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Deconstructing the dichotomies of solar photovoltaic (PV) dissemination trajectories in Ghana, Kenya and Zimbabwe from the 1960s to 2007 ☆

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HIGHLIGHTS

- ▶ I examined the disparate disseminations of PV in Kenya, Zimbabwe and Ghana.
- ▶ Kenya's PV market successes not down to private sector alone.
- ▶ Varied antecedents underpin the dissimilar disseminations of PV in these countries.
- ▶ Replication of Kenya and Zimbabwe success stories in Ghana demands certain factors.

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ABSTRACT

The profuse dissemination and utilisation of solar PV technology in the world is indispensable, especially in this era of climate change. However, in the African continent, between 1960 and 2007 Kenya and Zimbabwe were among countries with the highest PV dissemination, while Ghana was among countries with the least disseminations. Analysing empirical data through the lens of the Social Construction of Technology (SCOT) theory, the article aims to uncover the drivers underpinning the disparate dissemination trends of PV in the three countries within the stated period and to tease out lessons apropos replicating the successes within Kenya and Zimbabwe in Ghana. SCOT theory is chosen because it provides an excellent framework for analysing the social shaping of PV's development and diffusion processes in these countries. This theory posits that the shape and meanings of a technology do not reside in it, but are acquired through the heterogeneity of social interactions. Findings in the paper reveal that a gamut of socio-economic and political antecedents informed the varied dissemination outcomes of the technology in these countries. Premised on these findings, the paper recommends critical steps, which Ghana needs to undertake to enhance the replication of the Kenyan and Zimbabwean PV success stories.

1. Introduction

Climate change and its attendant consequences have brought into perspective the dangers of developed and developing countries' continuing with conventional economic development paths, with the accompanying greenhouse gases. In recent years, a green economy development paradigm, has dominated international development dialogues and policy debates. The advocacy for a paradigm shift from the dinosaurian economic development models to a green economy is predicated on the latter paradigm's ability to improve intergenerational welfare and social equity, and concurrently reduce environmental risk and ecological scarcities (UNECA, 2011). A shift from the current path of large fossil fuel consumption to the uptake and utilisation of renewable energy technologies will enhance the global agenda on the green economy.

The choice of renewable energy technologies (RETs) includes solar photovoltaic (PV), wind, geothermal, biofuels, biogas, mini hydropower, among others. According Greenpeace and EPIA, 2011 "Solar can and must be a part of the solution to combat climate change, helping us shift towards a green economy" (p. 6). An enhanced deployment and utilisation of these RETs could generate considerable benefits for the whole world. Their uptake will foster the protection of natural resources to serve as carbon sinks; reduction of health related risks associated with the use of non-modern sources of energy; increase access to modern energy; reduction of the oil dependency risks; economic development through creation of jobs, and so on (Laumanns et al., 2004; Radulovic, 2005).

☆This paper is based on the author's doctoral thesis, which was accepted by the University of Hull, UK in 2008. Thus, the majority of PV data cover the 1960s through to 2007. However, the paper infuses current and relevant literature, whenever possible.

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The natural resources for most of these RETs are ubiquitous. Solar energy, for example, is the most abundant energy resource on earth, and the reliability of PV technology has gained grounds over the years (IEA, 2010). The global PV market has been on the rise, particularly in this 21st Century. With a worldwide PV cumulative installed capacity of about 1.5 GW in 2000, it rose rapidly to roughly 40 GW in 2010, producing some 5 TW h of electricity annually (EPIA, 2011). Although very encouraging, the distribution of this cumulative installed capacity has been, however, very lopsided between continents and between countries.

In Africa, for example, the dissemination of the technology has flourished in countries such as South Africa, Kenya and Zimbabwe, while many others including, Ghana, Uganda, Malawi among others, have lagged behind, and there is paucity of data giving understanding to such disparities. Examining empirical data and literature sources through the lens of the Social Construction of Technology (SCOT) theory, this article unlocks the varying antecedents that have underpinned the disparate dissemination trends of PV technology in Kenya, Zimbabwe and Ghana from 1960 to 2007. Kenya and Zimbabwe were chosen for this three-country analysis, because they are among the largest PV markets in Africa (Jacobson, 2004). In particular, the Kenyan PV market is viewed as an archetypal success story in the developing world (Duke et al., 2002; Otieno, 2004). In contrast, Ghana appears to be one of the least developed PV markets in Africa. Based on the findings, the article draws lessons apropos the feasibility of Ghana replicating the high dissemination trends of PV in Kenya and Zimbabwe. Bryne (2009) study for example, revealed that initial attempts to replicate the success of the Kenyan SHS niche in Tanzania, failed. The primary reason for this failure is that the two countries have disparate institutional and political structures, which emanated from their dissimilar political and economic development paths in the past.

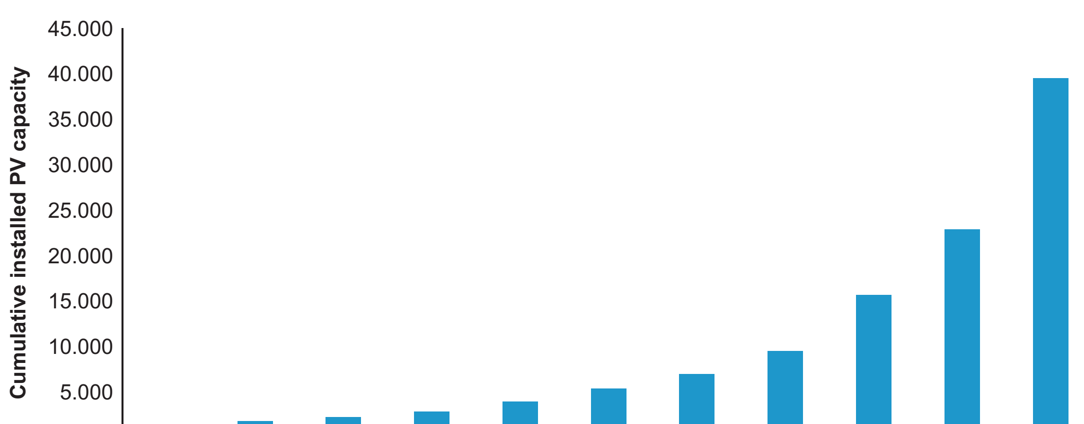
2. Global dissemination perspectives of PV

The development of PV has been rapid since its first application in small quantities in the 1950s. It emerged in the last decade as a potentially major technology for power generation in the world (EPIA, 2010; Greenpeace and EPIA, 2011). The average annual growth rate over the last decade was about 40%. With a global cumulative installed capacity of 0.1 GW in 1992, installed PV power capacity grew to 14 GW in 2008, 22 GW in 2009 and over 37 GW by the end of 2010 (IEA, 2010; Greenpeace and EPIA, 2011) (see Fig. 1). This rapid change in the installed capacity of PV has not only taken place at the global level, but also at the country level. The evolution of installed capacities in countries around the world hitherto, shows that different countries have been at the forefront at different times.

Fig. 2 depicts the changing trends of the relative cumulative installed capacity of PV in different countries from 2000 to 2010. In the year 2000, Japan was the leading PV installer in the world, followed by the Rest of the world, United States of America and Germany. In 2004, Japan continued to lead in the global share. However, Germany leapfrogged to second place (35%), followed by the Rest of the world (14%) and the United States of America with (13%). Since 2006, however, Germany became the frontrunner of the world's PV installation and dissemination. Germany had a share of 57%, Japan (20%), rest of the world (10%), United States (7%) and rest of Europe (6%) of the total global PV installed capacity in 2006. In 2008, Germany had 36% share in world-wide PV installation, followed by Spain (23%), Japan (15%), rest of the world (11%), United States (8%), and Italy, Korea, France, China. In 2009, Germany controlled about 53% of the global PV market and an installed PV capacity of about 10 GW. Italy was second, followed by Japan, USA, Czech Republic, Belgium, France, rest of the world, China, Korea, Australia, Canada and Spain. Germany continues to lead in 2010, followed by Spain, Italy, Japan, USA, the rest of the world, Czech Republic, France, Belgium, China, Korea and other EU.

As a sub-set of the rest of the world, Africa's share of the global installed capacity of PV is less than 1%. On a country level, however, as of 2007 Kenya and South Africa were leading all the African countries with approximately 150,000 installed PV systems each, followed by Zimbabwe (see Fig. 3). There is a clear gulf between the disseminated PV systems in South Africa, Kenya and Zimbabwe and the rest of the African countries.

In respect of the disparate market shares and installation figures in different countries, most authors draw links between the countries' dissemination rates and their prevailing conditions. For instance, it has been argued that solar power booms in countries where the so called boundary conditions are right (Greenpeace and EPIA, 2011). It has been argued that the dominance of Germany in PV installations and market shares stems from the existence of good conditions, including the introduction of the feed-in-tariffs (FiT), good financing opportunities, a large availability of skilled PV companies, and a good public awareness of the technology (EPIA, 2010). It has also been argued that the sharp rise in Italy's installations in 2009 was attributed to the implementation of the



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
MW	1.459	1.790	2.261	2.842	3.961	5.399	6.980	9.492	15.655	22.900	39.529

Fig. 1. Evolution of global cumulative installed PV capacity: 2000–2010.
Source: Adapted from EPIA, 2011.

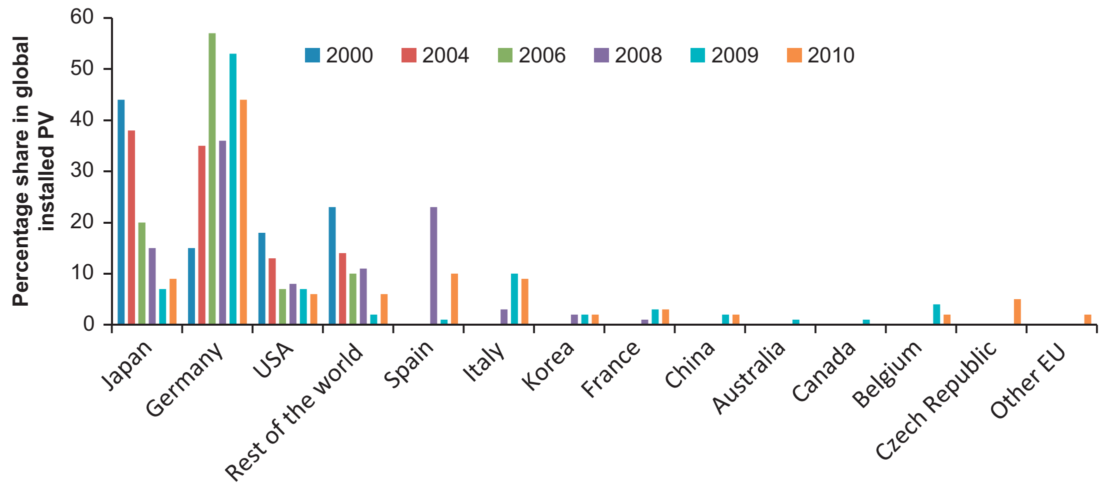


Fig. 2. Installed solar PV capacities in various countries from 2000 to 2010.
Source: IEA, 2010; Bawakyillenuo, 2011; Greenpeace and EPIA, 2011.

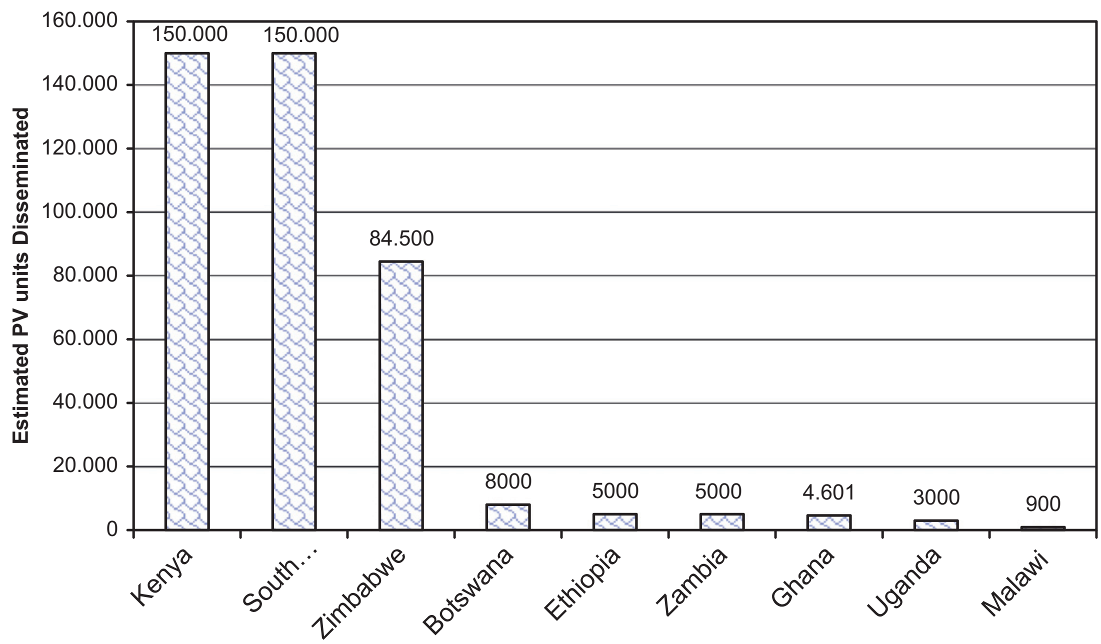


Fig. 3. Estimated number of solar PV systems disseminated in selected African countries.
Source: Karekezi, 2002; Edjekumhene, 2003.

FiT; and Japan's successes attributed to the subsidy for residential PV systems (ibid). Others, including Laumanns et al. (2004) point to the imperative of a secure financial basis for the promotion of renewable technologies.

Addressing issues related to an institutional framework for the analysis of solar energy technology diffusion in developing countries, Brew-Hammond (1995) identified policy, regulatory institutions, science and technology institutions as the key enabling agents for solar technologies' development. Apart from comparing skeletally, solar issues in Ivory Coast and Ghana, this paper dwelled on the general institutional issues of solar diffusion in developing countries.

3. Social construction of technology (SCOT) theory

Theories of social construction of technology, examine the development of technologies, defining working or non-working not as intrinsic properties of technology, but a socially constructed meaning attributed by *relevant social groups*. As Bijker (1995a) points out "one artefact comprises different socially constructed artefacts, some of which may be working while others are non-working" (p. 75). 'Artefact' as used in his analysis refers to a technology with a clearly defined user or consumer group, because it is a term that minimizes social and technical distinctions by refusing the language of objects and machines.

The Social Construction of Technology (SCOT) theory conceptualises the social shaping of technologies and the technological shaping of societies. It examines the interplay between socio-economic, political and cultural factors in the process of technological development and diffusion. In Bijker (1995b) version of SCOT for instance, he notes that technologies are not only shaped by the power strategies of different groups but also form part of the micro-politics of power themselves. Central to this theory is that the meaning of a technology does not reside in the technology itself; rather, its shape and meanings are acquired through the heterogeneity of social interactions. As Bijker (1995b) notes "artefacts [technologies] are…described through the eyes of the members of relevant social groups" (p. 252). In other words, social groups, which may or may not be homogenous, define which technological issue or 'artefact' is a problem to be addressed (Pinch and Bijker, 1987, pp. 30, 33, 34).

Central to SCOT's conceptualisation are: the relevant social groups, interpretative flexibility, closure and stabilisation, and the wider context (Pinch and Bijker, 1987). The concept of *relevant social groups* denotes "institutions and organisations as well as organised or unorganised groups of individuals…[that] share the same set of meanings, attached to a specific artefact" (Pinch and Bijker, 1987, p. 30). In SCOT the relevant social groups are considered the agents, and the meanings they attribute to the technology are traced to their actions.

The concept of *interpretative flexibility* means that "different social groups have radically different interpretations of one technological technology" (Pinch and Bijker, 1987, p. 41). The diverse interpretations which social groups accord a technology help to unravel the *problems* and *conflicts* they have with respect to this artefact.

The concept of *closure and stabilisation* are two aspects of the same process (Bijker, 1995a). It involves the process by which different interpretations of a technology by social groups, lead to its continual design in order to bring about solutions to the conflicts. At a stage, when the design of the technology no longer poses a problem to any social group, then a closure to its design is achieved as well as the stabilisation of its final form. The fourth key concept of SCOT—*wider context,* refers to the wider socio-political milieu of the development of a technological technology (Pinch and Bijker, 1987).

3.1. Shortcomings of the social construction of technology (SCOT) theory

SCOT has been criticised for being more agency-centred in its approach to the neglect of structure (Russell, 1986; Klein and Kleiman, 2002). For instance, with respect to consensus building in the design of a particular technology, SCOT posits that it comes about as a result of the interaction of different relevant social groups. Deriving consensus in this manner therefore neglects the roles and influences of social structural factors, such as economics, politics, power, ideology in the design of a particular technology. As Russell (1986) argues "An explanation of technological change must show not only what different social groups think of an artefact, but also what they are able to do about it" (p. 336).

The theory's methodological approach of identifying the relevant social groups by "rolling a snowball" has also been criticised since some relevant social groups may not be captured in the process. The absence of such relevant social groups' influences, could therefore distort the complete understanding of a particular technological artefact's development.

3.2. Modifications introduced in scot in this article

To overcome these limitations of SCOT so as to provide a comprehensive conceptual framework to underpin this paper, some modifications have been introduced in the theory based on Bawakyillenuo's (2011) work. First, to help address the agency-centeredness approach of SCOT, the concept of *intermediation* is incorporated in its conceptual framework to examine the roles of intermediary bodies that intervene between an innovation and its potential adopters, and their influence in shaping the interpretation of the innovation and adoption. Thus, incorporated in the modified SCOT is a more explicit discussion of the resource (economic, political, cultural, wealth) capacity and power of different social groups, the existing social structures, and how these influences shape the adoption patterns of an innovation.

Second, the pitfalls of applying the snowball sampling approach (i.e., the possibility of excluding relevant social groups) in the SCOT theory's methodology has been reformed to incorporate such possible exclusions through the undertaking of two fieldworks: an exploratory study and a major fieldwork. The exploratory study is very important because through the analysis of the data that are gathered, the researcher will be able to tease out all the relevant social groups, who will then be part of the sample during the major fieldwork.

4. Trajectories of solar PV dissemination in Kenya, Zimbabwe and Ghana

An overview of the historical socio-economic and energy profiles of the three countries between 1960 and 2007 is imperative for a composite understanding of their PV dissemination disparities. Table 1 is a summary of these profiles.

Historically, after independence in 1963, Kenya had 10 years (1963 to 1973) of steady and rapid economic growth in a stable political environment (see Fig. 4). This steady economic growth was realised through the promotion of public investment, smallholder agricultural production, and incentives for private industrial investment (Acker and Kammen, 1996). During this 10-year period, the Kenyan GDP and agriculture grew at an annual average of 6.6% and 4.7%, respectively (Bureau of Africa Affairs, 2007a). The post-independence economic growth was interrupted by the first and second oil shocks of 1973–1974 and 1979, respectively. However, Kenya rebounded from both oil shocks and recorded one of the strongest GDP growth rates (23%) in 1970; and from the mid-1980s through to the early 1990s GDP hovered around 6.2% (Dunne and Asaly, 2005).

Zimbabwe had a chequered economic history before and after independence (see Fig. 5). In the early 1970s, the economy experienced a modest boom, but slumped between 1974 and 1978 (Bureau of Africa Affairs, 2007b). However, between 1979 and 1981, Zimbabwe experienced a brisk economic recovery, with an annual real GDP growth rate exceeding 20%. The pattern of economic growth in the remainder of the 1980s to the early part of the 1990s was replete with fluctuations. The annual real GDP growth rate declined in 1982, 1983, and 1984; increased in 1985; slumped to zero in 1986; registered 3% in 1987 and averaged about 5% in 1988 through 1991 (Richardson, 2006). According to Richardson (2006) "Economic growth [of Zimbabwe] from 1980 to 1989 averaged 5.2% in real terms…" (p. 2). Similarly, real GDP growth rate of Zimbabwe in the remainder of the 1990s to date has also been characterised by fluctuations.

The economic growth record of Ghana has been one of unevenness since independence in 1957 (see Fig. 6). With a reasonably high GDP real growth in the 1950s and early 1960s, the Ghanaian economy began to experience a slowdown in GDP growth in 1964. According to Aryeetey and Fosu (2003) "Growth was turbulent during much of the period after the mid-1960s and only began to stabilise after 1984. In 1966, 1972, 1975–1976, 1979, 1980–1984, the growth rate was negative" (p.4). The lowest growth rate of −14% was experienced in 1975, while the highest peak rate of 9% was experienced in 1970 and 1978 (ibid). The economy of Ghana recovered from its negative growth rate of about −5% in 1983 to a large positive rate of 8% in 1984, and has been growing favourably since then.

4.1. Analysis of drivers of the disparate dissemination rates of PV—Kenya, Zimbabwe and Ghana

Critical analysis of the various elements in Table 1 above shows that while Kenya and Zimbabwe have much in common economically and on PV development, they contrast with Ghana.

Table 1
Summary of historical demographic, socio-economic and energy characteristics of Kenya, Zimbabwe and Ghana between 1960 and 2007.
Source: Acker and Kammen, 1996; Mapako and Afrane-Okese, 2002; Aryeetey and Fosu, 2003; Edjekumhene, 2003; AEO, 2003; Dunne and Asaly, 2005; IAEA, 2006a; Richardson, 2006; Werner et al, 2011.

	Kenya	Zimbabwe	Ghana
1. Population (2007 est.)	34.7 m	12.3 m	22.4 m
% Rural	79%	68%	54%
% Urban	21%	32%	46%
2. Total electricity production (2007 est.)	4.34 TW h	8.88 TW h	5.36 TW h
% Hydroelectric plants	74%	49.2%	84%
% Thermal plants	17.8%	50.8%	16%
% Solar and other plants	7.9%	Unknown	<0.5
3. National access to grid electricity (2007 est.)	15%	32%	43%
% Urban	20%	70%	77%
% Rural	4%	5%	17%
4. Number of Installed PV systems (2007 est.)	150,000	85,000	4600
5. Installed PV capacity (2009 est.)	7.05 MW p	0.22 MW p	0.55 MW p
Year/period of solar PV inception	1970s	1960s/1970s	1990s
6. Past economic growth rate trends			
Early 1970s–mid-1980s	Steady economic growth with a few intermittent declines	Steady economic growth with a few intermittent declines	Continual economic decline
Mid 1980s–mid-1990s	Steady economic growth	Steady economic growth with a few intermittent declines	Steady economic growth
Mid 1990s–early 2000s	Steady economic growth with intermittent declines	Initial steady economic growth in the mid-1990s, massive and continual decline from 1999 onwards	Steady economic growth

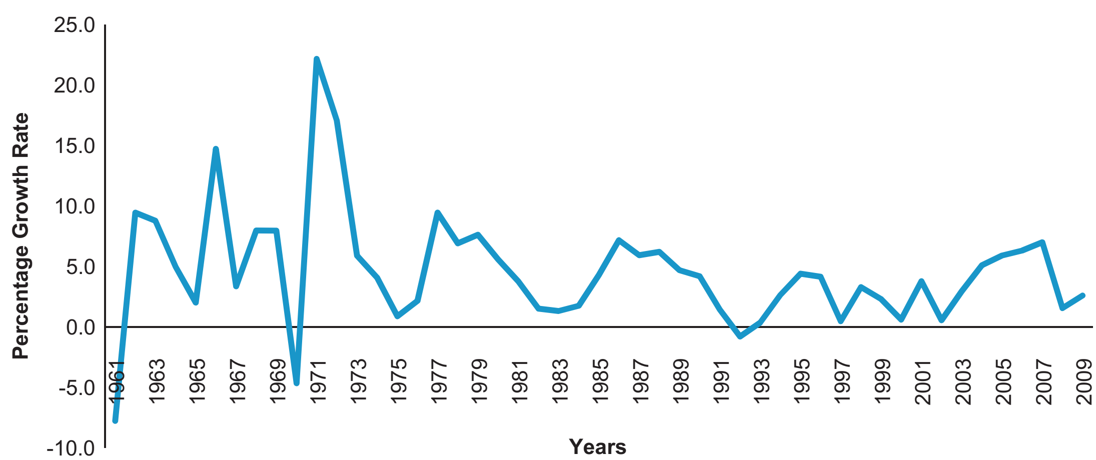


Fig. 4. Kenya's annual economic growth rates based on changes in GDP (constant 2000 US$) from 1961 to 2009.
Source: World Bank, 2011.

The PV industry started becoming active in Ghana in the 1990s, while it grew rapidly in the1960s/1970s in Kenya and Zimbabwe. Economic growth rates flourished in Kenya and Zimbabwe in the early part of the 1970s to the mid-1980s, while growth was quite turbulent in Ghana.

Examining the gathered data using the SCOT theory, an understanding of the disparate dissemination levels of PV in the three countries is situated in an interconnection of contextually specific historical processes and factors (see Table 2).

4.1.1. *International funding/donor support influence*

A historical factor that helps explain the high levels of PV dissemination in Kenya and Zimbabwe compared to Ghana is the different levels of influence exerted by western donors on PV issues in these countries. One area of donor agencies' influence is investment, which would have either contributed to wide dissemination of PV or low dissemination.

In Kenya, donor investment on PV has been catalytic to its market growth. Donor agencies' investment in PV was substantial, especially from the 1970s to the middle of the 1980s, and eventually triggered the private market development. According to Acker and Kammen (1996) "…the 'donor market' – mostly large-scale photovoltaic projects funded by donor agencies – was for a number of years the only PV market in Kenya" (p. 87). In the 1970s and 1980s, Kenya had a comparative advantage over other African countries in the light of donor investment in PV, because Nairobi became the regional "hub" for the donor driven solar industry. According to Jacobson (2004) "… in the late 1970s and early 1980s, PV sales were sufficiently limited …In East Africa,

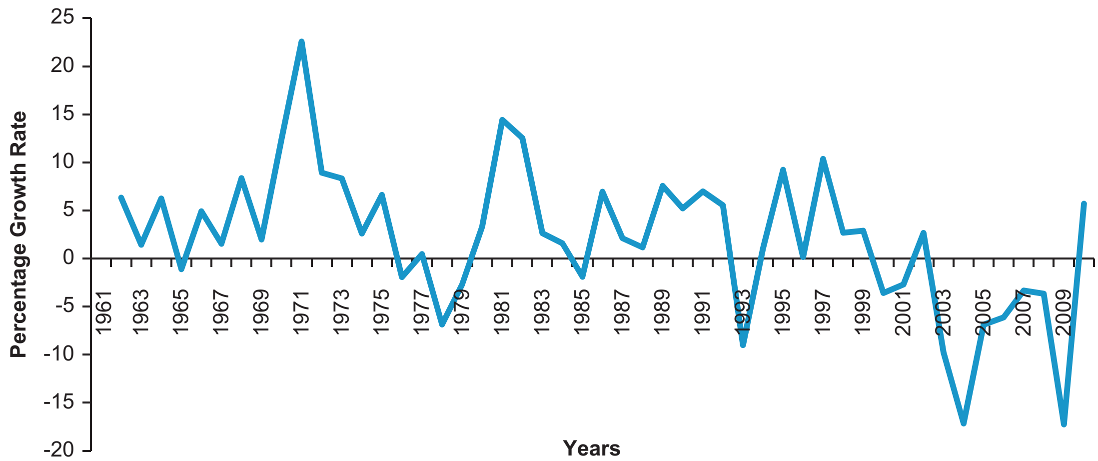


Fig. 5. Zimbabwe's annual economic growth rates based on changes in GDP (constant 2000 US$) from 1961 to 2009.
Source: World Bank, 2011.

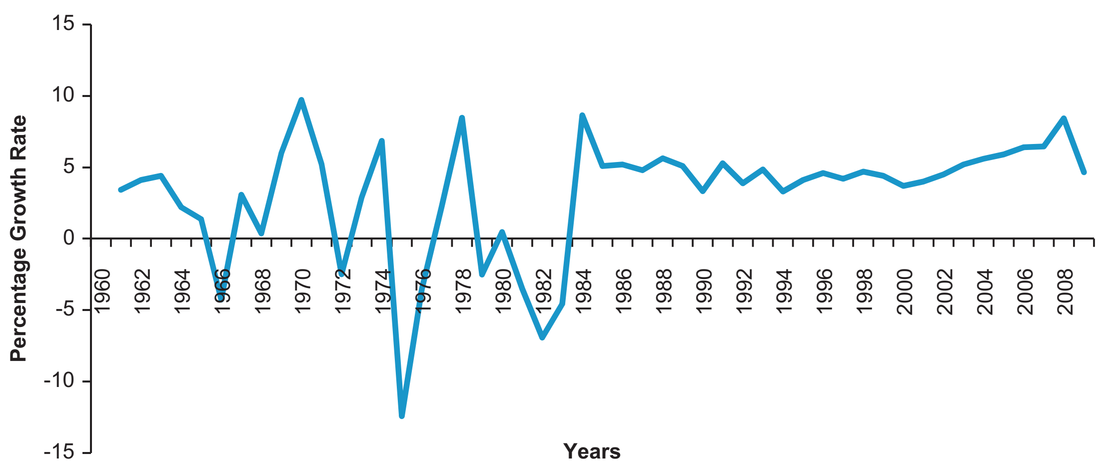


Fig. 6. Ghana's annual economic growth rates based on changes in GDP (constant 2000 US$) from 1961 to 2009.
Source: World Bank, 2011.

Nairobi, served as the 'hub' for the regional PV supply chain" (p. 131). Nairobi was also the regional hub of UNEP. This therefore created the initial PV supply chain in Kenya.

Available donor funding figures for Kenya in the 1990s for example, give an insight on the large investments Kenya has had compared to countries like Ghana. In 1998 the International Finance Corporation (IFC), the private lending arm of the World Bank Group (WBG) allocated $5 million to Kenya through the Photovoltaic Market Transformation Initiative[1] (PVMTI). Only this single injection of finance exceeds the total international funding for PV in Ghana from 1990 to 2007.

Similarly, donor funding for PV activities in Zimbabwe, arguably influenced the relatively high dissemination level of PV as compared to Ghana. As depicted in Table 3, Zimbabwe experienced considerable international donor funding for PV in the 1990s. Prominent among these donor funding sources were the UNDP-GEF and the JICA PV programmes. Like Kenya, the overall past international donor investment on PV in Zimbabwe surpasses that of Ghana.

In comparison with Kenya and Zimbabwe, past donor funding on PV has been relatively lower in Ghana. The first major donor PV project was the Spanish/Ghana governments' project in 1998 and the second being the UNDP/GEF Renewable Energy Service Project in 1999. The sum of these two major projects (US$4.5 million) is lower than the one-off IFC funding alone in Kenya or the UNDP-GEF funding in Zimbabwe. The relatively high amount of international investment in PV in countries such as India, China, and South Africa in the 1990s, with their corresponding high PV installations corroborates the catalytic role of donor funding. India had US$15 million IFC funding in 1998; China, US$20 million UNDP/GEF funding in 1995; and South Africa, 27 million EUR PV funding from the Dutch government and European Commission in 1995 (IEA-PVPS T9-07, 2003).

4.1.2. Government policy direction on energy

A direct driver that arguably contributes to shaping the disparate levels of PV dissemination in the three countries is the different make-ups and foci of their energy policies. As will be highlighted in this sub-section, the characteristics of each of these countries' energy policies a propos grid and PV have directly

[1] "The Photovoltaic Market Transformation Initiative (PVMTI) is a strategic intervention to accelerate the sustainable commercialisation and financial viability of PV technology in the developing world. It is based on the premise that private sector project design and financing on commercial basis will stimulate more sustainable ventures than government or donor financed PV procurements" (IFC, 1998, p. 1).

Table 2
Classification of the drivers underpinning the different rates of PV development and dissemination in Kenya, Zimbabwe and Ghana.
Source: Author's own construction.

Direct drivers	Indirect drivers
Role of international funding	
Government policy direction on energy Policies on grid vis-à-vis PV Rate of grid extension	Disparate political historical landscapes of the three countries
Market approaches/access dynamics Targeting the rural affluent group √ Entrepreneurial spirit of solar PV businesses Awareness creation Adoption of favourable financing schemes	
Technical capacity building on solar PV Sizes of PV systems sold Estimated number of solar PV companies and technicians Estimated number of other PV institutions	
Disparate historical economic forces, especially in the rural areas	
Geographic scales of drivers	
International drivers	**National/local drivers**
International funding	Government policy direction on energy Market approaches/access dynamics Technical capacity building on solar PV Disparate economic and political historical landscapes

shaped the energy consumption patterns and behaviour of energy end-users in the rural areas.

Since independence in 1963, Kenya's national electrification policies have been based largely on the supply of electricity from the grid. The 1974 Rural Electrification Programme (REP)[2] was based on the extension of the grid. However, after more than three decades as of 2007, only 4% of rural households had access to the grid, while PV household systems (SHS) serve almost the same percentage of rural households (3.7%) (Hankins, 2001; Kenya National Bureau of Statistics, 2005; Kenya National Bureau of Statistics and ICF Macro, 2010). The annual number of homes electrified privately with PV in rural Kenya exceeds those being electrified through the grid (IEA-PVPS T9-07, 2003). A major characteristic of the Kenyan REP that probably helps to explain the high adoption rate of PV systems in rural Kenya is the slow pace of the grid extension. In an interview with stakeholder "**A**" in 2004, he pointed out that:

> *Most people in rural areas in Kenya rely on solar PV to power their electrical equipments, because the government has not honoured its rural electrification promises*[3]

Results of studies in Kenya support the argument that the slow pace of the grid extension is one of the major drivers for PV's market growth in rural areas. Acker and Kammen (1996) observed that "For most rural consumers, prospects of grid electrification are dim…For the Kenyan government, rural electrification is of secondary importance compared to urban electrification" (p. 89). Rural consumers needed to overcome many hurdles to connect to grid: high cost; multiple organisational barriers and bureaucratic/political lethargy (ibid). Similarly, Jacobson (2004) contends that "…the emergence and growth of the solar market was strongly tied to the slow pace of grid based rural electrification" (p. 134).

Furthermore, past Kenyan government policies, especially duties and tariffs waiver on PV, also help to explain the country's high adoption rate of the technology. From 1986 to 1991, the Kenyan government removed all import duties on all solar modules, which were then reintroduced in 1992 (Jacobson, 2004). Nonetheless, in 1996 import duties on PV modules with or without diodes were reduced from 53% to 27%, but were removed again from 2000 to 2002 (Duke et al., 2002; Jacobson, 2004; Magambo, 2004). The removal of duties on the PV modules prevented the high increase in PV modules' prices, and thereby stimulated sales and demand as many could then afford to purchase them. While the removal of the import duties on PV modules and the onwards reduction in their prices benefitted many, especially low income groups, private businesses also gained from the high patronage by consumers and the savings made from the import duties exemptions.

Past rural electrification policies in Zimbabwe also paralleled those of Kenya. With extensive coal reserves, the emphasis of Zimbabwe's rural electrification policies after independence was on the extension of the existing national grid. However, as shown in Table 1 above, as of 2003 only 5% of rural households had access to electricity from the grid; with almost the same percentage (i.e., 4.6%) of rural households privately adopting PV (United Nations Development Programme , 2000). Like Kenya, it could be argued that the main focus of the Zimbabwean Rural Electrification Programme and the pace of the national grid extension to the rural areas, are part of the processes that shape the high adoption pattern of PV in rural households. According to the IEA-PVPS T9-07 (2003) "In its effort to promote rural electrification, the [Zimbabwean] government initiated a ten-year programme in 1997, under which local economic centres, are electrified by existing grid extension. No special programmes [were] planned for households" (p. 32).

Other features of Zimbabwe's energy policies, especially in the 1990s that have accounted for the high dissemination of PV are taxes and import duties' waivers. During the GEF/UNDP PV project (i.e., 1993–1998), all PV components imported under the project were duty-free.[4] This had the possibility of reducing prices and enhancing end-users' affordability. As Mapako (2002) reveals "Over the five-year period, over 9000 45-watt systems were delivered under subsidised conditions…in the form of duty waiver on imported components and a low interest rate of 15% per annum for clients purchasing systems under the [GEF/UNDP] project" (p. 21).

The past rural energy policy approach of Ghana was akin to those of Kenya and Zimbabwe—grid focused. However, while Kenya and Zimbabwe have considerable low levels of rural electrification through the grid, it is relatively higher in Ghana—17%. This indicates that the implementation of grid-based rural electrification programme in Ghana, although not excellent, has been more rapid compared to Kenya and Zimbabwe. The government of

[2] The REP has been jointly operated by the Kenya government and the Kenya Power and Lighting Company (KPLC)—a parastatal agency that is 51% owned by the Kenyan government.

[3] Stakeholder "**A**" is a solar PV technician for the Solarnet organisation in Nairobi, Kenya.

[4] However, all other solar PV importations attracted duties during the GEF/UNDP project's period and post-GEF/UNDP project phase (United Nations Development Programme, 2000).

Table 3
kdo1990s International donor funding for PV in Kenya, Zimbabwe, Ghana.
Source: IFC, 1998; Davidson and Mwakasonda, 2003; Energy Commission-Ghana, 2003.

Donor	Country	Year	Area of support	Total amount
UNDP-GEF	Zimbabwe	1993–1998	PV programme	US$7million
JICA	Zimbabwe	1997–1999	Installation of clusters of PV systems	US$10million
GTZ	Zimbabwe	1992–1994	PV water pumping	US$6.5million
Chinese government	Zimbabwe	1999	110 PV household systems and a water pump	–
Italian government	Zimbabwe		Lighting of rural schools and clinics	US$92 thousand
IFC	Kenya	1998–2008	Market development PV	US$ 5 million
Spanish/Ghana governments	Ghana	1998	Street and community lighting, vaccine refrigeration	US$2million
UNDP/GEF	Ghana	1999–2004	Installation of PV in rural communities	US$2.5million

Ghana's expenditure on the national grid over the years has been considerable compared to PV (see Table 4). Thus, grid extension to rural Ghana is one of the key drivers of the low dissemination of PV compared to Kenya and Zimbabwe. For example, during one focus group discussion in 2006, some rural interviewees in Ghana indicated that "*We will wait for the national grid no matter how long it takes*". This could be because they had seen evidence of the grid extension.[5]

Other aspects of Ghanaian government energy policy that have driven the low dissemination of PV in Ghana are the import duties on PV components and the high tariffs on PV systems vis-à-vis the national grid. Whilst grid users in Ghana benefit from tariff subsidy, PV users do not, which drives a lot of people to crave for the grid.

4.1.3. Market approaches/access dynamics

The diverse market approaches used to disseminate PV in the three countries by both private and public sectors in the past have influenced the disparate dissemination levels. While Kenya and Zimbabwe share similarities regarding the market approaches/access dynamics to the development of PV market, Ghana's approaches are different.

4.1.3.1. Targeting the rural affluent social group. One of the market approaches used by private businesses in Kenya and Zimbabwe to disseminate PV to rural areas at the early stages of its development and later on, was through targeting affluent rural communities without electricity. A catalyst group in these countries demonstrated the possibility of commercially viable private sector sales of PV systems directly to the rich rural off-grid population (Jacobson, 2004). The successes of these catalytic or pioneer *social groups*, which took place without donor assistance boosted other private businesses' entry into the PV rural market.

The market for PV in rural Kenya was initiated in 1984 by one Harold Burris in the south of Mount Kenya (Acker and Kammen, 1996). Firstly, 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 (Acker and Kammen, 1996; Hankins, 2001). Burris' successes attracted other local entrepreneurial groups and individuals to join the rural PV market (Duke et al., 2002). The market approach of targeting well-off individuals within the rural areas was also used to market PV systems in rural Zimbabwe at the early developmental stage of the technology. In the 1980s according to Mulugetta et al. (2000) "…solar companies largely targeted the affluent rural dwellers or urban dwellers with second homes in rural areas" (p. 1069). This also manifests the entrepreneurial spirit of PV companies in Zimbabwe at the time.

Table 4
Comparison of government funding between the national grid and PV in Ghana from 1996–2006.
Source: Bawakyillenuo, 2011.

Years	National grid (Akosombo)	Years	Solar PV
1996	↑	1996	–
1997	US$130 m to extend the grid	1997	–
1998	under phase 3 of the Self Help Electrification Program (SHEP)	1998	US$2 MOE-Ghana/Spanish government
1999	↓	1999	↑
2000			US$3.131 m to implement RESPRO (GEF $2.5 m & MOE-Ghana $500,000)
	↑	2000	↓
2001	US$105 m[a] to extend the grid under phase 4 of the SHEP	2001	
2002		2002	
2003		2003	
2004		2004	
2005		2005	–
2006	↓	2006	–

[a] This amount is part of the total amount US$350 m required to implement the whole of SHEP-4.

In contrast, PV companies in Ghana have not adopted this approach of targeting affluent rural dwellers. The few PV businesses in the country – all of which were established in the 1990s and 2000s, are located in the capital city of Accra, except one, which is also located in the capital city of Northern region – Tamale. These private businesses have rarely promoted PV technology in rural areas. The absence of a rural focus by these businesses in the country emerged per the views of the director of Solar Light Company in Accra during an interview in 2005:

"The PV businesses currently operating in Ghana were all established in the 1990s and 2000s, especially 1998, when the country experienced power crisis. Thus, we entered the market to meet the urban electricity demand due to this crisis. However, when the crisis was over, many PV businesses became defunct. Those currently operating are very small, because the market is not guaranteed. Also, we have not ventured into the rural areas, because of financial risks".

4.1.3.2. Awareness creation. Another phenomenon that has underpinned the differences in PV dissemination levels in the three countries is the level of awareness creation.[6] According to Hankins (2004) "…PV markets grow in an organic manner. Consumer demand grows once awareness is built up…" (p. 34).

[5] As of 2007 all the then 120 district capitals of Ghana had been connected to the grid. Thus, a lot of extension poles had passed through many villages before reaching the district capitals. Upon seeing the extension poles, many rural people are therefore full of the expectation of grid extension.

[6] It should be noted that awareness creation and targeting of affluent people are complementary.

While the level of education on PV is low in Ghana as a result of the overreliance on the national grid (Bawakyillenuo, 2009), it has been very high in Kenya and Zimbabwe. Hankins (2000) indicated that "by 1999, 3-4% of rural population [in Kenya] had acquired a PV system, and at least 70% knew what such a system was" (p. 95). Awareness creation approaches in rural Kenya included: demonstrations in schools and houses to educate potential clients; direct marketing at district agricultural shows; visits to consumer homes by sales agents and technicians; education of consumers and sales agents through educational seminars; advertisement in newspapers, and encouraging early adopters to tell others about the utility of the technology (Acker and Kammen, 1996; Hankins, 2001; Duke et al., 2002).

Through inferences, it can be argued that the high level of PV awareness in rural Zimbabwe has also been created through similar approaches since these are some of the most effective approaches that can be used to reach and convince the affluent segment of the rural population. The GEF PV project complemented this awareness creation in Zimbabwe. According to Mulugetta et al. (2000) "… the [Zimbabwean] GEF Solar project … enhanced national public awareness of the benefits of PV electricity …due, in no small measure, to the publicity that was undertaken …to popularise the technology across the country…" (p. 1074).

4.1.3.3. Adoption of favourable financing schemes. The adoption of favourable financing schemes in Kenya and Zimbabwe would seem to have enhanced the high level of PV adoption. Some private PV businesses in Kenya have used consumer financing schemes such as the Hire Purchase (HP) credit system. Through the HP system workers in both rural and urban Kenya are able to purchase PV systems on credit and pay on a monthly instalment basis. By 2001, about five major HP firms were supplying household PV systems to the Kenyan market, with over 10% of the PV market (Hankins, 2001). Also of note is the Kenyan consumer micro-credit scheme, introduced in 1998 by the PVMTI. This scheme promoted the installations of hundreds of systems (Jacobson, 2004). With respect to Zimbabwe, the 1997 JICA project also utilised the Energy Service Company (ESCO) approach to disseminate the PV systems (Mapako, 2002), while the GEF project used a revolving fund financing scheme that helped increase the accessibility of PV systems to many consumers in both rural and urban areas.[7] According to United Nations Framework Convention on Climate Change (UNFCCC) (1998) "The major driving force for the achievement of the Zimbabwe GEF is the revolving fund, managed by the Agricultural Finance Corporation (AFC), which provided low-interest loans to potential PV owners" (p. 14). Contrastingly, in Ghana the few existing PV businesses continue to rely solely on the cash sales module, with only few people able to afford the technology through it.

4.1.4. Technical capacity building on PV

The diversity of the three countries' technical capacities for PV is another variable that feeds into the disparate levels of PV dissemination. The line of reasoning herein is that the better developed the technical capacity for PV in a country is, the higher the level of PV adoption and vice-versa. Key elements of technical capacity building on PV, in the context of this analysis are:

- the various sizes of the PV systems being sold in the three countries;
- the estimated total number of PV companies and technicians in each country;
- the number of subsidiary institutions supporting the PV industry in each country.

The different sizes of PV systems being sold in the market in the three countries is one of the technical capacity elements that has contributed to the high levels of PV adoption in Kenya and Zimbabwe, and the low adoption level in Ghana. While PV markets in Kenya and Zimbabwe seemed to have a range of low and high wattage sizes of PV modules that can satisfy different income levels; in Ghana, only high wattage PV systems were available, satisfying the few high income social group. Unlike Kenya and Zimbabwe, where PV components can be bought piece at a time, in Ghana PV businesses only sell the entire package to consumers (Bawakyillenuo, 2011).

For example, in the Kenyan PV market, the low cost 12 Wp amorphous silicon module[8] (a-Si) PV system is the smallest PV module system and is found in many shops. The biggest module is over 60 Wp. Findings in the BCEOM, EAA and FONDEM Consortia's (2001) study on Kenya PV market indicated that the small size PV systems (12 Wp to 40 Wp) constituted 70% of the market, 45% of which belonged to the 12 Wp a-Si module. Indeed, authors such as Duke et al. (2002), and Hankins (2001) argue that most PV SHSs in rural Kenya are based on the 12 Wp a-Si module systems due to their relatively low cost and the opportunity to buy their components piece by piece[9] at a time. The situation is similar in Zimbabwe where a range of PV system module sizes are available, spread fairly evenly from 12 Wp to 60 Wp (United Nations Development Programme , 2000). Davidson and Mwakasonda (2003) argued that "One reason for … the large number of PV systems in Zimbabwe has been the low-cost silicon-type PV modules imported from Botswana and South Africa…[while] some companies in Zimbabwe have also been known to sell do-it-yourself PV kits, thus making the dissemination of the PV technology user friendly" (p. 30).

Another technical capacity element that has accounted for the disparities in PV dissemination levels in the three countries is the total number of companies and technicians involved in the PV industry, as a large number of PV businesses augment awareness and vice-versa. As indicated above, while there is high awareness on PV in Kenya and Zimbabwe, it is low in Ghana. The PV businesses profiles in the three countries are as follows. The Kenyan market has more than ten major PV importers, 100 to 200 PV retailers and agents, and approximately 500–1000 installers (Hankins, 2000; ESD, 2003). For Zimbabwe, by 1993, there were approximately 10 companies in the PV business, but by September 1998 this had increased to about 73 companies and retailers (Bacon, 1998). The 2005 data on Zimbabwean PV organisations reveals 15 PV companies with extensive distribution and installation networks in the country (Solarbuzz™, 2005). For Ghana, the situation is different: as of 2007 there were only seven small PV companies in Ghana, located in the urban areas (Bawakyillenuo, 2011).

Available data also show that there are more subsidiary institutions to support the PV industry in Kenya and Zimbabwe than in Ghana. In Kenya, there are approximately 15–20 small scale manufacturers of PV lamps and battery control units or

[7] The basic tenet of revolving fund is that an organisation gets a reserve of money to set up the operational structures and to lend to borrowers at an agreed interest rate. Thus, in the GEF/UNDP project, this reserve money was given to the AFC.

[8] As at 2002, the 12-peak-watt a-Si module was sold as low as $US50, because competition for customers has increased among retailers (Duke et al., 2002).

[9] In the early days of PV development in Kenya, installers and companies sold the entire package to consumers. However, by the 1990s consumers had gained enough experience using automatic batteries for TV power that majority of rural people started with the 'do-it-yourself' installation, which involves purchasing systems one piece at a time and installing by themselves. In most cases, however, charge regulators which help protect the batteries are left out (Hankins, 2000).

charge regulators (BCEOM, EAA and FONDEM Consortia's , 2001; IEA-PVPS T9-07, 2003) and three principal battery manufacturers (ESD, 2003). As of 1998, there were four local companies producing PV lamps and four battery[10] companies that serviced the solar market in Zimbabwe (United Nations Development Programme , 2000). By contrast, the PV market in Ghana lacked these subsidiary local organisations, with almost all PV components being imported.

4.1.5. Disparate economic and political historical landscapes

Disparate economic and political histories of Kenya, Zimbabwe and Ghana in the 1970s and 1980s also account for their dissimilar dissemination levels of PV.

4.1.5.1. Political historical landscapes. Analysis of the political histories of Kenya, Zimbabwe and Ghana in the 1970s and 1980s, demonstrates that the political status of these countries in these periods have influenced the development disparities of their PV industries.

Since independence in 1963, Kenya has consistently maintained a remarkable political stability. This is especially relevant, as a stable political environment is fundamental to attracting foreign direct investments (FDI). Suffice to mention that Kenya is one of the few African countries that have never experienced a coup d'état since independence. It can therefore be argued that Kenya's political stability indirectly impacted the growth of its PV industry, especially in the 1970s and 1980s, when the technology was gradually being transferred to Africa. Jacobson (2004) for instance, observed that, "Kenya's position as the regional 'hub' for solar equipment in the 1980s is due largely to its ties to 'the west'… [because]…in the decades following independence in 1963, Kenya had developed a reputation as a stable, pro-capitalist country that was a reliable Cold War ally to the U.S and the UK" (p. 132). This unique political[11] stability and the pro-capitalist approach helped Kenya to attract relatively high levels of foreign investment and donor assistance (ibid).

The 1970s and 1980s in the political history of Zimbabwe represent the colonial and post-independence epochs, respectively. Prior to independence in 1980, developments in all sectors of the economy, including energy provision, were skewed in favour of the white settler regime (Davidson and Mwakasonda, 2003). Hence, it could be argued that native Zimbabweans that were deprived of electricity but had disposable income started patronising PV. In particular, Zimbabwe's proximity to South African and Botswana, (both with a relatively well developed PV sector), enabled people to import the low-cost silicon-type PV modules. Also immediately after independence, Zimbabwe experienced relative political stability, which might have boosted foreign direct investment in PV.

On the other hand, while Ghana attained independence in 1957, it got entangled in a prolonged political instability until 1992. From 1966 to 1992, Ghana was successively ruled by different military governments through coup d'états[12] which is unparalleled in any other country in Africa. According to Aryeetey and Fosu (2003) "…one characteristic of the political economy of Ghana has been the high incidence of coup d'états [as] existing evidence suggests that among African countries, Ghana has had the largest indicator of this form of 'elite' political instability…" (p. 28). This period of political instability in Ghana did not create a congenial atmosphere for FDI in the PV industry compared to Kenya and Zimbabwe. Unlike Kenya and to some extent Zimbabwe that allowed foreign entrepreneurs to stay after independence, the first military government of Ghana in 1966, expulsed almost all foreign nationals in the retail trading sector. First, it required all retail trading concerns, whose capital outlay did not exceed half a million cedis[13] at the time to be reserved for Ghanaians; and second, the "Alien Compliance Order" was introduced to evict all resident foreigners without proper documentation (Asare and Wong, 2004).

4.1.5.2. Historical economic landscapes. The relative historical economic development trends of Kenya, Zimbabwe and Ghana in the 1980s also offer explanatory power apropos their uneven dissemination levels of PV technology. For instance, the Kenyan economy recorded strong economic growth in the 1970s and 1980s—the periods that PV began to attract attention in rural areas. This growth was largely due to expanding exports of Kenya's principal export commodities (coffee, tea and horticulture) (Acker and Kammen, 1996). Thus, in the 1980s and early 1990s coffee and tea growers in the rural economy had high earnings. These farmers together with rural civil servants, rural business entrepreneurs, constituted an affluent "rural middle class" with purchasing power, but with little hope of getting connected to the national grid. Jacobson (2004) opines that "Income from tea farming has, in fact, contributed significantly to the growth of the [Kenya] solar market" (p. 129).

Similarly, economic growth in Zimbabwe was fairly steady from the latter part of 1970s through to the latter part of the 1980s. This was due largely to export earnings from the then commercial farms and ranches, agro-processing industries (e.g., tea, sugar, coffee, tobacco), located in the rural areas and employed many people.[14] Like Kenya, there was a rural middle class in the 1980s in Zimbabwe (comprising civil servants, employees in the commercial agricultural sector, private entrepreneurs) with purchasing power for PV systems. Indeed, the work of authors such as Mulugetta et al. (2000) shows that the emergence and development of the Zimbabwean PV market was driven by rural middle class purchasing power.

In contrast, Ghana had a turbulent economic growth in the 1970s and the first half of the 1980s, with predominantly negative growth rates. One of the underpinning factors of this decline was the political instability in those years, because the years in which negative growth was experienced generally coincided with coup d'états. Thus, the prevailing economic situation at the time could not have helped create a rural middle class to start purchasing PV. Although pockets of rural affluent groups would have existed, the political instability might have derailed all investment plans.

5. Conclusions

This article aimed to critically examine the various trajectories that underpinned the lopsidedness of PV dissemination in Kenya, Zimbabwe and Ghana between 1960 and 2007 through the lens of the SCOT theory. Premised on the tenets of SCOT, the discussions

[10] Data on product manufacturer in 2005, however, indicate that one battery manufacturing company currently exists (Solarbuzz™, 2005).

[11] While Kenya had such political stability at the time, several of its neighbours were either still embroiled in independence struggles (e.g., Uganda, Sudan, Mozambique) or were practising socialism (e.g., Tanzania, Somalia, Ethiopia)—both being distastes of foreign investors.

[12] In all, five military coup d'états took place in Ghana from 1966 to 1992—1966, 1972, 1978, 1979 and 1981 (Asare and Wong, 2004).

[13] The cedi, with its symbol—GH¢, is the currency of Ghana. As at 2005 (when the fieldwork for this paper was conducted), GH¢9,127.42 was the equivalent of US$1.

[14] As of 1997 for example, Zimbabwe was the second largest exporter of tobacco in the world and employed about half a million people in the rural areas (United Nations Development Programme, 2000).

in this paper reveal that the different *social groups* (the three countries) with their varied *interpretative flexibility* of PV had disparate dissemination levels of the technology within the period in question, attributable to a host of drivers. The establishment of the right conditions or agents such as good policies, institutions, awareness creation, favourable financing schemes, and technical capacity, as noted in the literature are indeed, some of the factors that spur on the dissemination of the technology. However, the findings in this paper also show that the flourishing of the PV technology in Kenya and Zimbabwe were not driven solely by such good conditions; neither did bad policies alone led to the low dissemination in Ghana. Rather, the synergy of several structural intermediary phenomena including, the economics and political landscapes of the nations, international influence, the state of the energy industry and so on, coupled with the aforementioned agents mediated the ascendancy in PV dissemination in Kenya and Zimbabwe compared to Ghana. These findings therefore contrast Hankins' (2000) argument that "…the [Kenyan] Government's hands-off approach to the off-grid private sector has helped the PV industry to flourish" (p. 98). Clearly the extant features of these intermediary structures between 1960 and 2007 shaped the significant roles the private market played in the dissemination of the technology in the three countries.

The biggest question emerging from these findings is that can Ghana replicate the enhanced PV dissemination stories in Kenya and Zimbabwe? The answer is NO and YES. In other words, the answer is NO because there are still outstanding structural intermediary *problems* impeding PV dissemination, that have to be resolved. On other hand, it is YES, because if these *problems* are resolved there will be a *closure* and *stabilisation* on the fundamental issues impeding PV dissemination in the country. Thus, in order for the latter answer to take effect, the following recommendations are imperative, starting with their perceived feasibility: most feasible—1, to the least feasible—4:

1. Continual political stability is needed in Ghana, because it is the beacon that attracts foreign direct investments into many countries. Especially, with the introduction of FiT in Ghana, foreign investors in PV will have the desire to invest in the industry. However, without the assurance of a long term political stability, many investors will be dissuaded from investing in the technology in the country.
2. Rural economies, especially agriculture should be strengthened to yield more returns. As the Kenyan and Zimbabwean success stories revealed, with good returns from income generating activities in rural areas, individuals and families without access to the national grid will adopt PV to enhance lighting, entertainment, and education of children.
3. The technical capacity for PV should be stepped up in the country. Besides government creating a congenial policy environment to attract the establishment of PV companies, subsidiary supply chains and entrepreneurs, there is the need for the creation of technical institutions, and also departments at the various Universities in the country for the studies of PV and other RETs. In addition, hands-on trainings, workshops and seminars on PV and other RETs should be instituted and ran very often for electrical artisans and others wishing to work on RETs issues. These trainings, workshops and seminars will enable them to upgrade or acquire new skills and knowledge, necessary for quality assessment, installations and maintenance of PV and RETs in general.
4. The national grid should be de-politicised while PV is promoted, especially in the remotest parts of the country. The empty promise of the extension of the national grid to even the remotest parts of the country in the past by politicians to secure votes, stymied the adoption of PV. Politicians should be discouraged from such rhetoric; awareness should be created on grid supply zones as well as the rationale for PV supply to remotest areas; establishment of favourable financing schemes – concession and fee-for-service models – for PV in rural areas; and offer the same subsidies to PV users, which grid consumers are benefiting.

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