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Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

UNEP Risø Centre Working Paper
Series no. 12
March 2014

Review of Solar PV market development in East Africa

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Abstract

While the diffusion of solar home systems in Kenya has been market-based for some years, the diffusion of PV in most other Sub-Saharan African countries has been driven by government and donor-supported projects aimed at serving specific needs for electricity while at the same time creating a national niche market for PV. This practice is rapidly changing and, as in industrialised countries, there is evidence of a transition towards more market-based diffusion and private-sector involvement for PV systems for private consumers, institutions and villages. This transition has been facilitated to varying degrees by conducive enabling frameworks comprising innovative financing schemes, exemptions from VAT and import taxes, standardised power-purchasing agreements and feed-in tariffs. Few analyses have so far been conducted on the effects of such measures. This paper aims to contribute to understanding these effects by reviewing the development of markets for solar PV in Kenya, Tanzania and Uganda, focusing on how the differences in market development have been explained in the literature. The paper finds that, although Tanzania and Uganda are rapidly catching up, Kenya is still leading the development of PV markets not only in terms of installed capacity and market volume, but also with regard to local industry and PV business development. The paper concludes by drawing attention to particular factors that have been used in the literature to explain disparities in market-development trajectories in the three countries.

Review of Solar PV market development in East Africa

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1. Introduction

Worldwide PV is currently the fastest growing renewable energy technology. Globally, annual production capacity has increased from 1 to 40 GW_p over the last decade, and the sector has experienced annual growth-rates of 40-60 % (REN21 2013; Jäger-Waldau 2013) in the past five years. This is mainly due to a combination of economies of scale and market development in selected countries in Europe (Germany, Italy and Spain), China and the US created by favourable framework conditions, such as feed-in tariffs. In the period from 2008 to 2013 this led to a decrease of 60% in residential system prices in the most competitive markets and a decrease in module prices of 80% (Jäger-Waldau 2013).

While the diffusion of solar home systems (SHS) in Kenya has to some extent been market-based for some years, in most Sub-Saharan African (SSA) countries until recently the diffusion of PV has been driven by government and donor-supported projects aimed at serving specific needs for electricity while at the same time creating a national niche market for PV (Nygaard 2009). This practice is rapidly changing and, as in industrialised countries, a transition to more market-based diffusion and private-sector involvement for PV systems for private consumers, institutions and villages can be observed. Notably, in the last three to four years a new market for large-scale grid-connected PV plants has emerged as PV moves towards 'grid parity' (Bazilian et al. 2013). Most notable are developments in South Africa, where 1400 MW_p is currently being procured through three concurrent bidding rounds,[1] and Morocco, which has a plan to produce 2000 MW_p by 2020 (Cîrlig 2013). Also, a number of other African countries, such as Ghana, Burkina Faso and Rwanda, are currently implementing large-scale grid-connected PV systems 10-20 MW in size (Cîrlig 2013; Clover 2013; Willies 2014; Hall 2012).

In parallel with the general development of markets for PV in SSA, local solar PV industries also seem to have emerged, mostly in the form of solar panel assembly plants in Kenya, Ethiopia, Senegal and South Africa (Ondraczek 2011; OIRERE 2013; IRENA 2012; Meza 2014) and the planning of similar production facilities in a number of other countries. In some countries this industry development is leading to a mushrooming of local providers of PV components such as batteries, controllers, inverters, as well as total solution providers and specialised installation and service companies in these countries, hence stimulating local industrial development and the creation of employment.

The transition towards market-based diffusion has been facilitated to varying degrees by conducive enabling frameworks comprising innovative financing schemes, exemptions from VAT and import taxes, standardised power-purchasing agreements and feed-in tariffs (FIT), but few analyses have been conducted on the effects of these general measures.

Given the developments described above and the consequent demand for policy measures covering the market-based diffusion of PV technologies, interest in understanding the importance of key drivers for PV market development in SSA has increased. This can to some extent be explained by analysing the reasons behind different PV market trajectories in a number of countries. The objective of this paper is to provide a contribution to such insights by reviewing the development of markets for solar PV in Kenya, Tanzania and Uganda, focusing on how the differences in market development are explained in the literature. The review is based on empirical research published in the peer-reviewed literature and sources in the grey literature, such as donor reports, consultancy and policy documents, and occasional use of media reports where relevant.

The paper is structured as follows. Section 2 describes the dynamics of different solar PV market segments, which will be used to guide the subsequent analysis. Section 3 provides a review of solar PV market status and development in Kenya and the government policies and donor programmes that support the different solar PV market segments. Sections 4 and 5 conduct a similar review respectively for Tanzania and Uganda. Section 6 will provide a crosscutting discussion of the

[1] http://www.ipprenewables.co.za/#page/303

key factors informing differences in solar PV market developments in Kenya, Tanzania and Uganda as explained in the literature. Finally the conclusions of the study will be presented in Section 7.

2. Solar PV market segments

Solar PV systems range from the smallest pico-applications, such as solar lanterns and small mobile-phone chargers, via solar home systems (SHS) installed in private households and mini-grids at village level to utility-scale, grid-connected plants. Therefore, although solar PV is often considered a distinct type of technology, it is clear that solar PV systems are quite different in terms of scale, capital-intensity, technological characteristics, target groups and competing technologies. Accordingly, it is crucial to distinguish between the different market segments in which these PV systems are being diffused, as these are characterized by fundamentally different dynamics. In Table 1, a fivefold categorization of solar PV market segments is presented, which will be used to guide the subsequent review.

Table 1. Characteristics of five different solar PV market segments

Technology and products	**Market segments**	**Installed capacity / size**	**Owners and buyers**
Small pico-systems: solar lanterns, LED lamps, solar chargers	Lighting and charging of batteries and mobile phones in mainly non-electrified areas	1-10 W_p	Private (over the counter) consumer devices
Solar home systems (SHS)	Off-grid electricity demand in private homes in dispersed settlements, in smaller non-electrified villages and on the outskirts of electrified towns and villages far from existing distribution lines	10-100 W_p	Residential SHS (private households), ESCOs
Stand-alone 'institutional PV systems'	Institutions located in villages without grid or mini-grid, or on the outskirts of grid-electrified villages	50-500 W_p	Government/municipal procurement for public institutions (schools, hospitals, health clinics)
Telecommunications and tourism	Powering telecom base receiver stations (BTS), link sites, and remote tele-centres, and basic electricity supply (mainly lighting) for rural lodges and hotels	0.2-15 KW_p	Procurement by commercial companies in the telecom and tourism sectors (e.g. telecom service providers, hotel owners, etc.)
Mini-grids (e.g. hybrid PV-diesel)	Villages and towns located far from existing grid	5 kW-1 MW_p	Utilities, cooperatives (community-based), ESCOs (village electrification projects)
Large-scale, grid-connected PV systems	Expansion of production capacity in existing grid	1-50 MW_p	Utilities, IPPs (incl. foreign investors)

The 'small pico-systems' segment has been excluded from what follows, as this market segment is substantially different from the other segments. While the other market segments comprise fixed installations based on standardized PV panels, controllers and batteries installed by skilled technicians, pico-systems are integrated products which are more similar to other appliances such as lanterns or torches and are naturally bought over the counter. In the description of the five market segments of interest to this paper, the focus will be on assessing the scope for public intervention by governments and donors in order to promote the development of specific market segments.

The market for solar home systems is similar to that for various types of over-the-counter consumer products, such as air-conditioning, that need to be installed by a technician, but are readily available in specialised shops. Governments and donors may provide indirect support to this mainly private market through various measures, such as i) exemption from import duties on PV

components, ii) enforcing systems of product quality standards, and iii) supporting specific credit schemes to suppliers and customers.

The 'institutional PV systems' segment is different not only because of its larger scale and capital-intensity, but also because of the supporting instruments and typical interventions that are used to promote this segment. Most interventions in this segment are direct, as institutional PV systems are in general procured directly by donors or government agencies (often in combination) to provide electricity in schools or public buildings located in off-grid areas.

The 'telecommunication and tourism' market segment is characterised by PV systems procured directly by private, commercial actors in the communications technology industry (e.g. telecom service providers) and the tourism sector (e.g. hotel owners and rural entrepreneurs). These PV systems are typically installed at remotely located base transceiver stations in order to reduce operating costs or in rural lodges to cover basic lighting needs. As this segment is purely market-based, government and donor support are limited to providing broad enabling incentives, such as general VAT and duty exemptions for PV components.

The 'mini-grid' segment includes new hybrid PV-based plants and hybridisation of existing, conventional diesel-fired power plants with solar PV, which are typically installed in larger towns far from the national grid. Mini-grid systems can range from covering a relatively small number of households and commercial consumers to providing whole villages or groups of villages with electricity over a local distribution grid. They can be owned and operated by local cooperatives in so-called community-based systems, by national utilities or by foreign or national energy service companies (ESCOs). In some cases, mini-grids are also established in connection with cell-phone towers, factories or plantations with support from donors or governments. Rural electrification is in general heavily subsidized, either through rural electrification agencies or cross-subsidization within utilities. The scope for government and donor interventions to support PV in rural electrification can be directly by providing project development support, subsidies and finance and, more indirectly, by providing the necessary regulatory set up for operators.

Finally, the 'grid-connected' PV market segment is characterised by large-scale capital-intensive plants, which can be owned and operated by utilities and private operators, so-called independent power producers (IPPs), which often involve foreign investors. Government interventions to support this segment may consist of indirect measures, such as feed-in tariffs, but also more directly through the management of bidding rounds and contractual arrangements with operators.

3. Kenya

3.1. Market development and status

While Kenya today boasts a solar market that is one of the most mature and well-established in Africa, its origins date back to the 1970s, when the Kenyan government started to use solar energy as a means to power signalling and broadcasting installations in remote areas. Subsequently, from the 1980s onwards, international donors (and NGOs) began to play a greater role, as they included solar in their development programmes by means of workshops, training programmes and demonstration projects that contributed to generating a demand for PV in Kenya (Acker and Kammen, 1996; Hankins, 2000). While government and donor programmes have continued to play an important role in promoting PV in Kenya, this support has gradually been phased out in parallel with the establishment of a private market, which slowly started to emerge during the 1980s with the first established suppliers of solar equipment to customers in rural areas (Bailis et al., 2006).

During the 1980s and 1990s, this private market grew rapidly along with a continued reduction in PV system prices, which led to a genuine boom period during the late 1990s (Hankins et al., 2009a). Thus, while overall installed PV capacity was estimated at around 1.5 MW peak (MW_p) in

the early 1990s, by 2000 installed capacity had more than doubled to approximately 3.9 MW_p (Moner-Girona et al., 2006; Ondraczek, 2013). A decade later, total installed capacity had reached between 8 and 10 MW_p of installed capacity according to the comprehensive market review undertaken by GTZ in Kenya in 2009 (Hankins et al., 2009a). Although information about subsequent developments in installed PV capacity has been sporadic, Ondraczek (2014) estimated that at least 320,000 SHS were in operation in 2010. Similarly, Ramboll (2012) claimed a figure of 16 MW_p for 2012 and Tobias Cossen of GIZ a figure of 20 MW_p in November 2013 (Meza, 2013a).

During the initial development phase in the late 1980s and early 1990s, the Kenyan solar PV market was dominated by donor-funded projects and public procurement of systems providing electricity to schools, health centres, missions and other social institutions in rural off-grid areas. According to Acker and Kammen (1996), this 'institutional PV system' market segment amounted to approximately two thirds of the total installed capacity in the early 1990s, when it was overtaken by the increasing market for residential SHS, which, according to Ondraczek (2013), amounted to around 75 % of installed capacity in 2000. In 2009 the installed capacity of residential SHS and institutional market segments comprised about 80% and 20% respectively (corresponding respectively to 6–8 MW_p and 2 MW_p of the total installed capacity of 8-10 MW_p) (Hankins et al., 2009a). Recently, annual sales of solar PV systems have reached 1–2 MW_p with much of the market dynamic stemming from demand for residential SHS (Ondraczek 2013). In 2009 installed capacity in the telecommunications and tourism segment was estimated at 150 kW_p, a relative low share of total installed PV capacity in Kenya (Hankins et al., 2009a). The emergence of new mini-grid PV installations in rural Kenya has appeared to be limited until now (Ondraczek 2011), although (Muchunku 2013) estimated that seven out of twelve existing diesel mini-grids in the country (with a total installed diesel-based generating capacity of 7.7MW) had been hybridized with PV (see also Hankins, 2013). Three grid-connected PV plants have evidently been installed in Kenya so far: one plant in the UN compound in Nairobi with an installed capacity of 575 kW_p, another at the SOS Children's village in Nairobi with an installed capacity of 60 kW_p (Hille and Franz, 2011; Ondraczek, 2011), and a third, 72 kW system installed at a flower farm in central Kenya in early 2013 (Meza, 2013a).

3.2. Policies and donor programmes supporting different PV market segments in Kenya

a) Solar home systems (SHS)

According to Hankins (2000), the Kenyan government has generally adopted a 'light touch' regulatory approach to supporting the development of a private (household) market for SHS and thus resorted mainly to the use of indirect policy measures. This has primarily been in the form of exemption from value-added tax (VAT) and duties on imported PV products and components, enacted in 1986. Government targets or legislation designed specifically to increase the uptake of SHS have been absent (Hankins et al., 2009a; Abdullah and Markandya, 2012). Since the 1990s it has therefore often been argued that SHS market development in Kenya has been driven mainly by commercial and private-market actors (Acker and Kammen, 1996). Nevertheless, a number of international donor organisations have been active in supporting the development of the private SHS market segment in Kenya through various programmes, especially in the period from 1995 to 2007 (Hankins, 2009). Of particular importance was the photovoltaic market transformation initiative (PVMTI) implemented by the World Bank in the period 1998-2008, with a total budget of US$ 5 million. By providing favourable loans to consumers and suppliers of SHS in Kenya, PVMTI was instrumental in improving the financial conditions for the diffusion of SHS. The German development organisation GTZ [2] has also been active in supporting the diffusion of SHS in Kenya in many cases,

[2] Now GIZ

with the objective of exploiting commercial opportunities for German suppliers of SHS (Hankins et al., 2009a).

b) Stand-alone 'institutional PV systems'

The development of the institutional PV market segment has been led by various international donors and development agencies, particularly during the initial stage of market development during the 1980s (Byrne, 2009; Hankins, 2009). These have focused mainly on providing lighting to schools through individual projects in rural areas. Kenya also has many active NGOs and missions providing services in the remote off-grid parts of the country, such as solar PV-powered water pumping and vaccine refrigerators in health clinics. More recently, the government's so-called Solar Energy Development project aims to electrify 500 rural institutions through solar PV systems (GoK 2013), and the National Energy Policy has set out to install solar PV systems in 50% of all the remaining public facilities in the off-grid areas by 2016 (GoK 2012).

c) Telecommunications and tourism

The information and communications technology (ICT) sector, especially mobile telephony, has grown substantially in Kenya since 2002. Indeed, subscriber growth in the period from June 2007 to June 2008 alone grew by 39%, a trend that has continued since. This has led to a substantial expansion of base transceiver stations (BTS) in rural areas, and a number of telecom operators have begun implementing PV systems at these sites (Hankins et al., 2009a; Ondraczek, 2013). PV installations have also been increasing in the tourism sector, mainly to covering lighting and basic electricity needs in rural lodges and tented camps (Hankins, 2009).

d) Mini-grids (e.g. hybrid PV-diesel)

Support for the establishment of mini-grids, either fully powered by solar PV alone or in combination with diesel generators, is a fairly recent development in Kenya (Meza, 2013a). The Kenyan government's rural electrification master plan from 2008 supports the retrofitting of existing diesel-based decentralised power stations into hybrid schemes with solar PV, which, according to Gichungi (2013), is motivated by a wish to reduce operating costs (see also Hankins et al., 2009). International donors have also been supporting PV-powered mini-grids in Kenya, most importantly the World Bank's Scaling-Up Renewable Energy Program (SREP), which aims to install 3 MW of hybrid (PV and wind) mini-grids with the existing diesel generators in 12 isolated mini-grids with a total installed capacity of 11 MW (GoK 2011). Likewise, through the so-called Energy for Development (E4D) project, the Department of International Development (DFID) in the UK has also supported PV-powered community based mini-grids in Kenya (University of Southampton 2013).

e) Large-scale, grid-connected PV systems

In 2008, the Kenyan government launched a feed-in tariff (FIT) policy to support grid-connected renewable energy, which was later revised in 2010 to include solar PV and again in 2012 to adjust tariff prices. Current FIT prices for solar PV are 0.20 USD/kWh if a fixed amount of generation has been agreed upon between independent power producers and the utility, and 0.10 USD/kWh if there is no such clause in the power-purchasing agreement (Nganga et al. 2013; Ondraczek 2014).[3] Given the increasing demand for energy in Kenya, fuelled mainly by rapid

[3] There seem to be some uncertainty regarding FIT rates. According to an article in PV magazine from November 2013, Tobias Cossen of GIZ claims that the tariff for solar is fixed at US$0.12 per kilowatt hour. The main principle underlying the calculation for FIT is that the tariffs reflect generating costs plus a reasonable return for investors. Furthermore, the tariffs should not exceed the long-term marginal generating costs

economic growth, a main objective of the FIT policy is to contribute to expanding capacity in the existing grid in order to maintain an adequate reserve margin and ensure security of electricity supply. According to Willis (2014), 25 projects with a total installed capacity of 750 MW are currently proceeding from the initial feasibility stage towards the power purchasing agreement stage under the FIT policy. Although this would seem to suggest substantial interest from private investors, some observers are stressing that PV tariff rates are currently too low to attract domestic and foreign investors (Meza, 2013a; Ramboll, 2012). Nonetheless the Government of Kenya has high expectations regarding the future of grid-connected PV in Kenya. According to the National Energy Policy (GoK 2012), Kenya expects installed capacity to grow as follows: to 100 MW_p by 2016, 200 MW_p by 2022 and 500 MW_p by 2030.

4. Tanzania

4.1. Market development and status

Tanzania, like Kenya, started using PV for the government-financed electrification of rural institutions, such as schools, churches and health centres in the 1970s, and subsequently the PV market has continued to be dominated by government procurement projects and donor-supported programmes for such rural institutions. A consumer market for PV in Tanzania started to evolve from the late 1990s and early 2000s onwards, mainly as a result of the expansion of the solar PV industry in Kenya into Tanzania (Hankins et al., 2009b). The development of this private market for solar PV evolved from an installed capacity of 300 kW_p in the late 1990s to approximately 1.2 MW_p in 2003 to around 3–4 MW_p in 2009 (Ondraczek, 2013) and to more than 5 MW in 2012 (Meza 2013b). During this development, annual sales grew from 70 kW_p in 2002 to 200–300 kW_p between 2003 and 2007. Recently, Meza (2013b) has estimated sales of solar energy to have reached 2 MW in 2011, and they are thought to have been higher in 2012 and 2013 due to large-scale project initiatives and continued SHS demand.

SHS and small-scale commercial systems make up around 75% of installed capacity in Tanzania and are hence the biggest segment in the country's solar market (Ondraczek 2013). This capacity was installed in an estimated 40,000 SHS by the end of 2008, with annual sales of 4000-8000 or more systems, which, according to Hankins et al. (2009b), translates into an annual increase of around 200-300 kW_p. The remaining 25% of installed PV capacity in Tanzania largely consists of institutional PV systems in schools, health centres, missions and government offices, while the telecommunications and tourism segment (and other uses of PV, such as in game parks) only play a minor role in comparison. Currently the mini-grid market segment in Tanzania is also limited, and although Ondraczek (2013) claims that a few PV mini-grid installations do exist, information about these are scarce. There are currently to our knowledge no grid-connected PV plants in operation in Tanzania.

4.2. Policies and donor programmes supporting different PV market segments in Tanzania

a) Solar home systems (SHS)

In 2005 the Tanzanian government took steps to support the SHS market segment by exempting solar systems from 20% of VAT and reducing import duties to 5% (Bleeker 2013). Besides this, two larger programmes have been implemented to increase demand by lowering consumer costs.

(LRMC), which are US$0.12 per kilowatt hour according to the Least Cost Power Development Plan for Kenya (Meza 2013a).

The so-called Tanzania Energy Development and Access Project (TEDAP) (earlier known as Energizing Rural Transformation) reduced consumer costs by providing a subsidy of US$ 2/W_p per sold system for systems below 100 W_p for qualifying companies. TEDAP was a World Bank/GEF-funded programme implemented by REA to promote SHS uptake in Tanzania. The total budget was 22.5 Mn USD (Hankins et al., 2009b; Nchwali, 2010). Recently, REA has lowered consumer costs through the so-called PV Clusters Project, which supported private households in buying and installing SHS collectively (bulk purchasing) to reduce the overall cost. The project targeted clusters consisting of organised labour or farmers' groups with a minimum of a thousand members. These clusters engaged in annual wholesale procurements of solar PV systems through tendering, and REA provided subsidies for systems procured (20% of the cost) (CAMCO 2014).

Beside these demand-side interventions, international donor agencies have focused on supporting the supply side, that is, the private solar PV market actors. From 2004 to 2009, UNEP led an initiative entitled Transformation of the Rural Photovoltaic Market in Tanzania with a specific focus on using the 'private sector as a vehicle for providing basic services from PV' (UNEP 2014). The programme included the business and technical skills training of private-sector merchants, as well as the establishment of financing mechanisms to provide consumers with access to SHS. The SIDA /MEM Solar Energy Project was implemented in 2005-2011 with a USD 3.2 million budget providing technical, business and sales support to PV businesses, with the aim of improving the market for solar power and building up the solar industry in the country (Bauner et al., 2012).

Another supply-side support project is the Developing Energy Enterprises Project East Africa (DEEP EA), a five-year initiative established in 2008 by the Global Village Energy Partnership (GVEP) which focused on micro- and small energy enterprises in Kenya, Uganda and Tanzania. DEEP EA supported the development of energy enterprises formed by, and for, rural and peri-urban entrepreneurs by assisting them with the identification of viable energy market opportunities, technology options and service structures to generate revenue and sustain business (Bauner et al. 2012).

b) Stand-alone 'institutional PV systems'

The main driver for institutional PV systems in Tanzania is direct procurement through REA, together with international donor programmes and development organisation projects (such as TEDAP). One element of this is the Sustainable Solar Market Packages Project (SSMP), implemented by REA from 2007 and designed to establish a functioning institutional framework for commercially based service delivery for rural electrification (World Bank 2006). Each SSMP arranges the supply of solar PV energy equipment with long-term maintenance contracts to rural institutions such as schools, clinics and other community facilities in a defined rural area, together with requirements and incentives for commercial sales to households in the same area. Another programme, the Transformation of the Rural Photovoltaic Market in Tanzania, resulted in the installation of solar PV systems in more than a hundred public institutions, such as health facilities and schools (UNEP 2014). The programme also facilitated the inclusion of PV in the local authorities' annual budget plan in Mwanza and in three other regions: Kagera, Mara and Shinyanga.

c) Telecommunications and tourism

Although this segment only played a minor role in the solar PV market in Tanzania in 2008, Hankins et al. (2009b) estimated this sector to be growing substantially, mainly due to an increasing use of solar-powered base stations in mobile-phone networks and PV in tourism establishments (such as rural tented camps and lodges) for lighting and basic electricity needs (due to environmentally conscious visitors).

d) Mini-grids (e.g. hybrid PV-diesel)

Through the newly established Scaling Up Renewable Energy in Low Income Countries Program (SREP) funded by the Climate Investment Funds, the government of Tanzania aim to provide electricity to 400,000 off-grid households and other consumers using renewable energy mini-grids, micro-grids and SSMP projects (GoT 2013). Further, the Ministry of Energy and Minerals (MEM) has established a framework for the development of renewable energy power projects, ranging from 100 kW to 10 MW (Bauner et al. 2012). The framework includes the introduction of standardized power purchasing agreements for wind, hydro, PV and co-generation with standardized FITs. MEM has also established simplified procedures for private-sector investment in solar, wind and micro-hydro projects, including a 100% depreciation allowance in the first year of operation. For small power producer's (SPP) operating on an isolated mini-grid, installed capacity must not exceed 10 MW. SPPs generating less than 1 MW are required merely to register with the regulator, instead of applying for a license, which, unlike registration, entails approval by the regulator. For very small power producers (VSPPs) with an installed capacity of 100 kW or less, the Tanzanian regulator requires no prior regulatory review or approval of proposed retail tariffs. On that basis, Tenenbaum et al. (2014) argue that Tanzania has made more progress than any other African country in developing a comprehensive regulatory system to supporting SPPs. Moreover, TEDAP provides two types of subsidy to project developers: performance grant and matching grant (Nchwali 2010). For rural mini-grid projects under the performance grant, a subsidy of US$ 500 is provided for each new connection, with a maximum amount of up to 80% of total investment costs. Matching grants include primarily training and consultancy services. Such initiatives may have contributed to spurring investment interest in mini-grids, as reflected in two recently announced PV-powered mini-grids to be developed by private investors under power purchasing agreements with the Tanzanian utility TANESO (Meza 2013b).

e) Large-scale, grid-connected PV systems

According to Ondraczek (2013), there are no signs that the government is intending to include solar PV in the national electricity mix in any significant way in the coming years. In the long-term plans for the energy sector and the state-owned utility's pipeline, the focus is almost exclusively on the expansion of natural gas, coal and hydro power (Ondraczek 2013). One policy potentially supporting grid-connected solar PV is the FIT policy introduced in 2009. Tariffs are differentiated depending on whether the small power producer is grid-connected or mini-grid. For 2012 the average tariff for grid-connected electrification was 0.095 USD/kWh (152.54 TZS/kWh). For mini-grids in 2012 the tariff was 0.30 USD/kWh (480.50 TZS/kWh). This is a common FIT for all technologies, and consequently the majority of projects currently under development and in the pipeline are mini-hydro. Lack of technology-based payment differentiation is, according to Nganga et al. (2013), one of the greatest weaknesses of Tanzania's FIT policy.

5. Uganda

5.1. Market development and status

The PV market in Uganda started to develop from the early 1980s, and, as in Tanzania and Kenya, was initially driven mainly by government and donor-funded programmes along with NGO projects, mainly for lighting and vaccine refrigeration in health centres (GTZ 2007). From the mid-1990s a private market slowly started to emerge, which grew from an estimated 3,000 PV installations across Uganda in 1999 (Eliah and Louineau, 1999) and 10,000 in 2004 (Mark 2012) to over 20,000 in 2007 and 30,000 in 2012 (Baanabe 2012). In 2009, total installed PV capacity in Uganda was estimated at 1.1 MW_p, with annual sales of about 200 kW_p (Hankins et al., 2009c). According to an interview in 2014 with 'SolarNow', the largest players in the SHS market in Uganda,

this company alone installed 3600 SHSs in 2012 and 4500 in 2013.[4] According to SolarNow they control about 30% of the established market, indicating a total market for SHS of 12,000 in 2013 and 15,000 in 2013. Given that the smallest modules are 50 W_p, this amounts to 600 and 750 kW_p for these two years respectively for the SHS market alone, or four times annual sales in 2009.

The commercial market for SHS in Uganda, with an estimated installed capacity at 200 kW_p in 2009, has been increasing mainly due to a growing demand in households for backup power in the urban centres of Kampala and Entebbe, where the grid electricity supply is unreliable. The combined telecommunications and tourism segment has also been increasing and reached 340 kW_p installed capacity in 2009 (Hankins et al., 2009).

The largest proportion of the PV market in Uganda is accounted for by the institutional PV market segment, which in 2009 was estimated at around 470 kW_p installed capacity. PV applications in this segment were mainly utilised in the health (e.g. rural health clinics), water (e.g. pumping systems), education (e.g. off-grid boarding schools) and local government sectors (e.g. public agency offices). Only one hybrid solar PV and diesel-powered mini-grid has to our knowledge been installed so far in Uganda, at a rural boarding school (Brandt 2005). Grid-connected, utility-scale PV power plants have not been put into operation in Uganda.

5.2. Policies and donor programmes supporting different PV market segments in Uganda

a) Solar home systems (SHS)

The Ugandan government has stimulated the private market for SHS both through indirect measures, such as VAT exemption for imported PV components, and directly, by providing a subsidy of 5.5 USD/W_p (with a maximum system size of 50 W_p) on solar equipment purchased by households (and 4 USD/W_p (for systems below 500W) for businesses) (Hankins et al., 2009c). The subsidy was funded partly by the World Bank's Energy for Rural Transformation (ERT) programme and implemented by the Rural Electrification Agency in Uganda in the period 2002-2013 (in two phases between 2002-2009 and 2009-2013) (World Bank, 2014). ERT also aimed at stimulating the SHS market by reducing costs for end-users through rural-based micro-financing institutes and by providing business start-up support and technical training to PV suppliers. Despite high ambitions at the outset of the programme, only 7,000 of the 80,000 initially planned PV installations had actually been installed when the programme was terminated (GoU 2012). A precursor of the ERT programme was the so-called Uganda Photovoltaic Pilot Project for Rural Electrification (UPPPRE), which was funded by the United Nations Development Programme (UNEP) and implemented in the period 1998-2002 (UNDP 2002). Similarly to ERT, UPPPREE targeted the development of the SHS market by providing finance to PV suppliers and credit guarantees to local banks so that they could provide loans at favourable conditions to end-users.

Programmes targeting the supply side were also implemented in Uganda. The so-called Promotion of Renewable Energy and Energy Efficiency Programme (PREEEP), funded by GTZ during the period 2007-2011, was aimed at strengthening the SHS market segment by supporting Kampala-based solar companies with branches or agents in rural areas, local solar dealers and micro-finance institutions (REA 2008). A similar project entitled Providing Access to Energy in Northern Uganda (PAMENU) provided training to local technicians and supported local PV suppliers. This project was also implemented by GTZ during 2008-2011 (European Commision 2014).

b) Stand-alone 'institutional PV systems'

[4] Interview with Willem Nolens, Managing Director, and Ronald Schuurhuizen, Business Development Manager, 16 January 2014.

According to Hankins et al. (2009c), the ERT programme has been the main driver behind most of the direct public procurements of PV systems in the institutional market segment in Uganda. Other international aid programmes and NGOs have similarly targeted the institutional PV market segment. For example, the PREEEP programme mentioned above was specifically aimed at electrifying government institutions (such as health centres, boarding schools, vocational training centres and local government offices) with solar PV systems by providing an 80% subsidy for the procurement of a PV system, the institution being responsible for providing the remaining 20% (European Commision 2011). This segment is therefore still strongly influenced by donor support, although channelled through the Ugandan rural electrification agency.

c) Telecommunication and tourism

The market for PV systems in the telecommunications and tourism sector in Uganda has been rapidly increasing during the past decade and comprises a relatively large share of the country's total installed PV capacity. Driven mainly by an increase in the use of mobile phones in Uganda, the telecommunications sector has grown rapidly, resulting in a substantial increase in national coverage through the widespread establishment of base transceiver stations (BTS) and link sites in rural areas (Hankins et al., 2009c). As most of these BTS facilities operate on diesel-based generators, PV has been implemented to reducing operating costs for telecom operators at these rural sites. To support this development further, in 2012 GIZ launched a programme entitled 'develoPPP.de' aimed at supplying telecommunication masts with PV and at the same time electrifying off-grid villages close to the masts. The project, which has a scope of 250 masts, is being carried out in partnership with a German supplier of solar systems, the telecompanies in the country and GIZ (GIZ 2013).[5]

In the tourism sector, PV systems are mainly implemented to provide basic electricity supply (mainly lighting) for remotely located lodges and hotels.

d) Mini-grids (e.g. hybrid PV-diesel)

Through the ERT programme, the rural electrification agency in Uganda has promoted the establishment of isolated mini-grids (including PV), for example, by providing investment subsidies to investors (Hankins et al., 2009c). The Rural Electrification Strategy Plan (RESP) from 2012 (covering 2013-2022) also specifically prioritises rural electrification through PV-powered mini-grids and has set a goal of reaching 140,000 additional off-grid installations of solar PV systems and mini-grid distribution service connections in 2022 (GoU 2012). Beside this, a recently announced agreement with the East African Chamber of Commerce indicated that foreign investors are also becoming interested in developing mini-grids in Uganda (Parnell 2013), though only a few have been installed so far. These include four set up in connection with the telecommunication masts described above and a PV-powered mini-grid financed by Together: Assistance for Uganda, a German aid organisation (Brandt 2005).

e) Large-scale, grid-connected PV systems

Under the Renewable Energy Policy adopted in 2007, the Ugandan government introduced the first phase of the Renewable Energy Feed-in tariff (REFIT) programme to encourage grid-connected bagasse co-generation and hydropower plants. A second phase of the REFIT programme, implemented in January 2011, introduced a PV tariff rate at 0.362 US$/kWh (for systems below 2 MW_p), along with changes in tariff rates for the other eligible technologies under the programme. Later, in 2012, PV was removed from the REFIT programme after a tariff revision had identified that

[5] Four of these installations were in operation in January 2014.

the drop in PV system prices was deemed to have made large-scale, grid-connected PV plants competitive without subsidies (Tsagas 2013). This led to a greater focus within the government on tendering and soliciting bids from private investors to develop grid-connected PV systems. To meet this demand, the so-called GET FIT programme introduced in 2013 established a special window for support to an auction process for grid-connected PV. Under this reverse bidding process, selected developers will receive a premium payment to bridge the gap between a predetermined tariff set by the Ugandan Electricity Regulatory Authority and their offer (GET FIT, 2014). The funds for the GET FIT programme are being made available from a number of international development organisations. The programme has attracted some interest from private developers, and in late 2013 a memorandum of understanding (MoU) was signed between the Government of Uganda and a private company for building 500 MW_p, but plants have yet to be realised (Parnell 2013).

6. Key factors for differences in market development

This section explores the main underlying reasons for the different levels of market development in Kenya, Tanzania and Uganda, as illuminated in the literature. The aim is not to provide a comprehensive explanation of this highly complex issue, but rather to draw out some of the key factors that resonate across papers. This discussion focuses on the SHS market because the literature has mainly concentrated on this segment.

6.1. Generic aspects conducive to PV market development in all countries

From the literature, at least three main generic aspects seem to have been conducive to market development in all three countries: i) the decline in world market prices for crystalline silicon based-based PV modules; ii) the substantive and prolonged support for solar PV from international donors and humanitarian aid organisations; and iii) conducive framework conditions provided by national governments.

First, underlying many government and donor initiatives over time to stimulate PV markets has been a continued expectation that module prices would be reduced and thus enable PV to compete with conventional technologies. Often based on so-called learning-curve projections and actual prices, this understanding has led in some cases to over-optimistic goals to be set regarding what can be realistically achieved from policies and interventions. In the literature, it is evident that the price reduction in PV modules that has occurred especially since the 1990s was ascribed a key role in explaining market development. Acker and Kammen (1996), for example, pointed to falling world prices for PV modules as a main reason for the growth of the Kenyan PV market. As PV module prices continued to decline from the 1990s, several papers engaged with exploring the economic feasibility of solar PV compared to traditional electricity generating technologies. Gullberg et al. (2005), for example, demonstrated that PV generation was able to compete with diesel generation in Tanzania, while Moner-Girona et al. (2006: 41) more explicitly stated that 'the price of equipment is perhaps the single most important factor in the growth of solar markets in Africa'. Later, Twaha et al. (2012) concluded that grid-connected solar PV had greater feasibility than diesel as a source of electricity in Uganda. In a similar vein, Ondraczek (2014) recently found that the price level for grid-connected PV was competitive with diesel generators and gas turbines in Kenya, a finding that the author contrasted to the prevailing understanding in the donor community and many African country governments that PV is suited only to remote off-grid and small-scale applications. These analyses showed the increasing competitiveness of PV, especially in the period from 2009 until now, when PV module price per watt has been drastically reduced. However, at a time when it would now seem reasonable to put forward optimistic goals from supporting interventions to promote PV, Bazilian et al. (2013) have stressed that African planners and policy-makers seem to be largely unaware of this.

Secondly, it is widely recognised in the literature that international donor programmes have been a key driver in stimulating solar PV uptake in all three countries examined, primarily through support to the institutional PV segment (Duke et al., 2002). Various papers describe such donor-funded projects aimed at electrifying social institutions in rural areas. Kivaisi (2000), for example, investigated a PV project designed to provide power to key functions in a large village in Tanzania, such as a school, a mosque and a health centre (see also Hogarth, 2012). In their analysis of the development of the Kenyan PV market, Acker and Kammen (1996;88) highlighted the importance of donor interventions by stating that 'not only did their funding create a demand for PV that allowed the private market subsequently to develop, but the donor agencies supported workshops, training and demonstration projects as well [which] played a vital role in educating the first Kenyan solar technicians, sparking an initial interest among Kenyan consumers, and proving the viability of the technology in Kenya's conditions'. Hence donor programmes provided direct financial resources to promote PV market development, but also contributed to creating the supporting industry and supply-side conditions for this (Bawakyillenuo 2012).

Thirdly, the literature has identified government support for promoting PV in all three countries as important for market development. Hankins et al. (2009c: 1), for example, stressed that the historical growth of the PV market in Uganda was accounted for mainly by 'conducive regulatory policies that encourage investment and trade in the solar sector [and] government projects that specifically promote the use of solar in rural electrification'. This is similar to Kenya and Tanzania, and in all three countries governments have stimulated PV markets indirectly through feed-in-tariff systems, subsidies and exemptions from import duty and VAT on PV components, as well as directly via public procurement projects.

6.2. Specific factors explaining the relatively more advanced position of Kenya

While the broad trends mentioned above are common to all three countries, other factors have been used to explain the disparities in market developments. We will focus our following discussion on five key points emphasized in the literature as primary explanations for these disparities: i) demand structure; ii) geographical conditions; iii) local champions; iv) business culture; and v) batteries and components.

i) Demand structure

An often repeated explanation for the growth of the SHS market segment in Kenya is the general rise of an affluent rural middle class from around the 1990s, which increasingly demanded electricity to power televisions, radios, cell phones and other modern electronic appliances (Bawakyillenuo, 2012; Ondraczek, 2013). According to Jacobson (2004), the increasing income from tea farming was particularly important in improving the purchasing power of these rural customers. Indeed, Hankins et al. (2009a: 2) state that the development of the SHS market segment was mainly attributable to 'high incomes among farmers (coffee, tea, horticulture), rural teachers, civil servants and businesses with a strong demand for consumer electronics (TV's, radios, cell phones)'. Consequently, the business model of many PV system suppliers in Kenya was to target this growing rural middle class that lacked access to electricity (Byrne 2009). Further, Hankins (2000: 92) argued that, 'most buyers are rural, middle-class households that lack confidence that the power grid will be extended, are knowledgeable about photovoltaic system performance, and want to make existing battery systems less maintenance intensive. Local entrepreneurs have played a key role in the process by aggressively moving photovoltaic systems to market and by downsizing the product to the needs of the lower-income market'. This would indicate that, besides the effects of the demand from the rural middle class, the lack of prospects for grid connection was an important factor for customers in deciding to purchase SHS. At an early point in the market's development, Acker and Kammen (1996: 90) stressed that 'an enormous demand for electricity in rural areas has gone

unsatisfied because they cannot count on grid connection [and so] rural households have increasingly turned to photovoltaics to meet their electrification needs'. More recently too, Bawakyillenuo (2012: 416) stressed that 'a major characteristic that probably helps to explain the high adoption rate of PV systems in rural Kenya is the slow pace of the grid extension', which the author associates with the ineffective rural electrification programme in Kenya.

ii) Geographical conditions

A number of papers employ a geographical explanation for the disparate patterns of SHS market development in Kenya, Tanzania and Uganda. Ondraczek (2013), for example, argues that the Tanzanian population is more geographically spread compared to Kenya, where a majority of the population is concentrated in the central and western parts of the country (Kassenga, 2008; Hankins et al., 2009b). Coupled with a relatively well-developed transport infrastructure in terms of road and rail links, establishing effective distribution channels and a PV supplier network has therefore been easier in Kenya. This is reflected by Hankins et al. (2009b: viii, 3), who point out that 'distribution linkages are poorly established across Tanzania, partly due to the geographical size of the country [and] the geographical distance between players [being] a major barrier to the development of the market'. Byrne (2009) also points to the geographical proximity between the PV industry, which is concentrated mainly in Nairobi, and market demand, as the customers (living mainly on the southern and eastern sides of Mount Kenya) were located relatively close to the suppliers. Indeed, Ondraczek (2013) considers the close distance between the PV supplier industry and the end-market to be a key explanation for the initial growth of the commercial SHS market in Kenya during the 1990s.

iii) Local champions

Various papers have accentuated the importance of particular individuals who have worked to support the overall development of the PV market in Kenya. Two expatriate engineers in particular – Harold Burris and Mark Hankins, both ex-Peace Corps volunteers – have been widely cited as playing a key role in the initial development of the SHS market segment in Kenya (see e.g. Duke et al., 2002). Indeed, Acker and Kammen (1996: 87) state that 'the private market's genesis may be roughly dated as 1984. That year, an American engineer, Harold Burris, founded a small company called Solar Shamba'. According to Bawakyillenuo (2012: 417), 'Burris trained a group of about a dozen local technicians to market and install PV lighting systems. By reaching out to the high-income households on the southern and eastern sides of Mount Kenya, the rich white coffee and tea farms [and] Burris' successes attracted other local entrepreneurial groups and individuals to join the rural PV market'. After meeting Mark Hankins in the early 1980s, these two individuals provided training to local technicians in PV systems, as well as preparing various PV-related technical tools and guide books and broader consultancy and promotional activities. Through Burris's company, they also engaged in a number of demonstration projects showcasing PV systems in Kenya, which, according to Byrne (2009), was instrumental in attracting interest from donors and the Kenyan government.

iv) Business culture

Ondraczek (2013: 414) ascribed a generally enabling business environment in Kenya a key role in stimulating the SHS market by pointing to 'a strong entrepreneurial culture in Kenya and openness to foreign investors and business practices/ideas', while deploring that 'the lack of entrepreneurs hindered the emergence of successful solar companies in Tanzania during the 1980s and 1990s'. Similarly, Byrne (2009: 207) highlighted that the 'opportunistic behaviour of entrepreneurs once the demand had been demonstrated' was a key to promoting market

development, thus pointing to the widespread opportunism and risk willingness of local firms in Kenya to enter the PV market during its initial development (see also Hankins et al., 2009a). These findings link the emergence of a PV market mainly with the existence of a particularly dynamic and entrepreneurial business attitude in Kenya compared to Tanzania and Uganda.

v) Batteries and components

Acker and Kammen (1996: 88) highlight the development of a local battery supplier industry during the 1990s in Kenya as a key factor for PV market development and in particular emphasize that ‘technical modifications, known and utilized in the manufacture of batteries for other applications for years, improved PV system performance’. This points towards cross-fertilisation of the technical development mainly of car batteries to suit PV systems and thus a fruitful interaction between two emerging industries in Kenya. This is supported by Moner-Girona et al. (2006), who stress that increase in the local availability of components such as batteries, wiring, circuitry and charge controllers in Kenya led to substantial decrease in PV system costs, as this reduced the need for imports, which contributed to stimulating market development. Similarly, Hankins et al. (2009a: 2) stress that ‘the successful development of the household and small commercial system markets is attributable to the availability of balance of systems components [and] local battery manufacturing’. Finally, Ondraczek (2013: 409) too highlights that ‘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’.

7. Conclusion

This paper set out to investigate the development of solar PV markets in Africa by reviewing developments in the solar PV markets in Kenya, Tanzania and Uganda. In the following, we will first present the main conclusions from the review of market development and status in these three countries and then present the main conclusions from the review of the key drivers behind the different market developments in these countries.

Generally, it is evident that, compared to Tanzania and Uganda, Kenya is leading the development of PV markets not only in terms of installed capacity, but also with regard to local industry and PV business development. As the market in Kenya started earlier, it seems that the subsequent development of PV markets in Tanzania and Uganda was influenced greatly by a gradual expansion of PV suppliers into neighbouring countries and by the spill-over of policy experiences from Kenya. While Tanzania and Uganda seem to be rapidly catching up, Kenya will most likely remain at the forefront in terms of PV market development for some time to come.

To gain a deeper understanding of PV market development in each country, it was considered useful to distinguish between different market segments for PV, as these are quite different in terms of scale, capital-intensity, the actors involved and technology characteristics, and hence important to separate in order to understanding the drivers for PV diffusion. For this purpose, five main market segments were introduced to guide the analysis: i) solar home systems (SHS); ii) institutional PV systems; iii) telecommunications and tourism; iv) mini-grids; and v) large-scale, grid-connected PV systems.

Using these categories, we found that SHS play a major role in all three countries, especially Kenya and Tanzania, where SHS currently account for around 80% and 75% of total installed capacity respectively, compared to around 20% in Uganda. This market segment is generally encouraged by a growing demand from private households with increasing purchasing power, but it has also been promoted through VAT and import duty exemptions for imported PV components and various government and donor programmes. The institutional PV segment also accounts for a large share of total installed PV capacity in all three countries, especially Tanzania and Uganda, and has mostly

been driven by direct government and donor procurement of PV systems for rural schools, health clinics and public buildings. The telecommunications and tourism segment is expected to increase in all three countries, but while this segment is relatively large in Uganda, it seems to play a lesser role in Kenya and Tanzania. While the market for PV-powered mini-grids currently only comprises a limited number of installations, this is expected to increase in the coming years, as is reflected in the increasing number of planned mini-grids in all three countries. Similarly, a growing number of grid-connected PV plants are currently in the pipeline that have yet to materialize.

In summary, two broad trends are evident from the above: i) a movement from donor-supported initiatives towards commercial-based market development; and ii) a movement from off-grid to mini-grids and large-scale, grid-connected PV plants. The first trend refers to a movement from PV being mainly a small niche for government and donor procurement towards it increasingly becoming a viable alternative for consumers and private investors in all markets. Not only has the commercial part of the SHS market gained an increasing share of total installed capacity, private investors are also playing a greater role in the other segments, such as telecoms operators and foreign IPP investors.

The second trend refers to the change in market segments that is currently taking place. Whereas the off-grid market for SHS and institutional systems is dominated by small-scale systems for individual consumers or a relative small community, the increasing focus on mini-grids and grid-connected plants comprises a significant increase in the scale and reach of PV installations.

Concerning the explanations for market development provided in the literature, we revealed that these cover a relative wide spectrum of findings focusing mainly on explaining the relatively more advanced position of the Kenyan PV market compared to Tanzania and Uganda.

We also found that the following three generic factors were important for encouraging PV market development in all three countries: i) the decline in world market prices for PV modules, which have made PV increasingly competitive compared to conventional technologies; ii) the prolonged support for solar PV from international donors, which has stimulated both the supply and demand sides of market development; and iii) conducive framework conditions provided by national governments that have encouraged PV both directly through procurement and indirectly via tax incentives. Beyond these generic aspects, we pointed to the following five key factors that have been elaborated in the literature to explain the disparities in market development in the three countries: i) demand structure; ii) geographical conditions; iii) local champions; iv) business culture; and v) batteries and components. The first issue relates to the increasing purchasing power of rural consumers, which has arguably led to increasing demand for SHS, especially in Kenya, but also in Tanzania and Uganda. The second factor is about the apparently more conducive physical conditions in Kenya with regard to transport infrastructure and the relatively close localization of the PV supply and consumer demand. Thirdly, the importance of local champions playing a key role in kick-starting the PV market in Kenya by training local PV technicians and implementing the first demonstration projects has been highlighted in the literature. The fourth issue concerns the apparently more widespread entrepreneurial culture in Kenya that has encouraged risk willingness, which was particularly important during the initial phase of market development. Lastly, the parallel development of a PV supplier and battery industry has been considered a key factor in explaining the relatively more advanced state of PV market development in Kenya.

While these explanations do indeed provide plausible elements in understanding PV market development in Kenya, Tanzania and Uganda, the complexity of the topic needs to be recognised. We see this paper as a first modest step in gaining a deeper understanding of this complexity.

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