Solar PV rural electrification and energy-poverty: A review and conceptual framework with reference to Ghana

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Abstract

In spite of the intention of governments to increase the use of renewable energy in electricity supply, particularly the use of solar photovoltaic (PV) for energy poverty reduction in rural and peri-urban areas of Africa, there is relatively little information on how solar PV electrification impacts on energy poverty reduction. Therefore, there is a gap in the literature and hence the need for continuous research. Using Ghana as a reference country, the historical trend, donor cooperation and other aspects of solar PV rural electrification are discussed . The paper illustrates the intersectoral linkages of solar PV electrification and indicators on education, health, information acquisition, agriculture and micro-enterprises. It also reviews sustainability related issues including costs and market barriers, subsidies, stakeholders involvement, political and policy implications, which are critical factors for sustainable market development of solar PV and other renewables. Finally, a common framework is developed to provide a basic understanding of how solar PV electrification impacts on energy-poverty. This framework provides a structure of the interrelated concepts and principles relevant to the issues under review.

Keywords: Rural electrification, solar PV electrification, energy-poverty, Ghana, Africa.

1. Introduction

This paper brings together three strands of literature on rural electrification, solar photovoltaic (PV) electrification and energy-poverty. The deployment of solar PV in rural and peri-urban areas in most African countries is primarily meant to address the problem of low access to grid-electricity. The abscence of energy services such as lighting or motive power provided by electricity to support socioeconomic development is described as energy poverty (Reddy, 2000; Obeng et al 2008a). In spite of governments' intention to increase the use of renewable energy in electricity supply, particularly the use of solar PV for energy poverty reduction in rural and peri-urban areas of Africa, there is relatively little information on the relationship between solar PV electrification and energy poverty reduction. Therefore there is a gap in literature and hence the need for continuous research.

The purpose of this review is twofold: First, to focus on solar PV rural electrification (with reference to Ghana) and energy-poverty relationship so as to provide knowledge and a clearer understanding of the link to goals in education, health, information and communication, agriculture and micro-enterprise. Second, to bring together interrelated concepts that will guide future researchers to determine the variables to measure for analysis. The paper will also attempt to link some of the inherent, but parallel issues emerging between rural electrification using solar PV and energy-poverty, drawing them into a body of literature that is currently being developed. The argument of the paper is far from portraying the thinking that the provision of electricity services in rural and peri-ruban areas will automatically engender a reduction in poverty in general. It is rather to clarify that unavailability of electricity services, particularly in rural areas are among the most serious problems confronting everybody (Lorenzo, 2000; UNDP, 2004).

Although electricity per se does not alleviate poverty, its link to poverty cannot be denied (Department of Energy, 2004). Besides the harsh living conditions poor people find themselves, they also feel a sense of social exclusion (World Bank, 2000; Lorenzo, 2000; BMZ, 2001). Social exclusion can happen when people or areas suffer from unemployment, poor skills, low incomes, unfair discrimination (Social Exclusion Unit, 2004). Given this context, it is therefore very crucial to 'tie together' territorially disjoined or isolated rural areas, by providing a physical infrastructure such as electricity to increase social resilience as well as facilitate direct social production processes (Mueller, 2001).

The promotion of knowledge on this linkage is important, because various poverty reduction strategies (PRS) for multilateral assistance have rural electrification components. For example, within the framework of the National Electrification Scheme (NES) of Ghana and the Ghana Poverty Reduction Strategy (GPRS), solar PV electrification is included as an integral part of rural electrification (Institute of Economic Affairs, 1999; Energy Foundation, 2004).

Given this background, Section 2 of the paper provides as a reference the historical trend of solar PV electrification projects in Ghana. Section 3 discusses rural electrification, energy poverty and the linkage to quality of life. Section 4 analyses sustainability issues. Section 5 develops a conceptual framework, presents the interrelated concepts relevant to the review. Finaly some conclusions are drawn.

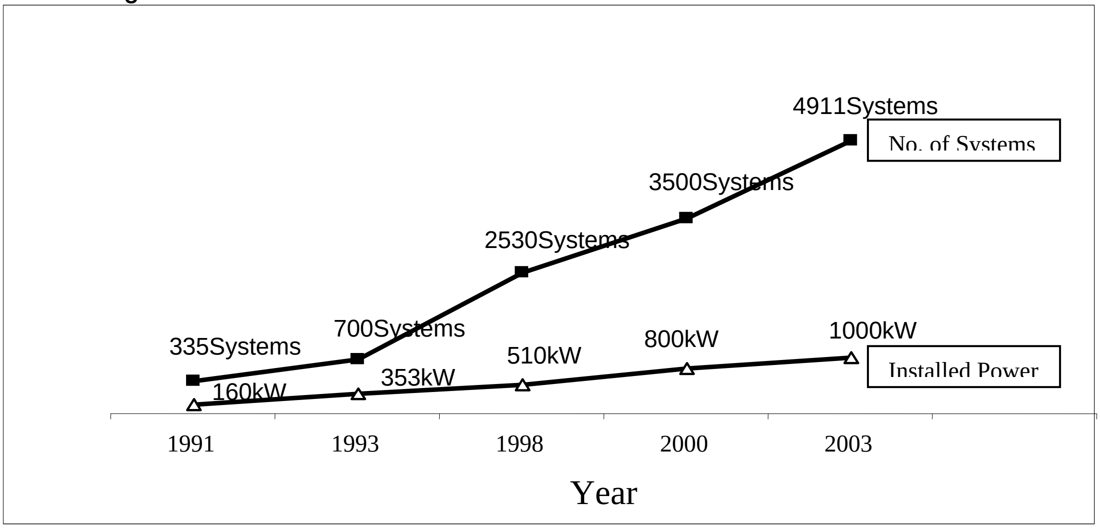
2. Historical Overview of Solar PV Electrification Projects in Ghana.

This section provides a historical overview of formally reported solar PV installations in Ghana. Though the evolution of national policies relating to renewables can be traced to 1983 when the National Energy Board (NEB) was established (KITE/UCCEE, 1999), public solar PV electrification projects were first implemented in the early 1990's. By 1991 there were about 335 solar PV installations in Ghana with total estimated power of about 160 kilowatts (Institute of Economic Affairs, 1999).

Figure 1 shows the historical trend (1991-2003) of solar photovoltaic installations in Ghana. The graph labeled installed power shows an increasing trend in power from 160 kilowatts in 1991 to 1000 kilowatts in 2003. The increasing trend was a result of government's National Electrification Scheme

(NES), which has the objective of securing electricity services for all parts of Ghana by 2020 (Energy Commission, 2004, 2005). The early years of 1990's and 2003 are postulated to represent significant turning points of solar PV projects in Ghana. The implementation of the NES in 1990 influenced a sharp increase in the number of solar PV systems from 700 in 1993 to 2,530 systems in 1998. By December 2003 about 4,911 systems were installed with total installed power of 1.0 peak megawatt (MWp) (Ministry of Energy, 2003).

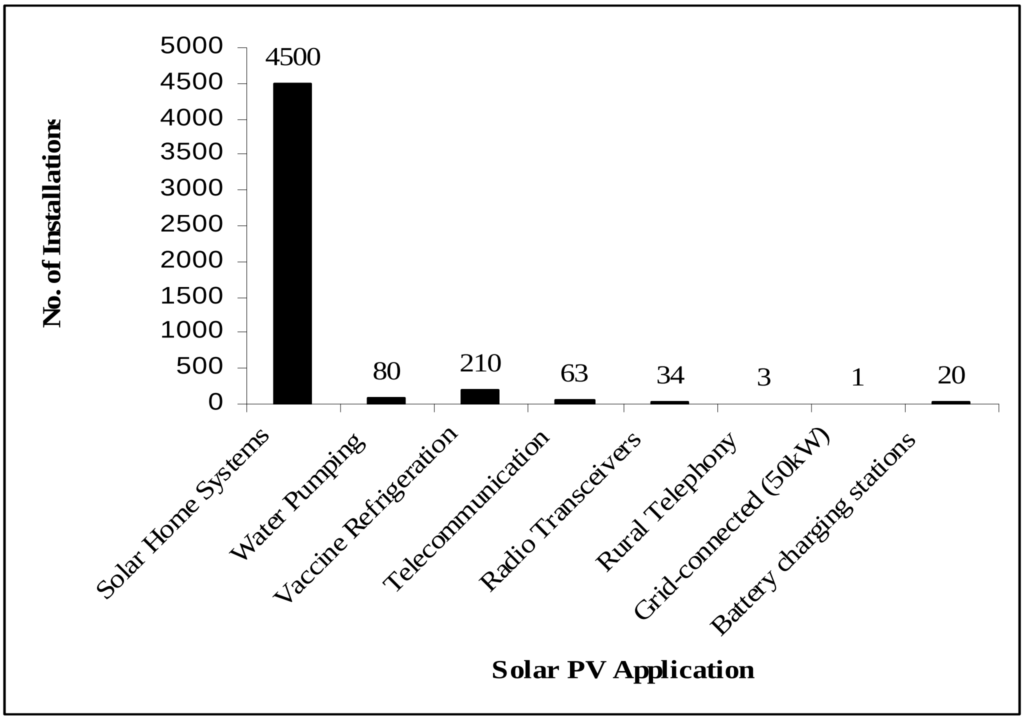
Figure 1 Historical Trend of Solar Photovoltaic Installations in Ghana



Source: Own graph plotted using data from various sources.

Figure 2 provides a more detailed description of the different applications of solar PV systems. The graph shows that 4911 systems were installed as of December 2003 with a corresponding total installed power of 1.0 peak megawatt (Ministry of Energy, 2003).

Figure 2 PV Applications in Ghana as of December 2003



Source: Own graph plotted using data from Ministry Of Energy, 2003

The introduction of the Ghana Poverty Reduction Strategy (GPRS I) also brought new policy directions aimed at expanding the use of solar PV in rural electrification programmes in Ghana (Ministry of Energy, 2006; World Bank, 2003). Despite this achievement, there are still more communities to be considered for solar PV electrification (Energy Foundation, 2002). For many of these communities solar PV is the alternative source of electricity and therefore there is the need for a continuous research on how solar PV electrification impacts on energy poverty, particularly in rural and periurban areas so as to attract resources to increase access and expand future markets.

3. Rural Electrification, Energy Poverty and Quality of Life.

Rural electrification can simply be defined as the supply of electricity to the countryside. However, this definition does not clearly delineate the boundaries and intent of the process of rural electrification. Putting the definition right will help to clarify the scope of regulation, financing of certain rural electrification obligations and further amendment of rural electrification Acts through legislative instruments (Rural Electrification Act, 1936-1993).

In this study, rural electrification is defined as the supply of electricity to small towns and villages, and agro-based industries outside the regional capitals to bring about important social and economic benefits (cf. Kjellstrom et. al., 1992; Department of Energy, 2004). Rural electrification supply can be achieved by using the national grid, mini-grid, isolated generator systems or renewable energy systems including solar PV, wind power plant, small hydropower, and bio-fuel engines among others. An idea being included in project designs is to integrate solar PV into on-going rural electrification programmes to increase access to electricity (Abavanah, 2000; Beck and Martinot, 2004; Cabraal et. al, 1996).

In general, energy is not considered as a basic human need. In the past, rural energy, in particular, was not widely accepted as a basic need like water and food in the development circles (Clancy, 1999 cited by Cecelski, 2003). Nonetheless, energy, particularly electricity is required for meeting basic needs such as health, agriculture, education, information and other infrastructural services and shows a clear correlation with per capita income and human development index (Anderson, 2000; Gillis et al, 1992; Rehling, 2002). Although rural electrification per se does not necessarily reduce poverty, its relationship to poverty reduction cannot be denied (Department of Energy, 2004). In this regard, in Ghana and other African countries, increased use of renewable energies such as solar, wind, biomass and biogas have been identified as alternatives to grid-electricity supply in remote rural areas for poverty reduction (World Bank, 2003).

In recent times efforts at the global, regional and local levels have been intensified to link energy to sustainable development and poverty reduction. It is understood that unavailability of electricity services in rural and peri-urban areas is usually associated with poverty and it is among the most serious problems confronting everybody (Lorenzo, 2000; UNDP, 2004). At the nineth session of the United Nations Commission on Sustainable Development (CSD-9) renewables and rural energy were identified among the key energy issues for sustainable human development (Chaurey et al, 2002). Several authors have provided analysis of the link between energy (electricity) and major global issues such as health, education, water, gender etc (Cecelski, 2003; DFID, 2002; UNDP, 2004). From all these, a common key finding is that energy alone cannot initiate development and reduce poverty. It must be linked to development strategies for education, health, agriculture, infrastructure, political and economic improvements.

Within this context, the linkages of energy strategies to poverty reduction and quality of life have been under-explored. This is partly because the definition of poverty has been centered around the money metric measures of income, expenditure, or consumption. Therefore, in addition to consumption poverty, the Ghana Living Standards Survey (GLSS) considered other dimensions of poverty including lack of access to services and limited human development (Ghana Statistical Service, 2007). There is the need to include other dimensions of poverty so as to fight all aspects of it (Cecelski, 2003). This underscores the need for continuous research to deepen knowledge on the relationship between rural electrification using solar PV and energy poverty reduction in rural and peri-urban areas, where there is low access to grid-electricity. The following subsection focuses on significant issues on the link between solar PV electrification and quality of life and .

3.1 Solar PV Electrification and Quality of Life

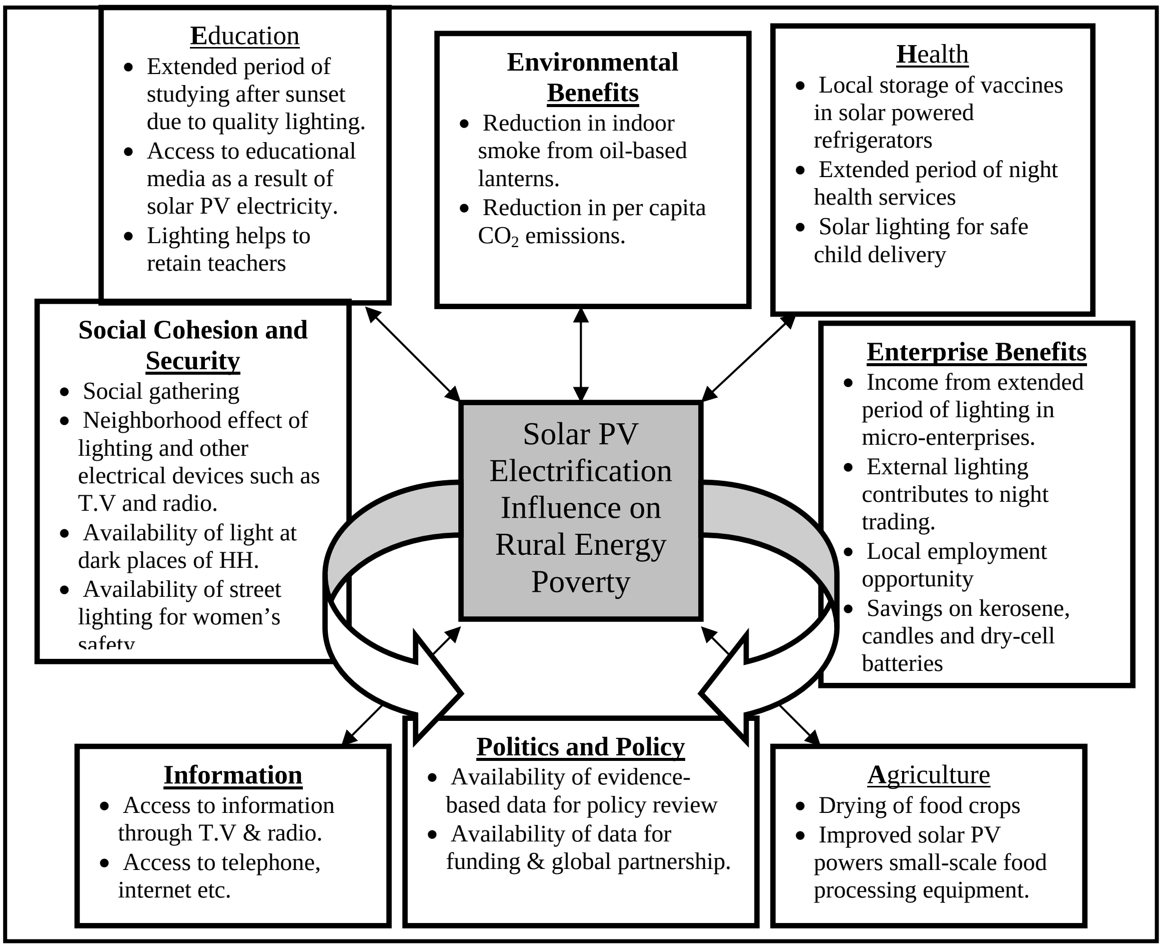
Solar PV electrification can improve the quality of life of rural households through positive impacts that cannot easily be expressed in monetary terms. Quality of life is simply life goals expected to be fulfilled: better education, health, access to information, indoor lighting, among others. Significant impacts of solar PV systems include better quality of light, car batteries do not have to be transported, indoor smoke and fire hazards from kerosene lanterns are reduced (Posorski, 1996; Obeng et al 2008b). Furthermore solar PV electrification contributes to improve quality of life in off-grid rural communities through the direct effect of the technology on household wellbeing and enterprise income (Cabraal et al, 1996; Fishbein, 2003; Martinot et. al., 2002; Posorski, 1996). It should be stressed that the gradual replacement of fossil energy electrification with renewables will not provide all the energy needs for quality of life improvements. However, there are many applications that can improve the quality of life of rural households. These include among others the replacement of kerosene lanterns and candles with solar PV lighting (Plastow and Goldstone, 2001).

On the expenditure side, rural households in developing countries typically spend between US$3 and US$20 per month on kerosene, candles, or other energy products (Plastow and Goldstone, 2001). With the use of kerosene and dry-cells, it is observed that monthly expenses can be as costly as US$ 10 per family (Lorenzo, 1997). Cabraal et al. (1996) report that in Sri Lanka and Indonesia, recurrent costs on kerosene, candles and batteries could reach $10-$30 per month. These are relatively high expenditures. Though the use of solar PV may reduce the recurrent costs associated with the use of kerosene, candles, and batteries, the amount of the reduction is uncertain and therefore deserves research attention.

3.1.1 The Energy Quality of Life Framework

Figure 3 is an illustration of the multi-sectoral linkages of solar PV influence on quality of life in off-grid rural communities. It indicates as well some social and economic benefits that may accrue to rural beneficiaries. Though solar PV rural electrification has linkages with several sectors, Figure 2 focuses on specific niches, particularly goals relating to education, health, information, agriculture and micro-enterprise known hereafter as the Energy quality of life framework . This is the authors' concept of how solar PV influences energy poverty reduction and contributes to quality of life improvement within the selected niches. This illustration is based on a combination of models and findings from relevant literature (DFID cited in UNDP 2004; Fishbein, 2003; Martinot, 2004).

Figure 3 The Energy Quality of Life Framework



3.2 Solar PV Electrification as a Means of Promoting Education

Poor people realize that education offers an escape from poverty and therefore any effort that goes to promote education, especially in poor rural communities is a welcome contribution. In the discourse on well-being, a key concept that is of significant interest to the review is access to education. How does access to solar PV electricity relate to education? It is reported that solar electricity lighting in remote rural schools permits children to extend their studies in the evening and helps retain teachers, especially if their accommodation has electricity (Allderdice and Rogers, 2000; PPIAF, 2002; DFID, 2002; UNDP, 2004). For many children, especially girls in rural areas the lack of electricity translates into a missed opportunity to attend school because they are overloaded with menial tasks such as fetching water and fuel during daylight hours (Allderdice and Rogers, 2000).

A survey to explore user perception about the positive linkage between rural electrification and education in Tunisia revealed that women and children especially benefited from improved access to education as a result of rural electrification (Cecelski, 2003). Although the study was not specifically on solar PV electrification, the findings may also apply to the linkage between solar PV electrification and children's extended study, particularly after sunset when lighting services are most needed. Drawing on this the following investigative question is posed: How does access to solar PV lighting in rural Ghana improve children's education? Does access to solar PV light enhance the academic performance of rural school children?

Furthermore, solar PV lighting enables access to educational media, communications in schools and at home. This increases education opportunities and allows distance learning (DFID, 2002; UNDP, 2004). If rural electrification policies, programmes and plans integrate solar PV as an alternative service for the supply of electricity services to dispersed rural populations and remote rural communities, children would have access to lighting in the evening to extend their studies. This would go in a long way to contribute to the international goal of ensuring that children everywhere will be able to complete a full course of primary schooling by 2015 - MDG Goal 2, Target 3.

3.3 Solar PV Electrification and Health

Public health is a critical sector where the contribution of solar PV is much felt especially in off-grid communities. As noted earlier, the replacement of kerosene lanterns with solar PV could reduce indoor air pollution, which affects the health and wellbeing of rural families. In this regard, this study focuses on environmental health considerations, which refer to the health risks associated with environmental factors (Kishore, 2006). They fall into two broad categories, namely traditional and modern hazards (Kishore, 2006). This study examines the association between traditional forms of lighting and environmental health risks. Traditional hazards are related to poverty and lack of development (Kishore, 2006).

'The World Bank has classed indoor air pollution in developing countries among the four most critical global environmental problems' (Cecelski, 2003: 27). Indoor air smoke contributes to respiratory infections that account for up to 20 percent of the 11 million deaths in children each year (DFID cited by UNDP, 2004). This trend if not stopped will have direct effects on future family lives of the poor since children are the future source and wealth of poor families (Fanworth, 2004). In the light of this it is important to re-emphasize the need for pragmatic policies on environmentally-friendly technologies like solar PV. When used as a substitute for a kerosene lantern solar PV can reduce the potential threat of indoor air smoke (Cabraal et al, 1996; Plastow and Goldsmith , 2001; PPIAF/AD 2002).

Nevertheless, there is lack of quantitative data on the likely proportion of reduction of indoor air smoke from kerosene lantern by using solar PV light. Solar PV powered refrigerators also play a very significant role in remote rural clinics, where medicines have to be stored for vaccination and the treatment of diseases at the village level. A healthy life is a key indicator in the capability approach to poverty (Pearce, 2002). Women in labour need clean light to have safe child delivery at any time. In a rural clinic where there is no electricity, women deliver under very uncomfortable conditions due to the lack of essential equipment, medical facilities and poor visibility after sunset. Lastly, solar lighting in remote locations helps maintain qualified health staff, who would otherwise opt to work in grid-connected towns and cities (DFID cited in UNDP, 2004).

3.4 Solar PV Electrification and Information and Communication.

There is a growing under-provision of investment in both grid-electricity and telecommunication facilities in rural areas of most developing countries (Economic Commission for Africa, 2004). For this reason, solar PV provides alternative power to meet the information and communication needs of off-grid rural and peri-urban communities. By powering radios, televisions or computers with solar PV, rural households are able to access health, education, business, agricultural and environmental information to better their standard of living (Greenstar, 2004; Amankwaah, 2005). Internet-connected community centers and rural business centers are emerging areas where solar PV is used to power the equipment for the delivery of information and communication technology (ICT) services in rural and peri-urban communities in Ghana.

Two innovations in this area are Greenstar digital culture e-commerce and the e-commerce and renewable energy (eCARE) models. The Greenstar model uses solar PV to power rural community centres that provide wireless and internet-based services in traditional music, artwork, poetry and dance. In Ghana, this model was piloted in Patriensah, a traditional Ashanti community. Similarly, the eCARE model uses solar PV to enable rural and peri-urban communities to have access to telephone, fax, email and internet (Amankwaah, 2005). Both models seek to provide new jobs and skills, strengthen local culture, affirm independence and generate income to gradually reduce rural poverty. However, unlike popular household durable goods such as radio and television, which over the years have been powered with grid-based or solar PV electricity in remote and isolated rural locations, solar-powered internet, fax, telephone and email based on GSM are emerging.

3.5 Solar PV Electrification, Agricultural Processing and Rural Enterprises.

Typically electricity to run a motor for a grain mill can transform a manual subsistence household activity into an income-generating enterprise, or help transform a barely viable enterprise into a more sustainable one (Allderdice and Rogers, 2000). Small rural stores can also expand their inventory by adding items that can be preserved using solar-powered refrigerators (Allderdice and Rogers, 2000, Etcheverry, 2003). For example, solar PV-powered icemakers can assist village micro enterprises in fishing, sale of ice cubes and cold drinks especially in tropical countries. Solar crop drying by small electric fans that circulate air around a heated surface, can also be used to preserve crops for export. Solar PV electricity helps micro-enterprises to generate additional income by extending their working hours after dusk (Grameen Communications, 1999; Allderdice and Rogers, 2000; DFID 2002). However, there are so few published data that indicate in quantitative terms the additional incomes likely to be generated after sunset by different solar-electrified enterprises.

Securing access to water plays a strategic role in ensuring agricultural production (FAO, 2005). In this regard, solar PV water pumping can supply water for dry land irrigation. This helps to sustain the conditions under which agriculture can contribute to food security, income generation and poverty reduction. However, the lack of proper maintenance of solar PV pumps has made some rural beneficiaries abandon them at the installation sites (Van den Akker and Lamba, 2002). Addressing energy issues related to agriculture and off-farm activities can help to increase prospects for income generation in rural households/enterprises by providing energy for irrigation, food processing, food preservation and many types of manual production during evening hours (Etcheverry, 2003; Martinot, 2004). Nevertheless, a sketchy account of the 'benefit values' of the association between the use of solar PV and income generation is presented in the literature and therefore there is the need for further research.

4. Sustainability Issues

4.1 Costs and Market Barriers

In densely populated and concentrated rural areas of poor developing countries grid extension may be feasible and cost effective (Chaurey et al, 2004). However, in practice, utility companies are usually not attracted to extend grid electricity to 'isolated' or remote rural areas because of cost implications and the relatively low revenue per kilometer (Chaurey et. al., 2004, Munda and Russi, 2005). For example, the high cost of electrification makes it financially unbearable to provide electricity to rural areas in Pakistan where 67.5% of the people lived (Aslam, 2000). In remote areas, where the extension of grid-electricity is found to be expensive, solar PV systems and other energy sources including mini-hydro, wind, biofuel-powered generators have largely demonstrated their potential for meeting the expectations of off-grid rural communities (Lorenzo, 1997). Although solar PV systems are cost-effective alternatives for low voltage applications, high installed system cost, lack of local market, lack of sustainable financing among others impede the expansion of solar PV electrification in poor developing countries (Basnyat, 2004; Johansson et al, 2004; Sawin, 2004; WCRE, 2004).

Apart from the high cost of solar PV systems as well as components, which is critical to sustainability, per unit price of electricity from solar PV systems are relatively high (Gustave, 2004; WBGU, 2004; Weingart, 2000; Zeitinger 1989). It is, however, agreed that costs are declining with growing market volume. In 1973, the price of an individual solar cell[1] fell from about US$ 50 per average watt and US$ 100 per average watt for an array in the USA (Sukhatme, 1991) to a module price of about US$4 per watt for large projects in the late 1990's (Osborn, 1997). Data available from First Solar, Inc., USA indicate current PV module manufacturing cost of $1.12/W and a wholesale PV module price of about $2/W (Fthenakis et al. 2009). If wide-scale electrification programmes associated with bulk purchase of PV and economies of scale in production and sales go ahead, the costs of PV systems would decline further (Plastow and Goldsmith, 2001; WGBU, 2004).

[1] The first solar cells were made of silicon and were developed in the USA in 1954 (Sukhatme, 1991)

Although some level of affordability is established through various financing mechanisms, findings on cost affordability to the rural poor have not been very encouraging and this raises concern about project sustainability. A survey carried out in Africa and Asia revealed that only 5 percent of rural populations could pay cash for a solar home system, 20 percent could afford it if short or medium term credit were available, and 25 percent could afford long-term credit or leasing (Plastow and Goldsmith , 2001). In this regard, the fee-for-service approach adopted by the public solar PV Electrification Projects in Ghana enabled some off-grid communities to acquire solar PV systems. Through this approach, project beneficiaries could overcome the barrier of high PV system costs and paid only fixed monthly service fees of ¢15,000 (US$1.63) for a 50pW and ¢25,000 (US$ 2.72) for a 100pW PV system (Amous et al, 2002).

There are considerable volumes of literature citing the high installed system costs of solar PV. But there are few published data on real maintenance costs (Lorenzo, 1997). There are equally some optimism expressed on perceived cost reduction strategies. In the wake of current energy challenges in several developing countries such as Ghana, there is the need for some quantitative data on costs and benefits to provide information for sustainability analysis.

4.2 Subsidies

Solar energy may reach a competitive stage before the year 2050, at least in some niches and therefore a strong research and development effort, combined in due time with subsidies at least for the most promising niches, is essential for success (Bacher, 2002). Subsidies are essential for increasing rural electrification access to the poor (Chaurey et al, 2004). However, there are two schools of thought about subsidies in the power sector. Some experts argue that electricity is a private good and hence electricity subsidies, particularly those encouraging consumption by keeping prices below cost, affect economic efficiency and government budget; and are increasingly seen as causing inequality (PPIAF/AD, 2002; Gillis et. al., 1992). Others however, argue that subsidies should be provided for the poor to enable them to opt for renewable energy alternatives. However, subsidies should be temporary in nature and be evaluated on regular basis (Van den Akker and Lamba, 2002; Sawin 2004).

In the context of off-grid rural Ghana the issue of subsidy is relevant in the sense that about 39 percent of the population live under the US$ 1 per day poverty line (Ghana Statistical Service, 2007), and would certainly need cost reduction measures to enable them derive the full benefit offered by solar PV electrification. In view of the extensive use of subsidies in the developing member countries of the Asian Development Bank (ADB), the ADB established a policy framework on subsidies in 1996. This policy framework suggests that subsidies be provided in specific instances - on pure public goods, while private goods should not be subsidized (PPIAF/AD, 2002). However, the policy views electricity as a private good that should generally not be subsidized, except in cases where poverty is a factor or where sudden and large price increase have negative economic impacts (PPIAF/AD, 2002).

In the discourse on renewable energy technologies (RETs) the much expressed concern about subsidies is that subsidies provided for grid-extension undermines possible markets for RETs in rural areas (Russell and Bunting, 2002; Beck and Martinot, 2004; Sawin, 2004). 'Even relatively small subsidies on kerosene and diesel can discourage the use of renewable energies' (Sawin, 2004: 22). Van den Akker and Lamba (2002) argue that without subsidies on solar water pumping for farmers in Punjab, there would be no markets in India because grid electricity prices are heavily subsidized for irrigation making the playing field unleveled. Drawing on the above, it is noted that subsidies targeted at the poor to enable them to meet their basic electricity needs from solar PV would encourage usage, sustainability and contribute to increase access to electricity services in off-grid rural areas.

4.3 Stakeholders' Involvement

In this review, stakeholders are defined as those persons who have something to gain or lose through the outcome of the projects (Start and Hovland, 2004). Their involvement in rural electrification projects are diverse, ranging from programme design to financing. Sawin (2004) reports that the U.S. state of California designed renewable energy programmes with stakeholders' input provided at public workshops. This underscores the potential role of stakeholders in developing sustainable renewable energy programmes, though it is often difficult to ascertain who actually has "a stake" in a project . In the context of Ghana's solar PV electrification programme, the stakeholders identified include community beneficiaries, government (policy formulation/regulatory framework), private-sector practitioners, research and training institutions, financial institutions and banks, power utility sector agencies and development partners (Abavana, 2000).

Over the years, development agencies such as the Canadian International Development Agency (CIDA), Danish International Development Agency (DANIDA), German Technical Cooperation (GTZ), the United Nations Development Programme/Global Environment Facility (UNDP/GEF), World Bank and the Spanish Government have supported the promotion of solar PV electrification in Ghana. The involvement of development partners or donor agencies in the promotion of solar PV electrification within the framework of the National Electrification Scheme (NES) of Ghana was aimed at the expansion of rural electrification (Energy Commission, 2005).

4.4 Donor Cooperation in Solar PV Electrification

Apart from a few privately owned solar home systems that were mostly installed in the urban areas of the country as back-up systems, public solar PV rural electrification in Ghana have been implemented in partnership with international donors. Development cooperation in this regard has been focused on Official Development Assistance in the form of technical and capital assistance. These have been used as a means of increasing access to energy services for the rural and peri-urban poor. Table 1 shows the extent of donor cooperation in solar PV rural electrification projects in Ghana.

Table 1: Donor Cooperation in Solar PV Rural Electrification in Ghana

Development Agency	Project Client	Objective(s) of Project	Duration
1.CIDA, Canada	University of Regina/KNUST Renewable Energy Project.	To strengthen KNUST's capacity to respond to national development priorities in renewables for sustainable development of rural areas in Brong-Ahafo, Ashanti and Eastern regions.	1992-1999
2.World Bank / GoG	Non-formal Education Unit (NFED), Ministry of Education & Sports, Ghana.	Off-grid solar PV for adult literacy programmes in rural communities.	Ongoing Since 1992
3. GTZ, Germany.	KNUST Solar Pump Project	To construct, test and evaluate the performance of solar pumps for rural irrigation.	1997-2000
4.Spanish Government, Spain	Ministry of Energy Spanish Solar PV Electrification, Ghana	Off-grid solar electrification of 10 rural communities in northern Volta to identify issues for a comprehensive policy on solar PV into the NES.	1998-2003
5. DANIDA, Denmark	1. Ministry of Energy, Renewable Energy Development Project (REDP). 2. Ministry of Health Solar Refrigeration Project.	1. Off-grid solar electrification of 14 rural communities: Eastern, Ashanti, Brong-Ahafo, Upper-West, Northern regions. 2. To equip rural health sectors with reliable energy service technology.	1999-2002
6. UNDP/GEF	Renewable Energy Services Project (RESPRO)	For off-grid solar electrification of 13 rural communities in Northern Ghana	1999-2003
7. JICA, Japan	Ministry of Energy	Policy, planning and formulation of a master plan for rural electrification using renewables in northern Ghana, where poverty is widespread.	Ongoing since 2004.
8.UNDP/UNEP/GT /KITE	E-commerce and Renewable Energy (e-CARE) Project	To accelerate access to Renewable Energy-enabled ICT services in rural and peri-urban communities in Ghana.	Ongoing since 2003

GoG= Government of Ghana; NES=National Electrification Scheme

Source: Compiled by authors, 2005

While international aid in solar PV projects for rural applications in developing countries was mostly witnessed in the 1980's (Lorenzo, 1997), in Ghana, donor cooperation in solar PV projects started in the 1990's and has been increasing. The development objective of the solar PV projects was to provide off-grid rural areas with access to alternative electricity services to meet their basic needs. Donor cooperation in community-based solar PV projects including solar home systems, solar water pumping, vaccine refrigeration, lighting of rural clinics etc. has focused on basic services essential to increase access and reduce energy poverty. According to Abeeku et al (2008) and Davidson (2008), sustainable renewable energy projects will require decisions and actions by multiple institutions and stakeholders. Mobilising sustainable local funding to cope with the burden of high upfront costs of renewable energy systems can help reduce the reliance on external sources (Davidson, 2008).

4.5 Political and Policy Implications

The 1973 oil shocks and concerns about global warming from the late 1980s are two developments that could have led to greater use of renewable energies (Russell and Bunting, 2002). However, national policies and political support have remained weak. The global growth rate of 20 percent for solar PV is a reflection of the current lack of political support for the rural off-grid sector (Plastow and Goldsmith , 2001). By contrast, in Japan and Germany, where government support schemes and targets are in place, growth rates for solar PV have exceeded 70 percent in recent years (Ibid). In Ghana, government support schemes, particularly the National Electrification Scheme backed by donor assistance have greatly influenced an increasing trend in installed power of solar PV from 160kWp in 1991 (Institute of Economic Affairs, 1999) to over 1 MWp in 2003 (Ministry of Energy, 2003).

In spite of the steady growth in solar PV applications over the years, its overall contribution to the total energy consumption of Ghana has been only 0.02 percent (Ghana Statistical Service, 2005). Although rural electrification is of crucial concern to the Government of Ghana (Energy Commission, 2004), data on the benefits of integrating renewables such as solar and biomass into large scale rural electrification programmes are uncertain. Without an effective evaluation of existing solar PV electrification projects, governments may not be fully convinced of the benefits that can be derived from full scale implementation of solar PV projects to increase access to electricity to reduce energy poverty in off-grid rural and peri-urban areas.

To realize the energy vision of Ghana, solar energy had been identified among the key energy sources for long-term development and sustainability of electricity supply to increase access, particularly for rural poverty reduction (Ministry of Finance, 2000). And this objective is addressed by the Strategic National Energy Plan, SNEP (Energy Commission, 2004). Although there was little credit available for purchasing solar PV systems privately, the Government of Ghana took steps including fee-for-service approach to encourage the use of PV systems in off-grid rural areas (Institute of Economic Affairs, 1999).

Under the National Electrification Programme (NEP), the Off-Grid Solar Electrification Projects were administered by the then Ministry of Mines and Energy (MOME), Ghana with internally generated financial resources (Institute of Economic Affairs, 1999). Due to the difficulty in generating continuous financial resources, the projects could not effectively increase local manufacturing capacity in the design and installation of PV equipment and components (Obeng, 2007). The projects also encountered some barriers and challenges (Ibid), which require indepth study and analysis to enhance policy and planning of future PV electrification projects in Ghana and other African countries.

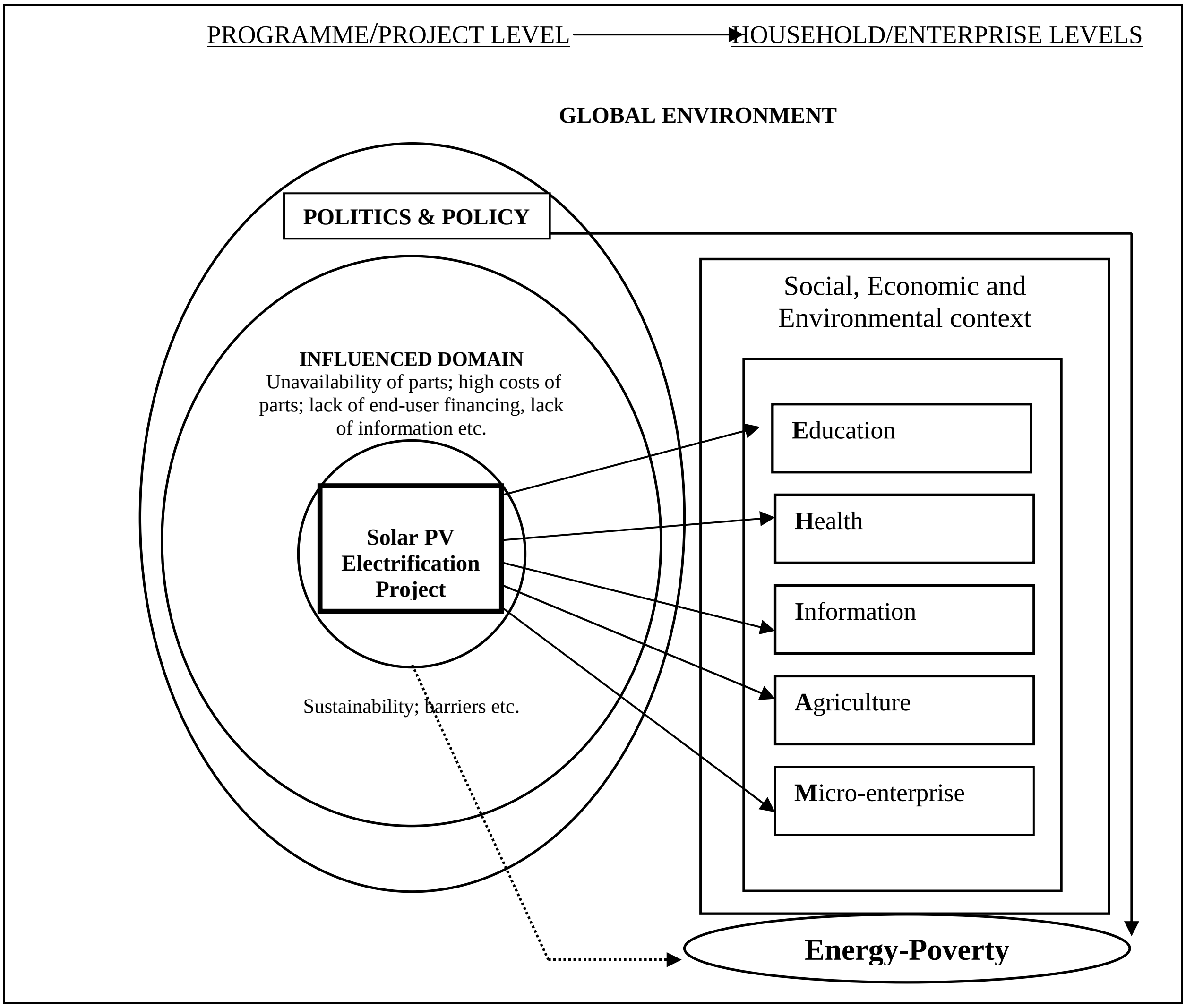
5. Conceptual Framework

To have a common framework that provides basic understanding of the relationship between the concepts of solar PV electrification, energy-poverty and quality of life, a conceptual framework depicting a solar PV electrification project is presented in Figure 4. The dimensions of quality of life examined include education, health, information, agriculture and micro-enterprises . These indicators are consistent with the goals of both the Ghana Poverty Reduction Strategy I (GPRS I) and the Growth and Poverty Reduction Strategy II (GPRS II).

It is conceived that surrounding a solar PV electrification project is its influenced domain within which barriers such as high initial costs, market, lack of information, lack of financing etc. limit the expansion of solar PV electrification in poor developing countries (Sawin, 2004; Basnyat, 2004; Johansson et al, 2004; WCRE, 2004). The left side of the conceptual framework in Figure 4 depicts the influenced domain of the project, the political and global environment. In order to extend the coverage of solar PV electrification, political and policy measures including regulations, government funding and political commitment among others influence the project domain. Influencing the political and policy domain is the global environment within which external financing, international trade, partnership, development cooperation etc. take place.

In order to show data on the different dimensions of energy-poverty, some indicators could be identified and selected taking into consideration the social, economic and environmental dimensions of sustainable development and goals relating to education, health, information, agriculture and microenterprises. [Right side of the conceptual framework in Figure 4]. Households, enterprises and communities are conceptualised (see Figure 5) as the basic sampling units for project impact assessment, which is usually demanded by project financiers to measure the change accomplished by project interventions.

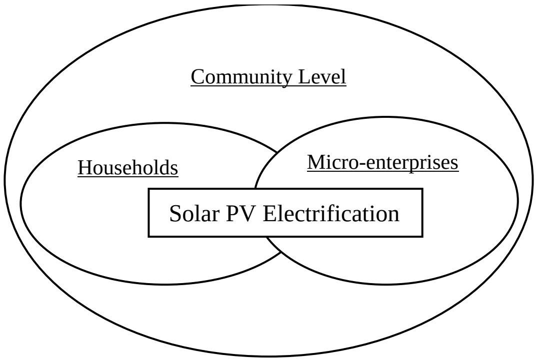
Figure 4 Conceptual Framework



5.1 Levels and Domains of Impact

The levels and domains of impacts are conceptualized in Figure 5. The framework shows household and enterprise as the basic units of analysis. It is assumed that households and enterprises are firmly embedded in communities, and any benefits accruing from solar PV electrification programmes to these units may spread to the communities. Any impact assessment exercise needs to determine what its key levels of assessment are, whether at the level of individuals, communities, organizations or at all of these (Roche, 1999).

Figure 5 Levels and Domains of Impact



Source: Adapted from SEEP-AIMS (2000a).

6. Conclusion

To broaden understanding of the relationship between solar PV electrification and energy poverty the concepts of solar PV rural electrification and energy-poverty are discussed. Information relevant for future assessment of the effect of solar PV rural electrification on energy poverty have been reviewed in the niches of education, health, information, agriculture, microenterprises . The energy quality of life framework was used as a guard rail to illustrate how solar PV electrification can be used as a means to achieve socio-economic development through the provision of basic energy services in rural and peri-urban areas. Information on costs and market barriers, subsidies, stakeholders' involvement, particularly donor cooperation in rural solar PV electrification in Ghana, were reviewed to guide future researchers, project developers and policy makers to determine interrelated variables relevant for analysis and understanding. The conceptual framework developed in the paper provided a structure of the interrelated concepts and principles relevant to the issues under review. To expand the frontiers of knowledge, future studies should add to the number of indicators that can be gathered from the review with the goal of reducing energy-poverty and enhancing quality of life associated with access to solar PV in rural and peri-urban areas without access to grid-electricity.

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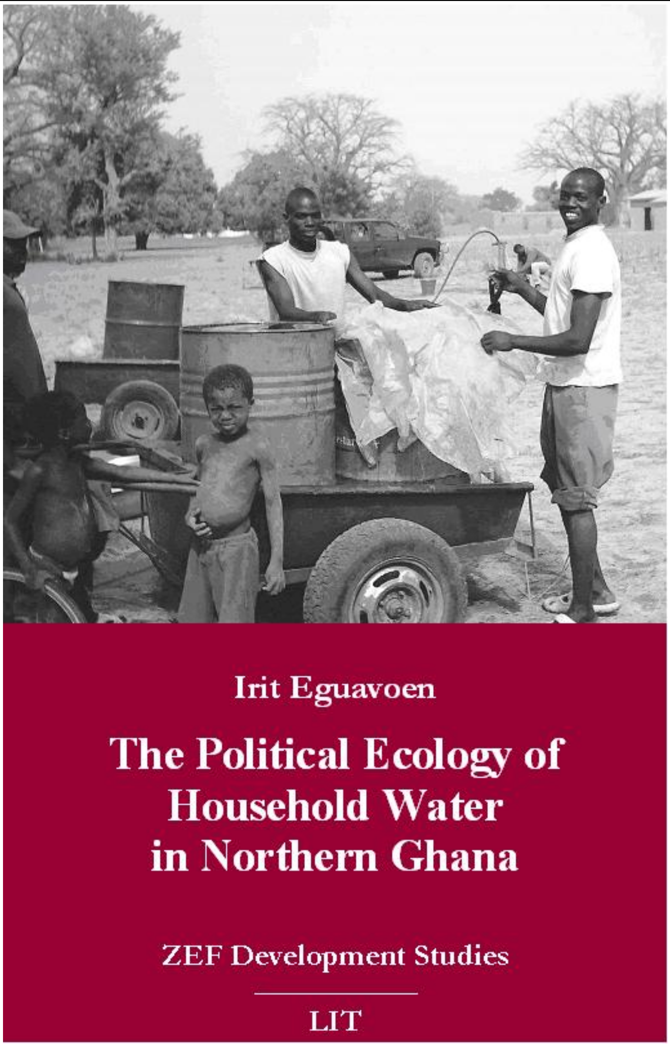

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