IVM Institute for Environmental Studies

Business model innovation – key to overcoming the challenges to biogas enterprises in Kenya

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Summary

The history of human development has walked hand in hand with improvements in energy access. This is best illustrated by the intrinsic link between the Millennium Development Goals adopted by the UN and energy. Additionally the threat of run-away climate change prompts the wider adoption of renewable energy technologies, especially in developing countries where classical energy infrastructure is still not in place and thus can be avoided altogether. It is therefore logical that the provision of cheap, clean and renewable energy is the easiest way of addressing both the lag in achieving the targets and thus improving the lives of millions of people living below the poverty line and avoiding severe climate change with all of its implications.

This study will focus on a single renewable energy technology, hailed as a cheap and appropriate way of providing energy for millions of rural households – biogas digestion. Specifically, the research will address the questions of why biogas dissemination has been slow in Kenya and can business model innovation be an important tool in hastening the adoption of the technology. Business model innovation has come into light as an analytical and strategic tool after the boom and subsequent crash of internet-based enterprises. Since, it has been hailed as the main way for multi-national corporations to reach the billions of people at the bottom of the global economic pyramid with their products. Questions about current business models, challenges and opportunities for business model innovation were addressed via an extensive literature review combined with on-site fieldwork.

Based on the results from the above, it can be concluded, that the biogas sector in Kenya has high growth potential which is yet to be captured by enterprises on the market. The main barriers to businesses are the lack of capital and human resource capacity for activities, including a lack of trained technicians and the low awareness and understanding of the technology by the consumers. Additionally the challenges identified in the fieldwork and in literature form a vicious cycle of market non-development and prompt businesses to shift to other opportunities. The high-risk, informal market environment exacerbated by low access to capital drives the biogas enterprises to adopt an opportunistic behaviour and flexible business models. This prevents them from focusing on a single sector while additionally the biogas sector is not lucrative enough to cause them to focus all of their resources on it. These challenges are not unique to Kenya, yet there they are more severe as short-term profit seeking there often displaces actions with long-term benefits for both companies and the sector. Hope for intensified development comes from the commitment of SNV with its successful model from Nepal and Vietnam, yet more coordination with other support organizations and the government is vital for success.

Despite the cyclical nature of the challenges facing biogas businesses and the opportunistic behaviour they've adopted in response to market circumstances business model innovation has been a tool in their strategies for development. The many small scale changes in their business models indicate they do strive for growth, yet they lack the capacity to implement more comprehensive models. Regardless of the entrepreneurs' efforts however challenges in the market are still the same as identified in literature years ago.

Alternative business models however remain an important part of the solution leading to wider biogas adoption in Kenya. There is high-demand for alternative ways of payment that avoid a large up-front payment, and ongoing developments in modular, movable and more compact digesters will surely lower risks of designing and

implementing alternative revenue models. Support by NGOs and the government needs to be non-financial as well as financial in order to prompt enterprises to develop their business models and to allow them to reach the BoP market.

Recommendations can be summed up as follows:

For development organizations

The biogas enterprises in Kenya need support not only in terms of construction workers – quite the opposite, managerial trainings, consulting in legal, accounting and financing matters should be supplied as part of the business development services already provided. Additionally if single-masons trained to build digesters are to become entrepreneurs, they also need to be trained how to do business, instead of just how to construct a biogas plant. On a larger scale, support organizations need to help in the push for quality standards and quality control, and include financing institutions in trainings so as to promote streamlined biogas credit products for both suppliers and consumers. In all forms of support it is imperative that a level playing field for all biogas contractors is preserved so markets operate closer to optimum and a healthy level of competition is present.

For companies

In order to succeed in the years to come biogas contractors in Kenya need to adopt a more long-term view at the expense of some short-term profits and increase quality of the service and product they supply while expanding the level to which they cooperate in the push for standards and in lobbying efforts. Business model innovation in order to supply more value to consumers is a high-potential endeavour and must be explored despite the higher risks involved.

For government

Government institutions of Kenya must be introduced to the wide array of applications and benefits biogas comes with. A better understanding of how biogas as a technology can help promote growth and alleviate current issues is essential for a more coherent support programme. More specifically support can come in the form of lower taxes and import duty on biogas relevant materials and appliances and additions to energy policies that would support small scale dissemination of the technology. On the larger more general level, the legal system and infrastructure base should continue to be strengthened.

1 Introduction

The history of human progress has been intrinsically linked to improved access to energy (UNDP 2009a). Access to clean, safe and reliable energy is an integral part of the development process. The rise in quality of life achieved since the industrial revolution was only possible through the use of fossil fuels – coal and later gas and oil. Yet in the same world where people in wealthy western countries use on average 125kWh/day (MacKay 2008 p105) live a large number of people who still rely on the most basic of energy carriers – firewood and charcoal. They consume less than 50kWh/day and are unable to move forward to modern forms of energy. The so called bottom of the economic pyramid (BoP) – the billions of people in developing countries living with less than $1-2 a day suffer the same efforts and ill side effects that plagued our ancestors millennia ago (Ashoka-Hystra 2009). Energy is not one of the Millennium Development Goals (MDGs) but is a major multiplier of these goals as energy is the prime factor for overcoming poverty and delivering good education and health services, and for creating enterprises, which in turn generate employment and incomes (UNDP 2005a).

1.1 Problem statement

The severe underdevelopment of Africa combined with a history of inequality, tribalism and land disputes has left it lagging in all MDGs despite the efforts of international development agencies (UNDP 2010). Providing a better access to energy is implicitly related to all of the MDGs (UNDP 2005a), yet progress has been slow and currently more than 70% of people in Africa are still relying on traditional biomass (Ashoka-Hystra 2009, IEA 2009).

Worse still there are implications for their shift towards modern energy sources with the threat of climate change and loss of biodiversity. The ideal case would then be to help the people in developing countries to switch directly from traditional sources of energy to modern renewables thus allowing them to avoid the high-environmental impact energy sources that the western countries have used in their progress up the energy ladder. This vision is impeded by the so called 'poverty trap', a gap in income levels between the world's poor and the necessary capital to access the new renewable energy technologies (Azariadis & Stachurski 2005).

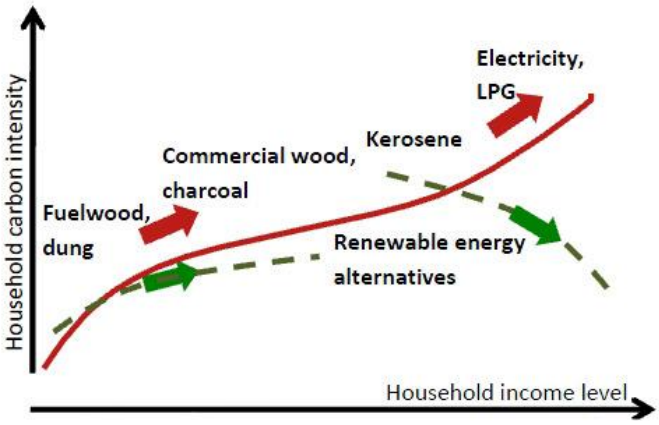

Figure 1. Illustration of the energy ladder with the 'poverty trap'; from Renew Project

One of the lowest capital-intensive renewable energy technologies is the biogas digester, converting animal dung into biogas that can be used for cooking, heating, lighting and electricity generation. Recognized by agencies like UNEP and UNHABITAT biogas is already widely used with great social and economic benefits in China, India, Nepal, Vietnam and others. Following those successes development agencies and independent funds are seeking to promote the technology in Africa and around the world, yet progress has been slower.

1.2 Link to IS Academy

The research done under the IS Academy is aimed at understanding how the Netherlands via its developmental aid and agencies can directly and indirectly promote the use of renewable energy in developing countries. The overall goal of the programme is to improve access to affordable energy, support development, reduce poverty and increase energy security at the national level. The project is commissioned by the Department of Research and Communication (DCO), Ministry of Development Cooperation (DGIS) both from the Netherlands. The Dutch project partners are the Institute for Environmental Studies (IVM) of the VU University, the Energy research Centre of the Netherlands (ECN), Unit Policy Studies and the Department of Environment and Water, Ministry of Development Cooperation (DGIS). This research will help focus and guide the more detailed study to follow.

1.3 Research Questions

In relation to the above this research paper will help focus and scope the work within the biogas business sector in Kenya. Specifically it will identify barriers to biogas enterprises and show which are local and which have been encountered and overcome before in other developing countries. More importantly how companies adapt their business to this environment will show the potential for business model innovation and capacity for overcoming the challenges.

This aim of this research paper will be to strengthen the knowledge base in relation to providing wider access to renewable energy through self-sustained market relations in developing countries. The main question this study will try to answer is can business model innovation overcome the current challenges to biogas enterprises and support sustainable biogas market growth.

In relation to this question the following sub-questions will be addressed:

1. What are the business challenges to entrepreneurs in biogas in Kenya
   1.1. What challenges are shared with other countries and which are local
   1.2. Which are the key factors for successful biogas dissemination in other countries
   1.3. How have the challenges been acted upon by local biogas stakeholders
   1.4. Have there been changes in the barriers due to stakeholder action
2. What are the current business models used by players in the market
   2.1. What are the benefits and shortcomings of current models
   2.2. Why are the current models in use – factors driving model choice
   2.3. Is there potential for a shift to alternative models
3. How can alternative business models alleviate the challenges in the market
   3.1. What alternative models have been used elsewhere and are in consideration locally
   3.2. What challenges can alternative models overcome

1.4 Structure of the report

In the following chapter an overview of the relevant concepts will be presented highlighting Kenya and the challenges to biogas dissemination. In chapter three current developments in market based development efforts and the base of the pyramid (BoP) discussion will be presented. The methodology used in this paper, will be shown in chapter four and in chapter five the fieldwork results will be presented. Results will be discussed and conclusions drawn in chapter six. Recommendations will be given in the final chapter seven.

2 Background

2.1 Introduction

To answer the research questions a good understanding of the progress on the topic so far is required. Local circumstances and developments as well as general information relating to the topic will be presented in this chapter. In section 2.2 the topics of climate change, access to energy and the sustainable development will be covered. The biogas technology and its benefits will be presented in section 2.3. More specific details on Africa and Kenya will then be presented in section 2.4, while section 2.5 will address the local biogas developments in Kenya.

2.2 Sustainable development, climate change, poverty and energy access

When talking about energy and energy access, sustainability has recently become one of the important aspects of the discussion. Development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN 1987) as it is most often defined has gained much traction lately as it reinforces its influence with the discussions on renewable energy, climate change, biodiversity and deforestation. Achieving it however has been a difficult task, so far too complex even for the richest nations of the developed world. Each step of the solution brings about a broad discussion that first needs to be resolved before the right actions are identified and performed. For example biofuels brought about the discussion about fuels competing with food and the renewable energy generation from wind has sparked many arguments from bird mortality and noise levels to landscape aesthetics (MacKay 2008 p109).

Together with these however, the problems with overpopulation, overconsumption and poverty have slowly moved into the mainstream. The main line of thinking is that the Earth can only sustain so much people and that the more people there are and the more they consume the higher the environmental costs and damage – some of it irreversible. Despite some discussion in academic circles, UNICEF has firmly linked poverty and population growth, explaining how development drives lower birth rates, and then refocusing the debate on the issues of poverty alleviation and developmental assistance (Lithlel 1992).

Poverty on the other hand, together with all the other MDGs, has been linked to energy access as shown in table 1 below, thus putting the focus of development discussions on improving energy access.

Table 1. Links between the MDGs and energy access as presented in UNDP 2005b

MDG	The role of energy
MDG 1: Eradicate extreme poverty and hunger	Energy inputs such as electricity and fuels are essential to generate jobs, industrial activities, transportation, commerce, micro-enterprises, and agriculture outputs. Most staple foods must be processed, conserved, and cooked, requiring energy from various fuels.
MDG 2: Achieve universal primary education	To attract teachers to rural areas electricity is needed for homes and schools. After dusk study requires illumination. Many children, especially girls, do not attend primary schools in order to carry wood and water to meet family subsistence needs.
MDG 3: Promote gender equality and empower women	Lack of access to modern fuels and electricity contributes to gender inequality. Women are responsible for most household cooking and water boiling activities. This takes time away from other productive activities as well as from educational and social participation. Access to modern fuels eases women's domestic burden and allows them to pursue educational, economic, and other opportunities.
MDG 4: Reduce child mortality	Diseases caused by unboiled water, and respiratory illness caused by the effects of indoor air pollution from traditional fuels and stoves, directly contribute to infant and child disease and mortality.
MDG 5: Improved maternal health	Women are disproportionately affected by indoor air pollution and water—and food-borne illnesses. Lack of electricity in health clinics, lack of illumination for night-time deliveries, and the daily drudgery and physical burden of fuel collection and transport all contribute to poor maternal health conditions, especially in rural areas.
MDG 6: Combat HIV/AIDS, malaria and other diseases	Electricity for communication such as radio and television can spread important public health information to combat deadly diseases. Health care facilities, doctors, and nurses, all require electricity and the services that it provides (illumination, refrigeration, sterilization, etc.) to deliver effective health services.
MDG 7: Ensure environmental sustainability	Energy production, distribution, and consumption has many adverse effects on the local, regional, and global environment; these effects include indoor, local, and regional air pollution; local particulates; land degradation; acidification of land and water; and climate change. Cleaner energy systems are needed to address all of these effects and to contribute to environmental sustainability.
MDG 8: Develop a global partnership	The World Summit for Sustainable Development called for partnerships between public entities, development agencies,

for development	civil society, and the private sector to support sustainable development, including the delivery of affordable, reliable, and environmentally sustainable energy services.

Building on the facts above the UN has tried to push for a stronger emphasis on developmental assistance and especially in the field of energy (UN 2010). However, the analyses of the IPCC clearly state that, if harmful climate change and other more local environmental problems are to be mitigated, the developing countries cannot follow the path of development that the industrialized nations have. In fact, the most pessimistic IPCC scenarios include just that – regionalization combined with low technology transfer (IPCC 2007c p44).

To additionally compound the problem renewable energy sources, that would offer a way to avoid the fossil fuel intensive development path of the western countries, are still prohibitively expensive. Here the renewable and sustainable solutions dubbed appropriate technologies come in – cheap technologies and products that provide benefits more focussed on the rural poor that comprise almost 50% of the world population and are in biggest need for assistance. Biogas is such a technology.

2.3 Biogas

Biogas originates from bacteria in the process of bio-degradation of organic material under anaerobic (without air) conditions and usually contains 55-70% methane when operating with cow manure and food waste (El-Mashad & Zhang, 2010). The remainder being CO2, and trace amounts of H2, H2S, NH3 and N2.This process of breaking down of complex compounds to simpler ones and methane is an important part of the circulation of nutrients through the biosphere and it is the source of the bulk of natural methane emissions and around half of the anthropogenic emissions (IPCC 2007a). Methane has a global warming potential of 72 over a 20 year time period and is the second most important greenhouse gas after CO2.(IPCC 2007a; IPCC 2007b, p4).

The idea to collect biogas and use it as an energy source emerged in the mid 19th century and entered practice in the early 20th century at the easiest source of diluted organic matter – municipal waste water treatment plants. Since then the technology has spread on its own and through developmental organizations due to its many benefits and has been endorsed by various UN agencies (UNDP 1997).

In developmental programmes the most popular way to disseminate the technology in developing countries has been through individual household level digesters due to the wide availability of family-owned cattle and farming land lack of waste water infrastructure thus hindering the centralized approach. There are many designs of digesters but the most popular are the fixed-dome digester – used widely in China and the floating drum type – popularized in India. Aside from these two major designs new plastic, tubular, soft, movable or super-compact digesters have entered the markets as well. All designs include an (usually) underground airtight chamber where the digestion takes place, a gas holder and a second tank where the digested material is being pushed by the increasing gas pressure. See figure 2 for an illustration of a biogas system.

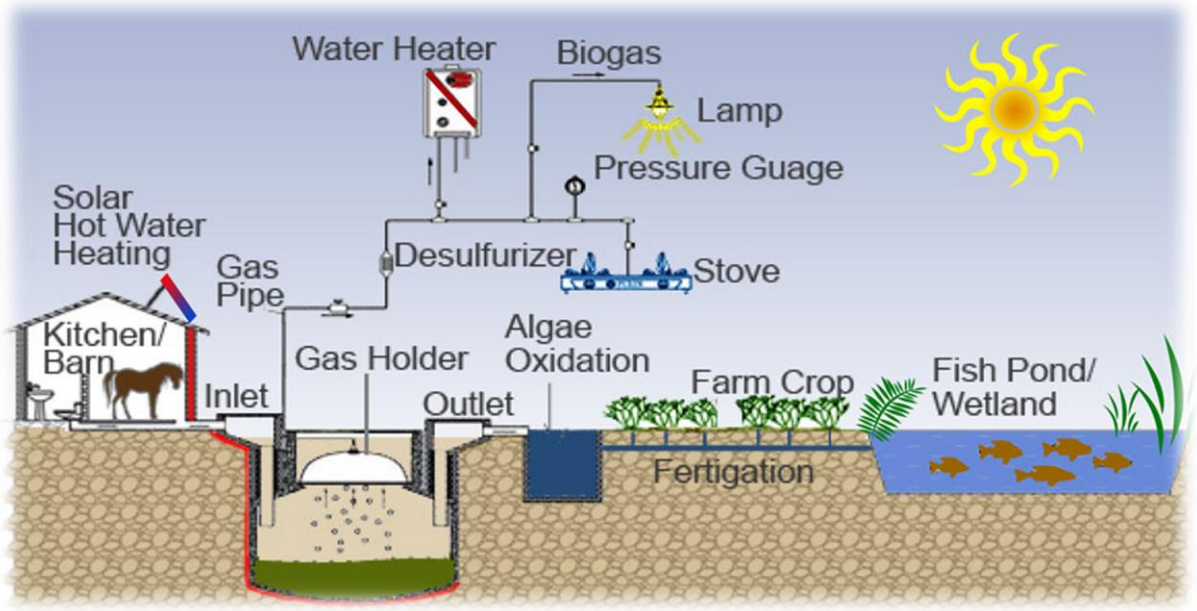

Figure 2. Illustration of a zero grazing unit where manure is collected, biogas digester and various appliances using the produced gas, slurry is oxidized and used as fertilizer

To properly assess the benefits that a biogas digester can offer to a household in a developing country we need to understand the situation with and without it. This comparison is presented in table 2 below.

Table 2. A comparison between circumstances with and without a biogas digester compiled from GTZ-ISAT 1999, Practical action project biogas introduction, Ashoka-Hystra 2009, WHO 2005, Wamukony 1995

Category	Without biogas system	With biogas system
Energy:	Firewood and charcoal have a low calorific value per measure of weight	Biogas is much more calorific allowing for faster cooking
	15-35% of income is spent on energy excluding the time spent to gather firewood	Biogas is produced locally with no external input and additional costs
	When not purchased by vendors, most often women or children have to spend at least an hour per day collecting fuel and then at least as much preparing food	Time savings from collecting firewood, access to energy and light in the evenings provides opportunities for productive, income generating activities and education
	Supplying firewood and charcoal in developing countries often leads to deforestation and all the ill effects it causes	Avoiding deforestation has huge benefits on communities and the world including better soils, better water retention in watersheds, lower emissions of CO2 from soils, etc.
	At least 3 different energy carriers need to be purchased – firewood or charcoal	Biogas is much more flexible and can be used for cooking, lighting, heating and

	for cooking, kerosene or paraffin for lighting and gasoline or diesel for engines	running an engine, at any time and quickly
	Around $500bn are spent annually by the BoP users for energy – a much larger percent of the income compared to developed countries	In suitable locations it takes between 1 and 4 years for households to reach breakeven for their investment. Much faster if there is a productive use of the biogas.
	In order for households to move to modern energy carriers like electricity, grid gas or LPG either expensive infrastructure or costly transport is required	Generates employment and offers decentralized energy generation
Smoke:	Firewood and charcoal produce large amounts of smoke that contains ash, NOX and volatile compounds	Biogas burns without smoke or other harmful emissions
	Most of the cooking is done indoors so impacts on health are large	
	Mostly women and children bare the impacts	
	Lungs, airways and eyes are affected	
	On average indoor air pollution kills 1.6m people per year and accounts for 2.7% of the global burden of disease (in DALYs)	
Manure:	It is a pollutant in waterways	The biogas digester increases the value of livestock by using waste as a feedstock
	It is often a contaminant or supports vectors of diseases	Digested manure is not infectious
	It is a inefficient fertilizer	Digested manure is a fertilizer almost as good as commercial N-P-K fertilizers
	It produces methane emissions	Using the biogas for energy substitutes methane emissions with CO2 emissions which is a benefit from a climate perspective
	In large quantities smell becomes an issue	Smell is reduced

From the above table it is clear that using biogas offers a large package of benefits, particularly for a household in a developing country. This package works toward many of the MDGs both via the improved access to better energy but also through its other advantages. In addition to working toward a better quality of life biogas improves a households' budget first via cash savings from other fuels and second by time savings when compared to traditional solid fuels and thirdly by allowing for longer study hours and productive uses. The UN Millennium Project estimated the impact of providing electricity to a rural Philippine household at $81 to $150 per month due to "improved returns on education and wage income" (UNDP 2005b), while a study in China indicates

that direct and indirect financial benefits from a digester can reach 8% of household income (Xiaohua et al 2005).

Biogas as a technology and complex measure towards the MDG targets has some drawbacks and hard requirements that limit its global dissemination. The technical requirements of current digester designs put limits to viable biogas production. These include stable temperatures throughout the year, at least 30kg of fresh manure and water at the minimum. Since water access is limited for a large amount of people in developing countries (WHO, 2003) and many households do not own sufficient livestock, this would prevent many households from having a personal digester.

On the social side – currently around 2 percent of the work force in SSA countries are employed in the supply chains of firewood and charcoal (Openshaw 2010), without counting the ones working with small scale distribution of kerosene and paraffin and the whole sector for appliances like lamps and stoves. This means a potential large scale shift from traditional biomass could impact all these jobs. This also might indicate some active opposition to any new technology and specifically - biogas.

2.4 Africa and Kenya

Africa is the poorest continent in the world, with a long history of underdevelopment (Myers 2009). It holds around 14% of the population and yet comprises less than 4% of the global GDP (UN 2008, World Bank 2010). The continent has a very low population density and this hinders development efforts by national governments and international donors. Development has been especially slow in Sub-Saharan Africa (SSA) as these countries have only recently gained independence and have since suffered wars, food shortages and a prolonged period of negative economic growth. This has in turn had its toll on natural resources, as firewood has been a primary source of energy and land is being abandoned, burned or managed as a common good due to frequent relocations or traditional practices (Myers 2009).

Households suffer insecurity and the heavy reliance on rain-fed agriculture means dry weather and the projected increase in climate variability will increase their vulnerability in the future. Additionally women and often children spend several hours per day gathering firewood to cover the energy needs of the family, in often life-threatening regions. This loss of time in combination with the low access to appropriate light sources in rural areas directly impacts education and productive activities. This in turn reinforces the gender inequalities in African societies (FAO 2006).

All of the above issues find reflection in the fact that Africa has become the biggest recipient of ODA especially after the Asian economies managed to become self-sustainable. The MDGs put forward by the UN also add to the optimism that Africa might follow Asia's example and develop economically and socially in the medium term.

A worrying fact however has been the drop in ODA and private investments, and especially in energy projects in SSA (Tharakan 2007). As presented in section 2.2, energy access is intrinsically linked to all of the MDGs.

Moving to Kenya, there are some indications that the situation there is better than on average. Kenya is one of the more developed countries in SSA (Myers 2009). By the latest estimates, the GDP per capita at PPP is $1,729, higher than the average for Africa (World Bank 2010). Economic activity has been rising and growth rates have been at a level of 5-7% for the last decade with the exception of 2007 and 2008, when severe droughts hurt the agricultural sector which contributes around 25% to the GDP.

Kenya will become a regional leader in renewables with the Turkana Wind Park entering operation in the coming years and contributing around 310MW, and hydro and geothermal plants supplying more than 70% of electricity in the country (KenGen 2009). Despite these developments more than 80% of the people still rely on traditional biomass for their energy needs and only 15% have access to electricity (ETC 2007). The ban on charcoal from 1986 in Kenya and other African countries has been hard to enforce and instead of protecting forests and prompting a shift to other energy sources has made charcoal a secretive business, prohibiting the use of more efficient methods and technology (Seidel 2008). Currently it is still the most widely used household fuel together with firewood.

The Power Act of 2006, put together by the government, clearly put renewable energy on the priority list, establishing targets and financial support via feed-in tariffs to all popular renewable technologies for electricity generation. These developments so far affect only large scale industrial operations. Additionally the government Vision 2030 calls for complete electrification by the year 2030. This however seems too optimistic as electrification rates and investments have been historically low for current trends to be sufficient. Investments in infrastructure from China have been rising steadily, however.

Despite these optimistic indications, Kenya still has a long road ahead in its development. Approximately 39.9% of the nations' 40m people live below the international poverty line of $2 per day at PPP and more than 50% live below the national poverty line (UNDP 2009b). Kenya is lagging in all MDGs and has no clear plan as to how to gain traction (UNDP 2010). The violent clashes between members of the more than forty distinct tribes, after the challenged presidential election in 2007, hurt both the tourism sector and the economy as a whole.

In these conditions however, biogas is the best possible technology due to its low price, many benefits to households and positive influence on the environment, the economy and the MDG targets in Kenya.

2.5 Biogas in Kenya

Biogas has been introduced in Kenya in the 1970s through financial and technical support by GTZ and other development organizations. Despite the initial optimism, less than a decade later few of the original plants were operational. Usually design or construction mistakes caused plants to perform below optimum or below expectations so they soon were abandoned (Day, et al 1995). These failures still have a significant impact on the biogas market in Kenya today. Since the technology didn't move out of those first pilot or feasibility studies awareness of it is low. Additionally those who know about it are sceptical and wouldn't consider investing in it (Amigun, et al 2006). Despite these obstacles in recent years international support organizations, NGOs and private companies have renewed their push for wide biogas adoption. Currently there are at least four parallel projects promoting biogas:

- ABPP – The African Biogas Partnership Programme is a public-private partnership between the ministry of Foreign Affairs of the Netherlands, Hivos and SNV (Netherlands Development Organization), established to support the large-scale dissemination of domestic biogas in six African countries. The programme was initiated in Kenya at the end of 2009. The Kenya national federation of agricultural producers (KENFAP) is the national implementation

agency. The overall goal of Kenya national domestic biogas programme (KENDBIP) is to improve the livelihood and quality of life of rural households in Kenya and contain the biomass loss through the exploitation of market and non-market benefits of domestic biogas. Specifically the objective during the period 2009-2013 is to assist in the development and construction of 8,000 household-level biogas digesters across the high-potential areas in the country. This will be supported via a 25,000KSh subsidy to end-users for building a digester. The programme supports only a specific design of a fixed dome type digester with sizes from 4 to 12m3. Users apply for the subsidy and are evaluated to ensure all technical requirements are met – a specific amount of dung per day, reliable access to water (KENDBIP brochure, SNV 2010)

- Africa biogas for a better life – The Biogas for Better Life is an African initiative that aims to provide cleaner and safer cooking facilities for at least two million households; improve family health; create jobs; and improve the position of women. The Initiative will be promoted using a market approach, working with audit and intensive marketing programmes. The initiative is aimed to involve local organisations in the promotion, extension and raising user's awareness along geographically concentrated areas in Africa. The program will be run by committed local organisations with demonstrated experience in biogas. Meanwhile, they will be assisted by International expert organisations. The implementers will carry out biogas marketing programs including promotion, development of local businesses, liaising with micro-credit providers, and collaboration with national and local Governments. Working together with Winrock International and ETC-UK the initiative has supported some of the most detailed studies on biogas in Africa and Kenya. (Programme website - http://www.biogasafrica.org)

- GTZ-PSDA – The German government through GTZ together with Kenya's ministry of agriculture are implementing a programme called Private Sector Development in Agriculture (PSDA). The programme looks mainly at supporting interventions in the agricultural value chain to further exploit the market chances and thus increase income for people involved in the sector. After the first year of the project however, it was realized that the waste generated from the activities in the production and processing of the agricultural products could generate extra income if properly processed. In addition a 35,000KSh grant would be supplied to users constructing 12-16m3 plants under the program. REECON, a renewable energy company from Kenya and AKUT Partner, from Germany entered into a contract to offer consultancy services to PSDA. REECON being the local company is in charge of all activities related to training and capacity building, logistical arrangements including awareness creation, identification, supervision, and monitoring of overall activities. The activities are presently limited to a small number of contracting firms and masons. The total number of masons under training is 34 from a total of 12 contracting firms. (ETC 2007, p16)

- Breathing Space – The Breathing Space Fund for Kenya is a programme supported by the Shell Foundation. The overall purpose of the Fund is to improve the health and socioeconomic status of poor households by increasing

access to, and use of, the improved domestic energy products and services that reduce indoor air pollution. These include LPG or cooking gas, biogas digesters, solar lighting and heating systems, improved cook stoves, solar cookers, fireless cookers and other renewable and efficient energy products. The Fund seeks to create a commercially viable model for provision of finance by banks and micro finance institutions to small energy enterprises and consumers in Kenya. At its start the programme worked mainly with liquefied petroleum gas and solar PV products but the success has led to mainstreaming of the loan products and now the local financing institutions are developing a market strategy for biogas loans. (ETC 2007, p18; Programme introduction websites - http://www.kwft.org/news.asp?ID=5, http://www.itpower.co.ke/shell_foundation.htm)

All of these projects come as no surprise considering the potential of Kenya for biogas – with 25% of the GDP generated by agriculture, widespread small scale farming and animal husbandry and stable temperatures all year-round, biogas could provide energy and fertilizer for a huge amount of people that are currently using biomass and are too costly to connect to the grid. In addition, at the micro-level households spend on average around 38,000KSh per year on energy without counting the time and effort spent on gathering firewood manually (Gichohi 2009, p39). This shows huge potential for benefits to all stakeholders via mass dissemination of digesters in rural areas. All of the major support projects have made estimates of how much biogas can be generated, how many households can be reached and so on. While theoretically large due to the availability of livestock and small farms, the specific potential for biogas installations in Kenya varies quite a lot in these assessments. The short table below describes the estimates by source and the assumptions and scopes they use.

In Kenya the burden of disease due to indoor air pollution from solid fuel use for the year 2002 is 2.9% - above the world average of 2.7%, while the total deaths attributable to indoor solid fuel use are 13,000 (WHO 2007).

Table 3. Estimates of technical potential for biogas installations in Kenya according to various studies and the main assumptions used. Compiled from ETC 2007, Gichohi 2009, ter Heegde 2007

Source of estimate	Number of potential biogas units in Kenya	Notes
Biogas for a better Life Initiative	1,259,000 units	Initial estimate for the Biogas for Better Life Initiative for the whole of Kenya, referenced as an SNV estimate
Biogas for a better Life Initiative	320,000 units	Estimate for top 8 districts, and update of initial estimate referenced as a WinRock International estimate
ETC Study 2007	38,000 units	Estimate of top 5 districts based on technical requirements and monthly wage income of above EUR 270. As formal employment is low and wage income isn't essential this figure is probably a severe underestimate.
ETC Study 2007	172,312 units	"Rough estimate" for all 35 districts that cover technical requirements and monthly wage income of above EUR 270.
GTZ Study 2009	240,000 units	Estimate for top 22 districts (noted to be 50% of whole country potential). Estimate is back-calculated from data on livestock, manure and gas generation assuming the use of 16m3 digesters only. An assumption of 6m3 digesters for households would yield a figure twice as high.

Although the estimates for technical potential of biogas in Kenya are quite variable in both values and scope a critical view of the numbers shows where under and over-estimates were made and allows us to conclude that the technical potential for the whole country should be between 200,000 and 600,000 biogas digesters and probably most of these will be small-scale single household 4-8m^3 digesters that can be fed with 2-5 grade or crossbreed grade zero grazing dairy cows. Compared to the 2000 registered units installed of which only a fraction are operational, the gap indeed explains the interest of international agencies and NGOs to step in and realize this potential with all the benefits to individuals, and the economy and environment as a whole.

2.6 Conclusion

Biogas as a technology is receiving renewed interest with the new emerging mindset aiming for sustainability and renewable energy sources. Most importantly in developing countries where households own both land and livestock while lacking infrastructure and clean energy, biogas can offer a significant improvement of quality of life, allowing users to enjoy its many benefits. Kenya is just such a country with the majority of households using firewood and charcoal for cooking and kerosene for light

while deforestation and land degradation is widespread and indoor air pollution effects are severe. A large portion of the income is spent on energy and in poor households women and children spend hours collecting and cooking on the low-calorific firewood. In addition more than half of the households own livestock and land. All these factors support the widespread dissemination of biogas in Kenya. In recent years international NGOs, government agencies and private funds have reinvigorated their efforts to push the technology via capacity building, grants and other forms of support.

3 Theoretical framework

3.1 Introduction

This chapter will present the theoretical foundations of the study. It will show the current perceptions and the leading theories when dealing with poverty alleviation and energy access (3.2), developmental assistance and the shifts in paradigm from aid to market development (3.3), the contribution of business to development (3.4), development at the bottom of the pyramid (3.5) and the business models issues encountered when attempting to do so (3.6).

3.2 The poverty trap and leapfrogging

One of the major issues when talking about development and particularly of poor countries is the fact that despite the amounts of aid provided by the World Bank and the International Monetary Fund (IMF), many of the poor countries are still poor with only a few exceptions. Poverty in developing countries is usually a long-term factor that cannot easily be overcome, unlike the poverty that sometimes emerges in developed countries and lasts for only a short period (Barrett & Swallow 2006). These observations and their persistence give rise to the concept of poverty traps. It has been argued that not only are the poor countries starting from an undeveloped point, but that there are also poverty traps that can be defined as "self-reinforcing mechanisms that cause poverty to persist" (Azariadis & Stachurski 2005). For example energy access has been shown to be a major part of development efforts in the previous sections. People in developing countries however lack the resources to acquire better access to energy and thus their productivity stays low and they cannot escape poverty. The case has been even stronger for the least developed countries, most of which are in Africa, where the capital stocks are very low (Karakezi 2002). Other poverty traps can be observed in the fields of savings and investment, education and technology access. Additionally poverty traps have been shown to exist on multiple scales in the economy – from households to companies to governments (Barrett & Swallow 2006). Development from this point requires external assistance that can break the vicious cycle of the poverty trap and bring sustained economic growth to the country, mainly by investments in infrastructure, education and public administration capacity. (UNMP 2005)

Some scientists however have combined the two problems of poverty traps and low capital stocks with the issues of climate change and sustainable development and come up with the idea of leapfrogging. Previously the developmental path of developing countries was very similar to the one western industrial nations have adopted - a gradual economic growth with major energy sources changing with the increase of income of households. This approach to development however translates into large scale deforestation and large increases in greenhouse gas emissions (IPCC 2007c p44). The logic of leapfrogging goes that, since some developing counties have practically no conventional infrastructure like natural gas networks, power lines, and power plants, instead of following the high-CO2 development of developed countries they can switch directly to renewables when planning power supply (Murphy 2001, Karakezi 2002). In order to overcome this step in capital accumulation an important role for Official Developmental Assistance (ODA) is identified, and increased volumes of aid are prescribed (Murphy 2001).

The poverty traps in energy, education, savings and other fields have been object to intensive quantitative scrutiny. Recent papers have pointed out inefficiencies in aid when tackling the poverty trap effects such as high volatility and unpredictability that hinder progress (Agenor & Aizenman 2010). Additionally there are some studies that show that neither low access to modern technology nor the low-savings low-investment poverty traps can account for real development data (Kraay & Raddatz 2007). Others have criticised the idea of leapfrogging as being impractical and not taking into account local circumstances other than the poverty trap effects (Murphy 2001). In any case the way to support developing countries in the medium term will be through ODA and there is much room for improvement there as the next section will show.

3.3 Aid

Development assistance gained popularity after the success of the Marshall Plan in war-torn Europe after World War 2. The success created optimism about the prospects for helping poorer countries in different circumstances through external assistance. Defined as such in 1969 – "those official transactions which are made with the main objective of promoting the economic and social development of developing countries" later became more and more important and operated with ever larger volumes of capital.

All throughout its existence and use ODA has been a hot topic with arguments for and against it while its efficiency is still under scrutiny. Since the 60s the questions on how to maximise positive effects of ODA and to avoid perverse incentives, ill effects of free markets and promotion of corruption have been discussed both inside the DAC and in the academia. Despite all arguments on efficiency, in the era of the Cold War, ODA also had political and strategic motives behind it. Perhaps best presented by Christopher Kilby in his analysis of World Bank loan disbursements over the period of 1984-2005 showing money flows more easily into countries more closely aligned to the USA (Kilby 2009). Other recent studies however show that aid has a long-term positive effect on economic growth (Minoiu & Reddy, 2010)

With the collapse of the USSR, ODA volumes dropped as could've been expected. Despite estimates that ODA would dry up until 2015, after the Monterrey Conference and the entrance of international terrorism into the social spotlight ODA received a boost back up to a high priority endeavour (Führer 1996, Mavrotas 2009).

Parallel to these developments run the criticisms that object to some inherent assumptions in the idea of ODA – although promoting economic development is one of the main objectives of foreign-aid programs and by far the most publicized, the motivations of donors are seldom altruistic. Even after the Cold War era, aid is given after a careful consideration of the donor's own economic interests (Alesina & Dollar 2000), particularly boosting exports from the donor to the recipient (Putzel 1998; Martinez-Zarzoso 2010; Wagner 2003). Even the official argument that foreign aid can improve investment environment and thus promote foreign direct investment (FDI) (OECD, 2004 - OECD (2004), Trends and Recent Developments in Foreign Direct Investment Paris: OECD) has been challenged in recent studies (Kimura & Todo 2009)

Finally various other biases – for example against bigger and poorer countries (Isenman, 1976) – that appear when dealing with large amounts of capital that can be vital to a developing country's economy have been observed, adding to the list of criticisms.

Focusing on energy and specifically renewables, aid has been comparatively small considering the importance of energy to MDGs and before them to economic

development as a whole. As of 1990 less than 10% of ODA targets the energy sectors in recipient countries and it has been dropping in both absolute terms and as a percentage ever since. In Sub-Saharan Africa both bilateral and multilateral ODA has been "erratic and showing no particular trend" (Tharakan 2007).

With renewables, ODA was only recognized as an international priority in 1981 and even so has been far less in volume than funds for conventional energy. The World Bank provided funds mainly for large hydro and geothermal, for the most part ignoring other technologies. Bilateral assistance for renewables constituted only 3% of the reported energy assistance for the period 1979-1990 with 56% of those going for geothermal projects as opposed to only 2.4% for biogas dissemination (Kozloff, 1995).

Since the 1980s there has been a transition in paradigm parallel to all the developments outlined above. Driven by political developments in the USA and Europe, and studies focusing on free markets multilateral assistance agencies start to adopt new market-oriented development strategies in developing countries as a prerequisite for attracting private investors and achieving sustainable long-term results (Führer 1996).

3.4 Business and development

Business was proposed to be the best driver of development in poor underdeveloped countries and ODA efforts slowly started to shift towards building more sustainable solutions for recipient countries. Development assistance began to be seen as part of a larger comprehensive strategy for commercial development thus spreading free-market capitalism and ensuring economic growth in both the recipient and donor thanks to viable new markets. Additionally such developments would be better for guaranteeing local technology diffusion than many large projects funded and often executed entirely by the donors (Kozloff, 1995).

In 1989 participatory development was one of the two major new notions introduced in DAC conceptual aid policy thinking, together with environmental sustainability following the developments in Rio. Participatory development in particular posits democracy and free-markets with minimum regulation. Coincidently the same recommendation was given by a major study by the Development Centre of the DAC in 1968 (Führer 1996).

The rationale behind this shift to market development is simple and it's based on both classic economic theory and the boost toward free markets in the 70s. When markets are free of distortions they allocate resources in an efficient matter through the actions of many actors striving for their best interest. In addition to standard theory, locally produced goods will be available to a broader consumer base, income from export and internal trade would help households and communities out of poverty and finally formal employment will rise, increasing the productivity of the economy as a whole. This would guarantee a much better developmental effect than the approaches used thus far.

This change in scope and aim of development programs was not spared from severe criticism, both in the ways it is implemented and in the rationale behind it. Questions have been raised on whether the development of markets in developing countries really improves the livelihoods of the really poor, or even whether markets can be free without democracy and sufficient transparency, adequate legal system and with widespread corruption (Singer A. 2006).

The efficiency of the most popular market based developmental support tool – microfinance – has come under scrutiny as well. The practice of giving out loans of $100-$200 was pioneered in India in 1976 by the Graamen bank, and since microfinance has been a major focal point in developmental programmes and especially those promoting renewable energy. Used by only 19% of the worlds' poor however, its impact has been lower than expected (Akula 2008). Popular counter arguments are contained in examples of China and India and other developing countries that sustained prolonged periods of high economic growth after opening and liberalizing their economies. Arguments from both sides seem very strong and the debate is still ongoing.

Directly stemming from the doubts that enough of the economic benefits of free markets trickle down to the poorest of the poor a new idea has been proposed recently that is based not only on the various motivations for ODA – whether used on a project base or for support of the markets as a whole – but calls for the wider involvement of the private sector driven by the promise of a huge untapped market and the profits hidden in it (Prahalad 2001).

3.5 The bottom of the pyramid

The so called bottom of the pyramid (BoP) proposition came into prominence through the work of C.K. Prahalad and Hart (2002) and Prahalad & Hammond (2002) who argue that the billions of people living near the poverty line around the world are a viable target for multinational corporations to explore. In order to visualise the world population by income the studies above present a four-tier categorization as shown in figure 3.

The core of their idea is that despite miniscule individual income at tier 4, the consolidated market consisting of 4 billion people not only can and should be targeted by MNCs but also the provision of products and services would help alleviate poverty. Precise estimates on the market value are not given in the above publications but in the book Fortune at the Bottom of the Pyramid: Eradicating Poverty through Profits (Prahalad, C.K., 2004) the author gives the figure of $13 trillion at purchasing power parity (PPP).

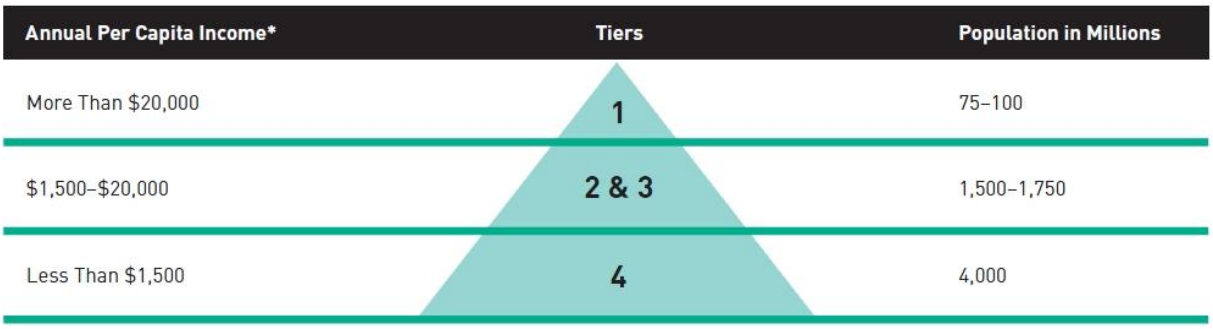

Figure 3. The world economic pyramid as presented in Prahalad and Hart (2002).

The main problem according to the BoP literature is that the 4 billion people in tier 4 are ignored due to their apparent lack of purchasing power and even interest in what MNCs can supply. Because of this the people in tier 4 are stuck in the informal economy and the vicious cycle of low income, savings and investments and cannot benefit from exchanges at the market and modern technology. Targeting the worlds' poor with modern products is a great opportunity to raise many people out of poverty and increase their quality of life. On the other hand the BoP if accessed properly could offer significant returns to companies. Indeed some enterprises basing their profits on high volumes and low margins from both the developing world and in developed countries have risen to fame. The simple fact that the potential market at the BoP is so large would make any product with even the smallest margin extremely profitable.

Alternatively the population forming the BoP can be viewed not simply as consumers to be targeted with innovative products and services but also as producers, although this is a more recent development in the BoP discussion (Rangan et al., 2007). Enterprises could be set up to consolidate and promote specialization, improve efficiency and foster cooperation between thus far separate micro-scale producers in order to increase the maximise the value they deliver to both internal and external markets (Anupindi & Sivakumar, 2007). This in turn will generate more income and thus help alleviate poverty among the poor.

For any business to operate in the BoP market, many considerations must first be made. The circumstances there are totally different from what MNCs from developed countries are used to and experience can rarely be transferred freely from western markets to tier 4 markets in developing countries. Customers at BoP are quite different from western consumers. The time frames for product deployment and customer adoption are very different from what it is in developed countries. Creating and applying a business model poses different challenges in developing countries as well (Chesbrough 2006). The landscape as well is entirely different – most often described as informal.

Informality is a relatively popular term as in "informal sector" and yet its theoretical understanding and its implications are still not clear and perceptions regarding it have changed several times since the term was introduced in the 1972 Kenyan Employment Report by the International Labour Organization (ILO) (Aguilar & Campuzano 2009, Fafchamps 1994). The informal sector is a rather fluid definition of the economic activities that are either illegal, or are small, non-regulated and not easily countable. Examples often include family owned small scale operations, home production, subsistence agriculture, small shops and workshops and so on. These are often combined with tax evasion, avoidance of labour legislation, use of barter and other effects that cumulatively hide a portion of the economic activities in a country from the authorities for various reasons. There are three rather different ways to look at the informal sector:

- The dualistic view regards it as a place where poor unemployed people operate during recessions or because population growth is higher than the generation of job opportunities in the economy.
- The structural view sees it as an inherent part of capitalism acting as an important support for the competitiveness of more formal companies via the cheap labour it can supply.
- The institutional position is that the informal sector is formed and persists mainly because of the over regulation imposed by the governments and actors there seek to lower their costs, time and efforts by operating outside of the formal economic framework (Aguilar & Campuzano 2009).

In any case it is seen as an important aspect of economies and especially in developing countries via the employment and profits these informal businesses create at the lowest levels. Because the informal market is generally larger in developing countries, the shadow sector can be thought of as adding a level of flexibility to the process of adopting capitalism by avoiding regulations that might otherwise make operating a company impossible (Aguilar & Campuzano 2009).

The size of the informal economy in the SSA was 42.2% in 2000, with usually lower levels in urban areas and higher levels in rural settings (Aguilar & Campuzano 2009). As this shadow part of the economies is 'inhabited' by the people at the BoP it is very important to note what other circumstances the companies trying to operate there will encounter.

Some common characteristics of these markets can be drawn from literature and examples (Chesbrough H., et al, 2006; Fafchamps 1994, Fafchamps 1997, Aguilar & Campuzano 2009):

- Contracts are seldom sufficient
- The legal system is weak and courts are slow to act
- Corruption is widespread
- Enforcement of laws, regulations and court decisions is hard
- Relationships are established slower, by first building trust
- Both information and transportation infrastructure is low
- Information flow is often slow or impossible thus creating strongly asymmetrical information distribution – decreasing the efficiency of the markets
- Transaction costs are usually high due to the time it takes to build trust.

Relationships must be built through establishing trust and mutual interest. The same applies for the demand side. The benefits of the products in the local context have to be demonstrated in the local context before customers will buy. This can be an issue for MNCs that are not used to such conditions and requirements for market success. Additionally progress will be slower due to these circumstances.

The BoP theory for poverty alleviation as presented by the original two papers co-authored by C.K. Prahalad has come under serious criticism however. Best articulated by Karnani (2007), many of the assumptions and values proposed have been scrutinized. Market size and value estimates have been shown to be highly overestimated in the initial papers and alternative figures put the BoP size at 2,7bn people taking the potential market value down with it. Additionally the PPP as a tool for both measuring how many the poor in a country are and for estimating the volume of spending among them has been criticized. Market exchange rates would be used to measure profits and combining that with the new market size would yield a figure for total spending of around $300bn as compared to the original estimate of $13 trillion (Karnani 2007). Despite the initial criticism, some have taken the proposition further, focusing more on BoP as producers instead of just consumers (Rangan 2007; Anupindi & Sivakumar 2007) and looking for ways for western MNCs to move into developing markets albeit with less promises of fortunes there. Ongoing research in the BoP field is aiming to distance its ideas from the already familiar market-based approaches to poverty alleviation. (London 2007)

In any case, a new approach to business, different from the one used in the rich western countries, would be needed in order to reach, interact with and profit from the BoP market. In addition to tailoring products to local needs and customs and designing them to be both cheap and reliable, the innovation of how business is conducted is the major challenge in front of enterprises seeking to operate at tier 4. Because of the lack of purchasing power and a single centralized market, new strategies to optimize supply chains and cost structures are required for a viable business at the BoP. Marketing activities would need to be adapted as the standard channels are either unavailable or underdeveloped. A major point is heightening the efficiency through the use of modern information technologies. The ideas of business model innovation, core to both the BoP proposition and the current research will be presented in the following section.

3.6 Business model innovation

Many innovative technologies with significant benefits for the poor in developing countries have not achieved massive market penetration or have been promoted entirely trough aid driven one-off projects. The most successful way to reach not only the tier 4 consumers but those in any market is through a self-sustainable profit driven effort. At the BoP such a business can thrive only by developing and adopting an innovative business model while leaving product design as a second priority (Chesbrough H., et al, 2006).

Business models became a popular topic during the Dot-com bubble at the turn of the century and while trust in online start-ups fell after the sector collapsed, the term has continued on its own both in academic and commercial circles (Osterwalder, et al, 2005). The theory and practice of analysing how businesses create, deliver and capture value, (Osterwalder A. & Pigneur 2010) as a tool to conceptualize the complexities of business has turned into a valuable tool for managers and strategists despite some inconsistencies in the definition and scope of the term.

In recent years the emphasis has begun shifting from product innovation to changing the way business is done, the way consumers are reached, the way the distribution works and so on, driven by successful examples both in the developed world – like Wall-Mart, Amazon or Apple – and the developing world – like Graamen bank in India, the Solar Electric Light Fund, etc (Prahalad 2002c; Comes 2008). Business models in academic literature vary in meaning but this variety can be viewed as a hierarchy of scope and focus beginning with business models as “an abstract overarching concept that can describe real-world businesses” all the way to parts or concrete real world instances of the conceptual blueprint such as different revenue models or the Dell model (Osterwalder 2005). A definition and breakdown of business models that will be used further on in this research is given in table 4 below.

Table 4. The nine blocks of business models as defined and presented by Osterwalder, et al, 2005

Pillar	Business model building block	Description
Product	Value Proposition	Gives an overall view of a company's bundle of products and services
Customer Interface	Target Customer	Describes the segments of customers a company wants to offer value to.

	Distribution Channel	Describes the various means of the company to get in touch with its customers.
	Relationship	Explains the kind of links a company establishes between itself and its different customer segments
Infrastructure & Management	Value Configuration	Describes the arrangement of activities and resources
	Core Competency	Outlines the competencies necessary to execute the company's business model
	Partner Network	Portrays the network of cooperative agreements with other companies necessary to efficiently offer and commercialize value.
Financial Aspects	Cost Structure	Sums up the monetary consequences of the means employed in the business model.
	Revenue Model	Describes the way a company makes money through a variety of revenue flows

As with other conceptual and strategic models the implementation and execution is often not that well analyzed in literature and too much emphasis is put on the particular business model. The way this blueprint or scheme is put to work in the everyday operations of a company will often have an influence just as significant as the model itself and the avoidance of these questions has been a major critique of the approach (Osterwalder, et al, 2005; Shafer S., et al, 2005; Magretta 2003).

Stemming from the popularity of business models as an analytical tool, business model innovation, as a term adopted to mirror product innovation, has been put forward to express the possibilities and need for changes in the way business is conducted in order to both create more profitable businesses in the western markets and to reach the BoP market. Many examples are brought forward to show how even small differences in the way enterprises operate could make the difference between commercial success and failure (Prahalad 2002a,b,c, Chesbrough 2006, Comes 2008). Though described as a complete overhaul in the way companies operate and even more importantly – costly and time consuming – business model innovation is thought of as the key element in BoP market access (Chesbrough 2006). Examples of generic business models used historically for the tier 4 market include:

- Smaller single-use packages – allows for perfect control of spending
- Pay per use schemes – allowing a slow but flexible return of investment in a community- or privately-owned product or facility
- Using shared distribution channels – allowing companies to lower costs on reaching their customers
- Product stripping – delivering a core service or product thus ensuring the price is as low as possible

As the research into accessing the BoP market progresses, additional details will come into light, such as success factors, requirements for poverty alleviation or barriers. Developing a successful business plan in principle takes a lot of time and money. Doing it in a developing country with regard to local circumstances of the heterogeneous BoP market is it even harder. As a result, marketing requires a lot of time, and the adoption cycle is often much longer than in a developed country. Large time investments and resource-intensive efforts such as live demos at the retailers' shops or at markets are required. These activities could make many business initiatives infeasible for MNCs (Chesbrough 2006). Larger companies and product and processing sectors have been shown to have a harder time changing or making their BoP models profitable (Chesbrough 2006).

3.7 Conclusion

Through its history aid has been the object of a debate on whether such assistance can deliver consistent, measurable and long-term positive effects to countries' economies. While the debate continues, as more precise roles for ODA are identified in the developmental process, developing markets and businesses that are self-sustainable and independent of external help has become a more prominent paradigm as a general approach. This shift has also prompted the debate on whether free markets can really deliver better quality of life for everyone at all and especially for the billions at the bottom of the pyramid. Following this debate business conscious people have connected the idea of business model innovation to BoP issues in order to tap into these thus far unexplored markets.

4 Methodology

4.1 Introduction

This chapter describes the methods used and their application details in order to answer the research questions. In addition to a literature the research consists of qualitative data collection via semi-structured interviews with biogas enterprises and

experts as presented in section 4.2. Frameworks and tools used to analyze the data will be presented in section 4.3 and the research scope and limitations will be discussed in the final section 4.4.

4.2 Fieldwork design

During the fieldwork in Kenya interviews probing the ways local enterprises conducted their business and the challenges to their business were conducted. The target group were biogas contractors of various size and company history based both in Nairobi and in rural areas. The chairman and the secretary general of the Association of biogas contractors in Kenya (ABC-K) were interviewed. Additionally biogas experts from GTZ and SNV and the KENDBIP were interviewed. The semi-structured interview can be found in Annex A. For an overview of interviewed companies and experts see Annex B.

4.2.1 Companies

Enterprises operating both on a district level and nation-wide were interviewed. Larger more structured businesses are better represented, however. While this is a bias towards more organized centralized companies which may have different challenges than smaller single-mason entrepreneurs, they are the ones with a more definite business model in the first place and the manpower, resources and knowhow for business model innovation.

Most of the companies were contacted via phone and while few of the large contractors were unavailable for various reasons (Pancom Energy, SCODE, PEMAGI were unavailable), most answered and accepted an interview. All interviews were conducted in good faith and no information was withheld on the basis of being a commercial secret and no questions were avoided. All interviewees were open for further contact and follow up.

4.2.2 Experts

In order to obtain a better overview of the market, biogas experts from the biggest support organizations were interviewed. These include Michael Franz from GTZ, Caroline Toroitich from SNV and the director of KENDBIP. During these interviews the same question list as with companies was used omitting the part probing business models. Their opinion on challenges, market barriers and alternative business models was gathered.

4.2.3 Informal interviews

On top of these interviews several users and non-users were interviewed as an indication of the demand on the market. These interviews were done in an informal and non-structured way mostly probing for the experience, awareness and perceptions of the technology and opinions on prices and interest toward alternative ways to pay. These will be used as a rough qualitative indicator of some sentiments on the demand side and not as a robust market research.

4.3 Analysis tools

The qualitative data obtained from interviews will be structured via several frameworks and tools in order to analyze and present it in a clear and logical way.

4.3.1 Business model canvas

Information on how enterprises conduct their business from the interviews will be presented in a summarized form via the Business model canvas developed by Osterwalder and Pigneur (Osterwalder 2003). The general structure of the framework is presented in figure 4. Since its introduction the business model canvas has become a clear and easy to use tool to visualize and analyze business models, especially in management. Here the canvas will be used to quickly outline a lot of information in a coherent way and it will offer a good structure to analyze the differences between businesses and the possible alternatives.

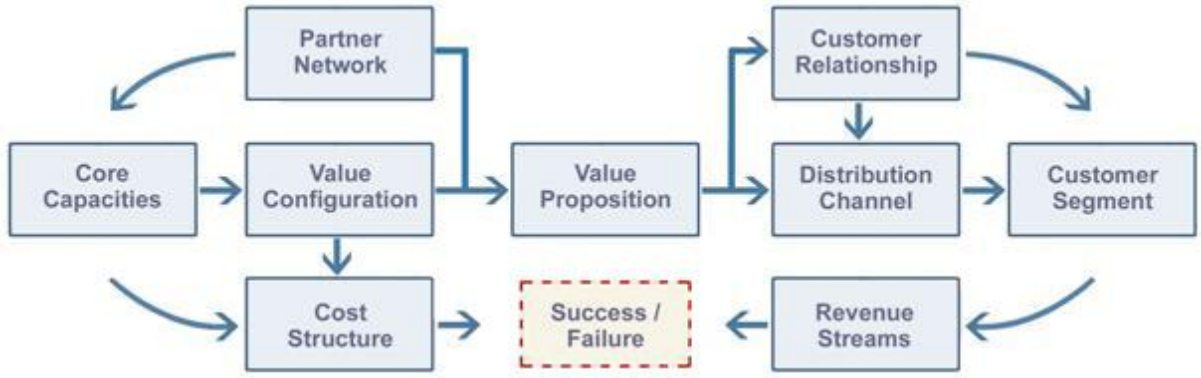

Figure 4. The Business Model Canvas as presented by Osterwalder & Pigneur 2003

As presented in A. Osterwalder and I. Pigneur 2009, the building blocks of the framework are:

- Customer segments: “defines different groups of people or organizations an enterprise aims to reach and serve”
- Value propositions: “describes the bundle of products or services that create value for a specific customer segment”
- Channels: “describes how a company communicates with and reaches its customer segments to deliver a value proposition”
- Customer relationships: “describes the types of relationships a company establishes with specific customer segments”
- Revenue streams: “represents the cash a company generates from each customer segment”
- Key resources: “describes the most important assets required to make a business model work”
- Key activities: “describes the most important things a company must do to make its business model work”
- Key partnerships: “describe the network of suppliers and partners that make the business model work”
- Cost structure: “describes all cost incurred to operate a business model”.

4.3.2 SWOT

The models summarized via the business model canvas will be analyzed via a SWOT matrix. This will allow for a very convenient way to sum up various observations and

insight from the fieldwork in a clear way. Information for this analysis will come from literature, interviews and government reports.

4.4 Limitations of the study

Based on the above several limitations to this study can readily be identified. Firstly experts from academic circles and other support organizations like the Shell Foundation were not interviewed. These could have provided a different and longer-term perspective on biogas developments in Kenya. Additionally experts from financing institutions were not interviewed. The impact should be minimized by the input of GTZ experts as this is the support organization with the longest presence in Kenya. Secondly the questionnaire was kept short due to time constrains and additionally most interviews strayed off topic – mostly into technical details – and thus some elements are missing from some interviews – like opinions on support organizations. Lastly the researcher had no previous experience and very little time to familiarize himself with some core concepts of this research. This might result in limited depth of the analysis and interview questions.

4.5 Conclusions

This chapter described the methods used in the study to answer the research question. Semi-structured interviews were used to collect information from both companies and experts. These results will be presented and analyzed via the Business model canvas and the SWOT framework in the next chapter.

5 Results

5.1 Introduction

In this chapter the results research will be presented. The biogas sector and the business models used in Kenya will be presented in section 5.2 and 5.3, while an analysis of challenges to biogas adoption will follow in sections 5.4 and alternative business models – in section 5.5.

5.2 Overview of biogas sector in Kenya

Via the data collected from both interviews and literature a scheme outlining the biogas sector is constructed as a base for understanding the market. Figure 5 presented below shows the most important stakeholders and their respective relations and actions in the market while some omissions done for clarity will be addressed below.

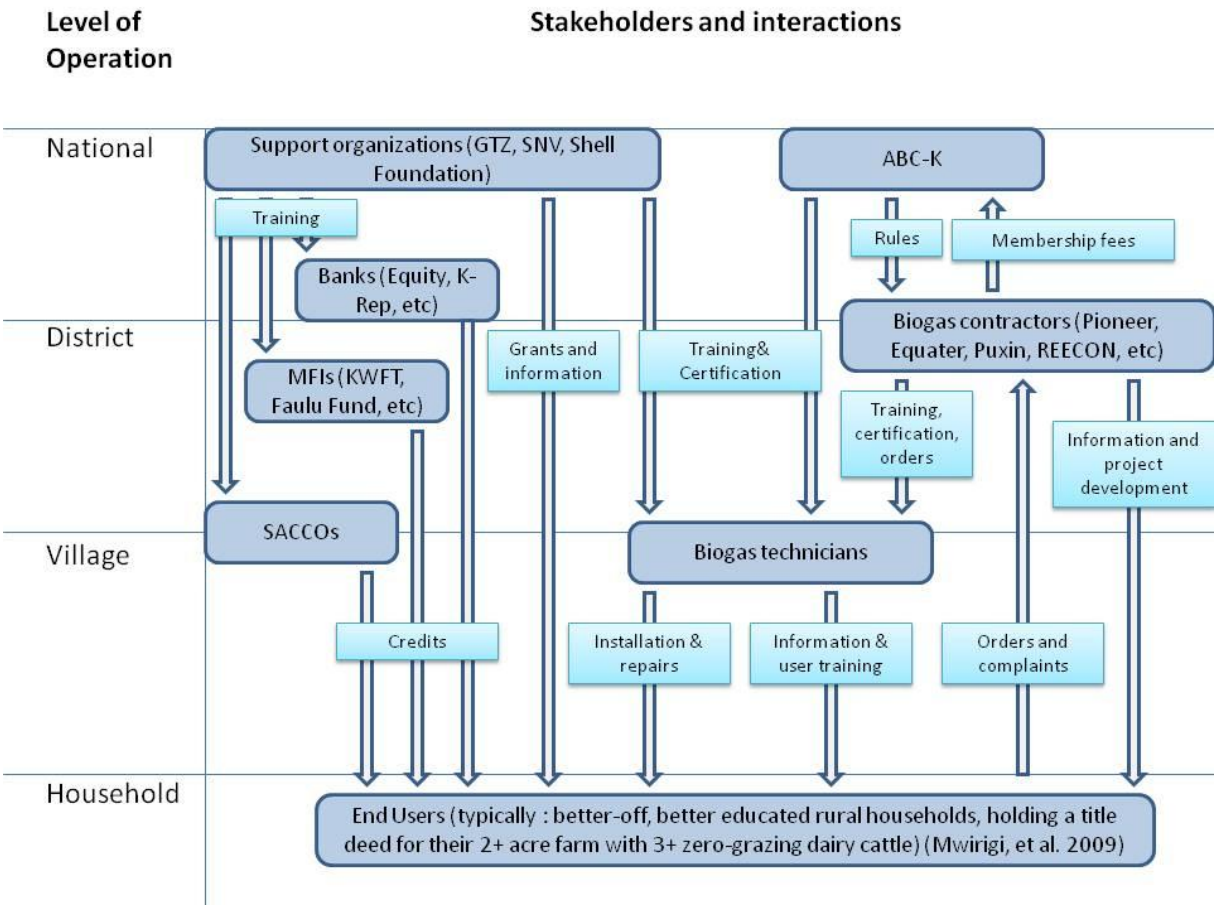

Figure 5. Illustration of the biogas sector in Kenya with some omissions for clarity (compiled via ETC 2007, interviews with Michael Franz, Caroline Toroitich, George Nyamu and Wycliffe Musungu)

The support organizations and the government act on the national level. Support organizations like NGOs or foreign development organizations – like SNV, GTZ, various funds and charities and biogas dissemination programmes strive to support the biogas sector in any way – via studies in cooperation with local academia, provision of grants, loans or covering interest payments. They supply information to other stakeholders and some of them like GTZ provide technical support as well (ETC 2007, Franz 2010). All projects aimed at biogas provide trainings for both masons – to construct biogas plants – and to willing stakeholders from MFIs, banks and the government (Franz 2010; Nyamu G. 2010). The government itself tries to promote the technology albeit targeting only large scale installations so far (Power Act 2006). Ministries of Agriculture and Livestock both support biogas via Farmer Forums, a large outreach network which biogas contractors can use and by promoting zero-grazing, eco-sanitation and the impacts of indoor pollution from cooking with firewood and charcoal (Nyamu G. 2010).

Despite this support the foreign NGOs have been criticised of distorting the market in various ways. Most of the criticism has come from local businesses and can be summed up as follows:

- Support organizations providing grants distort end-user price expectations for biogas plants, thus when their programmes are over and grants are no longer provided many users are not inclined to purchasing the same installations at a 20-30% higher price (Jesse 2010, Musungu 2010, Kariuki 2010).
- Support organizations distort the market by choosing local partner companies thus destroying the level playing field of the market. Biogas contractors that are closer to the support organizations get more business and receive more trainings/support. Aside from this due to the limited amount of trained technicians able to construct a digester the local partner companies pull them from the market via the increase in their business and leave the rest of the biogas contractors hardly able to fulfil their own orders (Jesse 2010).

The Associations of Biogas Contractors of Kenya (ABC-K) acts on the same, national level. While the association is national, however, it encompasses companies and individual masons, mainly from the high-potential districts of south west Kenya so it doesn't really have data on low-potential Northern provinces (Jesse 2010). The main responsibility of the ABC-K is lobbying and providing a base for commonly accepted quality standards, trainings with a common curriculum and certificates and general representation of the members. In return members pay a membership fee of 1000KSh for every digester built (Musungu 2010).

Despite being a rather recent (middle of 2008) organization, the ABC-K is already coming under criticism from some contractors for not being objective and professional (Kagiri 2010), lacking a proactive position, failing to show results (Nyamu J. 2010). Further evidence for the tarnished reputation of the association comes from the fact that even though it was first started by the GTZ with funds and capacity trainings, now both SNV and GTZ avoid working with it directly and both have their own training programmes (Musungu 2010).

Biogas businesses can be found at a lower level in the picture as they are mainly localized in one or two districts while only a few conduct wider promotion and construction activities.

The actions of the companies will be presented and analyzed in detail in the next section.

On all levels there are credit institutions, from banks and MFIs on the national and district level, to Savings and Credit Co-Operatives (SACCOs) at the village to district level. Cooperatives are well established and widely accepted in Kenya. There are more than 4,600 active SACCOs arising from various sectors and offering a variety of services to their members. Originally SACCOs started as associations of milk producers working for a better common selling price of milk which later expanded into milk processing, branding, quality control and financing (ETC 2007, Nyamu G. 2010).

Most of these credit institutions have very limited experience with biogas and lack the capacity to both quickly assess biogas projects and to streamline a credit product targeting biogas (Franz 2010, Kagiri 2010). In addition most of the smaller MFIs don't have access to international capital markets and thus offer only higher cost local capital (Franz 2010). Many interviewees pointed out that for various reasons they would not take a business credit (Kariuki 2010, Kagiri 2010, Musungu 2010). This is in tune with the dislike for credit that users themselves have as indicated by interviews with businesses (Kariuki 2010), support organizations (Toroitich 2010) and several non-users contemplating the purchase of a digester. High collaterals and interest rates, irregular income, high variability of agricultural income all contribute to this avoidance of credit (Franz 2010).

At the village/town level are the biogas technicians and local suppliers of construction materials. The masons and technicians are usually freelance construction workers that sometimes have completed a training session on biogas digesters at one of the many places you can do this – ABC-K, GTZ, SNV and the several companies train and issue certificates (Nyamu G 2010, Musungu 2010, Nyamu J. 2010). A significant portion of these specialists however have been trained into biogas by means of apprenticeship and not direct education which could make them "prone to cutting corners to save costs and time" (Nyamu G. 2010).

Local suppliers of construction materials have no relation to the sector but it is worth mentioning that the material costs of a biogas unit in Kenya are at least twice those in Vietnam (ETC 2007).

Relating to the above, a SWOT analysis will be presented based on interviewee feedback, personal observations and literature.

One of the main strengths of the market is that most interviewed enterprises were in the market for at least 7 years and had moved beyond their technical considerations allowing them to focus more and more on the business perspective – spending more time and money on marketing and polishing their connections and approaches instead of their plant designs (Nyamu J. 2010, Musungu 2010). As the realities of the market became apparent to the entrepreneurs, smaller and smaller digesters have become available allowing a user with 2 cows to be able to benefit from biogas with a 4m3 digester as contrasted by the situation from several years ago when only digesters larger than 10m3 were widely available (Franz 2010, Toroitich 2010). This move to smaller systems has effectively brought biogas to the truly poor users with only a few cows, as those with 5-10 animals are already better-off and have little issue with energy for cooking (ETC 2007 p31). Another positive is the new push for biogas from international development agencies, NGOs and funds, which in turn has put biogas on the government's agenda – adding feed-in tariffs for electricity from biogas although only larger industrial plants can benefit from this policy (Power Act 2006). In addition the wide penetration of mobile phones is allowing faster information access and bigger mobility by companies. On the demand side non-users have expressed interest and enthusiasm when presented with the technology and interviews with people that already have a digester indicate that the comfort and cleaner practices for cooking are

more important to households than a specific break-even period or return on investment (Informal interviews, Mwirigi 2009).

On the opposite side, awareness is still very low as information campaigns and marketing efforts have been fragmented and scattered both in time and target districts. In addition the different players in the market still do not cooperate in other activities like training courses for technicians, building and appliance standards and so on. The ABC-K itself has been strongly criticized by both support organizations and members. The economic landscape in Kenya also weakens the sector through the bad infrastructure, more expensive imports due to taxes and customs fees (Kagiri 2010) and the low volume of sales means both no economies of scale and no strong focus on biogas.

When asked about opportunities most interviewees indicated that there is demand and the high-potential districts are still unsaturated with digesters and only information barriers stand in their way. As the charcoal ban gets more and more enforced and prices of firewood and other fuels increase biogas will become an ever more viable solution for households. Coordination and a level of cooperation between the actors on the market will yield fast results in the form of better quality control, standards, better planned grants by support organizations and a single training curriculum and certificate for technicians and masons. On an even more positive note MFIs are streamlining products for biogas with better interest rates and new local designs are being brought in to offer even bigger flexibility and lower prices.

The threats to the sector come from various directions – climate change might cause more draughts that impact access to water required for the digester while other renewables are taking bites off the pool of potential biogas users sometimes with more focused promotional campaigns or international support. The users while able to access credit are still very much wary of it as anecdotal evidence reminds them they could lose everything if they use it. The same applies for companies and this could hinder the new efforts for wider dissemination. On the other hand the government will aim at full power grid coverage by 2030 as indicated by its plan Vision 2030 and the businesses themselves lack the capacity to deliver many digesters even where there's stable demand.

Table 5. SWOT analysis of the biogas market in Kenya as per interview data, ETC 2007 & Gichohi 2009

Strengths	**Weaknesses**
• Many companies active in market • Companies have been operating for a long time and have experience • Technological issues put aside to a large extent • Full range of sizes available • Biogas is on the government agenda • Support organizations have a renewed interest in biogas • MFIs, FIs and especially SACCOs are accessible to virtually everyone • Communication increases efficiency of market • End-users are positive of the technology in principle and don't approach it with strict ROI targets	• Awareness still low • Little coordination of marketing/awareness campaigns • Little coordination between support organizations, ABC-K and the government • Lack of strong support by government, taxes and customs fees are high. • Supply of new digesters is low, and below demand in some areas. • No quality standards accepted • ABC-K not delivering required results • Economic circumstances dictate a high price of building materials • Biogas appliances can be hard to obtain or of low quality

	• Companies rarely focus on biogas • Bad infrastructure drives costs up
Opportunities • MFIs and FIs are slowly moving toward biogas focused loans offering better conditions • Charcoal officially banned, while prices of other fuels rise • In the regions with highest potential there is still minimal penetration of the technology • Coordination between players could result in quick adoption of standards, subsidies and training programs • New technologies and designs are moving in and allowing for more flexible solutions • Kenya is one of the more progressive countries in Sub-Saharan Africa and as the economy grows costs will drop and market for biogas will grow	**Threats** • Other renewable energy technologies moving fast and promoted strongly • Vision 2030 aims at 100% electrification • End-users and businesses avoid credit • Users will demand low prices even after grant programmes have ended • Support organizations might leave the market in a severely distorted state • Climate change might cause more droughts or endanger agricultural income of households

5.3 Business models in use

In the market environment described in the previous section local businesses have adopted several strategies in order to survive. In this section the average biogas enterprise will be described via data from interviews. The way they do business will be sketched in order to analyze where improvements can be made.

All but one company (Puxin) had several businesses between which efforts and capital were divided allowing the company to follow opportunities as they arise without committing efforts on a single business and thus falling victim to the fluctuating demand for any of its products. Most biogas contractors were working with all types of renewable energy sources including small scale solar PV, self-contained solar products like lights, mobile chargers and radios (Musungu 2010, Kariuki 2010, Nyamu J. 2010,). Improved firewood and charcoal stoves were popular among biogas enterprises as well. These different branches of the businesses most often emerge as entrepreneurs followed market opportunities, including but not limited to external support programs offering trainings or other assistance, as was the case with the now closed Pemagi Energy (Musungu 2010) and other active enterprises (Nyamu J. 2010). In other cases a core business capacity was used to branch into other markets – companies like Kentainers and Pioneer technologies both work with plastics so making a tank that can be used as a digester was relatively easy and this flows naturally after their involvement with eco-sanitation programmes (Nyamu J. 2010, Madoc 2010). Other still grew from general engineering business that allowed them to move quicker into the fixed dome digester market as GTZ started promoting it (Kariuki 2010, Musungu 2010).

It must be noted that aside from these companies, that have at least some form of formal structure, staff and capital, most of the biogas builders are little more than a single mason trained in one of the many alternative training programs and then encouraged to start his own business (Musungu 2010, Franz 2010). These types of entrepreneurs spend even less time on biogas, rarely investing money and effort into

promotion or other activities. They usually have employment as construction workers and live off it, while biogas construction is seen as a source of income on the side if anyone expresses interest (Musungu 2010, Toroitich 2010, Nyamu G. 2010). Often these technicians are employed on a project basis by the larger enterprises to construct the plants after their own teams have conducted assessments and measurements and construction materials have been procured (Nyamu J. 2010, Kariuki 2010). Trained mason entrepreneurs rarely have any form of business training and even when there is work with biogas they don't make enough profits to support a business structure (Nyamu G. 2010). Instead they live off the income they receive and use general construction work as a back-up. In the majority of cases however masons drop out of the biogas market and keep the market starved for skilled technicians. However, while they are on the market, they pose a serious competitive threat to larger biogas businesses as they can offer extremely low prices. This often is combined with misleading or exaggerated claims about the technology in order to seal a deal. After completing a digester they rarely offer any post-installation support as due to the low price, quality is questionable (Musungu 2010).

In light of the above only the larger more established companies will be analyzed via the business model canvas.

Biogas businesses that consist of more than a single mason are still usually small, with up to 7 employees including the founder, that have entered the biogas business following a market opportunity with little previous experience (Kagiri 2010). These will most often be people with a technical background that promote biogas and when there are orders take measurements, prepare projects and later oversee work by hired external construction workers. They will also double as sales representatives and will do follow-up support for clients. A single office position is usually present for administrative work, logistical support and any other non-technical work that arises. Due to this simple structure all the companies have the variety of business models is minimal (see figure 6).

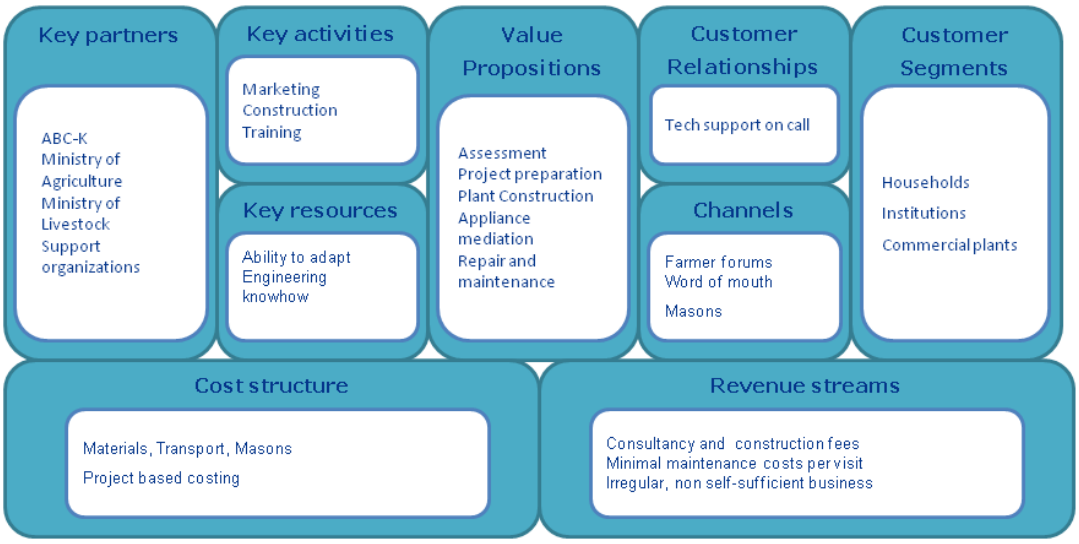

Figure 6. Business model used by the average biogas contractor in Kenya sketched using the business model canvas framework

Companies rely on the many different businesses they have in order to sustain the company. As such the biogas side of their business is not self-sustainable with a single exception (Puxin). They construct digesters using externally hired technicians managed by their own specialists.

Contractors do not focus on any particular customer segment as the market size is too small and they cannot afford to reject requests of any size – from 4m3 household digesters to industrial sized plants of 150m3 and larger. In several instances several companies have joined their efforts when large digesters have been ordered (Musungu 2010, Kariuki 2010). The smaller sized digesters from 4 to 16m3 for domestic use are the biggest share of sales however as large projects are still quite rare.

In order to serve their clients the companies will first conduct a survey, measurements and evaluations in order to come up with the best solution for the user. The result of this work is a proposal to the customer for a specific size and type of plant, list of materials necessary, optimal position of the plant and price estimates for both materials and work. The average company will then construct the plant and offer some way of procuring biogas appliances – either reselling them (SCODE)(Kagiri 2010), adapting LPG ones (Pioneer) or just pointing the user in the direction of a local distributor (Equater). This concludes the exchange and from here onward only on-call maintenance is offered.

The average company reaches its customers via several channels – most important of them are the farmer forums organized by the Ministry of agriculture where contractors get a chance to present the technology free of charge or for a minimal fee and spread fliers (Nuamy G. 2010, Musungu 2010). The outreach networks of the ministry are also a way to spread information via brochures. Aside from these main channels companies will try to present biogas at fairs and shows; the price of participation however is often prohibitive (Nyamu J. 2010, Kariuki 2010). Printed media in general is the most used channel of communication and while radio and TV have been tested with good results they are too expensive for regular use (Musungu 2010, Kariuki 2010). Additionally – word of mouth or the information dissemination efforts of employees and hired masons are important to the average business.

The companies rarely have any longer-lasting relations with the customers. They will assist with technical issues if the users call to complain yet no active connection is kept open in order to evaluate success, offer additional services or to ask for assistance in promotional activities.

Following the description above – the key activities companies focus on are marketing via the channels they use, actual work on plants – a single plant requires around 15 days work for a single mason including several days of project assessment and instruction for construction workers and last but not least – trainings of new masons.

In all activities biogas contractors rely heavily on their partners which usually include the ministries of agriculture and livestock with their farmer forums, outreach networks and push for zero grazing and sustainable agro practices. Additionally the ABC-K while criticised still offers a quality guarantee to users and requires a 1 year free maintenance to be provided by members; Support organizations that assist with grants for users or trainings for technicians and push for standards and quality control are also often a close partner to businesses.

Key resources of the average biogas enterprise are the core well educated engineering specialists. In addition the ability to survive in periods of low demand while using the same resources shows a great capacity to adapt to any circumstances.

As for revenue generation – the average company will get income only from sales of plants, while post-installation maintenance fees are usually very low and barely cover costs for repairs and visits (Musungu 2010, Nyamu J. 2010, Kariuki 2010). Recently most companies also charge a fee of around 5000KSh for the initial project phase (Musungu 2010, Kagiri 2010). This has been adopted as a practice since users decided to just take the project papers and measurements and then go with them to a local construction worker asking him to build the digester. The negative effects of this are twofold as the local masons are rarely trained to work with digesters so will produce a low quality plant, and on the other hand the biogas contractor has invested money and time in the project while seeing no return (Musungu 2010).

On the cost side – companies will usually spend a large part of its income on actual construction work – paying local masons and travelling costs for technicians that manage and control the operations. In addition to these, expenses on salaries and marketing activities take the rest of the budget.

In order to evaluate the above business model in relation to the business landscape in Kenya and the specifics of the biogas sector a SWOT analysis will be presented.

Table 6. SWOT analysis of the business model of an average biogas contractor in Kenya

Strengths	**Weaknesses**
• Flexible, able to adapt to circumstances and survive long periods of low demand • Low-fixed costs • Low marketing costs via ministries' outreach networks • Betting more on the more influential face-to-face marketing • Training of masons means people with proper experience are available in target districts.	• Due in part to lack of effort – low results • No strict accounting and poor understanding of returns and marketing efficiency • Lack of post-installation contact and support might cause companies to miss some user dissatisfaction and the following abandonment and negative publicity • Lack of proper instruction manual is sure to cause low quality maintenance by users and possibly dissatisfaction or damage to plant.
Opportunities	**Threats**
• Support organizations widen the market via the grants they provide and awareness raising campaigns • Ministries support biogas both directly and indirectly and this will only grow as their activities get more streamlined • Locally developed technological innovations like ultra small or modular digesters will prod business model innovation so enterprises can take full advantage of them. • Simple unencumbered structure is easy to change in response	• When support organizations withdraw grant programmes quality might drop in order to retain prices low • Due to lack of focussed effort and large enough market MFIs might be reluctant to roll out a biogas product • Dissatisfied users are more vocal than satisfied ones so negative perceptions can spread fast if performance is unsatisfactory • Single-masons enterprises will often exaggerate benefits in order to seal a deal causing dissatisfaction in users

The above description of business practices shows only the most common way to do business. There are however notable exceptions and differences that reflect the effort of companies to innovate in their business models and improve their results. They will be presented in section 5.5 after the challenges that have prompted them are revealed in the following section.

5.4 Business challenges

The various challenges and barriers from both the fieldwork and the academic sources were grouped in several categories as defined in table 7 below.

Table 7. Elaboration of categories of challenges to be used in analysis throughout the paper

Category of challenges	Explanation of contents
Low awareness and understanding of technology by users	Customers and potential customers: 1) Don't know about the existence of the technology 2) Don't know how to obtain a digester 3) Have unfounded expectations of the technology
Poor management and maintenance by users	Customers: 1) Disregard their daily duties in feeding the digester 2) Put indigestible material in the unit 3) Mismanage piping and appliances 4) Damage the plant or fail to protect it from damage
Lack of coherent government support	The government does not: 1) lower taxes and import duties 2) contribute to technology promotion 3) stimulate research 4) provide benefits to customers and companies
Bad design and low quality construction	The biogas plants are built: 1) With inherent flaws in design 2) With poor quality materials 3) By non-trained technicians
Contractors disregard technical requirements of digester	The biogas plants are built: 1) Despite lack of sufficient daily supply of water or dung 2) Ignoring temperature variations that would impact digestion process 3) Disregarding energy needs of households (too big or too small)
Poor/misleading promotional message	Stakeholders use an inefficient promotional campaign or exaggerate biogas plant capabilities
Lack of capital and Human Resource capacity for activities(incl. technicians)	Companies lack funds, know-how, experience and human capital to execute activities they would like to
High investment costs	End-user prices are prohibitively high

Poor customer support by companies	Customers do not receive satisfactory post-installation support, including maintenance, repairs, cleaning services, etc.
Bad infrastructure	Customers are spread over a wide area and roads are either in bad condition or lacking at all, phones are not widely used
Poor access to credit	Customers and companies cannot take a loan for financing a purchase or ongoing activities due to lack of financing institutions or a prohibitive cost of capital – high interest rates and high collateral
No standards and quality control	Biogas digesters and appliances need not conform to preset quality standards, quality of both is not checked and is often unsatisfactory
Poor social acceptance	1) A biogas digester clashes with traditional ways of cooking 2) working with manure is deemed unacceptable 3) Using the gas or digested slurry is viewed as unhealthy 4) Is viewed as lowering the social status of the user and labelled as "Pro poor"

Asked about the challenges to biogas in Kenya most interviewees, both businesses and experts started off with the well known issues of high prices, low awareness and lack of external support. Some however moved beyond these more trivial and well documented barriers and pointed out some very specific obstacles in the way of companies and the sector as a whole. Table 8 below shows the identified business challenges in the fieldwork, following the same categories as above.

Table 8. Challenges to biogas enterprises identified by interviewees in fieldwork

	Companies				Experts		
Challenge category	David Jesse	George Nyamu	Wycliffe Musungu	Josphat Kariuki	Michael Franz	Caroline Toroitich	George Nyamu
Low awareness and understanding of technology by users	√	√		√		√	√

Poor management and maintenance by users		√			√		
Lack of coherent government support				√			
Bad design and low quality construction						√	√
Contractors disregard technical requirements of digester							
Poor/misleading promotional message		√					√
Lack of capital and HR capacity for activities(incl. technicians)	√	√		√	√	√	√
High investment costs				√		√	
Poor customer support by companies							
Bad infrastructure							
Poor access to credit	√			√	√		√
No standards and quality control						√	
Poor social acceptance	√	√		√			√
Other	√	√	√	√		√	

The "Other" challenges identified were as follows:

- Unfavourable perceptions of the technology driven by observed failures (Jesse 2010, Nyamu J. 2010)
- Support organizations distort market by lowering price expectations of customers and by failing to preserve a level playing field by choosing local partners that can pull the limited number of trained technicians off the labour market due to increased business. (Jesse 2010)
- Users dislike working with manure (Nyamu J. 2010)
- "*Whatever happens, blame falls on the digester*" (Nyamu J. 2010), including issues with smells, health, crops.
- ABC-K is too new and weak for proper lobbying (Nyamu J. 2010)
- Single masons are really strong competition for a company, because they only have to support themselves (Musungu 2010)
- High quality work requires time and thus gets expensive and lowers the maximum volume the company is able to supply (Musungu 2010)
- GTZ and SNV refuse to work with ABC-K. They don't want the association to be the main player they would support. Sometimes companies train masons and

then SNV and GTZ take them in their own training workshops and push them toward founding their own companies and so companies lose (Kariuki 2010).

- KENDBIP still targets better-off people as current market grants are still too small for poor people. A government support program like in Nepal where people pay less than 20% of full price would be best (Kariuki 2010).
- Lack of a coordinated qualification system for masons - ABC, SNV and GTZ have their own (Toroitich 2010)

Similar to the above, an analysis of the literature is presented in table 9 below.

Table 9. Challenges to biogas enterprises identified in literature and local studies

Challenge category	ETC 2007	GTZ-ISAT 1999	Parawira 2009	Amigun 2006	Day 1990	Gichohi 2009	Mwirigi 2009
Low awareness and understanding of technology by users	√	√	√	√			√
Poor management and maintenance by users	√		√	√	√	√	
Lack of coherent government support	√		√	√		√	
Bad design and low quality construction	√		√	√	√	√	
Contractors disregard technical requirements of digester	√	√	√			√	
Poor/misleading promotional message	√	√	√	√		√	
Lack of capital and HR capacity for activities(incl. technicians)	√		√	√			
High investment costs	√	√	√			√	√
Poor customer support by companies	√		√	√		√	
Bad infrastructure	√			√			
Poor access to credit	√			√			
No standards and quality control	√					√	
Poor social acceptance		√			√		√
Other	√	√	√	√		√	

As with interviewees, studies found some specific challenges included in the "Other" category and presented below:

- Inadequate construction equipment (ETC 2007)
- The presence of bedrock hinders or prevents excavation of the site (ETC 2007)

- It's not really useful – used just for a status symbol – doesn't target a specific issue (GTZ-ISAT 1999)
- Might not ease the workload on the user (GTZ-ISAT 1999)
- Has a lot of competition – both traditional, local and in renewables (GTZ-ISAT 1999)
- Hostile social climate and political instability put off international support intiatives and businesses (Parawira 2009)
- Disregard for local curcumstances and uses of gas (Parawira 2009)
- Weak legal system (Amigun 2006)
- No printed manual for users (Gichohi 2009)

A simple comparison between those identified in literature and in interviews will be presented, using the same categorization (see figure 7). As could be expected interviewees never mentioned negative aspects of their own actions but those categories are still included in order to present the full picture drawn in literature. All of these challenges affect businesses and while some might not be explicitly challenges to a single company they will be a barrier to its growth.

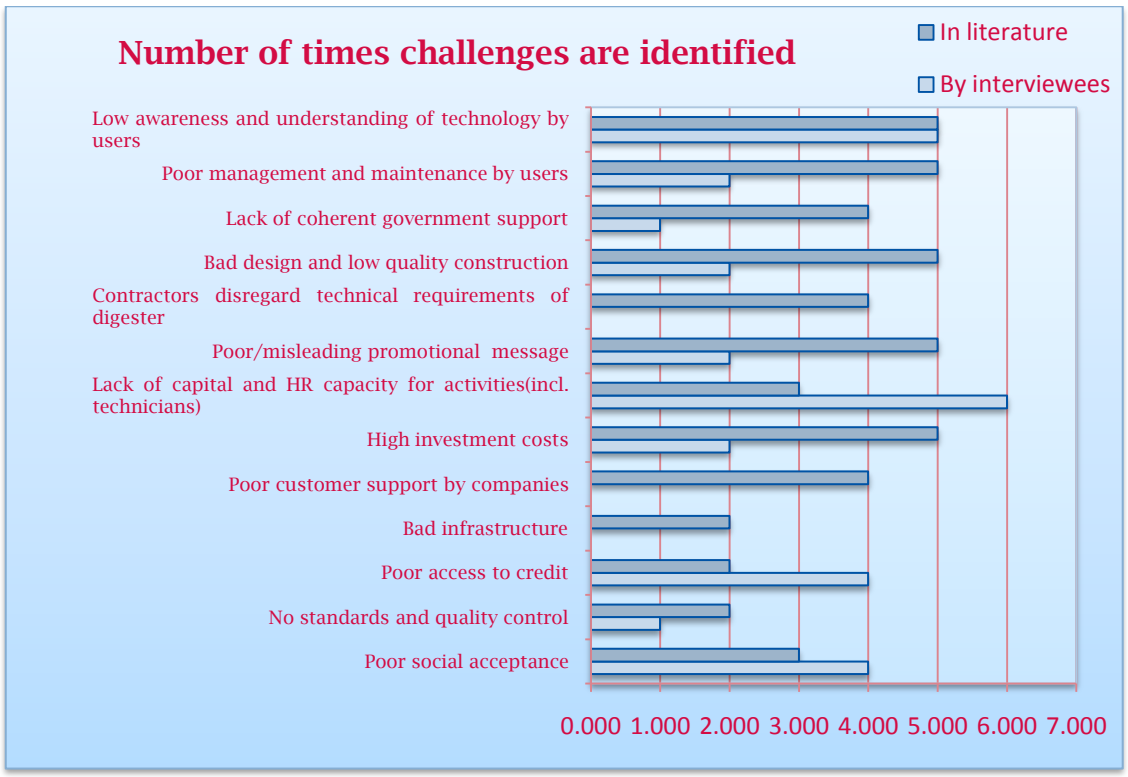

Figure 7. Histogram of challenges to biogas identified by literature vs. stakeholders, standardized to closest category where necessary.

What is immediately obvious from the figure above is that there are serious mismatches of challenges identified by NGO reports and academia and those pointed out by local stakeholders despite the fact some of the reports were based on interviews as well. Some of these differences are due to the different viewpoint – no business would admit that poor quality work, disregard for the basic technical

requirements (as in dung/day, water access, optimal size of plant, etc) or poor customer support following the installation is a problem for them despite the fact that this creates negative publicity following a failure or operation below capacity.

Surprisingly government support seems to be relatively better covered in literature compared to the feedback from companies. While some identified the lack of bigger involvement of the institutions it was rarely a major issue to entrepreneurs.

Two major differences which go in the opposite direction are seen in the lack of capacity and the access to credit. Almost all local companies pointed out that they don't have enough properly trained people and capital for good marketing activities and most importantly that well trained technicians are extremely scarce. According to ABC-K officials around 100 technicians have been trained in the last year by support organizations and around 50 by the ABC-K itself and the companies that do trainings independently (estimates by Musungu 2010). However technicians receiving training from support organizations are encouraged to become entrepreneurs themselves and often after several attempts become discouraged due to lack of business training and leave the market. Even internally trained technicians are not guaranteed to stay available as more secure construction work pulls them away from the biogas sector (Toroitich 2010, Nyamu 2010). Literature rarely identifies these shortages of human capital as a major issue.

Access to credit is another barrier given much more attention by businesses than in studies of the sector. This however doesn't only mean that there are no financing institutions like banks, MFIs or cooperatives. Instead most companies were unhappy with the high interest rates given to both users and businesses – around 15-21% from banks and 12-16% by MFIs and SACCOs – and the high collateral (Toroitich 2010, Kariuki 2010). This is partly explained by the inability of smaller local FIs to access international capital markets and the lack of expertise to assess biogas projects and thus lower risk and rates (Franz 2010). As a result none of the businesses and potential users interviewed would even consider taking a credit.

Despite the many serious challenges to biogas entrepreneurs, encountered in Kenya, academic literature identifies many of the same issues in other countries, even ones considered examples of successful wide adoption of anaerobic digesters like India and Nepal (see table 10)

Table 10. Linking of challenges identified in literature for Kenya to those from other countries.

Category of challenges in Kenya	Also identified in
Low awareness and understanding of technology by users	Pakistan (Mirza 2009), Thailand (Prasertsan 2005)
Poor management and maintenance by users	India (Quadir 1995)
Lack of coherent government support	India (Quadir 1995), Pakistan (Mirza 2009), Thailand (Prasertsan 2005)
Bad design and low quality construction	Tanzania (Mwakaje 2007), India (Bhat 2001), General (Jarach 1989), India (Quadir 1995)
Contractors disregard technical requirements of digester	India (Bhat 2001), General (Jarach 1989)
Poor/misleading promotional message	-
Lack of capital and HR capacity for activities(incl. technicians)	Tanzania (Mwakaje 2007), Nepal (Gautam 2007), India (Jarach 1989), India (Quadir 1995)

High investment costs	Tanzania (Mwakaje 2007), General (Jarach 1989), Pakistan (Mirza 2009), Thailand (Prasertsan 2005)
Poor customer support by companies	India (Bhat 2001), India (Jarach 1989), Pakistan (Mirza 2009)
Bad infrastructure	Nepal (Gautam 2007), India (Quadir 1995)
Poor access to credit	India (Quadir 1995), Pakistan (Mirza 2009), Thailand (Prasertsan 2005)
No standards and quality control	Pakistan (Mirza 2009), Thailand (Prasertsan 2005)
Poor social acceptance	India (Jarach 1989), India (Quadir 1995)

As shown above, most of the barriers that interviewees identified are not unique to Kenya and are sometimes typical of other technologies. This can be explained with the inherent issues of changing traditions, supplying costly new products to poor and rural customers and developing a whole new market for the new solutions.

5.5 Business model innovation

Despite the many challenges described in the previous section, there are opportunities for overcoming them and enabling the market to grow faster while being serviced by self-sustainable companies. In fact local companies have taken steps toward bringing innovation in their business models and overcoming the barriers that are in place. The table below shows some of the unique actions taken by some companies (see table 11).

Table 11. Business model innovations implemented by biogas entrepreneurs in Kenya

Section	Innovations	Representative company	Target barrier
Customer relations	Post-installation contact with new offers for appliances	Puxin	Poor customer support
Customer relations	Regular follow-up calls and visits	Equater WES	Poor customer support
Revenue	CDM financing for new plants via external offsetting company	REECON, Equater WES and others	Non-specific – increase in profits
Cost	Customers left to purchase construction materials over time as cash is available	Equater WES, Puxin	High investment cost
Value proposition	Manual for user	Pioneer technologies	Poor management
Value proposition	Better project proposal – with choice for user between sizes, types and so on for digester instead of top-down	Puxin	Non-specific – better customer service
Key partners	Local suppliers will offer better prices to user as he is purchasing the construction materials	Puxin	High investment costs
Key partners	Offering MFIs and banks assistance in evaluating biogas projects	Puxin	Low access to credit
Key	Technical innovations including	Pioneer	High investment

resources	movable, flexible and modular designs	technologies, Kentainers	costs
Key activities	Outsourcing trainings to ABC-K or the Polytechnic	Pioneer technologies, REECON	Low quality construction, Lack of HR capacity

These changes to the way business is done offer a solution to some challenges or provide an alternative element in their own business model that could give them a competitive advantage over the average biogas contractor. Additional possibilities will surely become obvious in case a proper market research is conducted allowing the companies to cut more costs or provide more value to the customer in order to make the prices more reasonable.

As the high investment cost is one of the most popular barriers to wider adoption of biogas identified in literature this study adopted an informal focus on alternative revenue models for biogas enterprises. Surprisingly however local businesses were not as unanimous in pointing it out as a major barrier standing in the way of their business growth. To some extent this may be explained by the fact that currently only better-off people are purchasing digesters and companies are focusing on raising awareness in this niche instead of broadening their reach. More objectively speaking however (see figure x) high costs indeed are the second most important challenge to mass biogas dissemination after awareness issues. The study carried out by ETC and commissioned by the Shell Foundation calculates that in Vietnam the cost of an 8m3 fixed dome digester is less than half the cost of a similar system in Kenya mainly due to the cost of construction materials (ETC 2007). Aside from the underlying issue of construction materials these facts point towards a need for alternative revenue model where cash need not be presented up-front as that will not be possible for the average household even with the grants offered by support organizations currently.

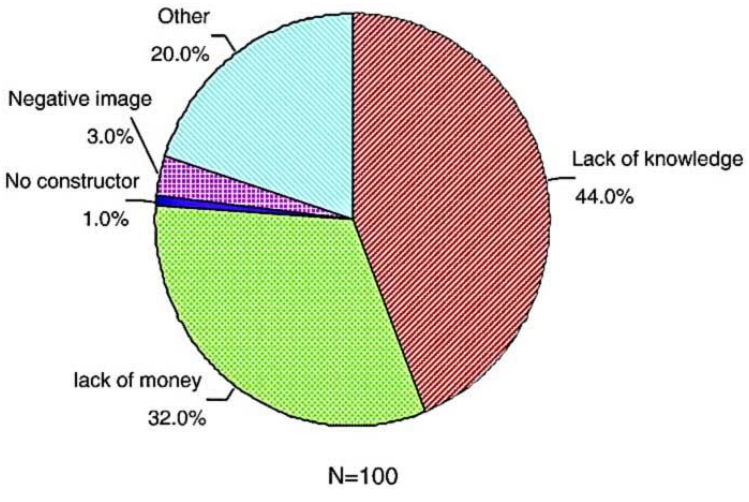

Figure 8. Reasons for Non- Ownership of a Biogas Plant; from Mwirigi, et al; 2009

Indeed preliminary results from focus group discussions among users and non-users conducted at the same time as this research by Gintare Jonusauskaite indicated an interest in payment schemes where the large up-front payment is avoided by spreading it out through time.

As a follow-up to this preliminary indication some of the interviewees were presented with alternative revenue models that would eliminate the need for a large lump-sum payment thus overcoming the high investment cost barrier to consumers. The models presented to interviewees all start with construction of a digester for a small up-front payment aimed at ensuring sufficient engagement by the customer. Further cash flows follow either a standard leasing scheme with regular small payments or a payment for amount of gas consumed at a pre-determined price until breakeven and sufficient profit are reached. Often mentioned issues with these alternative revenue models was the bigger risk endured by the company, the need for initial capital that is unavailable currently and the inability to plan and execute the projects in a way that guarantees profitability while managing risks (Franz 2010, Musungu 2010, Kagiri 2010). Unanimously interviewees agree that these business model innovations are beyond their current expertise and capital capacity and doubted their success in principle.

5.6 Conclusions

This chapter presented the results of the field study in Kenya. The biogas sector was outlined and studied showing how the various types of stakeholders interact and the flows of information and money. An analysis of how businesses operate in these circumstances was presented via the business model canvas and the SWOT tool. Additionally the challenges to biogas enterprises and biogas dissemination were presented and analyzed using both literature and interview data as a basis. Finally the steps companies have taken to alleviate the impacts of these changes via business model innovation was presented and further opportunities for changes and adaptations were pointed out and will further be analyzed in the following chapter.

6 Discussion and conclusions

6.1 Introduction

Following the results given in the previous chapter and returning to the theoretical framework, presented in section 3, a more in depth analysis of the sector and the barriers to the enterprises will be conducted in this section. The research questions brought forward in section 1 will be addressed. The challenges and the opportunities for business model innovation will be discussed in section 6.2 and 6.3 respectively. Section 6.4 will focus on the changes needed that are beyond the reach of individual actors in the biogas sector. Conclusions will be drawn in the final section.

6.2 Challenges

As shown in the previous chapter the biogas sector in Kenya faces many strong barriers and businesses have to navigate between the various challenges. Most important to the biogas enterprises seems to be the lack of capacity to conduct the activities they would like to – this includes marketing and sales efforts. An indirect observation from the fieldwork is that enterprises mostly lack in-depth financial know-how that would allow them to manage risks and loans in a way that would guarantee sufficient profits. Anecdotal evidence suggests single-mason biogas enterprises suffer from this even to a larger extent as they cannot calculate sufficient profits in their prices and make only enough for them to live off. A major note in the lack of human resource capacity is the insufficient numbers of trained masons that can build a quality biogas digester. Despite trainings by various stakeholders, most of the trainees will exit the market, turning the time and efforts invested in them into a loss, especially for private companies that train technicians. Surprisingly this lack of knowledge and people is not emphasised as much in market studies and research on the topic.

Government support is an issue that is often mentioned in literature but very rarely by interviewees. This can be explained either by their disillusionment in the government and a strong conviction in corruption – a widely spread phenomenon in Kenya according to the Corruption Perceptions Index results for 2009 (http://www.transparency.org), or with a limited awareness of what measures the government could actually take in order to support the sector. The latter can be supported by the fact that most of the companies' efforts had been in the engineering part of the business. Most interviews often digressed into technical discussions and the most active support program until recently – the GTZ-PSDA has had an extremely technical lean as opposed to a wider spectrum of activities (Franz 2010). In any case, the government can and should be an active stakeholder even without lobbying from the sector, as biogas can be seen as a multiplier to growth via its many benefits.

Another important observation from the fieldwork results is the low access to credit, even despite the many banks, MFIs and SACCOs. The lack of biogas-specific streamlined low-rate products stifles the market in two ways – first by hugely decreasing the potential customers to those with a secure cash income of a sufficient size, and second by limiting the companies to financing operations only with available cash and limiting their growth. This means the bulk of the customers will not be BoP users as intended by support organizations. The better-off and the urban workers will be the more likely market causing the paradox that some of the rural rich will think of the digester as a status symbol, purchasing it without a particular reason (GTZ-ISAT 1999, p20), while others see it as a "pro-poor" measure (Nyamu G. 2010) because of

the NGO promotion campaigns and avoid purchasing it. It is unclear which effect is stronger, although companies indicated that their customers are likely to be the better-off. This can most likely mean that only the very rich in rural and urban areas that can base their decisions purely on status considerations are experiencing such effects, while the "simply" better-off farmers are still considering the benefits biogas offers and are able to purchase the system. In conclusion, currently biogas systems in Kenya are not a BoP product due to high prices and requirements of land and livestock. They need to be marketed with larger grants and in smaller sizes in order to be attainable to the truly poor.

An important note in relation to intensified support organization activities is the perceived market distortions these create. In other countries such market distortions are parried by long-term commitments and a high level of coordination, however such programmes have yet to be implemented in Kenya. A more worrying development is the recent rift between support organizations and the ABC-K. Their relations have been tested after mutual accusations of fund misuse (Kimani 2008). Additionally SNV and GTZ both train masons but the newly trained technicians are not introduced to the ABC-K. This causes two-fold issues – firstly there are a multitude of certificates for biogas technicians and this can confuse customers and erode trust. Secondly the new technicians trained by support organizations do not have support from the association and do not need to adhere to its requirements in terms of quality and service. This undermines the ABC-K's efforts and leads to some of the new trainees to leave the market soon after completing the jobs assigned to them right after NGO trainings (Musungu 2010, Franz 2010).

In addition to the variety and severity of barriers identified in Kenya, they are not independent challenges that can be overcome one by one with specific benefits from the steps forward. The challenges identified so far are interconnected in a network where each causes another forming a vicious cycle (see figure 9) that requires coordinated actions from more than one direction in order to be broken.

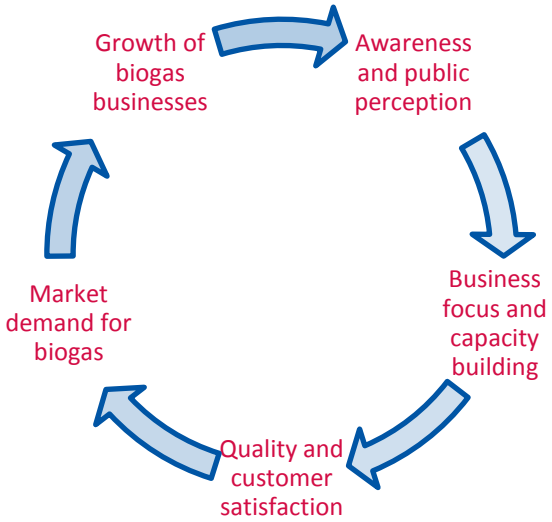

Figure 9. Illustration of challenges and their interrelations showing the vicious circle in the biogas sector in Kenya; a more detailed illustration of the challenge map can be found in Annex C.

As presented in the figure above, the main line of the vicious cycle is the one beginning with the negative image of the technology, created in the early years of biogas dissemination efforts in Kenya. Most plants failed or worked below capacity and were abandoned leaving an impression in users that although scientifically curious the technology is unreliable. This in turn, combined with the low awareness amongst potential users, left the market with a minimal demand for biogas. Faced with this situation entrepreneurs that are capable of supplying biogas have no other choice but to switch to other opportunities and work on biogas only whenever a customer asks, but leaving little manpower and financing to promoting and marketing the technology. This is expressed in the multifaceted lack of focus and in turn the lack of capacity for construction, maintenance and marketing. All of these operations are then performed with more improvisation and less planning and coherent effort. Because of this, quality suffers and the bulk of the potential users remain uninformed while the few that purchase a digester often get a low-quality product that fails or operates below capacity. Even worse entrepreneurs struggling to seal a deal will promise more than the product can deliver and even well performing plants will leave a user disenchanted and dissatisfied. All of the above will keep reinforcing the negative image of biogas. With time, as the cycle goes on, the government and MFIs will also not focus on biogas, seeing it as a failed innovation.

The challenges to biogas enterprises are quite severe and the cyclical nature of their interaction further hinders companies in overcoming them. In any case enough information was presented to allow the addressing of the main research questions.

As shown in the previous chapter the top two main challenges to biogas entrepreneurs in Kenya are:

- the lack of capital and human resource capacity for activities, including a lack of trained technicians
- the low awareness and understanding of the technology by the consumers

The next two places are taken by challenges that are more external to the companies – the social acceptability of the biogas system and the access to credit with better contract terms. An important note should be made that these challenges represent only the internal viewpoint of enterprises – while whole-market issues, identified in literature and objectively through analysis of cases, like low quality construction, negative perceptions among potential customers and poor post-installation support are rarely acknowledged by the companies themselves as they have to accept some responsibility. Thus the main barriers pointed out in interviews are either demand-side issues or are capacity issues that underlie the sectors' lobbying for external support.

Also, as indicated by the study of the literature, a large portion of the challenges businesses encounter in Kenya are also familiar in other parts of the world including India, Tanzania, Thailand, Pakistan and Nepal – popular examples of successful biogas dissemination. It must be noted however that not a single source examining the barriers on those countries reports issues that fit the "poor/misleading promotional message" category. The barriers belonging in the "disregard of technical requirements" category are also not frequently described. This is perhaps an indication that biogas businesses in Kenya are so pressured by market circumstances that they forfeit long-term considerations and focus on the short-term profits. With such a short-sighted approach however they continuously erode the biogas market and the trust that customers have in the technology. Failing to recognize this stark truth when interviewed means that enterprises are either unaware of the consequences of their actions or, what is more likely, that they would rather avoid mentioning them. Radical

improvements in success rates and value provided to customers, however is needed in order to build-up a positive image of biogas systems in the "public eye" and thus support demand.

6.3 Success factors

Since the countries deemed as successful examples for biogas dissemination are familiar with the challenges identified in Kenya it is imperative to also look at the success factors identified in those cases and perhaps find a link to some of the circumstances in Kenya. The most common success factors identified in literature for two of those nations are presented in table 12 below.

Table 12. Success factors identified in countries with successful biogas dissemination programs and their relation to local challenges to biogas. Compiled from Bajgain & Shakya 2005, ADB 2009 & Mendis & van Nes 2001

Country	Success factor	Related challenge in Kenya
Nepal	Long term donor commitment	Support organizations distort market
Nepal	Supportive government policies	Lack of coherent government support
Nepal	Credit support for poor farmers	Poor access to credit
Nepal	Subsidy program	High investment costs
Nepal	Training of users	Poor management of plant
Nepal	Post-installation support guaranteed	Poor post-installation support
Nepal	Institutional development and strengthening	
Nepal	Design optimization	Poor design
Nepal	Quality control	Low quality plants
Vietnam	Market research prior to programme launch	
Vietnam	Set up demonstration plants	Lack of awareness and understanding of technology
Vietnam	Promote biogas via brochures and radio	Lack of awareness and understanding of technology
Vietnam	Install an 'early-bird' promotion system	High investment costs & awareness issues
Vietnam	Trainings of users & their families	Poor management of plant
Vietnam	Biogas Information and Distribution shops set up in communities	Lack of awareness and understanding of technology
Vietnam	Setting up of local community suppliers and then training their technicians in both technical and marketing skills.	Lack of capacity

The approach in Vietnam and Nepal obviously targets many of the important challenges that hinder the biogas sector in Kenya. However it must be noted that both countries were supported by SNV, which only recently - Nov 2009 - began operations in Kenya and planning to use the same approach it used in Asia. Taking the high investment costs as an example – in Nepal SNV provided a $133 and later a $160 grant to households buying a biogas digester – covering roughly 45% of the digester at local

prices (Pokharel 2003). Credit was subsidised in order to achieve an effective interest rate of less than 10% and additionally digesters and appliances were exempt from VAT. It must be noted that during the years since 1997 there has been high coordination between the efforts of the three donors – The German development bank (KfW), SNV and the government of Nepal and indeed a coherent information campaign was ongoing for years. Additionally small digesters, areas with lower biogas penetration and remote areas were targeted with priority (Bajgain & Shakya 2005).

Similarly in Vietnam the subsidy is around EUR48 or equal to 12% of the plant and covers EUR80 worth of support services like user trainings, information campaigns, quality control and a 1 year guarantee (GFA Envest 2009). This adds up to ~27% subsidy on full plant costs.

As for China, being hailed as the leader in biogas dissemination, it must be noted that there were long-standing traditions of processing sewage and animal dung in a way similar to the anaerobic digestion in a biogas plant. While this was done for sanitation and health reasons, covering the digesters and utilizing the gas was a logical next step (Foley 1992). Overall based on these examples the most critical factors for a successful biogas dissemination strategy are a high level of coordination and cooperation between support organizations and government, well calculated financial support specifically designed to reach the BoP market and quick integration in the current cultural and market landscape via marketing and job creation. Long-term involvement also stabilizes the market.

The ABPP in Kenya by SNV is going to follow the same structure, offering trainings for masons, an awareness campaign and provision of a grant of EUR 250, covering between 25 and 50% of the plant costs depending on price estimates (ETC 2007, Gichohi 2009, Musungu 2010). This grant, while much larger than in Nepal or Vietnam, might still be insufficient as the remaining EUR 250-750 constitute a large portion of the yearly household income, especially for the BoP users. In contrast with the two Asian countries, the coordination between the two largest support organizations - SNV and GTZ, in Kenya seems extremely low. SNV targets small digesters – more feasible for the poor with a EUR 250 grant while GTZ targets much larger 12+ cubic meter plants that are only usable by the rural rich that have many livestock heads, with a EUR 350 grant. Thus a mismatch between who should be assisted the most and who receives higher subsidies exists in Kenya currently.

In addition SNV has yet to roll out its information campaign, while the GTZ PSDA project is more focused on efficient stoves than on biogas. Not surprisingly most biogas contractors were also selling efficient stoves and those often comprised their main revenue flow (Musungu 2010, Kariuki 2010).

What is becoming apparent from the analysis of challenges to companies and the market as a whole, is that only some of them are currently surmountable by the enterprises alone – e.g. via business model innovation. Table 13 presents the distinction between those barriers that local companies can currently overcome on their own, those that with some external support they can overcome again via business model innovation and those that are part of the landscape and so are out of the reach of individual businesses.

Table 13. Challenges categorized by the ease they can be overcome by biogas companies in Kenya in their current state

Low-level challenges	Capacity challenges	Landscape challenges

Poor customer support	Poor social acceptance	Bad infrastructure
Disregard for technical requirements	No standards and quality control	Lack of coherent government support
Bad design and low quality construction	Poor appliance distribution (Other)	Lack of academic research on the topic (Other)
Poor management and maintenance by users	Low awareness and understanding of technology	Unforeseen events – droughts, death of cattle, etc. (Other)
Poor promotional message	Lack of capital and HR capacity	Support organizations distorting market (Other)
	Poor access to credit	Weak legal system (Other)
	High investment costs	

The first category, low-level challenges, includes all the barriers that can be solved by biogas enterprises using their current resources – ways to reach customers, ways to focus sales efforts and to cater to the customers' needs. The second category, capacity challenges, includes the ones that are off limits to the efforts of a single company on the market at present – capacity issues – ability to negotiate better prices and interest rates, to make larger and better coordinated marketing efforts, ability to use alternative revenue models, risk management and financial analysis. The third group of challenges are landscape challenges – ones that are out of the reach to biogas contractors and probably will be despite potential growth and profits – bad infrastructure, lack of access to cheaper international capital for MFIs, strong government support and the structure and use of aid in the sector.

Obviously, as companies and profits grow challenges that are currently too big to take on will be manageable and even some landscape issues will be within reach or some influence might be extended. This distinction is made in order to draw clear lines of what business model innovation can and cannot achieve and what else can be useful in order to support the currently weak biogas enterprises. The implications of this categorization will be studied in the following sections.

6.4 Business model innovation

Despite the researcher's initial lean towards alternative revenue models aiming to overcome one of the main challenges – high up-front costs of the biogas digester – through interviews and the fieldwork as a whole it has become apparent that significant business model innovation requires more expertise and resources than are currently available to local enterprises. Implementing an alternative revenue model would require financial analysis and risk management beyond the abilities of entrepreneurs at present. In fact most interviewees were sceptical when contracts based on leasing or on gas consumption were presented to them. Models such as these are a typical way to avoid presenting a large lump sum cost to customers and have been successful for many other industries operating at the BoP (Prahalad 2004). The most cited reason for scepticism was the lack of trust that customers would follow the payment scheme. An additional complication came from the fact that biogas digesters are usually fixed assets to households and in case of non-compliance with payment costs cannot be recovered. Nevertheless even companies, which do offer a digester that could easily be moved if payments were not met by the user, still did not consider leasing a viable business model (Nyamu J. 2010, Musungu 2010).

The opportunistic behaviour practiced by most biogas enterprises is surely a part of the reason why alternative, usually more complex and risky, revenue models are avoided. With ample business opportunities in the renewables and other sectors and the lack of expertise in financial analysis, the investment in developing and implementing such an innovation is not very lucrative. The process of implementing a business model is costly and slow because each step requires training and education of the consumers, as well as iterations of the business model. The poor or non-existent transportation and communications infrastructure in the developing world makes this process still slower.

Also, the lack of a core business and the spread into many markets weaken businesses and limits their confidence. This in turn makes them more prone to risk-averse behaviour in all of their actions unlike more focused enterprises that tend to take risks in their core competence activities (Noy & Ellis 2003). Additionally a risk-averse behaviour is usually the only option for a small company with insufficient capital that would allow it to cope with unfavourable developments (Vickery 2008, Fafchamps 2000). The above points lead biogas enterprises in Kenya away from intensive business model innovation as for them it can be summed up as a high-risk investment.

In addition it must be noted that despite the apparent avoidance of pointing out market issues rooted in contractor actions, the larger Kenyan biogas companies are quite aware of these issues and have actually tried to overcome the barriers before them. As presented in the previous chapter most companies have attempts at improving their standing via business model innovation. From improving their post-customer support and providing more value to user via support in obtaining materials and loans, to interest in CDM financing and new cheaper designs, these small steps are still business model innovations. Based on the categorization of challenges from the previous section it is obvious that businesses are already trying to overcome the low-level challenges by altering the way they operate. Additionally they work toward providing more value to customers and avoiding some of the challenges that arise later, like poor management through education and manuals. It can be concluded that companies are trying to tackle those barriers that are within their reach – the low-level challenges, and most often with actions that can be seen as business model innovation. Despite these efforts however the main challenges identified have not changed significantly with time.

As shown above the second category of challenges – the capacity challenges – are currently beyond the capabilities of biogas enterprises. In order to be addressed, businesses will need to grow further and obtain more bargaining power for loans, more financial expertise and more streamlined operations supported by larger sales volumes. With the implementation of the thus-far successful SNV model in Kenya, the growth of the market might prove to be enough to spur more competition and more innovation in the sector. Alternatively however, companies could be assisted through business development services (BDS) provided by support organizations. This non-financial support has been pointed as the successor of typical program targets of providing capital to either suppliers or users (Barton 1997). Their potential contributions can be seen in table 14 below.

Table 14. Types of business development services, as presented in ILO (2003)

Type of BDS	Examples
Market access	Market research, Advertising, Market information, Packaging, Trade fairs, Marketing trips and meetings, Product exhibitions,

	Subcontracting and outsourcing, etc
Infrastructure	Storage and warehousing, Transport and delivery, Business incubators, Telecommunications, Courier, Money transfer, Information through print, radio, TV, Internet access, Computer services, Secretarial services
Policy and advocacy	Training in policy advocacy, Analysis and communication of policy, constraints and opportunities, Direct advocacy on behalf of small enterprises, Sponsorship of conferences, Policy studies
Input supply	Linking enterprises to input suppliers, Improving suppliers' capacity to provide regular supply of quality inputs, Facilitating the establishment of bulk buying groups, Information on input supply sources
Training and technical assistance	Mentoring, Feasibility studies and business plans, Exchange visits and business tours, Franchising, Management training, Technical training, Counselling/advisory services, Legal services, Financial and taxation advice, Accountancy and bookkeeping
Technology and product development	Technology transfer/commercialization, Linking small enterprises and technology suppliers, Facilitating technology procurement, Quality assurance programs, Equipment leasing and rental, Design services
Alternative financing mechanisms	Factoring companies that provide working capital for confirmed orders, Equity financing, Facilitating supplier credit

Through a package of such non-financial support measures, specifically trainings and technical assistance measures, the biogas companies in Kenya would be able to design and implement more complex market actions including revenue models and a wider array of actions aimed at providing more value or reaching more customers.

6.5 Landscape challenges

Despite progress in developing businesses either via traditional aid, BDS or other mechanisms, there will be challenges to biogas companies that are always beyond their capacity due to their magnitude. Such barriers to larger sales, lower costs and higher efficiency for companies are out of the scope of this research and are in the realm of government action influenced by coordinated lobbying and external support.

At this level of support, NGO actions can have an even bigger effect on the sector – both positive and negative. Some negative aspects have been identified in the fieldwork and must be addressed by NGOs so they remain a reliable source of support for the whole market. Positive actions on this level are mainly aimed at lowering transaction costs and risks and increasing information flows. By adopting domestic biogas as a relatively cheap technology that can also create local jobs and production capacities the government can achieve much more than by focusing only on large scale developments and more expensive renewables. Perhaps in relation to the targets set in the Vision 2030 and the Power Act of 2006, biogas entrepreneurs did not see much room for government intervention in their sector.

MFIs are a factor that can be viewed as a landscape issue as well, specifically because provision of credit is the most popular way of supplying goods that require a large up-front payment unbearable to the target customers. MFIs in Kenya operate at high rates for credit for various reasons like high-risk or relatively small size of their operation,

low efficiency, etc. This has prompted both businesses and consumers to avoid credits, thus 'disarming' development efforts. NGOs and the government can assist MFIs to acquire cheaper capital, streamline biogas credit lines and reduce risk premiums.

6.6 Conclusions

In this chapter fieldwork results were discussed and analyzed. It can be concluded, that the biogas sector in Kenya has high growth potential which is yet to be captured by enterprises on the market. The main barriers to businesses are the lack of capital and human resource capacity for activities, including a lack of trained technicians and the low awareness and understanding of the technology by the consumers. Additionally the challenges identified in the fieldwork and in literature form a vicious cycle of market non-development and prompt businesses to shift to other opportunities. The high-risk, informal market environment exacerbated by low access to capital drives the biogas enterprises to adopt an opportunistic behaviour and flexible business models. This prevents them from focusing on a single sector while additionally the biogas sector is not lucrative enough to cause them to focus all of their resources on it. These challenges are not unique to Kenya, yet there they are more severe as short-term profit seeking there often displaces actions with long-term benefits for both companies and the sector. Hope for intensified development comes from the commitment of SNV with its successful model from Nepal and Vietnam, yet more coordination with other support organizations and the government is vital for success.

Despite the cyclical nature of the challenges facing biogas businesses and the opportunistic behaviour they've adopted in response to market circumstances business model innovation has been a tool in their strategies for development. The many small scale changes in their business models indicate they do strive for growth, yet they lack the capacity to implement more comprehensive models. Regardless of the entrepreneurs' efforts however challenges in the market are still the same as identified in literature years ago.

Alternative business models however remain an important part of the solution leading to wider biogas adoption in Kenya. There is high-demand for alternative ways of payment that avoid a large up-front payment, and ongoing developments in modular, movable and more compact digesters will surely lower risks of designing and implementing alternative revenue models. Support by NGOs and the government needs to be non-financial as well as financial in order to prompt enterprises to develop their business models and to allow them to reach the BoP market.

7 Recommendations

7.1 Further research

In this research, opportunities for business model innovations for biogas enterprises in Kenya were studied. However for a more complete picture and a more in-depth analysis of the issue more quantitative studies with a focus on financial modelling should be performed and in order for the market to be fully understood the views of the various financing institutions (Banks, MFIs and SACCOs) and the government should be taken into account. In order for the sector to be better supported through

research a quantitative marketing research that would update and elaborate consumer behaviour and perceptions is needed. Additionally larger scale developments like community, municipal waste water and industrial digesters should be studied. Further several recommendations are given to specific groups of stakeholders.

7.2 For support organizations

While the usual approach SNV will use in the following years through the ABPP is considered a successful one, several additional measures could be taken by both SNV and other organizations that seek to support biogas dissemination.

The biogas enterprises in Kenya need support not only in terms of construction workers – quite the opposite, managerial trainings, consulting in legal, accounting and financing matters should be supplied as part of the business development services already provided. Additionally if single-masons trained to build digesters are to become entrepreneurs, they also need to be trained how to do business, instead of just how to construct a biogas plant. On the landscape challenges, support organizations need to help in the push for quality standards and quality control, and include financing institutions in trainings so as to promote streamlined biogas credit products for both suppliers and consumers. In all forms of support it is imperative that a level playing field for large, small, old and new biogas contractors is preserved so markets operate closer to optimum and a healthy level of competition is present.

7.3 For companies

Biogas contractors in Kenya have survived in a highly competitive market with little demand and fluctuating support. In order to succeed in the years to come they need to adopt a more long-term view at the expense of some short-term profits and increase quality of the service and product they supply while expanding the level to which they cooperate in the push for standards and in lobbying efforts. Business model innovation in order to supply more value to consumers is a high-potential endeavour and must be explored despite the higher risks involved.

7.4 For the government

Government institutions in Kenya must be introduced to the wide array of applications and benefits biogas comes with. A better understanding of how biogas as a technology can help promote growth and alleviate current issues is essential for a more coherent support programme. More specifically support can come in the form of lower taxes and import duty on biogas relevant materials and appliances and additions to energy policies that would support small scale dissemination of the technology. On the larger more general level the legal system and infrastructure base should continue to be strengthened.

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Annex A Semi-structured interview

1. How is business
    a. History of company
        i. When did you enter the biogas business
        ii. What did the organization look like then?
        iii. Why did you enter the business?
        iv. How many digesters have you built so far? How many in last year?
        v. Profits made Y/N
        vi. Self-sustainable business Y/N
    b. Organization
        i. Employees - numbers and positions if possible
        ii. Business model via canvas
            1. What are your target customers (peri-urban/rural, high/middle/low-class, HH/institutions/industry, etc)
            2. How do you find new customers/ how do you communicate with customers(local partners/directly with own outreach network/ABC-K/advertisements)
            3. What products and services do you offer(complete construction/appliances/trainings for users/follow-up support)
            4. What relationships do you have with customers(short term(<1y)/mid-term(~1y)/long-term(>1y), supportive/pay-for-service, close/distant)
            5. Which are your most important partners(masons, appliance-suppliers, material suppliers-cement, steel, piping, ABC-K, support organizations/programs, NGOs, Universities, SACCOs, MFIs, government agencies, consumer organizations, key figures in communities)
            6. What are your most important activities – on which activities do you spend most time and energy (promotion/looking for customers, plant installation, follow-up, coordination/negotiation with ABC-K, suppliers and partners, trainings)
            7. Which are your most important resources (construction teams, connections, partners, technology, promo-network, other cash-flows)
            8. How do you get revenue – what gets you income (installation, post-installation support, training workshops)
            9. What are the key cost-drivers – what do you pay most for (construction teams, materials, transportation, promotion costs, sales team, R&D?)
    c. Now that we've outlined the model you use let's discuss it
        i. Is it a good model – how do you think it could be improved(how can your business be improved)

   ii. Is there potential coming from this model that you still haven't tapped/used / What opportunities do you see for your business
2. Challenges and Changes
   a. What is your barrier to faster growth and bigger profits (discuss list of already identified challenges and comment which are important to them and which not)
   b. Responses to the barriers
      i. What has been done to address them
      ii. Has it worked
   c. Business model changes – have you thought about changing the way you deliver the service or make money
      i. Gas for cash / leasing / other designs of plants
      ii. Do you try to work closer with MFIs toward a more streamlined credit line
      iii. Do you try to coordinate efforts with competitors
3. Opinions
   a. Customers (do they know, is there high demand, why don't they want more)
   b. Of ABC-K
   c. Of ABPP and GTZ-PSDA and Breathing space / and other such support programs
   d. Of competition
   e. Of other renewables

Annex B Interviewee profiles

Michael Franz

GTZ Regional advisor

Regional energy advisory platform Eastern Africa (REAP-EA)

Caroline Toroitich

SNV-ABPP

Renewable energy/biogas advisor

George Nyamu

KENDNIP programme coordinator

Jesse David

Association of Biogas Contractors Kenya general secretary and biogas contractor

He owns a single-person company working around Nairobi and Ngong. Works mainly with fixed dome and has built around 20.

James Nyamu

Director, Pioneer Technologies director

Pioneer Technologies ltd. is an offshoot of Asami ltd. which works with plastics. They copied the idea about plastic tubular digesters from abroad but without specific designs. They started in 2006 and had to do extensive research and testing of the design to come up with materials that would withstand pressures, UV, volatile fatty acids. The company employs him and around 3 technicians while more are hired externally in case of high demand. Most of the employees also work in other companies of the group during low-demand periods. They have installed around 300 digesters and have worked with the Land'O'Lakes/USAID support project.

Wycliffe Musungu

Owner and director REECON; Chairman ABC-K

Renewable Energy Engineering Contractors is established in 1998. The company employs 8 people spread over their efforts in biogas, solar lighting and improved stoves. They have a lot of experience on large installations and have attempted CDM financing. The company is one of the most active players in the sector, consulting GTZ-PSDA and managing all activities related to training and capacity building, logistical arrangements including awareness creation, identification, supervision, and monitoring and more recently joining the Breathing Space Project by the Shell Foundation and providing biogas trainings to KUSCCO regional managers.

Josphat Kariuki

Equater Fuel wood energy saving

Started in 1998 as a company providing improved stoves, Equater moved into biogas in 2004. The company employs 5 people spread between stoves and biogas. Biogas is a small part of their business although they have built around 50 plants. They operate mostly around Meru and Nanyuki. Current plans aim for building a single showroom for stoves and biogas including a brick-baking facility.

Martha Kagiri

Owner and director, Kenya Puxin Renewable Energy

Puxin was founded in 2004-5 based on the founder's experience with biogas in Nepal and China. The company imports biogas appliances directly from China. Puxin employs 5 people and provides two types of digesters – concrete and brick-masonry of all sizes. They have installed around 200 digesters so far and plan to build a large scale municipal waste water treatment plant in Nyahururu under a Build-own-operate scheme.

Paul Madoc

Kentainers

They are a rotational/circular molding company. They make (the very popular) black water tanks and have experience also in eco-sanitation units (with GTZ) and other applications of big plastic tanks. They operate in Kenya, Uganda, Tanzania, Rwanda, Burundi, Southern Sudan and Ethiopia. In cooperation with REECON they have

developed a modular movable fixed type digester as small as 2m3. They are waiting for patents, design details and logistics to be polished before rolling out. ABC-K members will install their digesters while they only produce.

Annex C Detailed map of challenges to biogas in Kenya

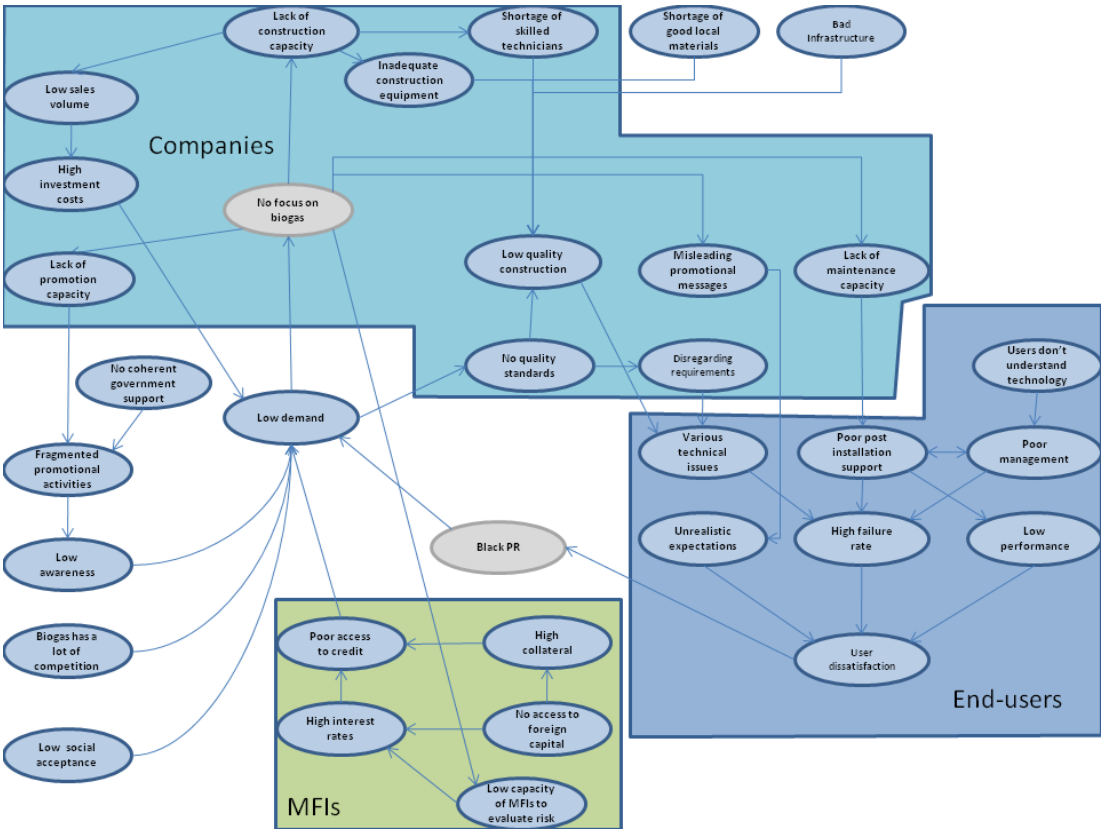

Figure 10. Detailed map of challenges identified in literature and in the field showing the vicious cycle