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The Sun Rises in the East (of Africa): A Comparison of the Development and Status of the Solar Energy Markets in Kenya and Tanzania

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Abstract

This paper describes and analyses the historical development and current status of the solar energy markets in Kenya and Tanzania. It examines the development of both markets since their beginnings in the 1970s, their current size and structure and it presents forecasts for their future development. In addition, it highlights and explains similarities as well as differences between the solar energy markets of these two East African countries. The paper is based on an extensive literature survey that takes account of academic as well as grey literature. The literature review has been complemented by 25 in-depth personal interviews with experts on the East African solar energy market. The solar market of Kenya is found to be one of the world's leading markets for off-grid solar uses, with an installed capacity of around 10 MWp and over 300,000 solar home systems. The Tanzanian solar market developed much later than the Kenyan market and still remains smaller than its neighbour, with an installed capacity of around 4 MWp and 40,000 solar home systems. In addition to solar home systems, other segments for uses of solar energy in social institutions, telecoms and tourism are also covered. Furthermore, the paper describes a number of differences and similarities between the Kenyan and Tanzanian solar markets and puts forward some likely explanations for these. It then highlights some initial policy implications regarding the regulation and promotion of solar energy in East Africa. Awareness, availability and affordability are found to be major drivers that all need to be present to enable the widespread uptake of off-grid solar technologies in emerging markets.

Keywords: Solar photovoltaic energy; Market development; East Africa; Kenya; Tanzania

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1. Introduction

Africa, probably more than any other continent, faces the double challenge of improving the living conditions of its population by dramatically increasing access to modern energy services, while simultaneously developing its energy sector in a way that is sustainable. The East African nations of Kenya and Tanzania are two examples of countries that face these challenges most acutely: Both countries have quickly-growing populations and rising prosperity that lead to increased energy demand. Yet, in both countries the electrification rates are among the lowest in the world, with 14% and 11% respectively in 2005 (IEA, 2006). At the same time, both Kenya and Tanzania continue to rely heavily on traditional biomass for most of their primary energy needs, while undergoing structural changes in power sectors that used to be dominated by clean and abundant hydro power as the primary source of electricity. The two countries therefore serve as good examples for economies that face the energy challenge and where solar energy, already exploited since the 1970s, might be part of the solution.[1]

This paper combines data and information from a broad range of sources to give an overview of the historical development and current status of the solar energy markets in Kenya and Tanzania. The paper is based on an extensive literature survey that takes account of academic as well as grey literature. The literature review has been complemented by 25 in-depth personal interviews with leading experts on the East African solar energy market that were conducted in September 2010. The paper provides an overview that focuses on two of the biggest economies in the region, which are also two of its biggest markets for solar energy applications. Given the current market

[1] Both Kenya and Tanzania are among the "Sunbelt" countries identified by EPIA (2010) that are located between the latitudes of 35°N and 35°S. Of the 66 countries analysed by EPIA, Kenya ranked 14th based on the installed capacity in 2009 (2010: 19th) and Tanzania 38th (2010: 36th), as estimated by Werner et al. (2011). Ranking Sunbelt countries by the share of solar PV in overall electricity generation capacities yields somewhat different results, with Kenya attaining the 8th rank and Tanzania the 18th in 2010 (2009 figures not available).

structure, the paper focuses on the market for off-grid solar photovoltaic (PV) systems, but also makes reference to other solar energy applications.[2]

In addition to presenting an up-to-date overview of the solar energy markets in both countries, this paper serves a second purpose by analysing and explaining the observed differences and similarities between Kenya's and Tanzania's solar markets. Both the up-to-date overview and the comparative analysis fill major gaps in current knowledge. The aim of this paper is therefore to contribute to the body of scientific literature on the diffusion of solar energy technologies and to provide academics, industry participants and policy-makers with a useful reference work that should facilitate the formulation of renewable energy policies in East Africa and beyond.

The remainder of this paper is structured as follows: Sections 2 and 3 present a concise overview of the development and current status of solar energy markets in Kenya and Tanzania, respectively. Section 4 describes major similarities and differences between both markets. Section 5 puts forward and analyses a number of possible explanations for the observed differences between Kenya and Tanzania. Finally, section 6 provides a short summary and concludes with some policy implications that emerge from the analysis.

2. Kenya's solar energy market

2.1. Market development

The origins of the Kenyan solar market date back to the 1970s. During that decade the Kenyan government started to use solar energy as a means to power signalling and broadcasting installations in remote areas. In the early 1980s, the government, international donors and development agencies began to include solar energy in their projects for the provision of electricity for various social uses in off-grid environments, such as school lighting, water pumping and vaccine refrigeration. The demand for solar power systems fostered the emergence of a

[2] For a more detailed description of the Kenyan and Tanzanian solar markets as well as a comparative analysis of both countries refer to Ondraczek (2011). That more extensive working paper version of this paper also contains further information on the literature reviewed and the interviews conducted.

national PV supply chain. At the same time, donors supported the first training workshops for solar technicians as well as demonstration projects. While donor and government procurement led to growing demand for solar power systems, some early pioneers started solar companies that specifically targeted the energy needs of off-grid consumers in rural Kenya. In the 1980s, a private market segment thus slowly started to emerge alongside the donor market segment (Acker and Kammen, 1996; Hankins, 2000; Jacobson, 2004).

Throughout the 1980s and 1990s the private solar market grew dynamically, as falling system prices and the introduction of smaller, more affordable solar power systems combined with rising incomes in rural areas during the agricultural "boom period" (GTZ, 2009a, p. 5) of the early and mid-1990s. It is the spread of radio and TV signals, however, that is most widely credited with inducing the rapid expansion of Kenya's solar home systems (SHS) market. As broadcasting signals reached more and more parts of the country, consumers were eager to own TVs and radios, but lacked grid electricity to power them. A lot of these households therefore turned toward so-called battery-based systems for their electricity needs, which many subsequently complemented with solar panels and wiring for the recharging of the batteries (Acker and Kammen, 1996; Hankins, 2000; ESDA, 2003; Jacobson, 2007; GTZ, 2009a; Hankins, 2010).

In the early 1990s the overall installed PV capacity was estimated at around 1.5 MWp, with approximately two-thirds installed in institutional systems (Acker and Kammen, 1996). By 2000, the Kenyan market had more than doubled to approximately 3.9 MWp and it was estimated that some 75% of the installed capacity was used in households (ESDA, 2003; Moner-Girona et al., 2006). One decade on, the overall market has reached between 8 and 10 MWp of installed capacity (GTZ, 2009b).[3] Annual sales of solar PV systems have recently reached 1-2 MWp and

[3] This figure might still understate the true size of the market. As Hankins (2010) pointed out, this is only a very rough estimate as no reliable statistics on the overall installed capacity are available. Some observers have remarked that there exists a strong incentive for both importers and dealers to underreport their turnover vis-à-vis authorities and researchers (e.g. Mumbi, 2010). While the Ministry of Energy (MoE) officially put the installed capacity in 2010 at 4 MWp, ministry officials confirmed that the actual market size was probably much bigger (MoE, 2010d).

annual growth rates have been around 10-15% since the 1990s, with much of the market dynamic stemming from demand for residential SHS (e.g. Hankins, 2010).

2.2. Market structure

Today's solar PV market can be divided into three broad segments. The biggest segment is comprised of the large number of residential SHS and some small-scale commercial PV applications (such as kiosk lighting and mobile-phone charging). These systems are usually smaller than 100 Wp and typically around 14-20 Wp (ESDA, 2003; Ondraczek, 2011). This segment constitutes around three-quarters of the total installed capacity, or an estimated 6 to 8 MWp (GTZ, 2009b). The second segment consists of systems that provide electricity to off-grid schools, health centres, missions and other social institutions in rural areas, with a system capacity that can sometimes exceed 100 Wp (ESDA, 2003). This segment used to dominate the Kenyan market in the early years, but was overtaken in the 1990s by the emerging SHS segment. However, increased procurement by the Kenyan government and development agencies has resulted in a limited revival of the role of institutional systems in recent years (MoE, 2010d; Ondraczek, 2011). Nonetheless, this segment still constitutes only around 20-25% of the market, or a total installed capacity of approximately 2 MWp (Moner-Girona et al., 2006; GTZ, 2009b).

While the use of solar energy in telecoms and broadcasting was among the earliest uses of solar energy in Kenya (ESDA, 2003), newer applications such as solar-powered base stations in mobile-phone networks and PV in tourism establishments are only slowly emerging as the third current market segment, which still remains very small (GTZ, 2009b). Likewise, the use of solar energy in isolated mini-grids in rural Kenya so far remains very limited, and only tentative steps have been taken with respect to regulation that would enable PV systems to feed into the national electricity grid (GTZ, 2009a; Chloride Exide, 2010; MoE, 2010a). So far, only two on-grid solar projects have been installed in the country with a combined capacity of 575 kWp (Enkhardt,

2011; BMWi, 2011; Hankins, 2011). Table 1 provides more details on the overall PV market and its segments in the year 2009.

Market segment	Estimated installed capacity in MWp
SHS and small-scale commercial	> 6-8
Off-grid community systems	> 1.5
Off-grid schools	> 0.5
Off-grid telecom	ca. 0.1-0.15
Off-grid tourism	> 0.05
Overall market size	**> 8-10**

Table 1: Overview of Kenyan solar PV market (based on GTZ, 2009b)

In addition to solar PV systems, a separate but related market is slowly appearing in the form of solar water heaters (SWH). The majority of SWH so far installed in Kenya are owned either by wealthy households or hotels in urban areas, who wish to cut their electricity bills, or by tourism operations, such as game lodges, when grid-electricity is unavailable (Karekezi et al., 2005; Chloride Exide, 2010). Annual sales were reported to have reached around 4,000-5,000 systems by 2008 (GTZ, 2009a) and the overall number of SWH was estimated at around 55,000-70,000 systems in the year 2009 (Ondraczek, 2011). This figure is expected to increase in the coming years due to new government regulations that stipulate the use of SWH in all new and existing urban buildings (ERC, 2010a).

2.3. Solar home systems

As already shown above, the biggest market segment for solar PV applications, and the major driver for the growth of solar energy use in Kenya, is mostly comprised of SHS. Annual sales of SHS increased from around 100 kWp in the late 1980s and early 1990s to approximately 500 kWp or more since the year 2000, leading to an estimated total installed capacity of 6 to 8 MWp in 2009 (Acker and Kammen, 1996; Jacobson and Kammen, 2007; GTZ, 2009b).[4] This capacity was installed in some 320,000 individual SHS that were sold in Kenya during the past three decades, as shown in Figure 1. Based on this estimate, approximately 4.4% of all rural households

[4] Cf. Ondraczek (2011) for a detailed account of how these estimates were derived from a review of 17 papers.

now own SHS (Ondraczek, 2011). This makes solar the second most important source of electricity in rural areas after grid electricity, with a rural electrification rate of 5% in 2008 (Legros et al., 2009).

Annual sales of SHS are estimated to have grown from 1,000 systems in the late 1980s to around 20,000-25,000 in the past years (Acker and Kammen, 1996; Karekezi et al., 2005; Bailis et al., 2006; Ngigi, 2008; KEREA, 2010). When compared both on the level of annual sales and the overall number of SHS, the Kenyan SHS market makes up around 10% of the global SHS market, putting it second only to China, which had a market share of around 16% in 2007. When only looking at Africa, Kenya's market continues to lead, with a share of around 40% of all installed SHS (REN21, 2008; Ondraczek, 2011).

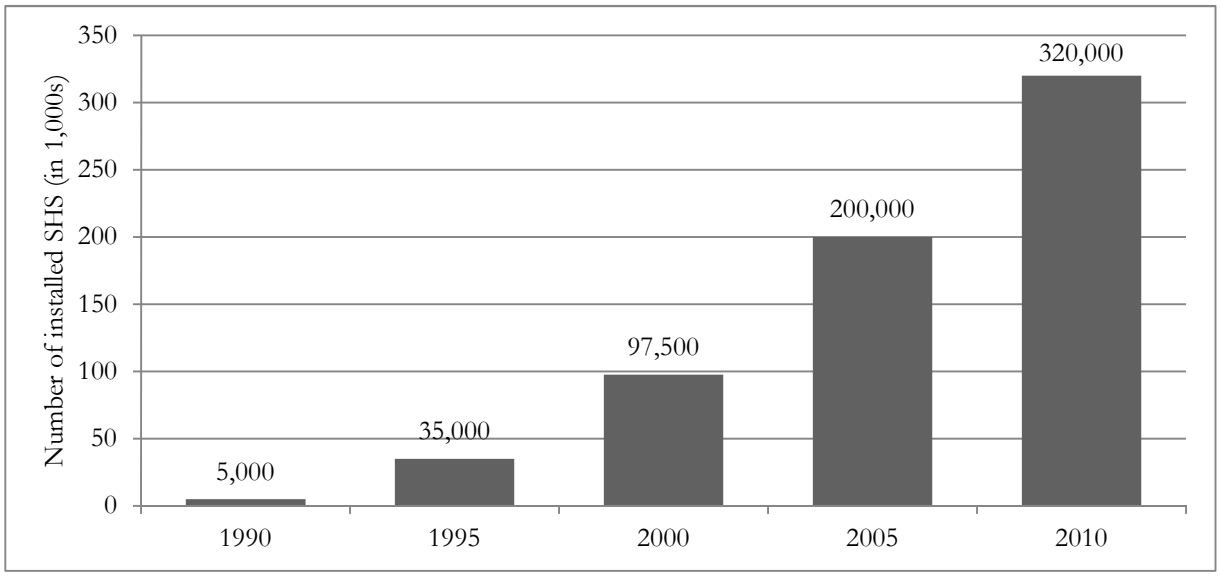

Figure 1: Estimated number of SHS installed in Kenya since 1990 (based on Ondraczek, 2011)

The key driver underlying the spread of SHS is the need for electricity from rural households that are not connected to the electricity grid. Since the early days of the Kenyan solar market, many consumers with a desire to own and use a TV set or a radio perceived SHS as a viable option to generate the electricity needed for powering these appliances. Incidentally, these two appliances reportedly consume the majority of the electricity generated in SHS smaller than 25 Wp and still account for a sizable proportion even in bigger systems (Jacobson, 2007). While the use of solar

energy for lighting is only secondary in many cases, it remains an important reason to purchase SHS. More recently, a major factor driving the demand for SHS has also been the rapid spread of mobile phones and the need to recharge these (ESDA, 2003; Moner-Girona et al., 2006; Chloride Exide, 2010).

2.4. Solar industry

Due to the long history, size and variety of the Kenyan solar market, a diverse and broad solar industry has emerged that is unrivalled on the African continent (with the possible exception of South Africa). In 2009 it was estimated that there were between 15 and 40 major suppliers of solar equipment in Kenya as well as three manufacturers of lead acid batteries and nine lamp manufacturers (IEA PVPS, 2003; GTZ, 2009a; Ikiara, 2009). In addition, five to eight companies regularly imported solar power systems and components and several hundred sales agents and around 2,000 installation technicians served the national market (ESDA, 2003; GTZ, 2009a; KEREA, 2010). Along with South Africa, Kenya is therefore the only African country with a sizable production capacity for solar modules, balance of system (BOS) components and lead acid batteries, and serves not only as an import hub, but also as a manufacturing centre for the wider region (Moner-Girona et al., 2006; Centrotec, 2009; Ikiara, 2009). The same, albeit still on a smaller scale, holds for the import and distribution of SWH, where up to six companies are currently active in Kenya (GTZ, 2009a).

2.5. Outlook

The future of Kenya's solar market seems to depend to a large degree on policies introduced by the Kenyan government. In the area of SHS and other off-grid systems, most researchers expect continued growth in sales and installations, but the potential market for both will ultimately be determined by a number of external factors, including the success of Kenya's rural electrification programme. If this programme succeeds in connecting large numbers of rural consumers and institutions to the grid, this will naturally limit the scope for off-grid solar in the long run. Yet it is

still expected that the long-term potential for SHS alone could amount to around 30 MWp, while the long-term potential for all off-grid PV systems is probably above 40 MWp (GTZ, 2009a), which underlines both the likely lasting importance of SHS and the scope for further market growth. At the same time, it seems likely that the market will not remain limited to SHS alone. Additional installations are forecast in other off-grid applications in rural social institutions, off-grid telecom, tourism and other small-scale commercial systems as well as some (isolated) mini-grids (GTZ, 2009a; GTZ, 2009b). The latter, as well as further on-grid PV systems and SWH will depend on the implementation of government policies that are currently being formulated and could have a major impact on future market development (GTZ, 2009b; ERC, 2010b). Notwithstanding this generally positive market outlook, the overall role of solar energy in Kenya's energy mix looks set to remain very limited, as the government and state-electricity generator KenGen plan to use other energy sources more extensively than solar (KenGen, 2010; MoE, 2010b).

3. Tanzania's solar energy market

3.1. Market development

Tanzania began to consider solar energy as a means to generate electricity for off-grid uses after the first oil crisis in 1973/74 (Sheya and Mushi, 2000). In the early years of market development, the electrification of rural social institutions such as schools, churches and health centres by various off-grid solutions, including solar PV, had been the main driver behind the initial demand for solar power systems in the country (GTZ, 2009c). Furthermore, the government and the government-owned telecoms and railway companies started to use solar power for repeater stations and radio communication systems as early as in the 1970s (Sheya and Mushi, 2000).

Whereas public-sector procurement of solar power systems began in the 1970s, the emergence of the Tanzanian consumer market was mostly the effect of a spill-over from Kenya's solar market.

After having emerged in Kenya during the 1980s, that country's SHS market expanded into Tanzania and Uganda from the late 1990s and early 2000s onwards. At that time, the first companies targeting Tanzanian households started their activities and Tanzania's own SHS market emerged (ESDA, 2003). While none of the earliest solar companies in Tanzania were directly related to Kenyan companies, their supply chain was closely integrated with that of their northern neighbour. This close integration of the Tanzanian and Kenyan markets is still present (Hankins, 2010).

The demand for SHS was initially driven by the spread of broadcasting signals and the availability of TV sets and radios in rural areas not connected to the grid (ESDA, 2003). More recently, rural consumers have started to purchase solar power systems also for mobile phone charging and to provide lighting in their homes, which are reported to be the main reasons for buying a SHS in Tanzania today (Camco, 2010).

3.2. Market structure

Much as in Kenya and other African solar markets, the Tanzanian market can be separated into two broad segments: solar PV and solar thermal. In the area of solar PV, the market had grown from an estimated 300 kWp in the late 1990s to approximately 1.2 MWp in 2003 and had reached some 3 to 4 MWp by 2009 (AFREPREN, 2003; ESDA, 2003; Karekezi et al., 2005; WEC, 2007; SIDA/MEM, 2010). This estimate is underpinned by annual sales that grew from 70 kWp in 2002 to 200-300 kWp between 2003 and 2007 (WEC, 2007; GTZ, 2009c; GTZ, 2009d). Since then the PV market has seen even stronger growth, at 600 kWp and over 1 MWp in 2008 and 2009, respectively (SIDA/MEM, 2010). Hence, while annual growth was 15-30% in the late 1990s and early 2000s (WEC, 2007; Chloride Exide, 2010; Hankins 2010), it has accelerated considerably in the past two years (Camco, 2010). Figure 2 shows estimated sales from 2005 to 2009.

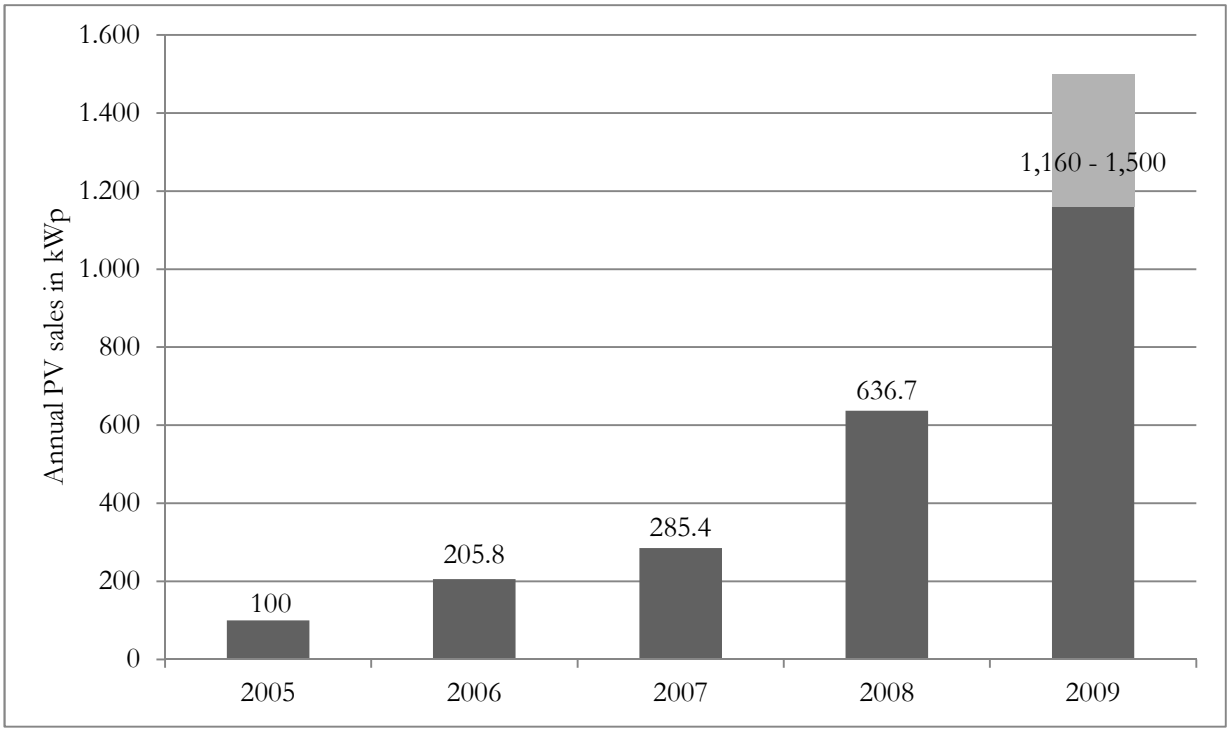

Figure 2: Estimated annual solar PV sales in Tanzania (based on TASEA, 2010)[5]

The solar PV market can be segmented into a number of categories, with SHS and small-scale commercial systems making up around three-quarters of installed capacity. The remainder of the PV market largely consists of institutional systems in schools, health centres, missions and government offices, with other uses of solar PV, such as in telecoms, game parks, tourism etc., playing only a minor role (GTZ, 2009c; Camco, 2010). Due to the increasing demand for SHS, which in many cases is promoted by donor-funded government programmes, the role of the Tanzanian government and donors as direct buyers of solar PV systems has diminished in relative terms during the past few years. However, various government and donor programmes for the electrification of social institutions mean that this segment remains important (Kassenga, 2008; GTZ, 2009c; Chloride Exide, 2010).

The uptake of advanced solar thermal technologies has so far been limited. Although some solar thermal applications can be found in agriculture, such as in the drying of coffee and fruits, the available information suggests that these technologies are not yet widespread (Kassenga, 2008;

[5] Cf. Ondraczek (2011) for further information on these estimates. Note that a subsequent report for SIDA/MEM confirmed the higher estimate for 2009, but reduced the 2008 estimate to 451.7 kWp (Camco, 2011).

TaTEDO, 2010). Likewise, the market for SWH remains very small according to most estimates. These currently range from 1,000-3,000 installed SWH, around two-thirds of which are reportedly used in tourism, such as game lodges and hotels (Nyamo-Hanga, 2010). The remainder is installed in households and some social institutions, such as schools and health centres. In the early 2000s, around 100 SWH were installed in the country, suggesting that sales probably have not exceeded a few hundred systems per year (Karekezi et al., 2005). More reliable statistics on the SWH market (and to some extent the SHS market) do not exist, as a large share of systems are imported from abroad without proper documentation (GTZ, 2009c).

3.3. Solar home systems

In recent years, SHS have become the biggest segment in Tanzania's solar market. Between 1993 and 2003 the market had already grown from a few hundred installed systems to around 500 kWp (Sheya and Mushi, 2000; ESDA, 2003). By 2008 the installed capacity had doubled to approximately 1 MWp (GTZ, 2009c; GTZ, 2009e). In the following year growth accelerated even further and the overall capacity was estimated to have doubled again during 2009 to around 2 MWp (Camco, 2010). This capacity was installed in an estimated 40,000 SHS already by the end of 2008, with annual sales of 4,000-8,000 or more systems (Camco, 2010; Ondraczek, 2011). These figures, as well as a 2007 household survey (NBS, 2009), suggest that approximately 0.6-1.0% of rural households in Tanzania currently use solar energy as their main source of electricity (Lighting Africa, 2010; Ondraczek, 2011), as compared to a rural electrification rate of 2% (Legros et al., 2009).

3.4. Role of government and donors

Large segments of Tanzania's solar market remain dependent on the funding and active support of the country's government, international donors and development organisations. These actors played a very active role in the establishment of the market and remain important in the segment of institutional systems, where they act as promoters and buyers of solar power systems.

Furthermore, Tanzania's government provides various subsidies to rural communities, households and suppliers of solar power systems in an effort to stimulate demand and supply for institutional and domestic solar power systems. These efforts have been, and in some cases continue to be, complemented by large development programmes funded and run by actors such as SIDA, UNDP, GEF and the World Bank (Magessa, 2008; REN21, 2008; GTZ, 2009c; GTZ, 2009f; Msigwa, 2010; Nyamo-Hanga, 2010; TAREA, 2010; UNDP, 2010; Zara Solar, 2010; Ondraczek, 2011). On a smaller scale, national and international non-governmental organisations (NGOs) remain active as buyers of solar power systems and providers of know-how and training (Kassenga, 2008; GTZ, 2009f; TaTEDO, 2010; Ondraczek, 2011).

3.5. Solar industry

Through the efforts of the government, donors and NGOs, as well as the growing demand for residential and commercial PV systems, a solar industry has developed in Tanzania during the past ten years. This industry serves both public and private buyers of solar power systems and is slowly reaching all regions of the country. In 2009 the industry was estimated to consist of around 20 companies with an explicit focus on solar energy, some of which were subsidiaries of Kenyan solar companies (Magessa, 2008; GTZ, 2009f). In addition to these major players, numerous importers, dealers and installation technicians are also actively providing solar power systems or solar-related services throughout the country. However, despite the growth in the geographic reach of Tanzania's solar industry and the emergence of new companies during the past years, the industry is generally perceived not to be very competitive. Furthermore, poor transport infrastructure and high transaction costs lead to consumer prices that exceed those in other countries, such as neighbouring Kenya, while the quality of products and installations is reportedly only slowly improving (ESDA, 2003; GTZ, 2009c). PV systems and components are almost entirely imported from other countries, such as Kenya and South Africa, as no national manufacturing capacity exists (Kassenga, 2008; GTZ, 2009c).

3.6. Outlook

The largest potential for further market growth is seen in off-grid solar PV installations in homes and social institutions, as rural electrification efforts look likely to remain limited in the coming years (Kassenga, 2008; GTZ, 2009f). A study undertaken in the 1990s estimated the potential for off-grid PV at 26-72 MWp, depending on whether rural electrification would progress or not (Karekezi, 1994). More recent estimates forecast an installed capacity of around 40 MWp largely in SHS and social institutions, but increasingly also in off-grid telecom, tourism and small-scale commercial systems (GTZ, 2009c; GTZ, 2009d).

The outlook for SWH and grid-connected solar PV systems is especially dependent on an enabling regulatory framework. While some tentative steps have been taken to promote SWH and on-grid solar PV, the government so far does not seem to intend to go much beyond existing policies, which would limit the scope for both applications. This is reflected in the government's long-term plans for the energy sector and the state-owned utility's pipeline, both of which focus almost exclusively on the expansion of natural gas, coal and hydro power (e.g. Kassenga, 2008; SNC, 2009; TANESCO, 2010). Therefore, it seems probable that solar energy, while continuing to contribute to rural electrification, will not play a major role in the primary energy and electricity mix of Tanzania in the years ahead.

4. Comparison of Kenya's and Tanzania's solar market

A number of similarities between Kenya and Tanzania would suggest that the solar energy markets of these two countries could have developed in more or less the same way. However, as the following comparison of both markets shows, there are some fundamental differences in their development paths as well as their current shape and structure. Therefore, the chapter following this one contains an analysis of the reasons for these differences that should not only

provide useful insights into the drivers behind Kenya's and Tanzania's market, but also allow a better understanding of the factors influencing the development of solar markets more generally.

4.1. Similar conditions for market development

Before looking at the differences in more detail, a number of observations regarding similar starting conditions for the development and growth of the solar energy markets in Kenya and Tanzania can be made. These fall into five distinct categories:

- **Resource availability:** Both countries are equally well-endowed with solar energy, i.e. their annual solar irradiation ranges from 1,460 to 2,430 kWh/m² and geographic and climatic characteristics are largely similar (Alfayo and Uiso, 2002; MoE, 2010c).
- **Demographics:** Both the population size of Kenya and Tanzania and their average population growth rates have been and continue to be very similar overall. Likewise, urban migration has occurred at largely similar rates (World Bank, 2010).
- **Economic development:** While there were and continue to be marked differences between their respective absolute and per capita GDP levels, both countries find themselves in the bottom 15% of countries worldwide when ranked on a GDP/GNI per capita basis (World Bank, 2010).
- **Energy sector:** Both countries depend very heavily on traditional biomass for their primary energy supply. Fossil fuels for cooking and transport and the hydro-dominated generation of electricity constitute the most important modern energy sources. In the field of electricity generation, both countries are slowly diversifying away from hydro power and towards other sources such as coal, natural gas and geothermal energy in order to meet rising demand and to counter declining hydro power resources (MoE, 2010b; SNC, 2009).

- **Rural electrification:** While Kenya's rural electrification rate has recently improved faster than Tanzania's, for most of the past four decades progress in this area was quite similar and very low rural electrification rates still prevail in both countries (IEA, 2006).

Despite these similarities in a number of exogenous conditions that could have suggested comparable developments in the use of solar energy, the solar markets of Kenya and Tanzania have in fact developed quite differently over the past 30 to 40 years. The following sections will therefore highlight the most important differences as well as the similarities that can be observed in the historical development as well as the current state of solar energy markets in both countries.

4.2. Market development

While both countries started to look into solar energy technologies as a result of the oil crisis of 1973/74, the development of their solar markets diverged quite quickly. With the exception of the use of solar technologies for government-funded telecommunications and broadcasting systems, which was pursued by both countries from the 1970s onwards, Kenya started to adopt solar technologies much earlier than Tanzania. Whereas institutional solar power systems were starting to appear in Kenya in the 1980s, it took until the 1990s for Tanzania to adopt solar technologies for the electrification of schools and other social institutions on a large scale.

Subsequently, the Kenyan market expanded into the consumer segment with the appearance of the first solar companies that targeted households and introduced SHS in the early to mid 1980s. In contrast, it took Tanzanian and Kenyan companies more than one decade longer until they started serving the residential market of Tanzania with SHS in the early 2000s, and for a number of years that market did not reach much beyond the biggest Tanzanian cities. While the Kenyan market therefore reached a certain maturity already in the 1990s, for a long time Tanzania's market was lagging behind Kenya's by 1-2 decades in terms of the geographical reach and size and structure of its solar industry.

4.3. Market structure

Kenya's solar market emerged earlier and grew faster than Tanzania's and is now much bigger, more diverse and more competitive than its Tanzanian counterpart. In 2009, Kenya's market was estimated at roughly 8 to 10 MWp of cumulative installed capacity, while Tanzania's was less than half as big with an estimated capacity of around 3 to 4 MWp. However, annual sales in Tanzania have recently approached those in its northern neighbour (Camco, 2010).

In both countries the SHS segment makes up around 75% of the market and the remainder is dominated by institutional systems in off-grid regions, where the government or donors act as project sponsors. Despite this similarity, Kenya appears to be ahead in the introduction of more novel uses of solar technologies, such as off-grid power for mobile-phone base stations, solar PV in the tourism industry and solar-powered mini-grids in rural areas, where only a few installations are reported to exist in Tanzania.

The advanced status of Kenya is even more pronounced in the area of SWH, where over the years an estimated 55,000 to 70,000 solar water heaters have been installed. This contrasts very sharply with the much lower estimate of 1,000 to 3,000 SWH in Tanzania.

4.4. Solar home systems

As explained in earlier sections, the market for SHS has been the key driver behind the growth in solar energy use in both countries for a number of years. The Kenyan SHS capacity grew to an estimated 6 to 8 MWp by 2009, while Tanzania's capacity in the same year was only around 2 MWp. Likewise, whereas there were an estimated 320,000 SHS in Kenya in 2009, only around 40,000 SHS were in operation in Tanzania during the same year. This means that the Tanzanian market has now reached as many households as Kenya's already reached in the early 1990s. Based on the latest available figures, some 15,000-20,000 SHS p.a. were sold on average in Kenya during the past two to three years, while in Tanzania sales in 2009 reached around 20,000 p.a., suggesting a certain convergence in annual sales between the two countries in recent years.

However, the time-lag in the development of the Tanzanian solar market is still reflected in the diffusion rate of solar power systems among rural households. Whereas this had reached almost 3.6% in Kenya in 2007 (and an estimated 4.4% by 2009), the number of rural households using solar electricity was only 0.6% in Tanzania in the same year, i.e. Kenya's diffusion rate for SHS was about six times as high as that of Tanzania. Given that many of the conditions for the use of solar energy are quite similar in both countries, this figure may point towards further potential for growth in Tanzania's SHS market.

The drivers behind the spread of SHS are quite similar in Kenya and Tanzania, i.e. that consumers in rural areas often need to meet their electricity needs with off-grid solutions due to a lack of rural electrification. As rural electrification rates in Tanzania are even lower and the probability of the grid reaching all parts of the country within the next decades is even more remote than in Kenya (Adenikinju, 2008; Kassenga, 2008), solar energy looks likely to remain an attractive source of electricity in the country for a long time, and even more so than in Kenya.

In both countries, increasing rural incomes, falling SHS prices and a wider variety of system sizes have led the SHS market to expand further down the income ladder. Reports and anecdotal evidence from Tanzania suggest that there, like in Kenya, a key ingredient for the successful expansion of the solar market has been the increasing purchasing power of rural middle class households, such as cash-crop farmers and teachers (Jacobson, 2007; GTZ, 2009c).

4.5. Solar industries

A further difference between Kenya and Tanzania lies in the structure of their solar industries. While the latter consists of hundreds of smaller and dozens of larger companies active in the manufacture of solar batteries, BOS components and, since late 2010, also solar modules, as well as the sale, installation and maintenance of solar power systems, the former focuses almost exclusively on the sale, installation and maintenance of solar components and systems. In other words, the earlier emergence and bigger size of Kenya's solar market was closely linked to the

development of a solar industry that is today able to cover many more parts of the value chain than its Tanzanian counterpart. As a result, while Tanzania needs to import nearly all its solar power systems from other countries, not least from Kenya, a lot more manufacturing activity is located in Kenya.

The different industry structures in both countries have a direct impact on prices for SHS, which are typically much higher in Tanzania than in Kenya for a number of reasons, such as a smaller domestic market, less competition and high transaction and logistics costs (ESDA, 2003). Hence a 50 Wp SHS reportedly cost US$ 9.5-16 per Wp in Tanzania (i.e. US$ 475-800), whereas in Kenya a similar system was reported to have cost only US$ 6-12 per Wp (i.e. US$ 300-600) in 2010, according to experts interviewed in both countries (Ondraczek, 2011).

4.6. Role of solar energy

Solar energy does not play any considerable role in the energy or electricity supply of either country. While solar is an important source of electricity (and in the case of SWH also thermal energy) for those households, institutions and business that have installed a solar power system, the contribution of solar energy to the overall primary energy supply or the electricity generation mix is negligible (Kassenga, 2008; KPLC, 2009; IEA, 2010a; IEA, 2010b).

4.7. Outlook

It can be expected that the solar markets of Kenya and Tanzania will develop in different ways during the coming years before possibly converging in the more distant future. This outlook is based on the assumption that, whereas Tanzania's market looks set to continue following the precedent set by Kenya during the 1990s and 2000s, the Kenyan market appears to be at a turning point when it comes to the introduction of more novel uses of solar energy. In Tanzania, newer applications such as SWH and on-grid PV will probably not appear on the market on a noticeable scale over the next years due to the absence of government policies and incentives.

Therefore the market will remain largely dependent on the continued demand for institutional and SHS.

In Kenya, on the other hand, changes are likely both in the field of SWH, where the recent introduction of regulation will most probably lead to significant growth in the number of installed SWH, and in the context of on-grid or mini-grid solar PV systems. While no major policies for the promotion of grid-connected solar PV have yet been formulated, discussions among regulators, policy-makers and the business community suggest that such policies will be implemented within the next years. When such policies are in place, Kenya looks set to lead the way in East Africa once again by becoming the first major market in which grid-connected solar PV and SWH could become sizable market segments alongside the off-grid applications that have shaped the market over the past three decades.

5. Reasons for divergence in solar market development

To my knowledge, no scholar has yet attempted to comprehensively investigate why the uptake of solar energy applications in Kenya has been so much faster and more widespread than in Tanzania. Some studies conducted over the past decade draw comparisons between some aspects of both markets (e.g. ESDA, 2003; Karekezi et al., 2005; Moner-Girona et al., 2006; Kassenga, 2008), while some presentations held by Mark Hankins on behalf of GTZ show comparative statistics for both countries (GTZ, 2009b; GTZ, 2009d; GTZ, 2009e), yet neither the studies nor the presentations have explicitly attempted to investigate the above-mentioned question. However, this question and the resulting policy implications certainly merit a closer inspection of the underlying causes for Kenya's relative success in exploiting its solar energy resource.

From a qualitative analysis of the development paths of the Kenyan and Tanzanian solar energy markets, as well as from a review of the available literature, a number of possible reasons for the differences between both markets emerge. These reasons, which can be grouped under four

headings (geographic, socio-economic, political and structural, and "other"), are described and analysed in turn in the following sections.

5.1. Geographic reasons

While the average population density in Tanzania is not that much lower than in Kenya (at 49 compared to 70 inhabitants/km² in 2009, according to World Bank, 2011), different settlement patterns in both countries may have disadvantaged Tanzania in the development of its solar market: Whereas in Kenya the majority of the population is located in the central and western parts of the country, Tanzania's population is spread much more evenly across the country's whole land area (Republic of Tanzania, 1997; UNEP, 2004).

Coupled with generally inadequate transport infrastructure (such as road and rail links), building up a national supply chain for a solar energy market in Tanzania was relatively more difficult than in Kenya for the following reason: whereas Kenya's solar market could largely be developed out of Nairobi, with most of the potential consumers located just a few hours' drive away, reaching customers in Tanzania was much more of a logistical challenge until a few years ago (ESDA, 2003; GTZ, 2009c; Hankins, 2010; Winafrique, 2010; Zara Solar, 2010).

Consequently, Tanzania's solar industry used to be centred more around the country's biggest cities and commercial centres, i.e. Dar es Salaam, Arusha and Mwanza, and did not reach the more remote parts of the country for a long time. This implies that many potential users of solar energy could not acquire solar power systems locally until the market recently expanded into more or less every part of the country (ESDA, 2003; GTZ, 2009c; Kassenga, 2008; Msigwa, 2010).

5.2. (Socio-) economic reasons

While GDP per capita does not differ much between Kenya and Tanzania, income inequality in Tanzania, as measured by the GINI coefficient, historically has been much lower than in Kenya, a fact that still persists (World Bank, 2011), implying that Tanzania lacked/lacks the vast number

of rural middle and upper class households that proved important for the initial demand for solar power systems in Kenya (Jacobson, 2007; Kassenga, 2008; ARTI, 2010; Camco, 2010; GTZ, 2010, Hankins, 2010; KIPPRA, 2010).

Furthermore, rural households in Tanzania for the most part missed out on the agricultural boom period that was reportedly very important for the growth of Kenya's solar market (Acker and Kammen, 1996). Therefore, the purchasing power in Tanzania (as measured by GDP per capita at PPP) was depressed for much of the 1980s/90s; at a time when Kenyan households were already busy buying solar power systems (World Bank, 2011). However, rural GDP in the 1980s/90s was not only lower due to a smaller number of cash crop farmers (OECD, 2008), but also more widely due to the planned economy that Tanzania only started to abandon in 1986 (Muganda, 2004).

Lower rural incomes combined with higher prices for solar power systems and rendered these systems much less affordable for most Tanzanian households. The higher prices were largely due to the size and structure of Tanzania's solar industry, which is generally perceived to be less competitive than Kenya's (this point will be revisited in the next section), implying that sales margins and system prices, especially for consumers but also for other buyers, tended and tend to be much higher in Tanzania (Hankins, 2010; Lighting Africa, 2010). Added to these already high prices were VAT and import duties that prevailed for much longer than in Kenya. They were only abolished in 2005, as compared to Kenya where they were already eliminated in the 1990s (GTZ, 2009a; Lighting Africa, 2010; Msigwa, 2010).

5.3. Political and "structural" reasons

Differences in the economic systems of Kenya and Tanzania and their impacts on market dynamics probably explain a major part of the delay with which Tanzania's solar market developed compared to Kenya's. This is also the reason most frequently cited by the experts interviewed in late 2010, the majority of whom pointed to a strong entrepreneurial culture in

Kenya and an openness to foreign investors and business practices/ideas that were generally lacking in Tanzania due to its socialist past (ESDA, 2003; GTZ, 2009f; Lighting Africa, 2010; e.g. GTZ, 2010; KIPPRA, 2010; TAREA, 2010). While no reliable empirical data exists to quantitatively test this claim, it appears plausible that the lack of entrepreneurs hindered the emergence of successful solar companies in Tanzania during the 1980s and 1990s. However, whether this lack of entrepreneurs is due to different mentalities or preferences, as claimed by some interview partners (ERC, 2010b; Mumbi, 2010; Winafrique, 2010), rather than the general business climate in Tanzania, is certainly debatable. More generally, the ease of doing business in Tanzania was perceived as worse than in Kenya in 2010, with ranks of 128 and 98 respectively in the World Bank's "Doing Business" report (IFC, 2010).

The effects of an overbearing bureaucracy and other factors detrimental to the development of Tanzania's solar market appear to have been compensated for by a more proactive role of international donors, development organisations and NGOs in Tanzania, who have helped establish the market through a number of market development and training initiatives (cf. Ondraczek, 2011). Instead of hindering the development of a sustainable private market through the crowding out of private sector involvement, these activities are generally regarded as necessary for establishing Tanzania's solar market and in enabling it to catch up with Kenya's (ESDA, 2003; Lighting Africa, 2010; Davis & Shirtliff, 2010; GTZ, 2010; Hankins, 2010; Mumbi, 2010). At the same time, some experts stress the important and positive role of civil society in Kenya during the early years of market development, as well as the fact that Kenya's government was and continues to be an active buyer of off-grid institutional systems (Chloride Exide, 2010; Hankins, 2010).

The generally higher prices for solar power systems and components in Tanzania mentioned earlier are largely the result of the past and present solar industry structure, which in Tanzania is characterised by fewer market participants and a shorter national value chain. Import

dependence, smaller delivery batches and poor logistics lead to higher transaction costs and the smaller number of industry participants leads to less competition, and hence pressure on prices (ESDA, 2003). However, this supply constraint is not limited to the solar industry, as Tanzania's manufacturing sector is generally less developed than Kenya's (ARTI, 2010; AEO, 2011a; AEO, 2011b). In effect, this implies that the Tanzanian solar industry emerged in an economic environment that was much less adept at opening up new markets than Kenya's.

5.4. Other reasons

Awareness among consumers and other stakeholders was frequently cited by the interviewed experts as lacking in Tanzania and probably serves as another explaining factor for why the adoption of solar technologies took longer in Tanzania than in Kenya. This lower awareness can probably be explained by a number of the above reasons, such as geographic obstacles in reaching prospective markets and fewer solar companies willing and able to educate their potential customers (Msigwa, 2010; TAREA, 2010; Winafrique, 2010).

The lower awareness combined to some extent with other factors, such as cultural differences in the attitude towards and the uptake of new technologies, where Tanzanians reportedly tend to be more sceptical and reluctant than Kenyans (Chloride Exide, 2010). Furthermore, the role of education in enabling or hindering adoption of new technologies was stressed as an explaining factor for why solar energy technologies took longer to be established in Tanzania (Zara Solar, 2010).

Lastly, one of the factors triggering demand for solar power systems among Kenyan rural households was the spread of TV signals throughout the country, which occurred to a much larger extent and much earlier than in Tanzania. Coupled with higher unmet electricity demand, the need for off-grid rural electrification served as a much stronger stimulant in Kenya than in Tanzania until the early 2000s (ESDA, 2003; Hankins, 2010; KIPPRA, 2010; Ondraczek, 2011).

In summary, a number of explanations for the differences in the development of solar energy markets in Kenya and Tanzania appear particularly plausible and were also most widely stated by the interviewed experts. These reasons are firstly the different economic systems that Kenya and Tanzania pursued since independence in the 1960s and that have helped shape an entrepreneurial culture in Kenya that is largely lacking in Tanzania. Secondly, the bigger size, lower population density and inadequate transport infrastructure in many parts of Tanzania have served as obstacles to market growth. Thirdly and fourthly, the lower purchasing power in rural areas of Tanzania coupled with higher prices as well as the generally lower awareness and openness to new technologies among consumers and other stakeholders, respectively, are perceived to have depressed demand for solar power systems in Tanzania relative to Kenya.

6. Summary and conclusions

This paper analysed the development of solar energy markets in Kenya and Tanzania from the 1970s to 2010. While both markets started to emerge some 40 years ago, they developed quite differently during the first 30 years of their existence and only recently began to converge. Kenya's solar market, on the one hand, started to grow strongly already in the 1980s, which was largely due to the emergence of a major SHS segment alongside procurement by the government and donors. By 2009, the market had grown to an estimated 8-10 MWp, approximately three-quarters of which were installed in SHS. These SHS, which numbered around 320,000 in 2010, were largely acquired by middle-class households in rural areas for the production of off-grid electricity for their TVs, radios, lights and mobile phones.

The remainder of the Kenyan market was largely in off-grid social institutions, with solar energy additionally being used in the communications and tourism sectors. Other forms of PV use, such as in mini-grids and on-grid electricity generation, are emerging only now. The major distinguishing feature of Kenya's solar market in comparison to Tanzania's is that it emerged

largely without government intervention. Since its early days, the Kenyan market was mostly driven by consumer demand for SHS and the development of an industry that caters to the needs of Kenya's rural households.

Tanzania's solar market, on the other hand, developed much more slowly and was for a longer time more dependent on government and donor support. The country's SHS market emerged only in the late 1990s and early 2000s, largely through a spill-over from Kenya and active market development programmes from foreign donors and the Tanzanian government. By 2009, the overall installed capacity reached an estimated 3-4 MWp, with around 2 MWp installed in SHS and the remainder in institutional systems as well as a few other applications. The number of SHS was estimated at 40,000 systems in 2008.

Compared to Kenya, the Tanzanian government and its development partners invested relatively large amounts in the development of the country's solar market, yet its industry remains much less advanced than that of its northern neighbour. Nonetheless, several major development programmes as well as purchases of institutional systems have been instrumental for the Tanzanian market to reach its current size and to span the entire country. Going forward, it seems likely that the Tanzanian solar market will be converging in many ways with the Kenyan market, as it grows especially strongly in the segments of institutional and home systems.

Some major differences have been observed between the solar markets of both east African nations, despite apparent similarities in the conditions for their emergence and later development. These differences can be found in the way the markets actually developed over the past decades, how they are structured today, the role that SHS have played in their development and how this segment emerged, as well as the shape and size of their solar industries and the importance of and outlook for different solar applications.

A number of possible explanations for these differences in the development of markets in Kenya and Tanzania emerged from an analysis of the respective development paths as well as the expert

interviews that were conducted. These reasons can be grouped under four headings: geographic, socio-economic, political/structural and other. More specifically, major reasons that seem likely to explain much of the differences in the emergence of solar energy markets in Kenya and Tanzania can be found in the different economic systems of these countries, different settlement patterns, the purchasing power of rural populations and the awareness among potential users of solar power systems. In light of these observations, it can be concluded that the Kenyan market could serve as an example for similar efforts of technology diffusion in other countries and for other technologies, as it demonstrates how a viable consumer market can emerge through private-sector innovation and with little government support.

In order to identify the reasons for the differences in the development of Kenya's and Tanzania's solar markets, this paper was based on a qualitative analysis of the relevant literature and expert interviews. In the future, this qualitative analysis should be supported and verified with quantitative approaches once sufficient quantitative data becomes available.[6] The results of the qualitative analysis conducted here should serve as a useful starting point for such future quantitative research. Furthermore, they already allow the formulation of some initial hypotheses regarding the enablers and obstacles for the development of solar energy markets in general, and lead to some important policy implications for the support of renewable energy markets globally. However, transferring the experiences of Kenya or Tanzania to other markets demands some additional work, as country-specific obstacles need to be addressed before any market can establish itself.

The Tanzanian experience, especially, shows that targeted programmes by the government or other actors may be in order if the establishment of such a renewable energy market becomes an official policy goal. Meanwhile, such programmes will need to achieve at least three things, as the

[6] Further research would be especially merited in providing quantitative answers to the question of what made Kenya's solar market develop so much quicker and more comprehensively than Tanzania's. However, this can only occur when sufficient quantitative data becomes available for econometric analyses to be conducted, which unfortunately does not seem likely in the near future.

lessons from both countries show: Raising awareness among consumers and other customer groups about the technologies and their applications, increasing the availability of solar power systems via market development, and ensuring that the systems on offer are affordable for their intended users.[7] In this context, this paper has shown the interdependence of these three factors as well as the wider interactions with some other external factors that will have an impact on the successful development of solar energy markets. As is evident from the comparative analysis of Kenya and Tanzania, these market-specific and external factors and their interactions need to be taken into account when attempting to build markets from scratch.

Finally, the analysis of the past development of solar energy markets in Kenya and Tanzania suggests that government policies will be crucial for the direction that the development of these markets takes in the future. Whereas Kenya's largest market segment has mostly developed without active government involvement, almost the entire solar market of Tanzania was the creation of an active government, its development partners and the NGO community. This suggests that decisions by all of these actors will shape the future of markets in Kenya and Tanzania. Therefore, the direction of both markets could diverge significantly in the coming years, as Kenya's government looks set to promote new uses of solar energy much more vigorously than Tanzania's, especially in the fields of SWH and on-grid solar PV. At the same time, the effectiveness of the rural electrification and procurement programmes for institutional PV systems will determine the future of today's biggest market segments in Kenya, while the market in Tanzania looks likely to follow recent trends with further growth in the markets for SHS and institutional systems, but only half-hearted efforts at establishing new solar applications.

[7] These three components of successful solar markets also emerge from research conducted for Kenya by Lay et al. (2012).

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