Energy for Sustainable Development 31 (2016) 178–184

Contents lists available at ScienceDirect

Energy for Sustainable Development

Developing rural markets for solar products: Lessons from Ghana

William F. Steel [a], Nana Akua Anyidoho [a], Frank Y. Dadzie [b], Richard H. Hosier [c,*]

[a] Institute of Statistical, Social and Economic Research, University of Ghana, Legon, Ghana
[b] ARB Apex Bank, Ghana
[c] World Bank, USA

ARTICLE INFO

Article history:
Received 11 January 2016
Revised 3 February 2016
Accepted 4 February 2016
Available online xxxx

ABSTRACT

This paper assesses market development as a sustainable approach to increasing the use of renewable energy, specifically solar, using the case of Ghana's Solar Project. This strategy is intended to overcome some weaknesses of donor-driven and fee-for-service models in sustaining gains beyond the end of projects. The literature shows that developing a sustainable market for solar products in underserved rural areas requires an integrated approach addressing demand, supply, financing, quality, and facilitation. The Ghana Solar Project was well designed to overcome constraints in all of these areas. Results were positive in terms of numbers of systems purchased and impact on perceived benefits and willingness to pay. Benefits were documented with respect to education, information, mobile phone charging, income generation, and health and fire risks. Competition increased, and system costs fell. Financial institutions expanded their products and outreach, and in most cases had good recovery rates. Nevertheless, sustained market growth may be constrained by the lack of local technicians and spare parts and by possible withdrawal of some local Rural and Community Banks from providing financing and Solar Project Officers to facilitate the process, in the absence of a line of credit and results-based bonuses.

© 2016 Published by Elsevier Inc. on behalf of International Energy Initiative.

Introduction

The purpose of this paper is to assess market development as an approach to increasing the use of renewable energy, specifically solar, using the case of Ghana's Solar Project. Given the limitations of other approaches, Lighting Africa – "a joint IFC and World Bank program to accelerate the development of commercial off-grid lighting markets in Sub-Saharan Africa" (Lighting Africa, 2010a: 9) – has advocated mobilizing private actors to accelerate the market for solar products, while recognizing the significant challenges in reaching remote, underdeveloped areas of Sub-Saharan Africa. This strategy is intended to overcome the weaknesses of donor-driven and fee-for-service models in sustaining gains beyond the end of projects. This paper analyzes Ghana's experience to evaluate the effectiveness of the multi-stakeholder approach in using incentives and facilitators to stimulate potential demand and supply for sustainable market development. The impact on public perceptions of solar and its benefits is also assessed.

The primary emphasis is on the demand side, taking advantage of a recent assessment to ask the following research questions[1]: (i) did the project help stimulate demand that could support a sustainable market? (ii) were the expected benefits to users realized? This paper also reviews the modifications that were made to the original design in order to overcome constraints on the supply side, in particular the role of facilitators. The findings indicate that some gaps will still need to be addressed before the rural market for solar products becomes truly self-sustaining.

Background

Africa's unelectrified population is largely rural and growing fast enough to surpass Asia in absolute numbers within the next 20 years (Lighting Africa, 2010a: 22). Key reasons to seek ways of making renewable energy accessible to Africa's rural population include the lag of grid growth behind demand growth, environmental consequences of petroleum-based energy, health considerations associated with reliance on kerosene for lighting, and growing demand for charging mobile phones (ibid.: 14–15 and 23). Access to better lighting and energy can also benefit education and income-generating opportunities in rural areas and facilitate access to information through television, radio and mobile phones. Approaches to promoting solar energy in rural areas have evolved in the light of experience with different models.

Alternative approaches to expanding solar

Martinot et al. (2002) highlight the shift at the beginning of the 21st century from the old paradigm of project-oriented, supply- and donor-

* Corresponding author at: 1818 H St NW, World Bank, MSN J7-708, Washington DC 20433, USA.
E-mail address: rhosier@worldbank.org (R.H. Hosier).

[1] The assessment interviewed 7 out of the 9 participating banks with more than 150 clients, and 11 focus groups, 355 clients (out of 16,822) and 85 non-clients in 40 communities, as well as suppliers and officials (Steel et al., 2014).

http://dx.doi.org/10.1016/j.esd.2016.02.003
0973-0826/© 2016 Published by Elsevier Inc. on behalf of International Energy Initiative.

driven promotion of renewable energy to market assessment with a user focus, viable business and financing models, and sharing of risks and costs to build sustainable markets. Nygaard (2009) identifies five variations of three basic approaches to promotion of solar home systems (SHS) in developing countries (Table 1):

- Donation, fully subsidized by a donor.
- Fee-for-service, in which national authorities award contracts that may give geographical monopolies (concession model) or involve limited competition (dealer or leasing model).
- Market sales, in which private suppliers sell directly to consumers, either with some subsidies and/or financing via other stakeholders (credit model) or without (cash sales model).

Historically, household and especially community use of solar has been driven largely by government and donor programs and subsidies (Hansen et al., 2014). Only rarely (India, Kenya) has the donation approach seeded a large enough market for competition to drive prices down such that commercial sales take over on a sustainable basis. Indeed Martinot et al. (2002: 330) conclude that "donations without any cost recovery destroy markets."

A significant challenge for the fee-for-service model is generating enough competition, price reduction and scale for a market to emerge. Suppliers may simply exit when their contracts end, as was the case in Zimbabwe (Mulugetta et al., 2000, cited in Nyaagard, 2009). The Sustainable Solar Market Package model, which was utilized by the World Bank to try to achieve sustainability relied upon a hybrid approach, where public institutions (health centers, schools, and other public photovoltaic (PV) installation sites in rural areas) were put out to a public competitive bid. The winning bidder was then contracted to supply these public installations and was also given an incentive to develop the market for private PV sales in those same local communities. An independent evaluation of the use of this model in Tanzania, Zambia, the Philippines and other countries demonstrated that in all but one case, the winning contractors showed little or no interest or ability to stimulate the market for private, household sales (Terrado, 2014). Other drawbacks of the model were the need for the contractor to make a large capital investment and the costs of collecting the fees (Martinot et al., 2002: 330).

Donor programs tend to be driven by broad socio-economic concerns. Lighting Africa (2010a,b) emphasizes impacts on the environment, health, education, income generation and reduced spending. However, evidence suggests that consumer demand for solar is driven more by the desire for improved services (television in particular) than decreased energy costs (vis-à-vis other substitutes for grid electricity; Martinot et al., 2002: 327). In Zambia, lighting for children to do homework and entertainment were the main perceived benefits by (the relatively wealthy) consumers, who were paying more than they previously paid for kerosene, candles and batteries (Ellegård et al., 2004: 1253). Hence a commercial approach based on direct sales of SHS to consumers is likely to require a substantial middle class in rural areas to generate sufficient demand, as occurred in Kenya (Nyaagard, 2009).

The multi-stakeholder programmatic model represents a step toward building up such demand, usually involving a credit programme to offset the lack of term financing available to most rural households, and facilitating expansion of suppliers into those areas through training and indirect support for market development, along with quality assurance. A review of PV projects in Africa revealed that the biggest remaining barrier to stimulating rural PV markets was the need for sustainable consumer financing in rural areas to enable potential consumers to afford the high up-front costs of SHS (Krause and Nordstrom, 2004). The Bangladesh PV program, which supported hundreds of thousands of household to obtain PV systems, was built largely around the well-developed market for of microfinance throughout rural Bangladesh (Khandker et al., 2014). However, there is a risk that financing, dealer presence and system maintenance will not be sustained beyond the end of the programmatic support; in the Zimbabwe Global Environment Facility (GEF) PV project, the dealers pulled out after donor support ended (Mulugetta et al., 2000). Hence it is important to have an exit strategy for gradual phasing out of subsidies and facilitation.

Conditions for market development

Conditions identified by Nygaard (2009: 19–23) for the rural market for SHS to reach sufficient scale and affordability to become sustainable include:

- *Competition*: the programmatic model is intended to expand demand to reach a 'critical mass' and attract enough suppliers to drive prices down and provide superior products
- *Financing*: Although projects may include credit schemes (often with subsidies to offset interest costs and incentive purchases) through existing financial institutions, sustained availability of financing to lower-income consumers is generally problematic, especially in rural areas. Even where microcredit is available, the small size, short terms and group orientation typical of microfinance tend not to be suitable to borrowing for SHS. In South Asia, Palit and Sarangi (2011: 9) found that "lack of suitable financing was regarded as the most significant barrier to the uptake of SHS…of more importance than the technical and policy issues." In Zambia, "the lack of a functional and dedicated financial market is one of the major constraints" to sustainability (Ellegård et al., 2004: 1256). Hansen et al. (2014) note that innovative financing schemes have been important in facilitating the transition to a market-based model.
- *Subsidies*: Subsides are generally regarded as necessary to level the playing field for solar PV against the grid and other sources whose capital costs are highly subsidized, as well as to stimulate demand. The different models (Table 1) vary in how they apply subsidies, but all face the challenge of minimizing market distortions and sustaining demand and supply as subsidies are withdrawn.

Table 1
Models for promotion of SHS.

Model	End-user	Owner-ship	Financing provided by	Subsidy level for investment	Responsible for installation, maintenance and after sales service
1. Donation	Institutions	End-use	Donor	High, 100%	End-user, committees
2. Fee for service:	Private, Institutions	Utility, ESCO[a]	ESCO	Medium to high	ESCO
2a. Concession					
2b. Dealer					
3. Sales:	Private	End-user	Donor, financing institution, dealer, end-user	Low to medium	Depends on circumstances
3a. Multi-stakeholder programmatic/credit					
3b. Cash sales	Private	End-user	End user	Zero	End user

Source: Adapted from Nygaard, 2009, Table 1.
[a] Energy Service Company.

- *Maintenance and quality assurance*: Although the programmatic model "aims at ensuring a higher quality of products through quality standards and certification," failure rates over time have often proven high, in part because of "consumers' lack of knowledge of battery charging and difficulties in identifying high quality products" (Martinot et al.: 22–23). It is important to proactively train technicians and support establishment of maintenance infrastructure in targeted areas, although there is no certainty that they will remain after projects end or that consumers will be able to afford the costs of repair and replacement. In South Asia, Palit and Sarangi (2011: 9) found that inadequate or delayed maintenance by suppliers was "one of the most critical determinants for limited success of many programs" and a source of consumer dissatisfaction.

Martinot et al. (2002: 336) also identify market facilitation organizations (MFOs) as important to support the development of markets. Various public or private entities "may provide networking, partner matching, information dissemination, market research, user education, business-deal identification and facilitation, technical assistance," etc. Because these services involve "public goods" aspects, they may have to be undertaken by government agencies or non-profit NGOs. Nevertheless, private businesses with a stake in development of the market may undertake some of these functions with partial funding from public sources. In some cases, "traditional NGOs have operated successfully as MFOs by adopting a greater private-sector orientation."

Lighting Africa's approach to market development

The potential for making modern energy available on an affordable basis has increased significantly during the 2010s due to cost-reducing supply innovations, such as light-emitting diodes (LEDs), advances in synergistic technologies that simplify cost recovery (pay-as-you-go technology), and growing investment in new business models for producing and marketing affordable solar products. Lighting Africa has sought to accelerate the uptake of newer, cheaper PV systems making use of these newer technologies, ensuring a rigorous quality-certification approach to drive out the low-quality, cheap products that spoil the market, and to rely more fully on a market development strategy placing the responsibility for market growth squarely on the private sector, not government or donor subsidies (Lighting Africa, 2010a: 12). This involves facilitating consumer access to a range of affordable, reliable, and high quality lighting products and services to build up demand, while also catalyzing private sector suppliers, including strengthening ties between the international solar energy industry and local service providers to profitably manufacture, market and distribute lower cost products. Attention must also be paid to financing and other market conditions for the scale-up of modern lighting products, by reducing existing technical, financial, policy, information, and institutional barriers. In addition, governments, private agencies, international organizations and non-government organizations (NGOs) must be mobilized to facilitate and promote penetration of modern lighting services for the poor in Africa. Lighting Africa recognizes, however, that "significant challenges" to developing the African marketplace include: lack of consumer awareness and education; bottlenecks in access to finance; high distribution and servicing costs, especially in remote areas; low quality products and durability issues; and high taxes and tariffs, compounded by bureaucratic hurdles (ibid.: 11).

In light of the above analysis, specific questions relevant to whether the Ghana project stimulated demand sufficiently to support a sustainable market include:

- Was public perception of and willingness to pay for SHS without subsidies substantially enhanced?
- Are systems likely to be maintained and are beneficiaries willing to pay for repairs?
- Was there an increase in competition among suppliers and did the increased competition affect pricing and product supplied?
- Is there likely to be continued access to financing?
- Can the market sustain itself beyond the end of the project?

Questions with respect to whether the expected benefits to users were realized include:

- How did beneficiaries (and non-beneficiaries) perceive the uses and benefits of SHS?
- How satisfied were they with the SHS and the financing?
- How satisfactory was system performance and repair?

Ghana context and solar project

The Ghana Energy Access and Development Project (GEDAP; World Bank, 2007) decided to include a small (relative to the core focus on grid extension) Solar PV Systems Sub-Component (SPVSSC, or 'Solar Project'), both as a means of reaching small, remote communities to fulfill the government's policy that "electricity should be provided to all communities in Ghana with population 500 and above by the year 2020" and "to improve living conditions and reduce poverty through increasing access…to basic energy services for household and commercial lighting, radio and television operation, battery charging, water pumping, etc." (Akuffo, 2007: 1–3). The fee-for-service model previously used for SHS under a program of the United Nations Development Program (UNDP) and Global Environment Facility (GEF) was rejected as "not financially sustainable for the service providers, because the monthly charges (USD 2) were too low to cover the operating and maintenance costs" (World Bank, 2007: 13).

However, at the time, there was "no significant rural retail household PV market," with provision of solar products over the previous decade only through "a stream of project based and contract based sales for health, education, telecommunications and other sectors" (Finucane, 2009: 3). Direct sales to consumers were limited to high-end products for relatively well-off households and businesses. The few companies providing solar products (most as a side-line, not a core business) had no rural retailing presence, let alone servicing capability. Low-cost, low-quality solar lanterns and other products were increasingly being sold throughout the country — with negative consequences for public perception of solar equipment as unreliable. On the positive side, Ghana had a significant number of redundant solar installers that had been trained by the Deng Solar Training Centre (the first in Sub-Saharan Africa certified by the Institute for Sustainable Power) or had worked in previous projects such as the Renewable Energy Services Project.

Against this background, the Solar Project, with support from the Global Partnership on Output-Based Aid (GPOBA), had to embark on creation of a market from scratch in the least-developed, most remote areas of the country. This focus was a consequence of Ghana's relatively high grid penetration[2] and a policy of avoiding communities where the grid might be extended within the next five years.[3] Consistent with the approach of Lighting Africa, GEDAP adopted a market-based strategy. This meant that it had to undertake activities in the following areas of market creation put forward by Nyaagard and Lighting Africa:

- *Demand*: building consumer awareness of the availability and benefits of solar products by providing information to targeted consumers and

[2] National electrification rate of 54% in 2005, vs. an average of 21% for Sub-Saharan Africa (World Bank, 2007: 6).

[3] The issue of identifying which areas were unlikely to be reached by the national grid proved treacherous, as no high level official was willing to provide a statement in writing specifying which villages would not receive electricity within the next five years. As a result, the Solar Project was forced to resort to an expert committee's assessment of where the grid was unlikely to connect villages, and this assessment had to be revised once during the project's lifetime due to unexpected grid advances.

partial subsidies of 50–60% of the cost of the equipment. The smaller systems less than 50 Wp received a grant of 60% while the systems from 50 Wp and above received a grant of 50%.

- *Supply*: strengthening technical capacities and supporting sensitization programs and outreach to rural areas by solar companies and their newly formed Association of Ghana Solar Industries (AGSI); facilitating access to potential buyers; addressing problems of tariffs and taxation on solar products.
- *Quality assurance*: verifying quality and satisfactory installation of equipment through field inspections of each installed system by qualified engineers contracted as inspectors under the project; requiring three-year warranty period for major components and provision of subsidy for the replacement of battery when required.
- *Financing*: Making financing available to consumers for the high upfront costs of SHS through a line of credit and incentives to Rural and Community Banks (RCBs); arranging financing for solar companies, especially to expand their importation of equipment to meet the anticipated growth of demand under the project.
- *Facilitation*: market surveys; engaging and initially financing the salaries of Solar Project Officers to facilitate the interactions between potential buyers and suppliers of equipment.

A principal instrument was the provision of incentive grants to partially offset the high initial costs of SHS and lanterns — particularly in the Ghana market, which is generally high-cost and where the suppliers were not yet obtaining lower-cost, good quality products from China. The grants were initially made available only to consumers, but eventually results-based bonuses were also made available to banks to help offset the high costs of reaching new customers in communities as far away as 100 km. The grants for SHS were made contingent on obtaining loan financing for the remaining cost (apart from a 10% contribution by the customer). The loans were to be made for three years, with a maintenance contract intended to ensure that the systems would remain operable so that the incentive to repay the loans would not be compromised. In practice, the subsidies were paid directly to the suppliers upon verification of sale at the subsidized price. This system of subsidies with a warranty was similar to that used in Sri Lanka and Bangladesh (Palit and Sarangi, 2011).

With retail interest rates ranging between 24 and 32% per annum, and the high costs of maintaining SHS in remote parts of the country far away from suppliers' location in Accra, these conditions more than doubled the costs to the consumers. The need to verify installations and the quality of the equipment added further costs (borne by the project). The average cost of a 50 Wp system in Ghana was USD 962 as against USD 500 or less in Sri Lanka and India (Palit and Sarangi, 2011).[4]

The support system as designed was reasonably comprehensive but necessarily complex, and untried. An initial review concluded that "the GEDAP business model…and the project arrangements are impractical in the current market context" (Finucane, 2009, p. 8). Nevertheless, it was considered worth proceeding to pilot the program to "document what works and what does not." In the course of implementation, a number of adjustments were made, the most important being the hiring of a dedicated Solar Project Officer in each of the participating RCBs. In the end, the quantitative target of 15,000 SHS and lanterns was exceeded, especially at the lower (lantern) and top (large SHS) ends (Table 2). A total of 16,822 households were served, benefiting nearly 170,000 people. The 8831 SHS installed and outreach to some 180 communities represented a substantial increase over the cumulative total of 4500 solar PV systems (about half for health services, schools, water and other non-household uses) installed in 89 communities in Ghana as of 2011 (Energy Commission, 2012).

Table 2
Project targets and sales by size.

	Lanterns	Pico/small/medium SHS	Large SHS (≥50 Wp)	Total
Project target (revised)	4500	8500	2000	15,000
Number purchased	7991	3604	5227	16,822
Subsidy rate	60%	60%	50%	

Source: World Bank 2015, Table XX.

Assessment of market development

This section assesses the results of project intervention in each of the key areas of market development identified from the literature. Issues of perceived benefits and sustainability are addressed in subsequent sections.

Demand side[5]

Overall satisfaction was very high: 94% of SHS and 93% of lantern beneficiaries said they would make the purchase again if they had to do it over. Hardly any SHS beneficiaries and no lantern beneficiaries said that they would not make the purchase if they had it to do over. Satisfaction rates were also very high (over 95%) with respect to the information provided regarding the systems and their usage, and for speed of installation (88%).

Consistent with experience in other countries, demand for SHS was driven more by desire for increased services than by cost reductions. Over half of SHS beneficiaries would like a bigger system, and half of the lantern beneficiaries expressed a desire for a system with a TV. The convenience of charging phones at home (saving about USD 1 a week) was also a key selling point. Income-earning uses were reported by 27% of lantern beneficiaries and 18% of SHS clients. The results indicate strong and continued demand for solar systems among beneficiaries.

The beneficiary assessment shows high appreciation for solar among non-beneficiaries as well as beneficiaries, and surprisingly willingness to pay (contrary to the initial market surveys). High penetration of mobile phones in rural areas and desire for TV are important motivating factors for further spread of solar. Willingness to pay for repair and expansion of systems is high, though constrained by the lack of local suppliers and servicing capability. Solar is now seen by many users as a complement to grid electricity, both to cope with outages and to save on cost. So the market is greater than just the off-grid communities.

Supply side

The open market approach, together with subsidies and facilitation to help mobilize demand, did attract additional suppliers to participate in serving the targeted rural areas, with the number of participating solar dealers rising from the initial three to seven. The effects of increasing competition and greater volume were seen in falling prices over 2011–13: average cost from the three main suppliers fell by nearly 30% for lanterns (from USD 72 to 50) and 16% for 50 Wp systems (from USD 962 to 810; ARB Apex Bank, 2014, Appendix B).[6] "Moreover, the dealers that provided the best services to the beneficiaries were the ones that sold the most equipment" (World Bank, 2015: 11), indicating that the market was becoming demand-driven.

[4] Solar system prices remain relatively high in Ghana when compared to other countries in Africa. Possible reasons discussed among the project team were the higher transport costs in bringing the products from East Asia and the relatively low volume of sales of PV equipment in Ghana as a whole.

[5] This section is excerpted from Steel et al., 2014: 43–6.

[6] Reduction in costs was also facilitated by the Ministry of Energy and Petroleum's efforts to have solar equipment exempted from import duties (World Bank, 2015).

Nevertheless, the rural supply system is still weak in terms of outlets and especially servicing. Delays in repairs were the biggest complaint by consumers. With limited presence in rural areas, the suppliers relied heavily on the RCBs to identify potential customers and need for repairs. Given problems of durability, breakdowns and lack of immediate availability of replacement parts, it is particularly important to expand the number of electrical shops that stock parts and technicians who are able to do basic repairs on SHS in the towns of rural Districts. Although the project design included matching grants and other support for training in servicing of the equipment, it was not clear that this was a priority for the suppliers, and implementation was weak. Local dealers were trained by the project in some of the communities The Solar Project Officers were also trained in maintenance and installation of the solar systems and encouraged to set up solar shops upon the expiration of the project. Over 50% of them have now established solar shops as part-time businesses.

Quality and maintenance

Ensuring good quality equipment was a priority of the project design, in order to offset poor perceptions of solar due to the incursion of cheap, low-quality products and the lack of servicing capability in rural areas. Since the Ghana Standards Authority was not yet equipped to be able to test solar product quality, equipment had to meet standards of Lighting Africa and be certified by the Energy Commission. Dealers had to agree to warranty their products and service them for a period of three years, giving them a strong incentive to provide durable equipment.

The ARB Apex Bank hired inspection agents, approved by the Energy Commission and paid with GPOBA funds. The five inspectors were engineers who had significant years of experience in the installation of SHS. Upon receipt of information from RCBs that systems had been installed, the agents were dispatched to verify the installation; any substandard equipment or other problems had to be resolved before the subsidy payments were disbursed to the suppliers. This system worked well and ensured customer satisfaction without significantly delaying payments, as in other projects.[7]

Nonetheless, 46% of SHS clients and 49% of lantern purchasers experienced a problem requiring repair (8–10% two or more times), and routine maintenance (apart from requested repairs) was performed on only 36% of SHS (Steel et al., 2014: 25). Low durability of equipment (especially batteries, bulbs and TVs) was the least liked feature of solar, followed by the non-availability and cost of parts (ibid.). It may be noted, however, that these concerns often focused on the batteries discharging too quickly, indicating possible lack of understanding of the nature of solar (as against dry cell and automobile batteries), and on the small size of the system relative to desired uses by the household.

Furthermore, whereas clients were predominantly satisfied with the timeliness of installation of their systems after making payment arrangements, they were quite dissatisfied (67% of SHS and 48% of lantern clients) with the timeliness of repairs (ibid.: 23). The lack of trained technicians in the targeted areas was a major constraint, only partially addressed by efforts of the dealers to train people locally. Without the latter, it is clear that market development is likely to stall if it depends on servicing dispatched from distant companies, with whom the clients have no contact after installation.

[7] Uganda's Photo-Voltaic Targeted Market Approach (PVTMA) of the second Energy for Rural Transformation Project experienced serious delays in payments to suppliers due both to the time required to procure a firm and to their reluctance to carry out inspections promptly, preferring to wait for a substantial number in order to reduce the costs of going to a particular rural area (W. Steel, 'Back-to-Office Report on Supervision of PVTMA Component,' World Bank, May 2012).

Financing

The availability of financing was important for potential demand for SHS to be realized, especially because system costs in Ghana were relatively high and the areas targeted were relatively poor. For consumers, the ability to spread payments out over time was highly appreciated and important to enable the purchase of SHS. Indeed, SHS clients were more likely to be satisfied with the cost than lantern beneficiaries, who had to pay the full cost (less the subsidy) up front. The main incentive for RCBs to participate was an IDA line of credit for refinancing up to 80% of loans, managed by the ARB Apex Bank, a mini-central bank servicing the rural banking system. The credit line enabled RCBs to overcome their liquidity constraints and undertake term lending, although most banks offered loans only up to one year rather than three years as suggested by the project. The adoption of the RCBs' normal credit appraisal methods and the requirement that all prospective beneficiaries pay at least 10% of the cost of the system were intended to mitigate the chances that repayment rates for project beneficiaries would fall below the repayment rates they achieved in their regular operations.

The active role of RCBs was especially important in expanding the outreach not only of solar but also the financial system into more remote communities: 68% of beneficiaries were new bank clients, and over half of these expected to take out another loan. A number of (but not all) participating RCBs have adopted and want to continue term lending for solar (and other equipment), which has helped to expand their outreach into more remote rural areas.

Repayment rates do not appear worse than the overall averages for the banks, but were low in some. Seven of the twelve participating RCBs had repayment rates of 98–100%; only one fell below 70%, but it pulled the overall average down to 78% (Table 3). Variations in rates tended to be inversely associated with the number of clients per loan officer, which ranged from 335 to 2629 (Steel et al., 2014: 42). A quarter of delinquent clients said they were waiting to harvest their crop in order to repay, while 8% cited adverse effects of weather on their crops and 5% complained that their system was not operational (Steel et al., 2014: Table 38). In contrast, the RCBs primarily blamed late payment on system malfunction. Key lessons that could help improve repayment are adapting repayment schedules to clients' cash flow (e.g., through grace periods and balloon payments for farmers), keeping the number of clients per loan officer below 500 to facilitate regular contact, and ensuring prompt response to repair requests.

Unfortunately, ARB Apex Bank has not indicated any interest in continuing to revolve and manage the loan funds. This could impair the future participation of RCBs with limited internal funds — and hence their facilitating as well as financing role. The termination of results-based bonuses for SHS loans also reduces the incentive for RCBs to continue offering them, and hence to continue engaging Solar Project Officers.

While the project design had anticipated the challenge of consumer finance based upon past experience (Krause and Nordstrom, 2004), it had neglected to address the need for supplier finance, including both trade finance and working capital. As a result, project progress halted for nearly one year as the various participating vendors struggled to obtain financing. Without such financing, these dealers were able to import equipment only in small quantities, rather than by the container.

Table 3
SHS loan recovery.
Source: Calculated from ARB Apex Bank, 2014, Sec. 6.3.

Number of RCBs	Level of repayment	Loan amounts (GHS '000) Disbursed	Recovered	Recovery rate
7	High (98–100%)	666	665	99.9%
5	Moderate (70–82%)	1750	1407	80.4%
1	Low (<60%)	786	437	55.6%
Total		3202	2509	78.4%

Average exchange rate approximately GHS 2/USD.

Eventually, both local and international financing institutions were mobilized to help overcome this hurdle. On balance, vendor or supplier finance is every bit as important as consumer finance in order to unleash the potential of the PV market to grow on both the supply and the demand-sides.

Facilitation

As noted in the preceding section, the ARB Apex Bank was an important facilitating agency in making the program attractive to the retail RCBs. The Apex Bank was supported to engage a Solar Project Manager,[8] who was the key driver in project implementation and making adaptations in light of experience on the ground, as well as monitoring the participation of RCBs.

Market facilitation was key to the project's success, in that it took off only when the project subsidized RCBs to engage Solar Project Officers who mobilized and sensitized potential customers and made arrangements with the suppliers while undertaking all required paper work. Retail marketing is too difficult and expensive for the solar companies themselves to undertake in rural areas. Furthermore, the RCB officers were the key link to obtaining servicing for broken-down systems and equipment — which in turn was important for loan repayment to be maintained. This represents an example of public funds being used to share the initial costs of providing facilitation by an interested private entity, which gradually takes over the costs. In the absence of a facilitating agency in the targeted areas such as RCBs, and until the suppliers view these markets as sufficiently profitable for them to establish local supply and servicing capabilities, it is unlikely that the rural markets will continue to thrive and grow at the pace achieved under GEDAP. The government's plans to reach isolated areas such as island communities will depend on providing further subsidies both to the RCBs and, likely, to the suppliers to offset the additional costs.

The Association of Ghana Solar Industries (AGSI) was an important interlocutor in the initial design of the project, and membership in AGSI was required to participate in the project. Project funds were available for capacity building and outreach. AGSI applied some of these funds to undertake periodic promotional activities in some of beneficiary communities, though on a limited scale. Although word-of-mouth seems to have improved perceptions of SHS among non-clients as well as project beneficiaries, promotional campaigns will be warranted in order to continue scaling up demand in the absence of subsidies.

The Project Coordinating Unit of the Ministry of Energy and Petroleum served as project supervisors and reviewed quarterly performance reports by the ARB Apex Bank.

The Ghana Energy Commission was also a partner in project design, certification of dealers and the quality of their equipment, and approval of inspection agents.

Assessment of benefits[9]

Positive benefits were documented with respect to education (use by children for studying), information (via TV, radio, and mobile phones), mobile phone charging, income generation, cost-saving, and safety relative to electricity and fuel.

The best-liked feature overall was lighting, especially for reading and studying. Indeed, 91% said children used the lighting for reading and studying. The respondents' systems were all small, in that they had only one panel. Nevertheless, 60% of SHS included a TV — which has become an important selling point for solar. Beneficiaries viewed better access to TV and radio not only as entertainment, but also as a means of acquiring knowledge about the outside world. Another key selling point is being able to charge phones at home — mentioned as a significant benefit by a third of lantern beneficiaries and a fifth of SHS clients. Besides weekly savings in fees for phone charging estimated at USD 1, a perceived benefit of being able to charge phones regularly was better and more consistent communication with family and friends.

Income-earning uses were reported by 27% of lantern beneficiaries (mainly for trading) and 18% of SHS clients (mainly for trading and production; 43% each). About 10% of SHS clients earned income charging other people's phones. In addition, many respondents said the lighting enabled them to do work after dark (both household chores and self-employment activities), leaving more time for farming and income-generating activities during the day.

The evidence shows that acquiring solar systems/lanterns led to substantially decreased reliance on kerosene lanterns — ranked by only 21% of beneficiaries among the top three current energy sources (vs. 86% before), well below the 52% of non-beneficiaries currently using kerosene. Use of candles similarly fell from 31% ranking in the top three prior to solar (and 26% currently for non-beneficiaries) to only 7%. Thus the advent of solar has substantially displaced use of energy sources that involve burning and hence pose health and fire risks. Solar clients reported lower current use of grid electricity than non-clients, and 17% ranked phone lights as a back-up source of light when needed — reflecting the ability to now recharge them consistently at home. There was little impact on the widespread use of dry cell batteries.

Sustainability

Certainly, the project helped to establish the conditions for sustained growth of the market for solar in previously underserved areas. Awareness of the benefits of solar, demand and willingness to pay were increased, and found to be much stronger than anticipated (Steel et al., 2014). The dealers gained experience working in those areas, and expanded their network of local service providers.

Nevertheless, two gaps raise concern as to whether the benefits will be sustained and the market will continue to grow on its own: first, the lack of local technicians able to service SHS and of locally-available spare parts; and, second, uncertainty about the availability of funds and willingness of RCBs to continue providing SHS loans and engaging Solar Project Officers. Although SHS beneficiaries indicated a strong willingness to pay for maintenance, repairs under the project were generally arranged with suppliers (under warranty) through the RCB officers, and were often not done in a timely manner. Given that about half of the systems required repair during the initial three years, and that panels, batteries and bulbs will need to be replaced, the absence of local technicians and spare parts supplies may result in steadily decreasing rates of use among the beneficiaries, as well as making it difficult for potential new clients to obtain, install and service equipment.

Despite interest from some of the participating RCBs in continuing to be able to refinance SHS loans through a line of credit, and the willingness of the government to let the recovered funds continue to revolve, the ARB Apex Bank has declined to continue managing it. Since the RCBs in the relatively poor rural areas targeted by the project are already undercapitalized, and their own funds are largely short-term in nature, their ability to continue offering term loans for SHS may be compromised, unless the Government finds another means of wholesaling the recovered funds to the retail institutions. Furthermore, some RCBs may be discouraged by low repayment, or by the cost of engaging a Project Officer to promote and collect SHS loans. Since these Project Officers were found to be critical in linking suppliers to potential buyers, as well as in ensuring quality and repairs, this critical market facilitation mechanism would be lost if RCBs decide not maintain their SHS loan portfolios.

Conclusions

The literature makes clear that developing a sustainable market for solar products in rural areas that are underserved by both solar

[8] Funds for the Solar Project Officers, as well as for capacity building, came from the Global Environmental Facility (GEF).

[9] This section is in part excerpted from Steel et al., 2014: 26–27 and 43.

companies and financial institutions requires an integrated approach addressing demand, supply, financing, quality, and facilitation mechanisms. The Ghana Solar Project was well adapted during implementation to overcome constraints in all of these areas. Results were positive in terms of exceeding objectives in numbers of systems purchased and having a positive impact on perceived benefits and willingness to pay. Competition increased, and system costs fell. Financial institutions expanded their products and outreach, and in most cases had good recovery rates.

The project was most successful in stimulating demand and willingness to pay the full costs of larger or new systems and of maintenance. These would likely not be affected by the end of subsidies for product purchase, especially as prices continue to fall. However, the high initial cost of SHS means that loan financing will remain important for continued demand growth, and the distance to rural communities from urban supply locations means that a facilitator to mobilize groups of interested buyers will remain critical to overcome the high costs of marketing in such areas. Without the line of credit for refinancing and the results-based bonuses for making SHS loans, some of the RCBs may no longer find it cost-effective to continue engaging Solar Project Officers. And without these facilitators at the local level, and with supplier presence and servicing capability still limited in these areas, continued growth and servicing of the potential rural market for solar is likely to be compromised.

The implication is that, even though direct subsidies for the capital costs of SHS and capacity-building of suppliers can be phased out after initial stimulation of the market, continued support for access to finance — on both supply and demand sides — and local facilitators may be needed to sustain growth of the market. For rural purchasers of SHS to continue realizing the benefits, it is also critical to ensure local availability of spare parts and trained technicians to service the equipment. This it is important to have an exit strategy for gradually phasing out subsidies and incentives, retaining only those needed to facilitate continued growth of the market.

Acknowledgements

Preparation of this paper was funded by the Global Partnership on Output-Based Aid, drawing on data from the Beneficiary Assessment funded by the Ghana Ministry of Energy and Petroleum (P074191- TF092833 and TF092834) with support from the Global Environment Facility. The authors would like to gratefully acknowledge constructive comments from Daniel Coila and Morgan Bazilian at the World Bank and Wisdom Ahiataku-Togobo at the Ministry of Power in Ghana. The findings, interpretations, and conclusions expressed in this volume do not necessarily reflect the views of the Executive Directors of The World Bank Group or the governments they represent.

References

Akuffo Fred O. Increasing access to solar PV systems by remote rural communities in Ghana. Report for GEDAP Solar PV Systems Sub-component; 2007.
Apex Bank ARB. Solar home systems project completion report (Accra) ARB Apex Bank; 2014.
Ellegård Anders, Arvidson Anders, Nordström Mattias, Kalumiana Oscar S, Mwanza Clotilda. Rural people pay for solar: experience from the Zambia PV-ESCO project. Renewable Energy 2004;29(8):1251–63.
Energy Commission. Ghana: sustainable energy for all action action plan (Accra) Ghana Energy Commission; 2012.
Finucane Jim. Report on Ghana GEDAP assigment. , 2Washington, DC. : World Bank; 2009. p. 2009 (draft back-to-office report, June).
Hansen Ulrich Elmer, Pedersen Mathilde Brix, Nygaard Ivan. Review of solar PV market development in East Africa. Copenhagen: UNEP RisØ Centre Working Paper Series no; 2014. p. 12.
Khandker SR, Samad HA, Sadeque ZKM, Asaduzzaman M, Yunus M, Haque AK. Surge in solar-powered homes: experience in off-grid rural Bangladesh. Directions in Development: Energy and Mining. Washington DC: World Bank; 2014.
Krause Martin, Nordstrom Sara. Solar Photovoltaics in Africa. Experiences with financing and delivery models monitoring and evaluation report series No 2. New York: UNDP-GEF; 2004.
Lighting Africa. Solar lighting for the base of the pyramid — overview of an emerging market. Washington, DC: World Bank Group; 2010a.
Lighting Africa. Catalyzing markets for modern lighting. Washington, DC: World Bank Group; 2010b.
Martinot Eric, Chaurey Akansha, Lew Debra, Moreira José Roberto, Wamukonya Njeri. Renewable energy markets in developing countries. Annu Rev Energy Environ 2002;27:309–48.
Mulugetta Yacob, Nhete Tinashe, Jackson Tim. Photovoltaics in Zimbabwe: lessons from the GEF solar project. Energy Policy 2000;28:1069–80.
Nygaard Ivan. The compatibility of rural electrification and promotion of low-carbon technologies in developing countries — the case of Solar PV for Sub-Saharan Africa. Eur Rev Energy Mark 2009;3:2. (June 2009).
Palit Debajit, Sarangi Gopal K. A comparative analysis of the solar energy programs for rural electrification: experiences and lessons from South Asia. Paper presented at the 3rd International Conference on Addressing Climate Change for Sustainable Development through Upscaling Renewable Energy Technologies, Kathmandu, Nepal, October 12 14 2011; 2011.
Steel William F, Anyidoho Nana Akua, Afutu-Kotey Robert. Beneficiary assessment of the GPOBA project: solar PV systems for rural poor in Ghana. (Accra) Report for GEDAP; 2014.
Terrado Ernesto N. 'TEDAP's sustainable solar market package (SSMP) approach: an evaluation of the experience with SSMP1 and suggestions going forward. Washington DC: paper prepared for AFTEG2. World Bank; 2014.
World Bank. Implementation completion and results report on a GPOBA Grant. Washington DC; 2015 (draft report, February, 2014).
World Bank. Project appraisal document on a proposed credit in the amount of SDR 59.1 million and a proposed grant from the global environment trust fund in the amount of US$5.5 million to the Republic of Ghana for an energy development and access project. Washington, DC: World Bank; 2007 (Report No. 39713-GH).

Glossary

AGSI: Association of Ghana Solar Industries
ARB: Association of Rural Banks
ESCO: Energy Service Company
GEDAP: Ghana Energy Development and Access Project
GEF: Global Environment Facility
GPOBA: Global Partnership on Output-Based Aid
GHS: Ghana Sedis
IDA: International Development Association
IFC: International Finance Corporation
LEDs: Light-Emitting Diodes
MFOs: Market Facilitation Organizations
NGOs: Non-Governmental Organizations
PRCBs: Participating Rural and Community Banks
PV: Photovoltaic
RCBs: Rural and Community Banks
RESPRO: Renewable Energy Services Project
SHS: Solar Home System
SPVSSC: Solar PV Systems Sub-Component ("Solar Project")
TV: Television
UNDP: United Nations Development Program
USD: United States dollar
Wp: Watt-peak