After-sales Service and Local Presence: Key Factors for Solar Energy Innovations Diffusion in Developing Countries

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Abstract--**In this study, we have investigated the practice of an international network of companies and organizations which are engaged in the diffusion of solar home systems in Africa and Asia. This research looks into a network called, StS Network for Rural Development in Ethiopia.To investigate the details of the network, local business managers and governmental officers were interviewed.Our case study explored that the network (registered first as NGO in Ethiopia through its Solar Energy Foundation) has managed to surpass other companies and even MNCs for its relatively unique approach aimed at the diffusion of rural solar home systems in Ethiopia. Furthermore, it is identified why the NGO has managed to diffuse relatively larger volume of solar energy innovations than other competitors, which is mainly related to its effort of building trust among the local community through its after-sales service and local solar centers. This case study would provide both policy makers and business managers with practical implications.**

I. INTRODUCTION

According to the International Energy Agency (IEA) and UN organizations, 1.4 billion people in the globe still lack access to basic electricity services [8].Most of these people live in Sub-Saharan Africa and South Asia countries [16]. In the context of no access to the electricity grid, off-grid energy systems have been promoted by several stakeholders as a remedy for the energy poverty in these regions. One of the potential off-grid renewable energy technologies (RETs), particularly, solar photovoltaic technologies have been promoted as a potential means of rural electrification in developing countries [2].Despite several efforts to develop and promote such technologies, uptake remains so low and sluggish [7, 14, 18, 19].

A Lighting Africa report estimated that 40 million households are potential adopters of solar home systems (SHS)[1] in Ethiopia, Ghana, Kenya, Tanzania, and Zamiba alone[13]. However, far less adoption has been achieved both through market and non-market mechanisms in the region. The diffusion challenges are numerous in number and shifting from conventional energy sources towards RETs has been an arduous work particularly in developing countries [14, 18, 19].

Ethiopia is one of the naturally endowed countries with a large array of renewable energy resources. But it remains one of the energy poorest nations in the globe and the main sources of light in homes and small businesses particularly in the rural community are kerosene lamps and candles. In this study, we investigated the practice of an international "hybrid" NGO called Solar Energy Foundation (SEF) engaged in the diffusion and further development of solar innovations in Ethiopia. Through our close investigation on the approach of SEF, we explored the relative success factors in the diffusion of SHS by SEF which is a member of an international network of companies and organizations (StS Network for Rural Development), currently active in Africa and Asia. Our findings from this case study would contribute to further development of the past and current scholarly debates on the factors influencing the diffusion of rural energy innovations, especially in developing countries.

II. LITERATURE REVIEW

In literature, different market models are identified as distribution ways of solar energy technology to the end users in developing countries. According to [7] the four major categories of distribution modes include *institutional partnership; company owned branches; micro- franchises;* and *traditional distribution models* [2][7].Reference [7] further discussed three essential project elements in the diffusion of solar PV systems in developing countries which include *technical considerations*, *project enabling structure* and *support structure*. The support structure is emphasized more as the components of a solar PV system/SHS have short life span, and particularly the battery is a critical part of the system and it causes early system/product failure. From their study, they identified that a system for product return and maintenance service network have to be there for successful diffusion of solar PV systems in developing countries [7].

Reference [3], putting their study in a relatively common marketing terminology, also surveyed and classified approaches of marketing SHS in developing countries into four: *Cash selling; credit system; leasing system;* and *fee-for-service*[3]. Friebe et al. also discussed that maintenance service was found to be a critical element in all the four marketing

[1] A typical SHS consists of a photovoltaic module, a battery, a charge controller and light bulbs.

[2] The author defines "traditional distribution models" as supply from manufacturer to major distributors, who in turn sell to dealers [7].

[3] Reference [3] defines the approaches as follows:

***Cash*:** The consumer pays for and receives the SHS, which is installed by the consumer himself or by the company. On completion, ownership is transferred to the consumer.

Credit: The consumer receives an SHS and pays regular instalments plus possibly a down payment. The loan may be provided by the company that sells the products or by a financial institution.

Leasing: The consumer is allowed to use the SHS and pays regular instalments. Initially, the company owns the system. Later, once the system is fully paid for by the consumer, the ownership is transferred.

Fee-for-Service: The consumer is allowed to use an SHS that is owned by the company. The consumer pays either a fixed fee for the system uptime or a variable fee depending on the kWh used

approaches towards SHS diffusion. As part of a solution to the maintenance problem, they recommended policy makers and development aid agencies to include maintenance services (after-sales service) into public programmes or public–private partnership [3].

Be it high-tech or low-tech, top or bottom of the pyramid business, provision of satisfactory service to customers requires the integration of value creating processes in the manufacturing systems, maintenance and spare parts supply systems, logistic systems, etc. [5].A major problem for renewable energy projects in rural communities has been a lack of maintenance and proper after-sales service. And this is worse when the project is a one-time donation project by NGOs or other stakeholders. Such kind of one-shot projects have been creating "bad image" of some technologies among the rural users [12]. The lack of repair or replacement service enforces the rural users to simply throw repairable and replaceable products and pollute the environment [7].

After-sales service, by itself, constitutes a business opportunity and it is becoming a differentiating factor for resellers and manufacturing companies as well [4].Effective after-sales service delivery guarantees a strong connection between customers and the supplier as it does increase customer satisfaction and loyalty. Unless a system for return or repair of SHS products is established, a vicious cycle of adoption may prevail, i.e. if early adopters face after-sales problems, they would never recommend for the potential adopters and that would affect further adoption of SHS [15,7].

The supply of SHS to developing countries, mainly African countries, is predominantly from Europe and Asia which made it difficult to trace the entire supply chain [7]. Experts and policy makers recommend extended producers' responsibilities as part of combating the short life time of usable solar products and the sustainable (re)use of such resources; however, the implementation requires a huge investment from every stakeholder. Part of the solution recommended included local presence of suppliers closer to the market [6].

In this study, we mainly rely on the conceptual framework developed by Hirmer and Cruickshank who proposed key sustainability criteria along the value chain of PV for sustainable deployment and diffusion of PV technology [7]. Besides showing the success factors for the diffusion, it is also a goal of this study to highlight characteristics of actors and market networks that show relative success in the diffusion of solar energy innovations. Without emphasizing more on the nature of actors, we explore the type of market networks needed for achieving faster and wider diffusion of solar energy innovations through provision of after-sales service and local presence. As presented briefly, in general, both the recent and the past literature addressed the role of after-sales service in the market success of the supply side and its impact on the demand side as well. In this section, we included brief literature addressing the role of after-sales service in the diffusion of SHS. But, still less emphasis has been given in literature in exploring success factors in the diffusion of rural energy technologies among developing countries. Hence, following the argument that after-sales service and local presence are among the key factors influencing SHS adoption in developing countries, we elaborate our argument in a case study in Ethiopia. The case study would reveal how local presence and after-sales service provided SEF a competitive advantage among other solar actors in Ethiopia.

Moreover, added contribution of this study would be in indicating the nature of market networks made by companies or organizations for a competitive position through establishing local presence and after sales service for rural users. This is elaborated in the penultimate section of this paper, exploring the peculiar nature of SEF and its network in Ethiopia.

III. METHODOLOGY

This case study is embedded in a larger research project on the diffusion of solar energy technology in Ethiopia. Data for the study was gathered from three respective field researches in Ethiopia. The selection of a case organization and its approach has been through a prior preliminary study of all solar energy actors and networks engaged in Ethiopian solar business/market. Semi-structured interviews, focus group discussions, and field observations were employed methods for data collection. In addition, secondary data and archival documents were used as data sources for study. As proposed in [22] such a case study is applied for explorative research purpose while addressing how and why events happened.

For the case study, we specifically took two villages, Rema and Minjar, two of the most solarized villages in the country, where SEF is also very active in. We interviewed eight villagers from Rema and thirty two villagers from Minjar in two field visits in 2012 and 2013. The data collected included how and why the villagers chose the SHS supply option and what problems they faced during the adoption and /or utilization period. This helped us to draw lessons on the approaches of the three solar energy actors in Ethiopia (NGO-SEF, Government- rural electrification programme, and private companies/dealers) and the key factors for the relative success in installing higher number of SHS. While focusing on in depth investigation of the practice of SEF, we also relied on expert interviews and focus group discussions for addressing the views of other interest groups in the solar market. This helped us to draw mainly the unique position of SEF in addressing the solar market in Ethiopia.

IV. CASE DESCRIPTION

A. Solar Energy Foundation

StS Network for Rural Development is the mother association of all "Stiftung Solarenergie - Solar Energy Foundation" worldwide, based in Europe. It is a hybrid network of for-profit organizations and non-profit

TABLE 1.ACHIEVEMENTS OF SEF IN ETHIOPIA (SOURCE: *SEF*)

Period	Achievements	
	History (2005-2012)	***Achievements(2005-2012)***
2005	1st pilot project-*Kechemober*	154 Primary schools ; 35Health centers; 83 Villages supplied with solar system from SEF; > 300,000 Euros micro-credit provided; 64 Solar -technicians trained; >400 Short term trainees; 21,580 total solar home systems installed
2006	2nd pilot project(large scale)-*Rema*	
2007	International Solar Energy School (ISES)	
2008	Revolving Fund-Microfinance Department	
2009	Network of Rural Solar Center	
2010	Sun Transfer Ethiopia	
2011	International Solar Energy Institute (ISEI); Rural Solar Micro Finance Institute (RSMFI)	

organizations. SEF, part of the network of organizations and companies first established in Germany, is currently operational in Ethiopia, Philippines and Kenya with the aim of *"alleviating poverty in developing countries by promoting the use of renewable sources of energy, mainly solar power"*.

Registered as Solar Energy Foundation (SEF), the StS Network has been active in Ethiopia since 2005. It was registered as an NGO and later as a company through its affiliates, works in rural areas electrification through solar innovations. SEF claims its approach as a "holistic, combining product development, human resource development, and financing". The basic philosophy of the foundation according to the founder, Dr. Harald is "balancing financial and social sustainability together" and "the profit-oriented enterprises in the StS Network are led by the non-profit foundation and not vice versa" [20].

SEF kicked off its pioneer larger project with 6, 000 households in the now called "solar village", *Rema*, 240km away from Addis Ababa. After modelling the Ethiopian experience, the first solar center was established in Kenya in 2012. SEF has got its own *daughter* company called *Sun Transfer* that supplies the solar innovations being diffused to the rural areas of Ethiopia, Kenya and the Philippines. It has also established its own micro finance institute and training school, which are independent business units by themselves.

Historical paths and major achievements of SEF in Ethiopia are summarized in Table 1.

B. Ethiopia and Its Solar Energy

In our exploratory study, it was identified that the main solar energy actors regarding rural energy market in Ethiopia are NGOs and very few private companies [10, 11]. There has been very limited participation of private companies which are currently relatively active in the lower end of the value chain, mainly in importing, retailing and installing 'institutional'[4] solar systems. Only recently at the end of 2012, a solar PV module factory was established in the country. SEF, however, has had a local assembly plant where they (dis)assemble solar lanterns and SHS components in the vicinity.

Ethiopia while possessing one of the highest solar radiations in sub-Saharan African countries remains one of the poorly electrified nations. Like many other developing countries, major barriers to the diffusion of solar energy technology in Ethiopia includes *market structure* problems, *infrastructural* problems, *institutional* problems, *financial* problems, and *capabilities* problems [18]. Financial problem prevails on both sides of the supply chain as users demand loans and private companies also need high start- up capital to engage in solar business [10, 11]. However, exploring the approach of solar actors, it was revealed that a relatively atypical and 'sustainable' approach for the diffusion of solar innovations is emerging in the country. Rather than dwelling on exploring the problems, we focused more on finding key success factors for this relatively better performance of SEF in terms of diffusion of SHS in Ethiopia.

V. KEY FACTORS FOR SOLAR ENERGY TECHNOLOGY DIFFUSION: LOCAL PRESENCE AND AFTER-SALES SERVICE

We had first asked respondents to nominate a 'model' company or organization, relatively successful in the diffusion of SHS in Ethiopia. Among the respondents, 42% mentioned SEF as a 'successful' solar actor in Ethiopia. Through such iterative and 'snowballing' approach of research,

[4] *Institutional* systems refer to large-sized solar systems installed in public institutions (organizations) such as primary schools, health and community centres.

we investigated the 'uniqueness' of SEF in its SHS diffusion approach in Ethiopia.

Next, we discuss the two differentiating factors for SEF among the solar actors in Ethiopia.

A. Local Presence

Although it is generally accepted that end-users are entitled to choose the best solutions for their own needs, this is not normally the case in SHS market in Ethiopia and other developing countries [21]. There has been a conventional thought that both the technology and the financing mechanism should come from the supply side while ignoring the purchasing capacity of potential adopters who are kept away from the technology for lack of awareness and unavailability of local supply.

Also ooften NGOs and companies (both national and international) in developing countries like Ethiopia address the rural market through their establishments (partners) located in the major cities. In some cases, suppliers may not have local presence at all except through on and off local importers.A business manager of a multinational company in Japan mentioned that his company found it expensive and challenging to have local presence and effective distribution channel to reach the rural community in sub-Saharan Africa.

SEF, however, first established its training, maintenance and after-sales service center("all in one shopping model") right at the users' area in Rema. The center was a warmly welcomed move by the Ethiopian rural community as they would have easy access to make any claim related to the product they purchased or they were offered, in some instances. As it happens quite often in developing countries, other NGOs only "throw their gadgets" and do not come back again [12].Credibility and trustworthiness through local presence are essential criteria in the diffusion of innovation among the rural community [1]. SEF could manage to earn trust by the local community through its local presence, as learnt from our informants in the rural villages.

The solar centers established by a team of solar entrepreneurs and technicians nearby the rural community is a major step taken by SEF. The solar centers are by themselves business units which are run by the graduates from the foundation's solar institute. The centers form a business network and they promote their solar business, install solar systems, provide maintenance services, and also deal with the micro-financing issues. SEF claims that it has launched 14 solar centers located throughout the country as depicted in Fig. 1.

A missing link in technology development and diffusion efforts has been the inability to address the demand of the users [15]; hence, the setup of solar centers closer to the demand side gave SEF a competitive advantage in customizing new product and service designs up to the requirements of the users. SEF through its daughter company has been producing and supplying from a 1.5 Wp(Watt peaks) lantern to a 60Watt solar TV to the Ethiopian market[5], depending on the needs of local users. A similar case in point worth mentioning is a recent marketing approach of a Japanese MNC which is currently supplying innovative solar solutions /solar technology package/ addressing both the lighting needs and malaria problems of African villages after a thorough local needs assessment, residing and testing its products in the villages. Local presence, hence, equips the supply side with the right knowledge to address the local market which in turn is reflected in the diffusion volume of the technology.

Fig.1 Rural solar centers for customer service of SEF [20, p.41]

The relative success of SEF can partly be reflected in the solar technology diffusion in Ethiopia from 30 SHS installations in the first project in 2005 to 22,000 SHS installations in 2012 as depicted in Fig.2.

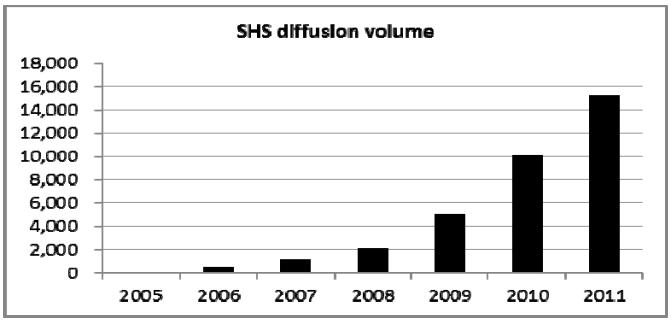

Fig.2. Cumulative SHS installation by SEF in Ethiopia (*Source:* SEF)

B. After-sales Service

Local presence alone may not guarantee delivery of service to the rural user of SHS. One of the complaints we

[5] The main products of SEF include: Sun Transfer-1**(ST-1)**:1.5Wpmodule with a high power LED and easily transportable; **ST-2**: 2.0 Wp module with a high power LED, 3 light settings; **ST-5**: 5.0Wpmodule with three portable solar lamps; **ST-10**:10Wpmodule, including 4LED lamps, connector for optional radio/cassette recorder; **ST-20:**20Wpmodule, incl.24CFL and LED lamps, connector for optional radio / cassette recorder *(Source*: SEF).

heard from the majority of the recent government electrification programme beneficiaries in the village of Minjar was that they do not know who to contact and where to get maintenance service when something goes wrong(including very minor problem) in the system. The government rural electrification programme was carried out as a one-time bulk purchase and installation project which did not well consider the after-sales service for the installed systems.

As part of the exploratory research, it was found that among the respondents, including business managers and solar energy experts, 60% mentioned lack of access to maintenance service is a critical problem in the diffusion of SHS in Ethiopia.

Also during our field research in Rema village, a solar technician working for SEF mentioned that three to four people daily visit the maintenance center in Rema for consulting even minor problems. As shown in Fig. 3(a) a small kid was carrying and taking a malfunctioning charger controller to the Rema solar center (Fig. 3b) while we were in the field research in February 2013.

Fig.3 (a). A small girl carrying a charger controller in Rema

Fig. 3(b). A maintenance center of SEF in Rema

Among the surveyed villagers, at least three of them changed battery during the three year service period. Some also mentioned that they never over utilize (over discharge) the system to avoid early damage of the battery. This is partly a manifestation of a relative awareness level created by the advice they get from the nearby solar technicians.

The local presence and its after-sales service, in general, provided SEF a competitive advantage in earning the trust of the local residents. One of our informants (a housewife) in Minjar mentioned that her family did not want to adopt SHS either from SEF or the government REF project[6]for several months due to the high upfront cost; later, they purchased a cheaper solar lantern from the market and it, however, failed in a short period of time. They were still keeping the malfunctioning lantern at home for they cannot return or get maintenance service from the dealer. The environmental impact of end of use or end of life of SHS also needs due attention. The availability of maintenance or collection point would lessen such long term impact on the environment.

Our study, in general, agrees with the generic conceptual proposal of Hirmer and Cruickshank, while our study emphasizes the practice of an organization in diffusion rural energy innovations to developing countries.

In the following section, we discuss possible elaborations of why SEF could be in a better position to have a closer attachment to the demand side (rural community) and manage to take a larger share of the SHS installation in Ethiopia. The discussion may also shed light on the nature of actors and networks who may be "fit" to address the SHS diffusion in developing countries.

VI. IS SEF IN A UNIQUE POSITION?

The approach of SEF, first through donation and pilot projects, and later turning into solar business through its affiliate business units (solar centers) is unique in that donation alone is not sustainable and the rural marketis untapped market if support institutions are in place. The non-profit and profit mixed approach of NGOs like SEF, however, is not welcomed by some actors. One of the interviewees claimed that "NGOs should pursue only what they are established forand they have to compete on equal ground with the private companies". However, as far as there is 'free market' and legal institutions allow such cases, the complaints on the establishment process of business affiliated units of NGOs like SEF remains less convincing.

As per our close investigation, SEF has got unique positions in at least three different market networks as discussed below.

[6]REF is a rural electrification funding project managed by the Ethiopian government; Its finance is solicited from World Bank and other donors/financing institutions.

A. Supplier –User network

SEF has got its solar center established and serving inside the community. They promote, sell, install, and provide maintenance service living within the community. The provision of such service has provided confidence to the local users as they get in touch with a closely available and accountable body for their bought product/service. As stated in literature, potential adopters would like to see the experience of early adopters about the reliability of the innovation [9].

SEF, having hands on both side of the supply chain, can address the demand of the rural market. It has got a company supplying the technology and it has got solar centers "listening to the demand".

B. International- Local network

As previously discussed, local presence alone, unless supported by a strong international value chain, may not suffice to diffuse a technology in developing countries as lack of resources prevails in this part of the world.

SEF gets its main solar technology supply from Europe and Asia while it also owns a local assembly plant in Ethiopia. The international-local network of SEF stretching from Europe down to the rural villages in Ethiopia might have uniquely contributed to its relative success in Ethiopia, while both "pure" local or "pure" foreign companies and organizations could find it challenging to address the market (See pictorial depiction in Fig.4). SEF in this perspective as a network of many international companies and organizations including donors could be in a unique position in the solar market in Ethiopia.

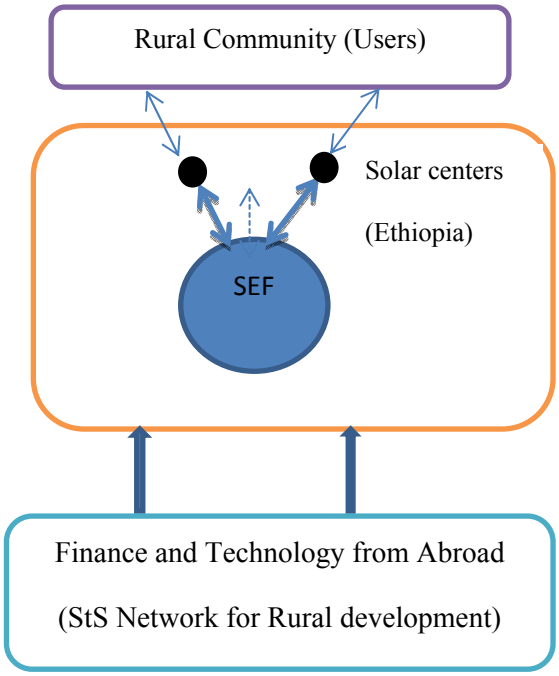

Fig.4 International and Local links of SEF (as drawn by authors)

C. NGO-Private network

SEF has got a social capital due to its unique nature as an NGO backed by international network of business companies and organizations. The connection it has had and its unique position working both as NGO (including through donation) and partnering with its "daughter companies" might have also contributed for having the higher share of solar innovations diffusion in Ethiopia. As neither "pure" NGOs nor "pure" companies could not address the rural SHS market in Ethiopia in a full-fledged manner, this "hybrid" nature of SEF might be the other uniqueness and back up for its relative success.

In general, the intention here is not to hastily conclude that SEF or its alikes are the only ones to address the SHS market but to support our argument that local presence and after sales service might require networking and addressing the supply chain comprehensively.

VII. CONCLUDING REMARKS

In this exploratory study, we tried to identify both from literature and a case study in Ethiopia that local presence and after-sales service are among the key factors in the diffusion of SHS. The discussion on the practice of SEF in Ethiopia may shed more light on the nature of partnership and strategy required to have a wider diffusion of rural energy innovations through local presence and provision of after-sales service to the rural community. Large multinational companies and organizations have limited access to their end clients in the developing world, which in turn affects the development and diffusion of technologies in this potential market. Hence, partnership with the local firms (organizations) that can easily access the rural community could be a better way to go for rather than establishing a (sales) branch in the cities which often stays far from the rural users. Local government and policy makers, in this regard, may also have to give due attention to the availability of effective after-sales delivery as equal as their attention to the provision of physical products through bulk purchase such as in government procurement mentioned in our case, Ethiopia.

With due understanding that a case study has its own shortcomings, this study tried to reflect on the two key factors currently affecting the diffusion of SHS in Ethiopia and other developing countries. With this aspect, the study affirmed the sustainability criteria proposed by previous researchers for sustainable deployment and diffusion of solar PV. Further study on the impact of local presence and after-sales service on the diffusion of SHS and other rural technology in other contexts would be essential.

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