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Commercialization of Renewable Energy Technologies in Ghana: Barriers and Opportunities

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Abstract

Although renewable energy technologies (RETs) have been in use in Ghana for many years, they have not seen much commercial success. Using solar PV as an example, this paper attempts to explain some of the factors that have prevented growth of a viable market for RETs. An adverse policy environment and lack of financing are cited as the main barriers. Recommendations are made for government and institutional support that would allow private participants to successfully engage in RET industries. An electrification fund is proposed to support grid extension to areas of proven economic potential.

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List of Acronyms and Abbreviations

AFREPREN	African Energy Policy Research Network
ECG	Electricity Company of Ghana Ltd.
GEF	Global Environment Facility
MoH	Ministry of Health (Ghana)

MoME	Ministry of Mines and Energy (Ghana)
NGO	Non-governmental organization
PV	Photovoltaic
RET	Renewable Energy Technology(ies)

List of Units

A	Amps
kW	Kilowatts
kWh	Kilowatt hours
V	Volts
W	Watts
Wh	Watt-hours

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1 Introduction

Renewable energy technologies (RETs) have held promise for Ghana's development for many years. However, efforts to make this promise a reality have not generally been successful. During times of energy crises–when there is prolonged drought in the catchment areas of the Volta Dam, or when the world oil prices increase sharply–there is sudden interest in RETs as a possible alternative to our dependence on the grid. This interest wanes as rapidly as the crisis is resolved. The cycle has been repeated most notably during the recent 1997 electricity shortfall.

Renewable Energy Technologies are methods of harnessing energy for human use in such a way that the source of energy is not depleted over time. For the purpose of this discussion RETs will be further defined as small-scale, decentralized energy technologies including, but not limited to the following:

1. Solar Photovoltaics (PV)
2. Solar Water Heaters (SWH)
3. Wind/Electric Turbines
4. Biogas Generators
5. Biomass Fuel Sources

RETs in general are considered more sustainable and environmentally benign than conventional energy systems that are based on fossil fuels (oil, gas, coal). By being small-scale and decentralized, they are usually considered to be less expensive because of the reduced cost of transporting and distributing fuel and energy. In most cases the RET produces energy at its source for use in the immediate vicinity.

This paper will use solar photovoltaics as an example of an RET that has the potential for commercialization in Ghana, with the expectation that the lessons drawn from this industry will be applicable to other industries and RETs as a whole. It should, however, be noted that there is a wide range of technologies and applications under RETs, and some of the issues are not applicable to other energy sources. For example, solar PVs are a source of electricity and require the use and maintenance of capital-intensive technologies. On the other hand most biomass fuel systems simply involve the sustainable gathering of fuelwood for cooking and other heating purposes.

1.1 Status of the Photovoltaic Industry

In early 1999, soon after the electricity crisis of 1997, there were an estimated 24 companies primarily involved in the design, installation, and sale of photovoltaic systems in Ghana. By the middle of 2000, fewer than half of these companies were actively involved in the industry. The reasons for this decline are varied, and include the possibility that the companies involved had not sufficiently developed their business plans. It is telling, however, that the surge in demand created by the energy crisis did not lead to a viable photovoltaic industry.

This phenomenon is not restricted to Ghana or developing countries in general. The sharp rise in oil prices during the 1970s led to energy shortages in most parts of the world, and created a boom in the number of companies offering renewable energy alternatives. When power stabilized and economies recovered, the number of companies immediately fell.

Table 1 shows the estimated size and growth of PV systems in Ghana, based on information provided by the ministries of Mines and Energy, Health, and other institutions.

Table 1. Status of Photovoltaic Electrification in Ghana

Number of Systems Installed (Cumulative)				
Application	**1991[1]**	**1994[2]**	**1998[3]**	**2000 (est.)**
Lighting	25	67	1,500	2,200
Water Pumping	5	n/a	50	80
Vaccine Refrigeration	68	56	180	210
Telecommunications	214	500	800	900
Other	25	77	n/a	100
Total	**337**	**700**	**2,530**	**3,490**
Peak Watts of Systems Installed (Cumulative)				
Application	**1991**	**1994**	**1998**	**2000 (est.)**
Lighting	12 kW	18 kW	100 kW	120 kW
Water Pumping	3 kW	n/a	20 kW	25 kW
Vaccine Refrigeration	32 kW	14 kW	40 kW	48 kW
Telecommunications	102 kW	292 kW	350 kW	450 kW
Other	11 kW	26 kW	n/a	50 kW
Total	**160 kW**	**350 kW**	**510 kW**	**693 kW**

1.2 The Promise for Renewables in Ghana

Renewable Energy Technologies, particularly PVs, can reduce the country's dependence on centralized power from hydro and fossil fuel sources. In times of domestic shortage, the cost of importing power from neighboring countries is even higher. Data from the Electricity Company of Ghana (ECG) shows that domestic users account for most of the electricity demand in Ghana[4]. Outside of the urban areas where demand per capita is high, most of the consumers of electricity use it only for lighting and low-consumption utilities such as fans, radio sets and televisions. These applications can easily be served by decentralized solar power.

In addition to domestic use, many specialized applications such as water pumping and vaccine refrigeration exist. For example, there are over 200 hospitals and nearly 1,000 clinics and health posts in the country. Many of them can be served with solar electricity more reliably than the grid, and at a lower long-term cost.

1.3 The Challenges

Many reasons have been given for the lack of a viable photovoltaic market in Ghana. In some cases the high taxes have been blamed, and policy measures have been taken to reduce the import duties on solar photovoltaics[5]. In others, it has been argued that the introduction of manufacturing will reduce the cost of solar electric systems and boost the industry. This paper argues that the absence of a viable industry is due to the lack of a coherent and coordinated policy on energy that takes RETs into account, coupled with a repressive manufacturing environment.

Each of the above reasons will be examined in turn to determine how well they assist the solar PV industry in Ghana to reach a sustainable state. In a review of the industry conducted on behalf of AFREPREN in 1999, members of the solar energy industry cited the following reasons among the factors inhibiting their growth and development[6].

- High cost of components, leading to high system cost
- Lack of financing for consumers
- Lack of financing for service providers and installers
- Perception of high cost of solar PV by the public
- Unresponsiveness of potential market groups; e.g., the real estate industry

These and other barriers can be overcome with a concerted effort from the policy, financial, and marketing sectors.

1.4 Is Local Manufacturing Feasible?

It is useful to review the question of local manufacturing, as it has often been cited as a way of reducing costs of solar photovoltaic systems. In order to assess the impact of local manufacturing on cost, we must first examine the main cost elements for the manufacture of photovoltaic modules, and for a typical solar home system (SHS).

The main argument for local manufacture, other than technology transfer, is that lower labor costs will reduce overall costs. Opportunities have been found in cell stringing as well as module lamination and framing. However, the labor component of module manufacture is less than 10%, and reduces further as volumes increase and automation is introduced[7]. Thus, a small plant with high labor component will be largely manual, and will most likely produce non-uniform parts that will not sell well compared to nicely finished imported modules from automated plants.

The solar electric system as a whole offers better opportunities for savings through local manufacture. This is mainly because the processes for many balance of system (BOS) components can be easily adapted to other, non-solar uses. Such a plant could flexibly manufacture components for other uses when demand for solar PV is low. For example, an electrical fabrication plant for manufacturing controllers and inverters can also be used to produce voltage stabilizers and battery chargers for automobiles. Table 2 shows the impacts of local manufacture for various system components.

Table 2. Relative costs of PV system components and opportunities for local manufacture

Component	Cost Factor	Opportunities for Mfg.
Modules	45%	Low
Batteries	25%	Medium
Controller	5%	High
Inverter	15%	Medium
Wiring	5%	Low
Frames/supports	5%	High

Note: The above is based on a household photovoltaic system delivering AC power with a system cost of about $2,000. Rural solar home systems are usually DC (no inverter) and typically cost less than $1,000 initially.

It can be seen from the above that cost reduction should not be the overriding reason to introduce local manufacturing, because it will be a difficult goal to achieve. Other reasons should be taken into account, such as the need to transfer technology, improve manufacturing, and strengthen the country's human resources in research and development.

2 Typical Photovoltaic system

Photovoltaic systems can be configured in various ways depending on the application. A typical system includes a set of modules for generating electrical energy from sunlight, a battery for storing the energy in case it is needed at night, a regulator or controller for maintaining proper charge of the batteries, and an inverter for converting direct current (DC) to alternating current (AC) voltage. The components are shown schematically in Figure 1.

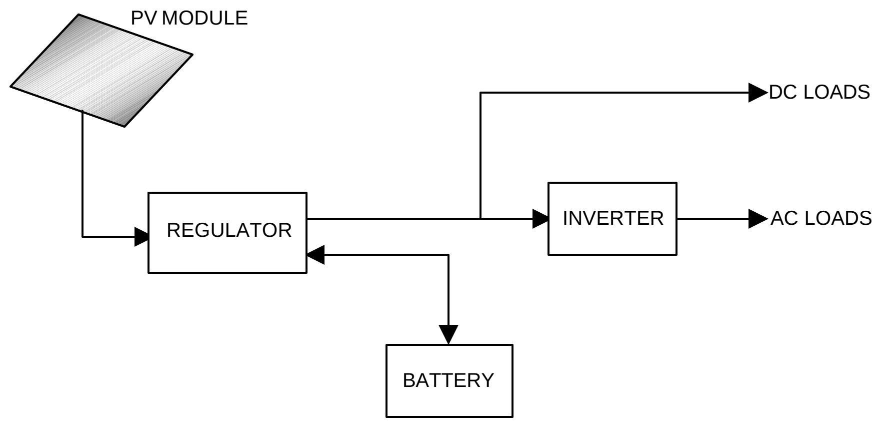

Figure 1. Typical photovoltaic system showing the major components

All the major components listed above can be found in a domestic home power system such as those used in rural applications. In water pumping applications battery storage may not be needed, and purely DC applications would omit the inverter. Other components may be added to interface a solar electric system with different power sources such as a generator or the grid.

2.1 Recent Advances

Much has been achieved in the solar electric industry in recent years. Several countries including the United States, Germany, Japan and South Africa have introduced major programs to boost their local industries by active government participation in the development of solar electricity. This is being pursued through research programs, tax incentives, policy initiatives, financing, and high visibility projects. In the US, for example, where tax obligations can be high, it has been shown that tax incentives can result in a significant burst of activity in the industry. Their effects, however, last only as long as the incentives exist, and many industries that spring up to take advantage of tax incentives are no longer viable when the incentives are removed.[8]

On the technical side, the efficiency of photovoltaic cells has been improved while costs continue to fall. Consolidation in the industry, with the expansion of companies like Kyocera and BP Solar, has meant more intensive R&D initiatives that will result in cheaper and more efficient modules in the near future.

2.1.1 Amorphous technology (Kenya Study)

Amorphous PV cells have been burdened with the reputation that they are less efficient (in terms of power per unit module area) and degrade faster than their poly- and mono-crystalline counterparts in spite of their lower costs. A recent study conducted by Kammen at al in Kenya indicates that the difference between systems that use amorphous and crystalline modules may not be that large, and the rate of degradation of amorphous modules may be lower than expected, after the initial Staebler-Wronski Effect.[9]

As the body of evidence on the field builds, such developments could provide benefits for the Ghanaian PV industry by introducing more cost-effective ways of providing energy to many customers who may not have access to it.

3 Market Potential

The Ministry of Mines and Energy in Ghana estimates that the grid reaches only about 30% of the country's population.[10] Put another way, it is estimated that about 4,000 communities do not have access to electricity.[11] Many of these communities will not be served by the national grid in the near future. In addition to the off-grid households, many institutions such as schools, hospitals, and government offices are located in off-grid areas. Finally, many applications in off-grid communities can be served by solar and other renewable energy sources. These include water pumping, learning centers, and streetlights.

Based on the 1998 level of penetration of the national grid, the Ghanaian market for solar electric systems can be classified broadly as shown in Table 3. All 110 District Capitals in Ghana have been connected to the grid, and therefore most of the 4,000 off-grid communities are likely to be small with populations of less than 10,000. Using 100 households as an average community size, it is further assumed that 5% of the households would be ready and willing to acquire domestic solar electric systems. A penetration level of 20% was used to estimate the number of communities that may be served with community-level applications. It should be noted that the table is merely indicative of the potential market, and a detailed demand analysis will be required to determine market size.

Table 3. Potential users of solar electric PV systems and their distribution.

Market Group	Example Applications	Estimated size (number of systems)
Households in off-grid and rural areas	Home lighting systems, home power systems, domestic water storage	20,000
Institutions in off-grid and rural areas	Rural telephony, vaccine refrigeration, irrigation, etc.	800
Community-based systems	Water supply, community lighting, street lighting	800
Other applications	Backup systems, communications, etc.	5,000

The achievable levels of penetration for each of the market groups will depend on the marketing efforts of solar energy companies as well as incentives provided by government programs and financing schemes. The income levels of most rural communities are well below what is needed to afford a durable solar home system without the assistance of appropriate financing mechanisms.

The opportunities within the Ghanaian market for locally produced systems and components will depend on the willingness of project sponsors and donors to promote local manufacturers. In this regard, projects that involve the wholesale importation of kits should be discouraged in favor of those that allow certain parts or components of the system to be sourced or produced locally. Adequate quality standards can be established and maintained to ensure that the systems perform to expectation.

4 The Policy Environment

4.1 Tax and duty exemptions

In the wake of an energy shortage in 1998 the Ghanaian government removed import duties and sales tax on "solar generation systems" as a measure to increase imports of solar electric systems and encourage the use of solar energy as an alternative source of energy. At the same time, the duties on diesel generators were also reduced. With the introduction of the Value-Added Tax at the end of 1998, solar electric systems remained exempt from import duties but were charged VAT.

The impact of these policy measures is unclear, but empirical evidence suggests that they have had little impact on the commercial success of the PV industry. Several factors may contribute to this. Firstly, the wording of the exemptions was unclear, and the Customs Service (CEPS) has often been unable to assign a Harmonized System (HS) Code to imported solar energy equipment. For example, an installation company that imports various components for assembly would have to pay duties and taxes on all components except the modules themselves. On the other hand a company that imports complete kits including lights and appliances will enjoy the exemption because the crate is labeled "Solar Generation System"

Secondly, the cost component of the duty exemptions makes very little impact on affordability of the systems. As discussed above, solar panels constitute less than half of the cost of the entire system. An exemption of 10% duty will result in a 5% price reduction if the savings are passed directly to the consumer. Even at a monthly income of 2 million cedis ($400 at mid-2000 exchange rates), a well-paid Ghanaian worker will have to devote five months' salary towards the purchase of a solar electric system for his home.

Finally, the policy of tax and duty exemptions does not recognize the alternatives available to most people when they make energy choices. In most cases the user can more cheaply meet their needs using grid electricity, even when it is a few kilometers away. At longer distances, diesel generators provide a less expensive short-term solution. Few potential solar customers choose it for environmental reasons.

4.2 Rural electrification

The National Electrification Scheme (NES) has been a largely successful government program initiated with donor assistance in 1989 with a goal of extending the grid throughout the country by 2020. To date all 110 district capitals are on the national grid, as are many communities along the high- and medium tension power lines.

With the stated goal of the NES, there is little room for decentralized energy sources such as solar home systems. In addition to the high cost of systems, people in communities without grid power remain convinced that the grid will be extended to them soon, and are not willing to pay substantially more for solar energy in the short term.

It should be noted that the cost of extending the grid to low-voltage points is estimated at $2,000-$3,000 per connection, a range which is comparable to the cost of a mid-sized solar electric system. This is in addition to the cost of medium and low voltage transmission lines.[12]

Under these circumstances, the National Electrification Scheme has shut out a large sector of the market for photovoltaic systems. The subsidies enjoyed by users under the NES are also not available to RET users, who are forced to bear the full cost of their power systems in advance.

5 Impact of Pilots, Donors, and Development Projects

Many projects have been initiated to test and deploy RETs in Ghana over the years. Most of these projects have not led to commercialization of the technologies, mainly because this was not the primary objective, and also because the institutions responsible for developing the projects did not involve the private sector in the process. As historical traders, Ghanaian entrepreneurs are quite efficient at making use of a commercial opportunity when they see one. This positive attribute has hardly been exploited in the projects that have been developed. One major PV project even envisions involving the private sector a full three years after the project has been initiated.

Donor projects are usually not necessarily aligned to national interests, and can derail commercial efforts of entrepreneurs. When equipment such as solar PV components is donated, it often serves more as a means to get rid of surplus materials in the donor country or generate employment for the donor country in times of economic downturn.

Development projects that do not take into account the after-effects of their impact end up doing harm to commercialization of RETs. Although many recent projects attempt to include entrepreneurial initiatives, there are still many that focus only on the immediate impact of the project objectives. A vacuum is created when the project winds up, leading to abandoned equipment, lack of ownership, and opportunities that are not viable for entrepreneurs. In many cases the assistance would have been offered at highly subsidized rates, and an entrepreneur who attempts to charge economic rates for the same service is bound to fail.

For policy measures to be effective, they must be broadly fashioned to provide fair access for a range of energy sources. The current environment heavily favors extension of the grid even to areas where it is not economically justified. The needs of such communities could be easily met with the same level of subsidy enjoyed by grid users if they were given the choice between solar, wind, micro-hydro, and other sources.

6 Financing

High cost is the reason most often cited for the low penetration of solar electric systems. A major opportunity therefore lies in the financing of the industry. Two forms of financing are possible: financing for end-users as a way of making the systems more affordable, and financing for retailers and service providers to boost their activities.

6.1 Financing for end-users

As discussed earlier, solar electric systems are beyond the means of most Ghanaian households, particularly if they have to bear the full cost up front. Many customers have expressed willingness to purchase systems if the cost were spread over a reasonable period of time. However, interest rates are presently high and such financing from banks is unattractive for most borrowers. Borrowing from institutions will have to be backed by certain guarantees that will allow repayment terms of ten years or more for homeowners.

Alternatively, revolving funds could be set up with seed funds coming from the government or development agency. Such revolving funds have been shown to be viable for small communities where there is high societal pressure on borrowers to maintain their payments. Many rural communities could benefit extensively from such a fund.

6.2 Financing for Retailers and Installers

Retailers and installers of solar electric systems are faced with the same harsh conditions as their counterparts in other fields. These include lack of access to capital, high finance costs, exposure to credit risks, and increasing import costs due to currency devaluations. In order to promote RETs in general, it would be necessary to provide additional incentives through financing for entrepreneurs interested in engaging in the development of renewable energy systems.

One suggested means of achieving this would be through programs of commercial loans through banks. Entrepreneurs would have to meet minimum requirements of the banks (years of operation, audited statements, etc.), but once qualified would be eligible for low interest loans, operational support, and import credit facilities. Particular incentives should be applied to companies that set up operations in rural areas, closer to the end-users.

6.3 Venture Capital for Manufacturers

Financing for the industry must pay special attention to the needs of entrepreneurs who add value to the systems they install. As mentioned earlier, the cost savings from local manufacture of solar electric system components are relatively small, but the advantages of technology transfer, employment generation, and maintainability, are big enough to justify special support.

In some cases, the potential entrepreneur or manufacturer may not be aware of the financial support available to him or her, both locally and internationally. To this end the Ministry of Mines and Energy and other research agencies can play a vital role by compiling and disseminating information on financing schemes and procedures to the entrepreneurs.

Manufacturing facilities must first be shown to be viable. This is usually evident from a strong business plan and flexible manufacturing facilities. Manufacturing activities should be coordinated to ensure that industries complement each other. Where possible, existing facilities should be selected for outsourced manufacturing instead of building new plants from scratch. For example, metal fabrication plants can easily accommodate orders for module framing even at high volumes, at a cheaper cost because the capital costs have already been sunk.

7 Recommendation

Successful commercialization of RETs in Ghana is possible, but the current market, economic, and policy conditions are working hard against it. If success is to be achieved, certain fundamental changes would have to be made, starting with a broad policy shift that will be based on energy provision rather than grid extension, as is the case presently. The new policy would need to take into account the various decentralized sources of energy and afford users the choice of the best energy option for all parts of the country.

Structures are also needed to guarantee financing for the users and providers of RETs. This is a good area of intervention for development agencies, where basic objectives such as health improvement, adult education, and economic development can be met.

Financing and policy mechanisms can be used to create the enabling environment for rural electrification using RETs, instead of extending the grid to areas where it is not economically justified. To justify grid extension, it is suggested that an electrification fund be set up for the financing of electricity to remote areas. Funds will be made available to companies such as mines, plantations, and agro-industries as part of an overall infrastructure plan. With the higher income levels, individuals will be able to afford grid extension to their homes if they wish.

With a level playing field in the policy arena and available financing for RET deployment, it will be possible to engage in the much needed task of educating the market on the benefits of renewables, and reducing the public perception that they are overpriced and exotic technologies suitable only for pilot projects.

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