THE SUN RISES IN THE EAST (OF AFRICA): THE DEVELOPMENT AND STATUS OF THE SOLAR ENERGY MARKETS IN KENYA AND TANZANIA

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1. Introduction

Africa, probably more than any other continent, faces the double challenges of improving the living conditions of its population by sharply increasing energy access, while at the same time 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.

This paper (which is based on Ondraczek, 2011) 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 personal in-depth interviews with leading experts on the East African solar energy market that were conducted in September 2010 (cf. Ondraczek, 2011, for further details). The paper provides a thorough 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 structure, the paper focuses on the market for off-grid solar photovoltaic (PV) systems, but also makes reference to other solar energy applications.

The remainder of this paper is structured in the following way: Sections 2 and 3 present a concise overview of the development and current status of solar energy markets in Kenya and Tanzania, respectively, and section 4 provides a short summary and some concluding remarks.

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 signaling 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 systems fostered the emergence of a national PV supply chain. At the same time, donors supported the first training workshops for solar technicians and demonstration projects. While donor and government procurement led to growing demand for solar 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 systems combined with rising incomes in rural areas during the agricultural boom years 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 these. A lot of these households 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; ESDA, 2003; GTZ, 2009a; Hankins, 2000, 2010; Jacobson, 2007).

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). Annual sales of solar PV systems have recently reached 1-2 MWp and 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 comprises the large number of residential SHS and some small-scale commercial PV applications (such as kiosk lighting and mobile-phone charging). This segment makes up around three-quarters of the total installed capacity, or 6-8 MWp (GTZ, 2009b). The second segment consists of systems that provide electricity to off-grid schools, health centers, missions and other social institutions in rural areas (ESDA, 2003). This segment used to dominate the Kenyan market in the early years, but was overtaken in the 1990s by the emerging solar home systems 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 (Ondraczek, 2011). Nonetheless, this segment still constitutes only around 20-25% of the market, or a total installed capacity of approximately 2 MWp (GTZ, 2009b; Moner-Girona et al., 2006).

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 tourism establishments are only slowly emerging as the third 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 enabling regulation for PV systems feeding into the national electricity grid (Chloride Exide, 2010a; GTZ, 2009a; MoE, 2010). So far, only two on-grid solar projects have been installed in the country with a combined capacity of 575 kWp (Ondraczek, 2011). Table 1 provides more details on the overall PV market and its segments in the year 2009.

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

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**

Similar to the success of the SHS market, a separate but related market slowly seems to be 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 (Chloride Exide, 2010a; Karekezi et al., 2005). 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 rise in the coming years due to new government regulations that stipulate the use

of SWH in all new and existing urban buildings (ERC, 2010).

2.3. Solar home systems

The biggest market segment for solar PV applications is mostly comprised of SHS. Annual sales of SHS rose from around 100 kWp in the late 1980s and early 1990s to approximately 500 kWp or more since the year 2000, bringing the total installed capacity to an estimated 6-8 MWp (Acker and Kammen, 1996; GTZ, 2009b; Jacobson and Kammen, 2007). This capacity is installed in some 320,000 individual solar home systems that were sold in Kenya during the past three decades (see figure 1), which implies that around 4.4% of all rural households now own solar home systems (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).

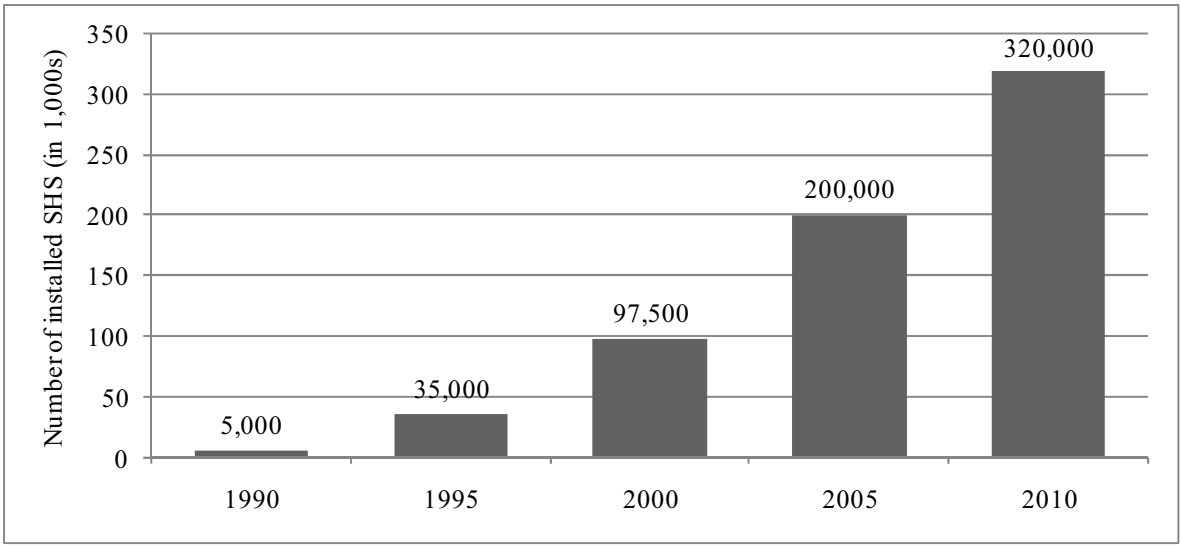

Fig. 1: Estimated number of SHS installed in Kenya since 1990 (based on Ondraczek, 2011)

While annual sales of SHS are estimated to have grown from 1,000 in the late 1980s to around 20,000-25,000 today, they have slowed somewhat during the past two to three years. This is reportedly due to stagnating or even falling rural incomes and political instability following elections in late 2008 (Acker and Kammen, 1996; Bailis et al., 2006; Karekezi et al., 2005; KEREA, 2010; Ngigi, 2008). However, when compared both to historical levels and internationally sales remain high. On a global scale, the Kenyan SHS market makes up around 10% of the market, putting it second only to China, which has a market share of around 16%. When only looking at Africa, Kenya's market continues to lead with a share of around 40% of all installed solar home systems (Ondraczek, 2011; REN21, 2008).

The key driver for the spread of SHS is the need for electricity of 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 and/or a radio perceived solar home systems 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 (Chloride Exide, 2010a; ESDA, 2003; Moner-Girona et al., 2006).

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 (GTZ, 2009a; IEA PVPS, 2003;

Ikiara, 2009). In addition, five to eight companies regularly imported solar 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 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 yet 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 program. If this program succeeds in connecting large numbers of rural consumers and institutions to the grid, this will naturally limit the scope for solar in the long run. Yet it is still expected that the long-term potential for SHS alone could be around 30 MWp (i.e. a four-to-fivefold increase), 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.

In conclusion, one can argue that the Kenyan solar market can be depicted as a good example of a renewable energy market that emerged largely without government intervention. The development of the past thirty years has shown that renewable energy technologies, in this case solar energy technologies, can be successfully deployed without major support from the state if they provide solutions that are attractive to consumers or donors.

Since its early days, the Kenyan market has seen brisk growth from a very low base, which was largely driven by the demand for solar home systems. In this context, the development of an industry that caters to the needs of Kenya's rural households (as well as the successful development of business models that accommodate the specific circumstances under which these households make purchasing decisions) is rightly perceived as a good example that could serve as a template for similar efforts of technology diffusion in other countries and for other technologies.

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 centers by various off-grid solutions, including solar PV, had been the main driver behind the initial demand for solar 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 already in the 1970s (Sheya and Mushi, 2000).

Whereas public-sector procurement of solar systems began in the 1970s, the emergence of the Tanzanian SHS market was mostly the effect of a spill-over from the Kenyan solar market that occurred much later: After having emerged in Kenya during the 1980s, that country's SHS market expanded into Tanzania and Uganda from the late 1990s 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 had direct links to Kenya, their supply chain was closely linked with that of the northern neighbor. The close integration of the Tanzanian and Kenyan markets is still present (Hankins, 2010).

Demand for solar home systems, which became the biggest market segment in recent years, was initially driven by the spread of broadcasting signals and the availability of TV sets and radios (ESDA, 2003). More recently, consumers have started to purchase solar systems also for mobile phone charging and to provide

lighting in their homes, which according to some sources are the main reasons for the spread of SHS in Tanzania today (e.g. Camco, 2010).

3.2. Market structure

Like in Kenya and other solar markets in Africa, 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 3-4 MWp by 2009 (AFREPREN, 2003; ESDA, 2003; Karekezi et al., 2005; SIDA/MEM, 2010; WEC, 2007). This estimate is underpinned by annual sales that grew from 70 kWp in 2002 to 200-300 kWp between 2003 and 2007 (GTZ, 2009c, 2009d; WEC, 2007). Since then the PV market has seen even stronger growth of 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 (Chloride Exide, 2010b; Hankins 2010; WEC, 2007), it has considerably accelerated in the past two years (Camco, 2010). Figure 2 shows estimated sales from 2005 to 2009.

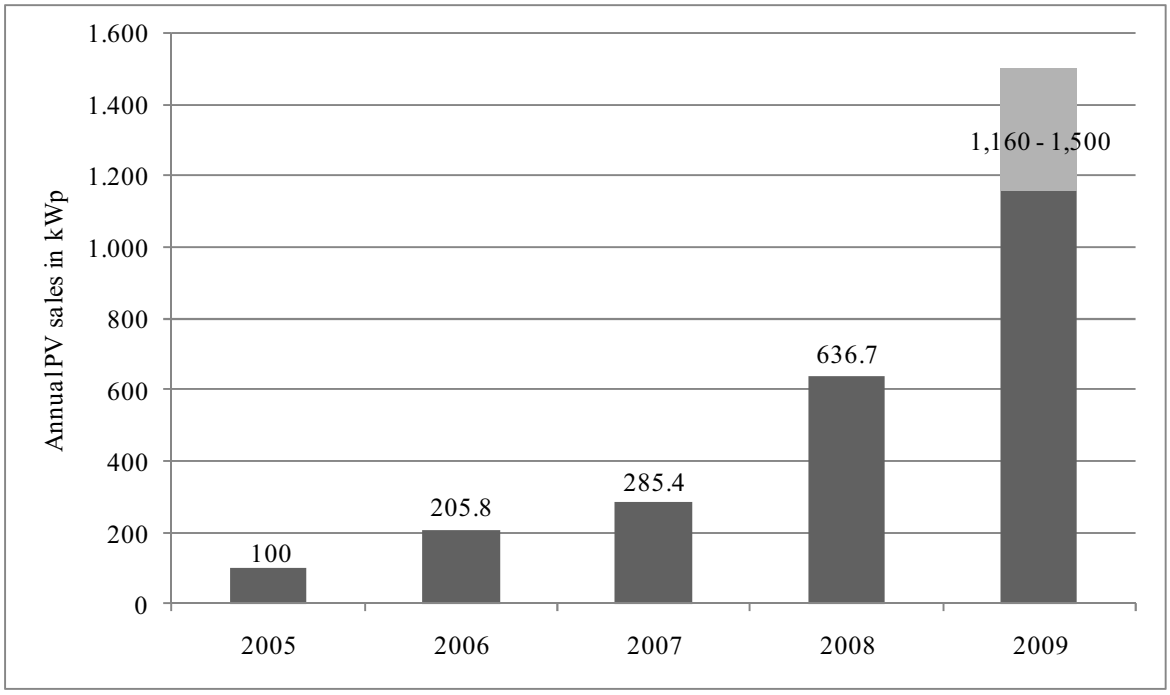

Fig. 2: Estimated annual solar PV sales in Tanzania (based on Camco, 2010)

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 centers, missions and government offices, with other uses of solar PV, such as in telecoms, game parks, tourism etc., playing only a minor role (Camco, 2010; GTZ, 2009c). Due to the increasing demand for SHS, which in many cases is promoted by donor-funded programs of the government, the role of the Tanzanian government as a direct buyer of solar PV systems has diminished in relative terms during the past few years. However, various government programs for the electrification of social institutions mean that this segment remains important (Chloride Exide, 2010b; GTZ, 2009c; Kassenga, 2008).

The use of solar thermal energy with advanced technologies has so far been small. Although some solar thermal applications can be found in agriculture, e.g. in the drying of coffee and fruits, the available information suggests that these technologies are not yet widespread (Kassenga, 2008; 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 used in tourism, e.g. game lodges and hotels (Nyamo-Hanga, 2010). The remainder is reportedly installed in households and some social institutions, such as schools and health centers. In the early 2000s, around 100 SWH were installed in the country, suggesting

that sales probably do not exceed a few hundred systems per year (Karekezi et al., 2005). A large part of this uncertainty is explained by the fact that many SWH are imported from abroad without proper documentation (GTZ, 2009c).

3.3. Solar home systems

In recent years, the market for solar home systems has become the biggest segment in Tanzania's solar market. Between 1993 and 2003 the market had already grown from a few hundred systems to around 500 kWp (ESDA, 2003; Sheya and Mushi, 2000). Since then, the installed capacity had doubled to approximately 1 MWp by 2008 (GTZ, 2009c, 2009e). In the following year growth has accelerated even further and the overall capacity is estimated to have doubled again during 2009 to around 2 MWp (Camco, 2010). This capacity was installed in an estimated 40,000 solar home systems already by the end of 2008, with annual sales of 4,000-8,000 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 expertise of the country's government, international donors and development organizations. 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 systems. Furthermore, Tanzania's government provides various subsidies to rural communities, households and suppliers of solar systems in an effort to stimulate demand and supply for institutional and domestic solar systems. These efforts have been, and in some cases continue to be, complemented by large development programs funded and run by actors such as SIDA, UNDP, GEF and the World Bank (GTZ, 2009c, 2009f; Magessa, 2008; Msigwa, 2010; Nyamo-Hanga, 2010; Ondraczek, 2011; REN21, 2008; TAREA, 2010; UNDP, 2010; Zara Solar, 2010). On a smaller scale, national and international non-governmental organizations (NGO) remain active buyers of solar systems and providers of know-how and training (GTZ, 2009f; Kassenga, 2008; Ondraczek, 2011; TaTEDO, 2010).

3.5. Solar industry

Through the efforts of these actors and the growing demand for residential and commercial systems, a solar industry has developed in Tanzania in the past ten years. This industry serves both public and private buyers of solar systems and slowly reaches all regions. 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 (GTZ, 2009f; Magessa, 2008). In addition to these major players, numerous importers, dealers and installation technicians are also actively providing solar 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 transportation infrastructure and high transaction costs lead to high consumer prices, while the quality of products and installations is reportedly still poor in many cases (ESDA, 2003; GTZ, 2009c).

3.6. Outlook

While the largest potential for short-term growth is seen in off-grid solar PV installations (GTZ, 2009f; Kassenga, 2008), the general outlook for SWH and grid-connected solar PV systems is also positive. However, these depend on an enabling regulatory framework to a much larger degree than off-grid uses. 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 current policies. This is reflected in the government's Power System Master Plan for the electricity sector, which almost exclusively focuses on the expansion of coal and hydro power (GTZ, 2009f; Kassenga, 2008, 2010; SNC, 2009; TANESCO, 2010; Zara Solar, 2010).

Recent estimates forecast an installed capacity of around 40 MWp largely in SHS and off-grid social institutions, but increasingly also in off-grid telecom, tourism and small-scale commercial systems (GTZ,

2009c, 2009d). Therefore, it appears likely that solar energy will continue to contribute to rural electrification, but will not play a major role in the wider energy and electricity mix of Tanzania.

In conclusion, it is probably appropriate to argue that the Tanzanian solar market is slowly developing into a viable market in its own right and no longer just the spin-off of the Kenyan market that it was during the early stages of its development. While a lot of the initial impetus, ideas, know-how and money for the development of Tanzania's market certainly came from its northern neighbor, the market in Tanzania is now reaching a stage where domestic demand sustains the solar industry and the supply chain becomes less dependent on Kenya. Nevertheless, personal and professional links between solar market participants in both countries remain strong and may even become stronger as the East African Community deepens the economic integration of the region.

4. Summary and conclusion

This paper tracked 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 following 30 years 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 government- and donor-procurement programs. 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 is largely in off-grid social institutions, with solar energy also being used in the communications and tourism sectors. Other forms of PV use, such as in mini-grids and on-grid electricity generation, are only slowly emerging. The major distinguishing feature of Kenya's solar market and its solar industry are that they emerged largely without government intervention. Since its early days, the Kenyan market was mostly driven by consumer demand for solar home systems 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 more dependent on government and donor support for a longer time. The country's SHS market only emerged in the late 1990s and early 2000s, largely as a result of a spill-over from Kenya and active market development programs from donors and the Tanzanian government. By 2009 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 some other applications. The number of SHS was estimated at 40,000 systems in 2008.

The Tanzanian government and its development partners have invested major amounts in the development of the country's solar market, yet its industry remains much less advanced that that of neighboring Kenya. Nonetheless, several major development programs as well as purchases of institutional systems have enabled the market to reach its current size and to cover the entire country. It seems likely that the Tanzanian solar market will be converging with the Kenyan market in the coming years as it grows in size and depth, especially in the areas of institutional and home systems.

A number of differences have been observed between the solar markets of both east African nations, despite some apparent similarities in the conditions for development of their solar markets. These differences can be found in the way the markets developed over the past decades, how they are structured today, the role that solar home systems have played in their development and how this segment emerged, the shape and size of their industries and the importance and outlook of different solar applications. The in-depth analysis of the reasons for differences in the development of markets in both countries will be the subject of future research.

In conclusion, one can observe that despite almost 40 years of market development and large solar resource endowments, both Kenya and Tanzania at present use only a small part of their solar energy resource for the provision of modern energy services. The role of solar energy in both countries so far remains mostly limited to rural areas. There, an estimated 4.4% of households in Kenya and a reported 0.7% of households in

Tanzania currently use solar energy for their electricity needs. Furthermore, thousands of rural institutions use solar energy when the grid is far away. Yet despite the importance of these systems for rural communities, the overall contribution of solar energy to the supply of primary energy or electricity is still minuscule and estimated at less than 1% of total primary energy supply (IEA, 2010a, 2010b; Kassenga, 2008; Ondraczek, 2011). Assuming that current government policies do not change, this contribution of solar will remain far below its economic potential, which may not be in the long-term interest of both countries.

An analysis of the past development of solar energy markets in Kenya and Tanzania suggests that government policies will therefore 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, the entire solar market of Tanzania is much more the creation of an active government, its supporters and the NGO community. This suggests that decisions by these actors will shape the future of markets in Kenya and Tanzania.

However, based on present policies and trends, the direction of these markets could diverge significantly during 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 program and procurement programs for institutional 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 enabling new applications, such as on-grid PV and SWH.

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