate that "Kenya has always had problems with getting cheap power, and this will only grow in the future" (R1, 2010), and "also, KPLC has always paid its IPPs in time" (R1, 2010) without doing any formal risk analyses before starting a project. Moreover, the networks of people in the LTWP consortium allowed them to draw in powerful

[7]The purpose of the LTWP project is the construction of a 310 MW wind power plant in the Marsabit District in Kenya, consisting of 365 V52 Vestas Turbines with a capacity of 850 kW each. Vestas will introduce the technology, and although it has a maintenance contract cost of the daily maintenance will be done by trained Kenyan engineers.

[8] The initator of the project is also CEO of AgriFresh Ltd, a company that exports vegetables to the European market

individuals, and such individuals are vital in getting the support of those who can effectively contribute to the support of advocacy coalitions [F7] in any context. The efforts of LTWP are widely seen as contributing to tying the institutional framework together (LG, YL, O1, PRP, 2010) which points to the relevance of activity of key individuals for institutional development.

The key strength about the energy act, according to my interviewee from the MoE, was that it made it a lot easier to express interest and to know where to go when you want to start a project (DB, 2010), which is of prime important to stimulate early entrepreneurial activity. Post-election violence in 2007 resonated in the consciousness of national and international entrepreneurs, and was pointed out to cause problems for the effective mobilization of resources in terms of financial capital in this period (DG2, 2010) [-F6]. However, the new government in 2007 also instigated a lot of Kenyans to come back from the Diaspora, making sure that a lot of valuable human resources were mobilized [F6] and knowledge flowed back into Kenyan institutions (PNK, 2010). Interviewees particularly pointed out how this positively influenced the staffing of government bodies relevant to the WTIS (R1, PNK, 2010). The increasing support for wind energy as an energy solution in these institutes – in concert with the price dynamics of electricity- led to the creation and publication of the first "Feed in Tariffs policy for wind, small hydro and biogas (FiT [F5]. This document was followed by a "FiT: guidelines for investors" document, which contributed to clarifying the steps an entrepreneur needs to take to be able to set up a wind power plant [F4]. Following the publication of the FiT policy, one can see the beginnings of increased activity by entrepreneurs mainly in knowledge development relevant to the local context. While KenGen had already put up their own wind energy department in 2007, a soft loan from the Belgian Government [F6] allowed started construction of a wind site in 2008 for a new 5 MW wind farm at Ngong Hills called “Ngong 2”, near the two turbines that were installed in 1994 [F1].

The efforts in Lake Turkana and Ngong 2 were increasingly making the news as good progress was made in both projects shaping expectations of wind energy potential positively [F4]. Over the course of 2008, four private investors other than KenGen and LTWP started carrying out site specific feasibility studies [F3]: Aeolus which is to set up a 60 MW wind farm to be commissioned in July 2013, Osiwo Wind, which is to set up a 50 MW farm also to be commissioned in July 2013, and WindFlow in Marsabit and Wind Energy Ltd in Malindi of which no data is available on the project status. Although the stages in which these projects are in vastly differ and it is not clear whether this increased knowledge development will contribute to an increase in installed capacity [F1], a positive development in most system functions are beginning to take shape.

3.5 Visions of a green future (2009- 2010)

From early 2009 onward, the Ministry of Energy starts to notice a great “increase of expressions of interest in setting up wind farms [F1]” (DB, 2010). KenGen places data loggers for 40 sites, collecting accurate data about potential for utility scale wind energy in Kenya, data that can be used by KenGen itself or sold to IPPs that are interested in setting up a wind project [F2]. Moreover, from 2009 onward, KenGen starts sending its staff to wind energy conferences around the world to become familiar with the latest developments in the wind energy sphere (R2, 2010) [F3], and is next to the training of engineers at the Ngong 2 site actively looking into building capacity to strengthen their activities in wind energy development [F3].

Key individuals from LTWP and the group of people behind the Aeolus 60 MW plant were pointed out to be the ones that also in this period engaged in “major lobbying for taking wind power seriously" (YL, 2010) [F7] in 2009 as well. These lobbying efforts, the media attention for LTWP, and the new 'expressions of interest' in wind energy to the MoE after the publication of the FiT document, 'were a great impetus for the founding of the Green Energy Committee' (YL, 2010) [F7] mid-2009, a commission headed by the office of the prime minister that is now taking the issue of renewable energy "very seriously" (YL, 2010). According to an interviewee who is a long term energy consultant now working in finance, the founding of the committee means that "we now have a huge force within government to remove small barriers" [F7] (PRP1, 2010). According to an interviewee from UN it was over the course of 2009 that one could observe a 'convergence in thinking across government that green energy is a very important part of the solution' (LG, 2010). In March 2009, the Ministry for Regional Development said it would initiate a project called the 'Chalbi wind power plant' project to add a 100 MW of energy for multipurpose use in the region and the excess being transmitted to the national grid [F7] (although the status of this project is not known to the researcher), which reflects that this trend could really be seen across government.

Finance minister Uhuru Kenyatta stated in his 2009/2010 budget speech, that it is of prime importance to "generate clean energy and transform Kenya into a green economy" thereby creating expectations around future budget allocation [F4]. These announcements were soon to be specified to different technology options, and during the Copenhagen Summit in December 2009 president Kibaki announced the start of investments of around 150 billion KSh each year in "wind energy and geothermal energy" (YL, 2010). In the financial sphere, important developments for wind in this period are numerous. The International Finance Cooperation –part of the Wold Bank group- sets up its Climate Change Investment Program late 2009. ACUMEN fund expanded its clean energy program in late 2009 with a program specifically aimed at

"Clean Energy Infrastructure" (PRP3, 2010). Similarly, the Deutsche Investitions- und Entwicklungsgezelschaft DEG (PRP2, 2010) and the French Proparco all start efforts in 2009 (OR1, 2010) that aim at directing funds to renewable energy infrastructure development in the future [F4]. So far however, no wind energy projects have been funded by these funds [-F6].

Some important events in the formation of a Kenyan WTIS can be seen in the first months of 2010. President Kibaki's New Year speech in 2010 called Kenyans to make 2010 the "green year for Kenya" placing emphasis on wind and geothermal energy [F4]. On the 5th of January, 2010, the Spanish government provided a concessional loan of Sh. 2 billion that was to go toward the expansion of the Ngong Wind Power [F6]. Later in January 2010, the Power Purchase Agreement for LTWP was finally signed with KPLC, which was pointed out to be a major signal to other entrepreneurs that wind energy, also on such a large scale, could happen in Kenya (YL, 2010) [F4]. In March, the government approved plans by Gitson Energy Ltd to build a 300 MW wind power plant in Marsabit, which is required to deliver detailed feasibility studies before the end of the year [F3]. In April 2010, the Kenya Forest Service started to float bids for private developers to build wind mills in Ngong Hills to expand the installed capacity there [F4]. At the same time, KenGen used the data collected in 2009 to invite companies to carry out feasibility studies for nine new sites around the country [F2] (R2, 2010). In May 2010, the Lake Turkana Wind Power project entered the UNEP Risoe CDM pipeline, bringing the total of CDM projects in Kenya to 16, marking the entrance of the first wind power CDM project in Kenya. During a presentation on the new LCPDP, in May 2010, which is yet to be published "wind energy will also in that document be an important source of future electricity generation" [F4] (PNK, 2010). The plans to set up a Climate Innovation Centre, for which workshops were held in March and June to outline the course this centre would take, signifies that efforts are being made to facilitate entrepreneurs to start businesses and engage in local knowledge development [F2, F3].

As things now stand, if one is to take the estimations of different interviewees together about how many parties are looking into setting up utility scale wind farms, it is possible to count about 15 parties that are either looking for partners or collecting data to do feasibility studies (OR1, 2010) [F3]. While these initiatives are there, it is difficult to estimate what the eventual result of these efforts in terms of installed capacity will be.

4 Understanding the formation of a Kenyan WTIS

4.1 Trend Patterns

The narratives described the overview of specific events that characterized the evolution of the Kenyan WTIS. The trend patterns can be summarized as follows:

Table 3: Overview of trends in the evolution of the Kenyan WTIS

Period	Episode	Character of Landscape	Functional Trends
< 1997	The oil crisis of the 1970s and the Beginnings of Liberalization	Struggling economy	Little to no activity
1997-2005	Emerging institutional framework	Power Sector Reforms, rise of the internet	[+F3, +F5]
2006-2008	The perfect storm	Extensive drought, Commodity Boom, Climate Change	[+F5, +F7]
2009-2010	Visions of a Green Future	Financial Crisis	[+F2, +F4 +F5, +F7]

In the prelude to the narratives we can observe an increase in the number of entrepreneurs experimenting with mechanical windmill technologies when oil prices went up during the oil crisis of the 1970s. When oil prices dropped wind energy quickly left the sphere of interest, which suggests that entrepreneurial activity in the Kenyan WTIS was at that time closely linked to price dynamics and no so much to sustainability. The narratives show that the set up of the two utility scale turbines in 1994 could have marked the early beginning of the formation of a WTIS in Kenya. However, because the energy industry was state-run there was no possibility for independent power producers to enter the electricity market, which probably caused the breakdown of the function entrepreneurial activity in the innovation system for some time.

The institutional organization for energy production changed in the first episode of the narratives, when more system functions are beginning to develop. This was driven by the early development of the market formation function for independent power producers though a restructuring of the energy sector. Important trends that could be observed in this period include entrepreneurial experimentation in micro and small scale wind and the creation of a market for wind energy through tax exemption for off-grid wind technologies. We also observe the early beginnings of the knowledge development and guidance of the search functions in this period.

The trends in the second episode, the period 2006-2008, were characterized as 'the perfect storm' for the beginnings of RET adoption in Kenya. After the institutions to stimulate independent power production were set up in the first episode, the increase of fuel prices globally, and power shortages through droughts locally, led to a situation where electricity prices were high. Investing in wind energy became more economically attractive and this stimulated the knowledge development function in the wind energy sphere. The feed-in-tariff policy for solar, small hydro and wind was an important step in the process of market creation, which quite clearly promoted a surge feasibility studies and interest in wind project development in Kenya. In this same period key actors in the lake Turkana Wind Power consortium and from Aeolus Wind succeeded in getting advocacy coalitions in place to promote wind energy as an important solution for power production in the future of Kenya, and this contributed to the "guidance of the search" and "support of advocacy coalitions" functions.

In the last episode 2009-2010 we observe a sharp increase in locally valuable knowledge development, where entrepreneurs are starting to carry out feasibility studies to assess wind potential in the local context. Because the government is increasingly supporting the development of wind energy, thereby creating positive expectations of a green future for Kenya, the guidance of the search function is positively developing. In terms of installed capacity of utility scale turbines, and number of entrepreneurs engaged in producing or selling small-scale wind turbines, it can be observed that there is still only moderate expansion from the early 2000s onwards. Only one project (Ngong 2) has so far led to an increase in installed capacity, so it is difficult to speak of an increase in 'entrepreneurial activity' using the indicators described in chapter 2. From interviews, it became clear that there had been virtually no new entrants in the small-scale turbine market and to the best of our knowledge, only Craftskills, Winafrique and Kijoto Wind energy are currently offering small-scale wind energy solutions in Kenya. Despite developments in the financial sphere, where specific renewable energy funds were set up in 2009 and 2010, both small-scale and utility scale projects have as of yet been largely unable to mobilize resources for the execution of these projects. The support of advocacy coalitions, however, remains high.

4.2 Interaction Patterns in the Kenyan WTIS

From the narratives it becomes clear that in some areas a 'motor' that facilitates an accelerated positive development of the Kenyan WTIS could be in the process of establishing. The number of actors entering the system is increasing every year, and it can clearly be seen that there is a trend of increasing activity in a number of functions.

The first mechanism that seems to induce these positive dynamics in Kenya are in line with Suurs' observation of 'motors of innovation' in the case studies undertaken about the innovation system of The Netherlands and Germany. He described that "[...] in a formative TIS, a first primitive motor [...] typically emerges as the result of a small but dedicated group of enactors" (Suurs 2009, 266). It is when the actions of these (committed) individual actors lead to the improvement of the functional dynamics of the innovation system that more (en)actors may be drawn in, and self-reinforcing dynamics may start to be observed. Enactors are the actors who are "directly involved in simulating the adoption of a particular technology, and are highly dependent on its success" (Suurs, 2009; 43). In the present case study the enactors are those dedicated actors described in the narratives that entered the system in an early stage and contributed significantly to 'knowledge development', 'guidance of the search', 'market creation' and the 'support of advocacy coalitions' functions; LTWP, Craftskills and Aeolus. The development of these functions has clearly facilitated the process for new actors who attempt to engage in wind power development in Kenya. Jacobbson and Bergek observed similar dynamics in their case studies and stated that "[e]ntrepreneurial experimentation is likely to be a first step, or one of the first steps, in discovering new opportunities and beginning the formation of an IS: via reducing uncertainties for followers and influencing their direction of search" (2006;15) It remains to be seen if the new actors that are currently drawn into the system will become 'dedicated enactors' who effectively reduce uncertainty and whether they will successfully develop wind sites.

Next to this, in Kenya, entrepreneurs benefited from the knowledge diffusion opportunities provided by developments in ICT, particularly increased possibility of access to the Internet. This development has significantly contributed as an inducing mechanism to internationally generated knowledge diffusion to Kenyan entrepreneurs. The importance of ICT in a catch-up context is stressed by Fagerberg and Verspagen who state that "nowadays a well-developed ICT infrastructure must be regarded as a critical factor for a country that wishes to catch up. Arguably, this not only holds for production capability but for the ability to innovate as well" (Fagerberg, Srholec, and Verspagen, 2010; 23). Both the importance of these new opportunities for knowledge diffusion *and* the ability to innovate was confirmed in the interviews with actors in both utility scale wind energy and small-scale wind energy. The interviewee from KenGen for example stated that "it is with the internet that I am learning and running a wind section here at KenGen. The internet taught me how a wind turbine works. I read about equipment, I read about grid connection, I went to the environmental impact assessment website to see whether it was really green. It would have been quite expensive to learn what I have learned without the internet" (R2, 2010). He explicitly stated that the engineers from the (Danish) technology provider (from the Netherlands) for the turbines in the Ngong 2 wind power project were less important in transferring knowledge about the functionality of wind turbines than the information the Internet provided. The dominant assumption that 'technology transfer' takes place automatically when foreign technology is installed is an important pitfall to be avoided.

In small-scale wind, the developer of the "Windcruiser" turbine stated that increased access to the internet contributed significantly to his ability to design the turbine (LB2, 2010). He pointed out that the decreasing costs of internet access allowed him to spend enough time online to find knowledge that could contribute to his designs (LB2, 2010). The interview data also supports that developments in ICT increased the ability to adopt off-the-shelf technologies as well. An interviewee from a distributing company for small-scale wind hybrid systems stated that the most important event for knowledge diffusion has been "the rise of the internet. Just by searching on the Internet we learned about how turbines worked, and which turbines we should use to set up this company" (LB1, 2010). This boost to the knowledge diffusion function stimulated these entrepreneurs to develop knowledge of the local market, find the cheapest and most reliable hybrid systems, and find existing knowledge on turbine technology and wind data.

A final important inducement mechanism for potential accelerated adoption started with the increased institutional coherence in the WTIS, which culminated in the publication of the "Feed-in-Tariff: guidelines for investors" document for wind, solar and biomass at the end of 2008. After enactors had entered the system, and the continuous development of an ICT infrastructure facilitated knowledge related activity, the FiT documents were an important effort in the institutional sphere to facilitate negotiations for power purchase agreements and increase trust among actors. This further induced knowledge development, guidance of the search, and market creation, as the document caused an increase in 'expressions of interest' in wind power development at the MoE and encouraged entrepreneurs to start doing wind measurements for their feasibility studies. This in turn contributed to the 'new thinking' across levels of government that reflects a positive increase in the 'support of advocacy coalitions' function from around 2009 onward. These dynamics culminated in the current increase in local knowledge development and the inclusion of wind energy in the yet to be published Least Cost Power Development Plan, increasingly 'guiding the search' for energy solutions toward wind energy.

Thus, it seems that some functions, notably knowledge development, knowledge diffusion, guidance of the search, market formation and support of advocacy coalitions are experiencing an accelerated pace of development in recent years.

4.3 Blocking Mechanisms in the Kenyan WTIS

The positive development of other functions is lagging behind. The current installed capacity for utility scale wind is only 5.2 MW (KPLC, 2009). Besides this, on a total of 15 actors identified that are currently interested in doing 'something' in utility-scale wind, only 3 projects are currently stated in KPLC's annual report to contribute to Kenyan power supply by 2013: LTWP, Aeolus, and Osiwo wind (KPLC, 2009; 9). To the best of our knowledge, only 1 of these projects has signed a signed power purchase agreement (LTWP), and none of the projects are currently already installing the turbines. Next to this, in the interviews multiple interviewees stated that also producers and sellers of "small-scale" turbines are struggling and have problems scaling up. This suggests that there are mechanisms at play that block the positive development of a WTIS, which seem to be particularly revolving around the functions 'entrepreneurial experimentation' and 'resource mobilization'.

The designer of the only patented Kenyan wind turbine, Simon Mwacharo is a pioneer in knowledge creation and entrepreneurial activity in small-scale wind turbines in Kenya. He is a well known actor in the Kenyan WTIS, as people from a variety of stakeholder groups know this key individual, and have without exception stated to be highly sympathetic to his endeavours. Still, his company has problems mobilizing resources to start larger pilot projects. An energy consultant working on the design of the Climate Innovation Centre phrased the reasons for these problems as follows: "There are Simons, and we are thinking a lot about how to spark the growth of these individuals. But currently, the entrepreneurs we have seen lack market knowledge, policy support and managerial skills to effectively scale up" (DG1, 2010). It seems that this leads to a negative spiral, where difficulties with scaling up have an influence on the price of locally produced turbines. This leads to dynamics where the installation of locally produced turbines is avoided in favour of the installation of the cheaper Chinese small-scale wind turbines. This year, UN-HABITAT chose to install two Chinese wind turbines of 20 KW each for an MDG project near Lake Victoria. To my question of whether he knew that similar turbines were produced locally the interviewee from UN answered: "of course I know Simon. [...] But I have to make decisions on quality, continuity, and price. Currently, Chinese turbines are just a safer choice" (LG, 2010).

The lack of market knowledge and managerial skills of a key actor in small scale wind seem to have hampered his ability to mobilize resources for a larger pilot project using his turbines (PRP3, 2010). A lack of resources to scale up has meant that positive developments in terms of price and quality are less easily made.

The lack of these capabilities might be in part due to the lack of experience of Kenyan actors with arranging the whole value chain of medium to large scale wind projects. An interviewee from KenGen points out that the conditions for the concessional loan given out by donor countries for wind energy projects – like for Ngong 2- make sure that contactors from donor countries responsible for the project design and the installation of the turbines. Similar dynamics hold true for the expansion of the Ngong project, as the concessional loan given by the Spanish government this project have the condition that the bids for the contractors are open to Spanish firms.

Theoretically, the entering of foreign firms only contributes positively to the performance of innovation system functions: they bring in knowledge and the positive externalities this knowledge development and diffusion induce stimulate adoption dynamics. The experiences with Ngong 2 however yielded rather mixed experiences in this regard, as the feasibility studies were done by foreign consultants, and the methods and calculations that support these feasibility studies are lost when the resulting study is delivered and the consultant leaves (R2, 2010). KenGen acts on the conclusions but the capabilities needed to get to these conclusions are not transferred if only the final document is presented. Although these dynamics differ between each project where international technology is used, in a formative WTIS like that in Kenya, with a relatively small number of actors, these micro-dynamics are significant for future dynamics. Moreover, because “there is only very limited interaction between universities, research institutions and entrepreneurs” (DG1, 2010) in Kenya, these firm-to-firm or firm-to-individual dynamics are even more important in stimulating capabilities in project development among local actors.

Furthermore, the market formation efforts taken up by the Kenyan government have not yet contributed to effective resource mobilization. This is likely due to the fact that the requirements of finance organisations and the capabilities of Kenyan entrepreneurs are not aligned; this is true for both international finance organisations and for local finance institutions.

An interviewee from DEG disclosed that, “we [DEG] have the money to invest in these projects. There is just a lack of good projects out there” (PRP2, 2010). Until now there have been a few entrepreneurs that came to talk to DEG about setting up a wind project in Kenya, but so far none of the projects were regarded as solid investment opportunities. According to multiple interviewees, there currently is limited knowledge among local banks on how to invest in energy infrastructure projects. An interviewee in finance phrases this as follows: “banks are very liquid, but they need the projects and understand the projects. They have to understand questions like: “If I lend now, how do I expect my money back?” (PRP1, 2010). Banks in Kenya are stated to be relatively competent in asset-finance, but for large private-sector infrastructural projects these competences seem to be insufficient.

Multiple interviewees stated that the problem of mobilizing resources was aggravated by the fact that that the balance sheet of KPLC is not big enough to support the currently planned expansions in power generation. Next to this, IPPs are facing large problems in finalizing the mobilization of financial resources because the Kenyan government is unwilling to provide sovereign guarantees. My interviewee from KenGen asserts that the government -possibly influenced by the financial crisis and the debt problems in Greece and Spain earlier this year- “fears spending because there are so many other sectors that are in demand of the limited resources” (R2, 2010). An opinion article in Daily Nation asserted that the reluctance of the government to issue sovereign guarantees means that several power projects in Kenya are now stuck: “[t]hey include Kenya’s flagship green energy project, Lake Turkana Wind Power, which is unable to progress because it is financial arrangers have indicated that a sovereign guarantee was imperative" (Kisero, 2010). These uncertainties at this moment severely blocking the entrepreneurial experimentation function.

Thus, the findings show that it is mostly getting access to finance that is blocking efforts by entrepreneurs to result in an increase in installed capacity. On the entrepreneurial side this could both in small-scale wind as in utility scale wind be due to a lack in managerial skills and project development capabilities. On the finance institution side this could be due to a lack in energy infrastructure finance capabilities, expectations on the development of demand and problems around the issuance of sovereign guarantees.

4.4 The CDM 'catalyst'

In the second chapter, it was hypothesized that the functionality the Kenyan WTIS would be catalyzed by the existence of the Clean Development Mechanism. This section will provide the results of the event history analysis with regards to this claim.

The results indicate that the influence of the CDM on the evolution of the Kenyan WTIS so far has been negligible. In the event history database, events that related to CDM project activities were absent until May 2010 when LTWP entered the UNEP Risoe CDM/Ji pipeline. Out of 15 stakeholder interviews, the influence of the CDM on the development of a specific system function was pointed out in only one interview.

An interviewee from carbon-consultancy explained that "the CERs in the Turkana project were used as an asset in the power purchase agreement negotiations" (OR1, 2010). It should be noted here that it was not the CDM that caused the LTWP consortium to initiate their activities. An interviewee in utility-scale wind stated: "KPLC was just hard-pressed to buy cheaper power. That is why, in contrast to the 80s and 90s, LTWP could start to think about setting up a wind farm" (R1, 2010).

In most interviews, it came to the fore that actors in the WTIS knew about the CDM but that it was seen merely as a complex element of the larger discourse around climate change and the transition to a green economy. The potential of the CDM to directly stimulate developments in the WTIS has not been realized, as actors in the WTIS indicated to see carbon development as 'too tedious' (R2, 2010) 'too technical' (LB2, 2010) and 'too complicated' (LB1, 2010).

In retrospect, this was not to be completely unexpected. Registration trends show that Africa is severely lagging behind in CDM project registration compared to countries like Brazil, Mexico, India and China (BMIC). From the UNEP Risoe CDM/JI pipeline analysis of August 2010, one can conclude that about 70% of all CDM projects are in these BMIC countries (Risoe 2010). In wind energy, registered CDM projects are highly concentrated in two of the BMIC countries: India and China, together totalling 91 % of the wind projects currently registered or at validation for the CDM (UNFCCC, 2010) with Africa accounting for about 1% of the total number of projects, and to about 3% of expected installed capacity.

It is however interesting to see that as we move along in time, the number of new projects in the CDM pipeline for Kenya is increasing (although the growth rate seems to be decreasing in 2010).

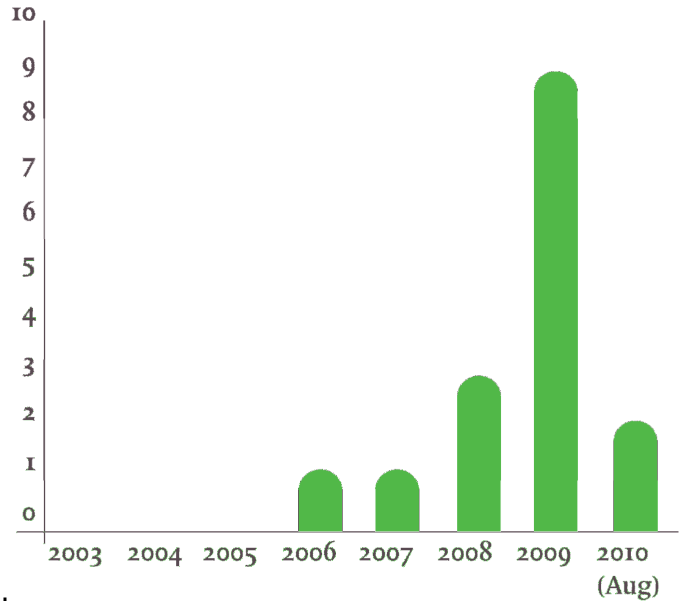

Figure 5: Number of Projects Entering CDM Pipeline for Kenya per Year

While the results of this thesis indicate that there has been little direct influence of the CDM on the evolution of the WTIS, dynamics in current requests for project registration, however, suggests that it could also be too early to observe a clear influence of the CDM on the Kenyan WTIS as CDM project registration statistics only started in 2006.

Thus, based on the stakeholder interviews this thesis concludes that the CDM has only marginally influenced the evolution of the Kenyan WTS until now, and we are forced to reject our hypothesis. However, if carbon development and the WTIS further converge in the future, the role of the CDM in the evolution of dynamics in the Kenyan WTIS might increase.

5 Discussion and Conclusion

5.1 Conclusions

The thesis concludes that the trend patterns for the Kenyan WTIS are in general characterized by an increase in functional activity. The sketches of the functional dynamics by interviewees presented in *Annex A* support this conclusion. It is possible to observe an increase in functional activity at the end of the period of research, where a number of functions show an accelerated increase somewhere after 2006. These functions are knowledge development, knowledge diffusion, guidance of the search market formation and support of advocacy coalitions.

The results in the inducement mechanisms section show that this increase in activity is induced by the efforts of key individuals (also called enactors), developments in ICT, and institutional development in the Kenyan energy sector.

The dynamics around resource mobilization and entrepreneurial activity are different from these findings. Concerning the mechanisms blocking these functions the findings show that the management capabilities in small-scale wind, and initial project development capabilities in utility scale wind are reasons why access to finance is limited. There are also problems observed on the finance side; banks show a lack in capabilities to deal with issues around financing energy infrastructure. Uncertainty about demand and uncertainties around sovereign guarantees for medium for projects are blocking the projects that are already in an advanced stage to start installing their turbines.

Lastly, the thesis concludes that the CDM has only marginally influenced the evolution of the Kenyan WTS, and we have to reject our hypothesis.

5.2 Recommendations to improve the theoretical framework

The results of the thesis shows that the innovation functions approach used in this thesis can serve as a valuable tool in explaining dynamics around the evolution of the Kenyan WTIS. However, one interesting result from the narratives has been unaccounted for so far. In the prelude, it was stated that

"Expatriates with ideas to start wind energy projects in the 1980s were hampered by the fact that most foreign wind energy developers thought Kenya to be 'too risky, and too far away' (R1, 2010)".

These references to Kenya being 'too risky, and too far away' might indicate that one important theoretical consideration has been omitted in setting up the interviews and the analysis; the inclusion of the concept of social capital, and particularly 'trust' in the innovation system functions approach.

Akcomac and Ter Weel point out that social capital and trust are vital concepts in the build-up of an institutional framework that is conducive to innovation. The idea in Akcomak and Ter Weel (2009) is that "more advanced historical institutions have established a higher stock of social capital. Social capital in turn influences the innovation process because the financing of risky innovative projects requires that researchers and capital providers trust each other. When they do so, more successful projects are carried out, which improves innovation outcomes by means of more patents (2009; 544). From this idea it is only a small step to assert that higher degrees of trust also influence the innovation process by means of more effective adoption of new technologies.

The institutional history of independent power production in Kenya started only very recently, with the 1997 power sector reforms and the 2006 energy act being key developments in this respect. With such young institutions, the stock of social capital and trust in the outcome of cooperation between actors in the energy system is likely to be smaller than in countries with an institutional base that has established a higher stock of social capital.

For future research, this thesis suggests to make social capital and trust important theoretical considerations in an innovation system functions approach in a catch-up context. One could perhaps see the concept of social capital as 'the motor grease of the innovation system', signifying that it stimulates self reinforcing dynamics around other functions, particularly 'greasing up' resource mobilization.

Another way in which the concepts could be included is by considering social capital and trust as an independent function. Akcomak and Ter Weel explicitly state that the 'stock' of social capital is important to the innovation process, indicating that a functional approach to the flows within this stock could be appropriate. Characterizing the dynamics around such a function and developing indicators to measure these dynamics could be an interesting path for future research.

5.3 Policy Recommendations

The results of the thesis can contribute to policy insights for the RENEW project in two ways. Firstly, to come to relevant policy conclusions using the results of this case study, we establish which functions in Kenya are performed positively or negatively. We then look at the inducement mechanisms that were identified in the formation of a Kenyan WTIS to draw lessons from the Kenyan case. Secondly, looking at the blocking mechanisms we can formulate recommendations that could deal with the negative development of different functions in a WTIS.

5.3.1 Lessons from Kenya

Firstly, the results of the thesis indicate that key individuals who stimulate functional development in the early formation of an innovation system are important to the future development of an innovation system. If it is possible to identify these key individuals at an early stage in the formation of an innovation system, there can be value in directing special attention to these individuals on a from a national policy level. Polices could for example aim at national strategies for business incubation (see for example Tsai, Hsieh, Fang, & Lin, 2009, Akcomak, 2009b) and specifically direct efforts and funds to incubating the companies of these key individuals.

Secondly, the results indicate that increasing access to the internet has been very important in stimulating knowledge development and diffusion in Kenya. Internet access in Kenya is relatively high with 10% and an average user growth rate of 1,897.8 % over the period 2000-2010 (IUS, 2010). In this respect it compares favourably to other countries in Sub-Saharan Africa like for example Mozambique and Rwanda, which have penetration rates of 2.8 and 4.1% (IUS, 2010) respectively. National and international policy makers could draw lessons from this and alongside efforts to stimulate the adoption of RETs also look at stimulating the development of the telecommunications industry or facilitate access to internet for entrepreneurs.

Lastly, institutional development to stimulate independent power production has played a key role in the development of the Kenyan WTIS. National policy makers in other contexts can draw lessons from this, and realize that a liberalization of the power production market is a first step in stimulating early efforts in locally relevant knowledge development in utility-scale wind energy. Next to this, the results of the thesis indicate that the publication of a Feed-in Tariff for wind energy was a very important event in the increase in expressions of interest for developing wind projects, and the associated knowledge development practices. Other countries in sub-Saharan Africa could draw lessons from the positive influence of a FiT on functional activity in the Kenyan WTIS, and make efforts to draft such a document. There is a lot of room for progress in this area, as Kenya and South- Africa are currently the only Sub-Saharan African countries with a Feed-in-Tariff document for wind energy (GFIT, 2010).

5.3.2 Dealing with blocking mechanisms

Firstly, to deal with the lack of management skills of actors in the WTIS, national policy makers can again draw lessons from other contexts where business incubation has proven to be of great value in promoting SME activity, and facilitate setting up business incubation centres.

Dealing with the lack of project design skills of aspiring entrepreneurs in utility-scale wind is somewhat more difficult and fundamental. While it was indicated that there is money in international donor-based finance institutions, entrepreneurs that do express interest in developing wind seem to lack the capabilities to propose a feasible project. The mobilization of international human resources with project design skills might be part of an answer here, and can be promoted by national policy makers through creating a favourable environment for ex-pats to establish in Kenya. It should be avoided that international actors work on a consultancy basis, so knowledge does not leave the system when projects come to an end.

To stimulate resource mobilization, efforts should be made that aim at capability building relevant to renewable energy infrastructure development in finance institutions. Currently, the International Finance Cooperation in Kenya aims to start cooperation with about six banks (PRP1, 2010) to transfer knowledge on how to deal with financing clean energy infrastructure and other efforts like this should be facilitated and stimulated.

Other ways in which resource mobilization could be stimulated is through decreasing uncertainties around the development of electricity demand; in this respect, an interviewee stated that efforts to interconnecting the African energy grids could be important (R2, 2010). Efforts of the international community could be aimed at stimulating this process.

To avoid issues around getting sovereign guarantees, an idea put forth in the interviews was to set up an international guarantee fund that could take away the uncertainties for local finance institutions (YL, 2010).

References

Abramowitz, M., 1989. Thinking about Growth, Cambridge University Press, Cambridge.

Akçomak, I. Semih, and Bas ter Weel. 2009. "Social capital, innovation and growth: Evidence from Europe" European Economic Review 53(5): 544-567.

Akçomak, I. Semih,. 2009. "Incubators as Tools for Entrepreneurship Promotion." UNU-WIDER research paper, November 2009.

Bergek, A., M. Hekkert, and S. Jacobsson. 2007. "Functions in innovation systems: A framework for analysing energy system dynamics and identifying goals for system-building activities by entrepreneurs and policy makers." In Innovations for a Low Carbon Economy: Economic, Institutional and Management Approaches. Edward Elgar, Cheltenham. Eds. T Foxon, J Koeler, and C Oughton.

Bergek, A., S. Jacobssonb, and B. A Sandénb. 2008a. "'Legitimation'and 'development of positive externalities': two key processes in the formation phase of technological innovation systems." Technology Analysis & Strategic Management 20(5): 575–592.

Bergek, A. et al. 2008b. "Analyzing the functional dynamics of technological innovation systems: A scheme of analysis." Research Policy 37(3): 407–429.

Bergek, A. et al. 2008c. "Analyzing the functional dynamics of technological innovation systems: A scheme of analysis." Research Policy 37(3): 407–429.

Bell, M. and K. Pavitt. 1993. "Technological accumulation and industrial growth: Contrasts betweendeveloped and developing countries" Industrial and Corporate Change, 2:2, pp.157-211.

Bosi, Martina (2010) Carbon finance for climate mitigation and development: CDM achievements, challenges and needed change. OECD Global Carbon Markets Workshop Paris, France April 19-20, 2010

Bradsher, Keith. 2010. "China Leading Global Race to Make Clean Energy." The New York Times. Available at: http://www.nytimes.com/2010/01/31/business/energy-environment/31renew.html [Accessed July 16, 2010].

Breschi, S, and F. Malerba. 1997. "Systems of Innovation – Technologies, Institutions and Organizations." In Sectoral Innovation Systems: Technological Regimes, Schumpeterian Dynamics, and Spatial Boundaries, ed. C. Edquist. London: Printer.

Burniaux, J. M et al. 2009. "The economics of climate change mitigation: how to build the necessary global action in a cost-effective manner." OECD Economics Department Working Papers.

Cowan, R., N. Jonard, and M. Özman. 2004. "Knowledge dynamics in a network industry." Technological Forecasting and Social Change 71(5): 469–484.

Dutta, S. 2005. "Energy as a key variable in eradicating extreme poverty and hunger: A gender and energy perspective on empirical evidence on MDG# 1." Report to DFID/ENERGIA project on Gender as a Key Variable in Energy Interventions. Draft version.

De Lopez, Ponlok Tin, Keisuke Iyadomi, Sergio Santos, and Bridget McIntosh Clean Development Mechanism and Least Developed Countries: Changing the Rules for Greater Participation The Journal of Environment & Development December 2009 18: 436-452, first published on September 16, 2009 doi: 10.1177/1070496509347744

Fagerberg, J., M Srholec, and Bart Verspagen, 2010. "Innovation and economic Development." The Economics of Innovation. Amsterdam: North Holland.

Fagerberg, J., and B. Verspagen. 2009. "Innovation studies—The emerging structure of a new scientific field." Research Policy 38(2): 218–233.

Freeman, C. 1987. Technology, policy, and economic performance: lessons from Japan. Pinter Publishing Ltd. London

Freeman, C., and L. Soete. 2009. "Developing science, technology and innovation indicators: What we can learn from the past." Research Policy 38(4): 583–589.

Freeman, C., and L. Soete. 1997. The economics of industrial innovation. MIT Press, London

Fu-Sheng Tsai , Linda H.Y. Hsieh, Shih-Chieh Fang, Julia L. Lin, The co-evolution of business incubation and national innovation systems in Taiwan, Technological Forecasting & Social Change 76 (2009) 629–643.

GDC. 2010. "Geothermal Development Company" About us. Available at: http://www.gdc.co.ke/index.php?option=com_content&view=article&id=139&Itemid=203 [Accessed June 22, 2010].

Geels, F. W. 2002. "Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study." Research policy 31(8-9): 1257–1274.

Global feed in tariffs, Africa, updated 20/08, 2010 retrieved Aug 28, 2010 at http://www.globalfeedintariffs.com/global-feed-in-tariffs/

Gupta, S., D. A. Tirpak, N. Burger, J. Gupta, N. Höhne, A. I. Boncheva, G. M. Kanoan, C. Kolstad, J. A. Kruger, A. Michaelowa, S. Murase, J. Pershing, T. Saijo, A. Sari, 2007: Policies, Instruments and Co-operative Arrangements. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Hekkert, M. P, and S. O Negro. 2009. "Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims." Technological Forecasting and Social Change 76(4): 584–594.

Internet World Stats. 2010. Internet usage statistics, updated June 30th 2010, retrieved July 17, 2010 at http://www.internetworldstats.com/stats1.htm#africa

IEA. 2009. "The Electricity Access Database" Sun-Saharan Africa Available at: http://www.iea.org/weo/database_electricity/electricity_access_database.htm [Accessed July 4, 2010]

IPCC, 1996. Technologies, Policies, and Measures for Mitigating Climate Change. IPCC Technical Paper 1, by R. T. Watson, M. C. Zinyowera, R. H. Moss, Intergovernmental Panel on Climate Change.

IMF. 2009. World Economic Outlook (WEO) Crisis and Recovery. World Economic and Financial Surveys. Available at: http://www.imf.org/external/pubs/ft/weo/2009/01/index.htm

Jacobsson, S., and A. Bergek. 2004. "Transforming the energy sector: the evolution of technological systems in renewable energy technology." Industrial and Corporate Change 13(5): 815.

Jacobsson, Stefan, and Anna Bergek. 2006. "A Framework for Guiding Policy-makers Intervening in Emerging Innovation Systems in 'Catching-Up' Countries.." 18(4): 687-707.

Keller, W. 2004. "International technology diffusion." Journal of Economic Literature 42(3): 752–782.

Kisero, J. 2010. "It's the wrong way to treat investors in power supply". Daily Nation, May 25, 2010

Kline, S. and N. Rosenberg. 1986. "An overview of innovation" In: Landau, R. and N. Rosenberg. The positive sum strategy: Harnessing technology for economic growth. Washington, DC:

National Academies Press, pp. 275-305.(eds), The positive sum strategy: Harnessing technology for economic growth. Washington, DC:National Academies Press, pp. 275-305.

KPLC. 2009. "2008/2009 KPLC Annual Report". KPLC, Nairobi.Available at: http://www.kplc.co.ke/index.php?id=39

Lall, S. 1992. "Technological capabilities and industrialization." World development 20(2): 165–186.

Lloyd, B., and S. Subbarao. 2009. "Development challenges under the Clean Development Mechanism (CDM)–Can renewable energy initiatives be put in place before peak oil?." Energy Policy 37(1): 237–245.

Lundvall, B.A. 1992. National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning. London: Printer.

M. N Matinga. 2005. Energy as a key variable in reducing child mortality: A gender and energy perspective on empirical evidence on MDG 4. Discussion paper, versión preliminar [en línea], dirección: www. energia. org/resources/reports/2005_emprev_mdg_goal4. pdf.

Narula, Rajneesh. 2003. "Understanding Absorptive Capacities in an "Innovation Systems" Context: Consequences for Economic and Employment Growth."

Negro, S. O, and Hekkert M. P. 2008. "Explaining the success of emerging technologies by innovation system functioning: the case of biomass digestion in Germany." Technology Analysis & Strategic Management 20(4): 465–482.

North, Douglas. 1987. "Institutions, Transaction Costs and Economic Growth." Economic Inquiry 25(3): 419-428.

NYS Energy Research & Development Authority. 2005. Wind Turbine Technology: Overview. NYS Energy Research & Development Authority. Available at: www.powernaturally.org.

Reynolds, David. 2000. One world divisible; a global history since 1945 New York. WW Norton.

Risoe. 2010. "The CDM/JI Pipeline Analysis and Database." August 1st. Available at: http://cdmpipeline.org/ [Accessed June 15, 2010].

Saxanian, A. L. 1994. Regional advantage. Harvard University Press, Cambridge

.

Schwab, K. et al. 2009. "The Global Competitiveness Report 2009–2010." Available at: http://www.weforum.org/en/initiatives/gcp/Global%20Competitiveness%20Report/index.htm

SEFI. 2009. “SEFI: GLOBALTRENDS2009” Available at: http://sefi.unep.org/english/globaltrends2009 [Accessed July 5, 2010].

Smith, Joel B. et al. 2009. “Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) “reasons for concern”.” Proceedings of the National Academy of Sciences 106(11): 4133-4137.

Soethe, Luc, Bas Ter Weel, and Bart Verspagen. 2009. “Systems of Innovation.” UNU-MERIT Working Paper Series, Maastricht

Solomon, S. et al. 2007. Summary for Policymakers. IPCC Summary for Policymakers. In (book): Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.))". Book publisher: IPCC, Geneva, Switzerland. This version: IPCC website. http://www.ipcc.ch/publications_and_data/ar4/syr/en/spms1.html. Retrieved 2010-04-17.

Stern, N. et al. 2006. “Review on the Economics of Climate Change” H.M. Treasury, UK, October.

Suurs, R. A.A, and M. P Hekkert. 2009. “Cumulative causation in the formation of a technological innovation system: The case of biofuels in the Netherlands.” Technological Forecasting and Social Change 76(8): 1003–1020.

Suurs, R. A. A. 2009. “Motors of sustainable innovation: Towards a theory on the dynamics of technological innovation systems.” Department of Innovation and Environmental Sciences. PhD study, Utrecht University

Szirmai, A. 2008. “Explaining success and failure in development.” Open Access publications from Maastricht University.

Theuri, Daniel 2008. SWERA Kenya country report: Solar Wind Energy Resource Assessment. Nairobi.

Toman, Michael, and Barbora Jemelkova. 2002. “Energy and Economic Development: An Assessment of the State of Knowledge.”

UN 2009. “Carbon Finance in Africa.” In Addis Ababa, Ethiopia: UN Economic Commission for Africa. Available at: http://www.oecd.org/dataoecd/29/56/43551050.pdf.

UNEP, 2009 “Climate and trade policies in a post 2012 world”. Geneva: UNEP

UNFCCC, 2010a. “CDM: About CDM.” Available at: http://cdm.unfccc.int/about/index.html [Accessed July 6, 2010].

UNFCCC, 2010b. “Mechanisms under the Kyoto Protocol.” Available at: http://unfccc.int/kyoto_protocol/mechanisms/items/1673.php [Accessed July 6, 2010].

UNFCCC, 2010c “Copenhagen Accord” Bonn, January 18, 2010. Available at: http://www.transport2012.org/bridging/ressources/documents/1/569,notification_to_parties_20100118.pdf

WEF. 2009. The Africa Competitiveness Report 2009. World Economic Forum. Available at: http://www.weforum.org/en/initiatives/gcp/Africa%20Competitiveness%20Report/index.htm

WWEA, 2009. “World Wind Energy Report 2009.” Bonn, Germany. Available at: http://www.wwindea.org/home/index.php

Zeller, T. 2010 “Estimates Suggest Spill Is Biggest in U.S. History - NYTimes.com.” Available at: http://www.nytimes.com/2010/05/28/us/28flow.html [Accessed July 6, 2010].

Annex A Results Drawing Exercise

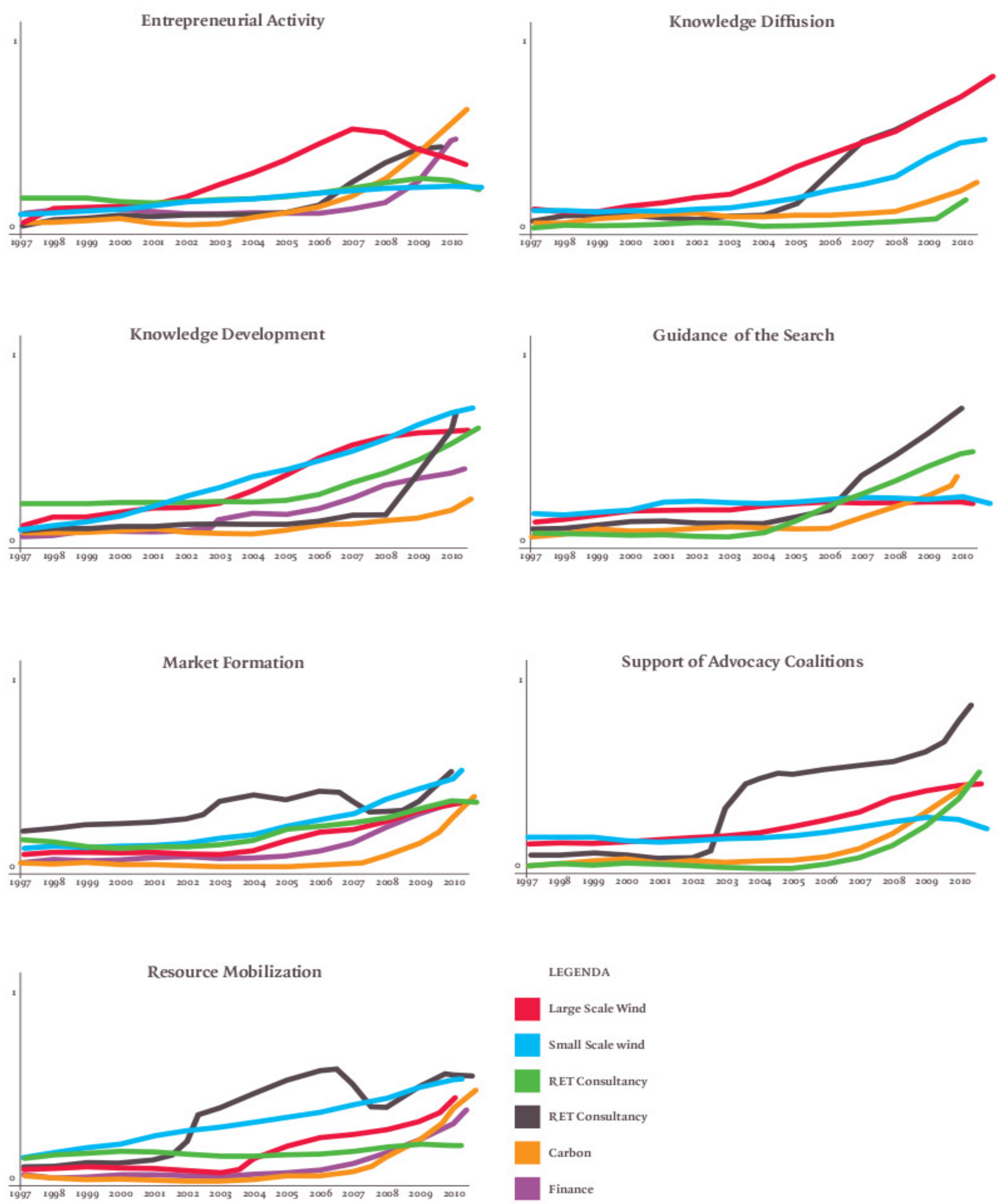

Figure 6: Stakeholder Sketches of Function Dynamics

Annex B Interview Codes

Table 4: Interview Codes

Stakeholder	Colour	Number of Interviews	Codes
UN	Light Green	1	LG
Media	Yellow	1	YL
Ministry of Energy	Dark Blue	1	DB
National Council for Science and Technology	Pink	1	PNK
Utility-Scale wind	Red	2	R1 , R2
Small-Scale Wind	Light Blue	2	LB1, LB2
RET Consultancy	Dark Green	2	DG1, DG2
Carbon Consultancy	Orange	2	OR1, OR2
Finance	purple	3	PRP1, PRP2, PRP3