



Exploring the link between products and services in low-income markets—Evidence from solar home systems

Christian A. Friebe^{a,b,*}, Paschen von Flotow^b, Florian A. Täube^a

^a EBS University for Business and Law, Strascheg Institute for Innovation and Entrepreneurship (SIIE), Rheingaustraße 1, 65375 Oestrich-Winkel, Germany

^b Sustainable Business Institute (SBI), Burgstr. 4, 65375 Oestrich-Winkel, Germany

HIGHLIGHTS

- ▶ Explorative quantitative study among entrepreneurs across different low-income markets.
- ▶ Specific combinations of product and service are identified and evaluated.
- ▶ Cash, Credit and Leasing can be feasible from a private sector point of view.
- ▶ Fee-for-Service is very challenging for the private sector without any policy support.
- ▶ Combining the SHS with services such as finance and maintenance is key to success.

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ABSTRACT

One of the key challenges of energy access in emerging markets and developing countries is how to reach households and communities that are unlikely to get a grid connection in the long term or those that are connected to the grid but suffer from regular blackouts or low voltage. By surveying entrepreneurs selling Solar Home Systems (SHSs) on a commercial basis in emerging and developing countries, this study is one of the first attempts to quantify the key elements of four potential Product Service Systems (PSSs): Cash, Credit, Leasing and Fee-for-Service. Whereas the Fee-for-Service approach was found to be suitable only under certain conditions, all PSSs share two key elements for successful market deployment: one or more years of maintenance, and customer support in financing these customers' new asset. Moreover, it appears that private sector companies are in principle able to deliver SHSs to households with incomes greater than USD 1000 per year. The implications for policy makers and development aid agencies are, first, to include maintenance services into public programmes or public–private partnerships and, second, to explicitly consider financial risks for entrepreneurs (e.g., customer commitment and repayment conditions).

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1. Introduction

Whereas many products and services have the potential to increase the standard of living or to stimulate economic activities in emerging and developing countries (London et al., 2010), researchers as well as practitioners and policy makers agree that energy access is not only an objective in itself but also an enabling technology that leads to many other important innovations (Gustavsson, 2007; Rao et al., 2009). According to the IEA, UNDP, UNIDO (2010), 1.4 billion people still have no access to basic electricity services. Although the potential market size for

energy services is substantial (USD 433 billion, according to Hammond et al., 2007), thus far, only a few companies are commercially successful, due to the specific conditions and barriers in these markets. The missing link between huge demand and limited supply is a sign of market failure that deserves the attention of policy makers.

Given the challenges of a limited public budget and broader commitments such as the Millennium Development Goals (MDG), many national and international policy makers aim to accelerate the diffusion, promotion, and development of off-grid power supplies on a commercial basis. However, many policy programmes in the past did not meet the expectations of national policy makers and donor agencies (Acker and Kammen, 1996; Sebitosi and Pillay, 2005; Wamukonya, 2007; Vleuten et al., 2007). Therefore, it is necessary to better understand how successful entrepreneurs and their energy service companies design products and related services to address

* Corresponding author at: Sustainable Business Institute (SBI), Burgstr. 4, 65375 Oestrich-Winkel, Germany. Tel.: +49 672399630; fax: +49 6723996321.
E-mail address: friebe@instoec.de (C.A. Friebe).

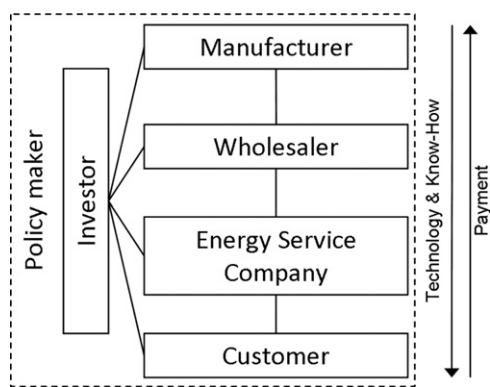


Fig. 1. Simplified value chain for delivering SHSs to customers in emerging and developing countries.

customers' needs and expectations (see also Fig. 1). This paper focuses on the Solar Home System (SHS), a combination of a photovoltaic module, a battery, a charge controller and efficient light bulbs that serves individual households, as a key technology that can be applied in many regions in emerging and developing countries. According to the World Bank, the largest market potential in SHS reflects Leasing and Fee-for-Service customers (up to 70%), e.g., the largest and poorest sections of society that cannot afford to buy an SHS outright (Terrado et al., 2008). Whereas some case studies focus on companies that offer Fee-for-Service as part of a public–private partnership (e.g., Lemaire, 2009), it is not clear how purely commercial companies are able to respond to this substantial demand and how they adjust their product and service offerings. This uncertainty calls for an inquiry into the motivations and preferences of entrepreneurs who deploy the large potential for SHS in low-income markets and how they do so.

A better understanding of this private sector perspective enables policy makers to first improve framework conditions for the SHS sector and its local entrepreneurs and to use limited public funding more effectively and efficiently. This is especially relevant as the entrepreneur directly interacts with consumers and their view and expectation on different product designs and related services. Therefore, the guiding question of this paper is as follows: “Which combinations of products and services are reasonable businesses for entrepreneurs in the SHS sector?” This research question is addressed by expert interviews and a quantitative explorative survey using a recently developed variant of the conjoint method (see Shepherd and Zacharakis, 1999; Patzelt and Shepherd, 2009; Loock, 2012 for other variations of the conjoint method).

In this way, this research complements and refines existing, mostly qualitative research on low-income energy markets. So far, researchers have conducted, on the one hand, surveys and interviews with end-users (McEachern and Hanson, 2008; Ndzibah, 2010; Abdullah and Mariel, 2010; Sovacool et al., 2011) or qualitative case studies of individual companies (Lemaire, 2009; Mukherji and Jose, 2010). These studies show a rich variety of contextual factors, such as knowledge, awareness, finance and social aspects. On the other hand, there are macro-level case studies that focus on one or several countries or technologies (Karekezi and Kithyoma, 2002; Hammond et al., 2007; Ketlogetswe and Mothudi, 2009; IEA, 2010; Chaurey and Kandpal, 2010; Rebane and Braham, 2011). These studies generally produce recommendations for policy makers at the national or international level.

Examining existing studies with the lens of diffusion of innovation (Metcalfe, 1988; Sarkar, 1998; MacVaugh and Schiavone, 2010) reveals that only a few studies (for example, McEachern and Hanson, 2008) explicitly address both the microlevel of individual

adoption decisions and the macro-level of countries and technologies. Our approach is to investigate patterns of companies across a variety of countries – the macroperspective – by conducting a quantitative survey among entrepreneurs – the microperspective. In this way, our study contributes to the on-going research debate that questions and refines our current understanding of low-income markets (see, for example, Prahalad, 2012; Seelos and Mair, 2007; Anderson et al., 2010).

The paper proceeds as follows: first, the research context, Energy Services and Product Service Systems, is introduced. Next, Product Service Systems are specified for the context of SHSs in low-income markets, which is followed by a discussion of the method and data. Subsequently, the findings are presented and discussed. We conclude with implications for policy and future research areas.

2. Research context

2.1. Access to modern energy services

While practically every public stakeholder in developing as well as industrialised countries agrees on the goal of achieving “universal” modern energy access, the definition remains under debate. Three issues require further elaboration, and we surveyed the extant literature accordingly:

First, from an engineering and a business perspective, different types of infrastructure are required to allow for electricity access. In rural areas, a mix of grid expansion, mini-grids and off-grid energy infrastructure is most suitable economically and technically. The optimal mix of different technologies depends largely on local demand, the natural resources available and the policy framework (Kaundinya et al., 2009; Levin and Thomas, 2012). The first approaches to compare different energy infrastructure types and their socio-economic consequences are developed (Wamukonya and Davis, 2001). However, in this paper, the focus is placed on the off-grid power supply because this is the most suitable starting point for large parts of the rural population that currently have no access to electricity services.

Second, the question of what modern energy exactly is must be considered. Brew-Hammond (2010) argues that the term modern energy is used to distinguish between traditional forms of technology (e.g., wood) and new technologies (e.g., electricity services). In this paper, the focus is placed on renewable energy technologies and, in particular, SHSs. Although other renewable energy technologies and even conventional fuels are relevant in some cases, solar energy technologies became commercially viable in many applications (Casillas and Kammen, 2011), especially due to their low maintenance requirements and the possibility for flexible system designs.

Third, what exactly does “energy access” mean? The definitions available often remain vague. One example is “access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses” (AGECC, 2010). More specifically, other definitions state that the term access refers to a household’s ability to obtain a modern energy service (Ranjit and O’Sullivan, 2002; Komatsu et al., 2011). In this case, access is a function of two interrelated factors: availability and affordability (Prahalad, 2012; Nakata and Weidner, 2012). In this paper, affordability is defined in relation to the level of household income.

Beyond the question of definition, it is clear that electricity services have a tremendous positive effect on the lives of people previously not using electricity. Major benefits include savings in energy costs and the improvement of living conditions. Existing studies measure these benefits, often by conducting field studies

Table 1
Barriers to the use of SHSs in developing countries (compiled by the author based on Urmee et al., 2009; Sovacool et al., 2011).

Category	Issue
Financial	Availability of capital High capital cost/high interest rates Lack of financing for the programme Lack of access of credit for the consumer No link with income generation
Technical	Limited product availability Logistical problems Improper maintenance Technical limitations (efficiency, capacity)
Policy	Lack of policy and legal framework Improper use of subsidies Donor dependency/donor driven
Implementation	Lack of institutional capacity Lack of technical knowledge Lack of private sector involvement Lack of involvement of local stakeholders
Social	Misperception regarding the technology Missing link to existing social structures and values

(Gustavsson and Ellegard, 2004; Gustavsson, 2007; Obeng et al., 2008). Beyond pure economic factors, other aspects, such as entertainment, the number of children and mobile phones, as well as safety considerations (replacing kerosene lighting) influence buying decisions (Wamukonya and Davis, 2001; Wijayatunga and Attalage, 2005; Komatsu et al., 2011). However, many issues remain to be solved (see Table 1).

To address the existing barriers to technology diffusion, policy makers and international donors developed public subsidy schemes and support programmes that are well intended but in many cases not sustainable. In fact, some scholars argue that donor efforts are often either ineffective or even undermined existing private sector initiatives, especially those of small and medium-sized local companies (Acker and Kammen, 1996; Sebitosi and Pillay, 2005; Wamukonya, 2007; Vleuten et al., 2007).

Due to the setbacks in the past, policy frameworks, sometimes combined with funding from international donors or development banks, shifted towards private sector development (Martinot et al., 2002). The aim of this shift was to avoid past mistakes and to facilitate market deployment for accessing electricity services. Development banks that act proactively in this context may have a positive and sustainable impact on the private sector (George and Prabhu, 2003). Depending on the local conditions and on the existing regulatory framework, a blend of different mechanisms is required. This blend includes capacity-building measures as well as tailored subsidy schemes. To design effective support policies such as cash grants or favourable refinancing conditions, it is key to understand the challenges from a private sector perspective.

2.2. Product service system—Towards further integration

To access low-income markets, suitable products must be designed. However, in most cases, doing so is not enough. Additional services – beyond conventional after-sales-services – such as consumer training, installation, maintenance and finance must be provided to create profitable companies (Terrado et al., 2008). With regard to the given case, Product Service System (PSS), a concept that was originally developed for mature markets in industrialised countries, seems to be useful (Mont, 2002). More specifically, a PSS can be defined as “as a

system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models” (Mont, 2002: 239). The aim of PSS is essentially to develop integrated solutions that also help to protect the environment. This relates nicely with business models that focus on SHS as in most cases the product not only includes technical components but relates also with advisory and maintenance services (IEA-PVPS, 2003; Krause and Nordström, 2004). In addition, environmental protection features strongly in SHS in the context of developing countries, as this product fosters green decentralised energy access instead of small diesel engines for electricity supply (IEA, 2010).

Combining products and services to different degrees has implications for both consumers and companies. On the one hand, such a combination requires consumers to shift from buying and owning products to buying integrated system solutions, which often effectively requires better consumer education and involvement (Mont, 2002). On the other hand, companies require a higher level of responsibility for the product as well as early interaction with consumers to achieve an optimal design with minimal environmental impact.

Whereas a general trend towards systems integration can be observed in many different industries, especially in mature markets (Hypko et al., 2010; Loock, 2012), the concept of PSSs focuses explicitly on realising positive environmental effects. It is very important to realise that not only pure technical questions but also other key influencing factors, such as public policies or institutional aspects as well as socio-cultural aspects, are relevant for the successful implementation of PSSs (Mont and Lindhqvist, 2003; Tukker and Tischner, 2006). This paper explores some of the most relevant aspects for the context of SHSs in low-income markets.

3. A PSS for SHSs in low-income markets

In the context of no access to the electricity grid, SHSs are more environmentally friendly than conventional off-grid power supply systems that are typically based on fossil fuels. To identify a relevant PSS for SHSs, the work of several researchers has been consolidated at a conceptual level (IEA-PVPS, 2003; Krause and Nordström, 2004; Chaurey and Kandpal, 2010). The four different PSSs are presented below and summarised in Table 2.

3.1. 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. The major benefits for the company include low capital requirements and minimal requirements regarding service infrastructure, whereas major risks include a loss of reputation due to system failure that is related either to low-quality components or to insufficient consumer education, poor system design, sizing and performance. Because this PSS is the most capital-intensive scheme for potential consumers, the use of cash transactions is expected to occur only above a given threshold income.

3.2. 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. This loan requires either a financially strong company or an equally strong partnership between the company and a financial

Table 2

Definition of the four PSSs: Cash, Credit, Leasing and Fee-for-Service (adapted from IEA-PVPS, 2003; Krause and Nordström, 2004; Terrado et al., 2008).

	Sales model		Service model	
	Cash	Credit	Leasing	Fee-for-Service
Market potential	Low (< 3%)	Medium (< 20%)	Large (< 50%)	Large (< 70%)
Ownership	Consumer becomes owner upon payment	Consumer becomes owner through contractual agreement	Service provider is owner during the leasing period, then consumer	Service provider
Initial investment cleared by	Consumer	Financial institution plus down payment by consumer	Service provider and eventually Financial institution	Service provider
Regular instalments	No	Yes, to cover the credit	Yes, to cover the rent	Yes, to cover the use of service
Responsibility for maintenance	Consumer	Consumer and eventually service provider	Consumer or Service provider	Service provider
Typical maintenance service	No	Often included for a certain time period	At least included during payment period	Included during contract duration
Major risk for consumer	High technical risk	Low technical risk	Low technical risk	Very low risk
Major risk for service provider	Technical risk covered by manufacturer, low financial risk	Technical risk and eventually financial risk	High technical and financial risk	Very high technical and financial risk
Major risk for financial institution	n.a.	High financial risk	Medium financial risk (for refinancing the service provider)	Medium financial risk (for refinancing the service provider)

institution. Both the co-operation and the financial involvement of the company result, in general, in better consumer training as well as more reliable maintenance services. Given that this PSS may benefit from a large network of micro-finance institutions in emerging and developing countries, it is expected that entrepreneurs prefer it in the context of limited financial resources on the part of the consumer.

3.3. 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. Similar to a credit system, this mechanism often involves a financial institution for refinancing. Due to the transfer of ownership only at the end of the repayment period, this PSS is expected to require advanced sales and maintenance services to be feasible.

3.4. 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. In both cases, it is in both the company's and any involved financial institution's interest to keep the SHS up and running in the long term. Maintaining the system includes the proper training of employees regarding a correct installation and maintenance as well as the proper training of consumers regarding the use and limits of the SHS. Again, this PSS is only feasible if advanced services are included. Because the ownership is never transferred to the consumer, this PSS includes considerable risks for entrepreneurs.

4. Method and data

To evaluate the four PSSs, two stages of data collection are implemented. As a starting point, interviews are conducted with four Indian companies and one German company, all of which are

active in the sector. Of the five organisations, two are more commercially focused, whereas the remaining three could be considered more as socially driven businesses. The results from the interviews are used to design a quantitative survey as well as to interpret the results of the survey. One of the key aspects derived from the interviews is that people do have multifaceted views about the meaning of the four PSSs, especially Leasing and Fee-for-Service. This complexity may lead to the confusion of respondents and consequently to misleading results. Therefore, the research team decided not to ask direct questions in the survey such as "Do you prefer Leasing over Fee-for-Service?" but instead to focus on the underlying principles of each PSS. Conjoint analysis is a particularly appealing method for this research as it offers the possibility of evaluating the preferences of respondents (utilities) for the various elements of the PSS.

4.1. Conjoint analysis

Based on the work of Luce and Turkey (1964), conjoint analysis (derived from *considering jointly*) was first applied in marketing research in the early 1970s (McFadden, 1986; Green and Srinivasan, 1990). The main idea behind this approach is to evaluate the preference for or utility of a stimulus that is composed of several independent attributes, each with a pre-defined number of levels. Different combinations of carefully selected and defined attribute levels allow the mirroring of real-life decision scenarios to a large extent (see also Fig. 2). While conjoint analysis is still mostly used in marketing, other applications are explored, including investment decisions (Riquelme and Rickards, 1992; Lüthi and Prässler, 2011; Loock, 2012) and entrepreneurship (Patzelt and Shepherd, 2009). In the context of this study, entrepreneurs are asked to imagine that they are starting from scratch to set up a business for SHSs in emerging and developing countries. The leading question throughout the survey was as follows: "Which product design represents a reasonable business opportunity for SHS in low-income markets?" The corresponding attributes and levels (Table 3) are derived from the PSS presented in Table 2, and a sample question is presented in Fig. 2.

Here you find different sets of product features and income levels. For each one, indicate whether it is a reasonable business model for you or not.

(1 of 8)

Household income	3000 US\$/year	5000 US\$/year	1000 US\$/year	5000 US\$/year
Your sales service	Advisory service plus on-site installation	Advisory service	Advisory service	No
Your maintenance service	1 year included	5 years included	included during payment period	5 years included
Down payment	100% (cash)	30% & regular installments	10% & regular installments	0%, regular installments
Ownership of the SHS	Private household	Your organisation, after repayment: private household	Your organisation	Private household
	<input type="radio"/> Reasonable <input type="radio"/> Won't work for me	<input type="radio"/> Reasonable <input type="radio"/> Won't work for me	<input type="radio"/> Reasonable <input type="radio"/> Won't work for me	<input type="radio"/> Reasonable <input type="radio"/> Won't work for me

Fig. 2. Sample question from the ACBC survey.

Table 3

Attributes and levels that are covered in the Conjoint Analysis.

Attributes	No.	Levels
Maintenance service	1.1	No
	1.2	included during contract duration
	1.3	1 year included
	1.4	5 years included
Down Payment	2.1	Regular instalments, no down payment
	2.2	10% down payment & regular instalments
	2.3	30% down payment & regular instalments
	2.4	100% down payment (cash)
Sales service	3.1	No
	3.2	Advisory service
	3.3	Advisory service & on-site installation
Ownership of the SHS	4.1	Consumer
	4.2	Your organisation, after repayment: private household
	4.3	Your organisation
Household income	5.1	USD 1000 per year
	5.2	USD 3000 per year
	5.3	USD 5000 per year

One of the concepts within conjoint analysis is adaptive choice-based conjoint (ACBC). The characteristic of this method is that it adapts subsequent questions during the survey based on answers already given by the respondent (Johnson and Orme, 2007). It does so by recognising attribute levels that are rated to be either absolutely required or not at all required. Consequently, the algorithm focuses on the remaining attributes between these two extremes in remaining questions. This is a more engaging survey experience, as questions ask mostly about combinations of attribute levels that are relevant in the perception of the respondent. From an academic perspective, ACBC enables an increase in the accuracy of the responses or reduce the required number of decisions. In other words, the method allows to reduce either the number of questions to each respondent or the sample size without compromising on the level of accuracy. The latter effect is especially relevant for this paper, as the survey sample is comparatively small stemming from a small overall population.

Once the survey is closed, statistical methods such as Hierarchical Bayes (HB) allow the calculation of the utility of each level and for each respondent (Lenk et al., 1996; Johnson and Orme, 2007). To arrive at the overall preferences of all respondents regarding each level, HB estimations calculate in an

iterative process the preference of each individual respondent based on the preference of the entire population. This calculation in turn changes the preference of the entire population to some degree, and the individual preferences are calculated again based on these new averages. This process is repeated in 40,000 iterations to curve the stability of the results. In this way, the balance between individual respondents' preferences and sample averages is identified by the amount of variance within the sample (Rossi and Allenby, 2003). Furthermore, the derived preferences or utilities can be an input for simulation methods that estimate the preferences for different combinations of attribute levels. Using them as an input helps, for example, to predict to some extent the market success of new products in comparison with existing products.

4.2. Survey sample

To identify experienced decision makers able to provide high-quality answers to the survey, a two-step selection process was followed: first, a set of 55 successful companies and organisations in low-income markets that are providing SHSs for households was identified by conducting a comprehensive desk study. The research team focused mainly on international awards and competitions for social businesses as well as on publicly available data from financial institutions and venture capitalists. After identifying the organisations, a list of up to two key decision makers from each organisation was developed. This procedure resulted in a sample of 93 key decision makers in commercially oriented companies that are selling SHSs in one or several emerging and developing countries.

Before launching the survey, a pre-test with 9 experts was conducted to validate the measurement and refine the survey. Then, potential respondents are invited individually through personalised messages either by email or via social networks such as LinkedIn. People who did not reply within 2 weeks are contacted twice again. To optimise the accuracy of responses and to limit the impact of self-assessment, it was guaranteed that all information would remain confidential and a promise was made to share with the respondents the study's final results, which would include a personalised feedback document (Huber and Power, 1985). The survey was implemented between September and October 2011.

This process allowed us to gather response data from 31 persons from 27 companies, corresponding to an effective response rate of 33% in terms of individuals and 49% in terms of companies in the total population. A total of 15 additional

responses are returned incomplete and are thus not taken into account for further analysis. Although the sample size was small, it was possible to cover a relevant share of the global low-income SHSs market. Based on freely available company data, we assigned each company to one or several PSSs as defined in this paper. The actual comparison of companies in the whole sample and companies that responded to the survey shows very similar patterns (Fig. 3). This finding increases the validity of the results by ruling out sample selection and non-response bias. The detailed sample description is presented in Table 4.

Most of the respondents belonged to the top management of their respective organisations. Slightly over half of the respondents had over 5 years of professional experience and ran organisations with more than 20 employees. The companies focused mainly on Africa and Asia, with most respondents focusing on either India (18%) or Tanzania (16%). The number of employees, as well as the total number of SHSs sold, indicates that one half of these firms can be considered start-up companies, whereas the other half represents companies with considerable experience with SHSs in low-income markets.

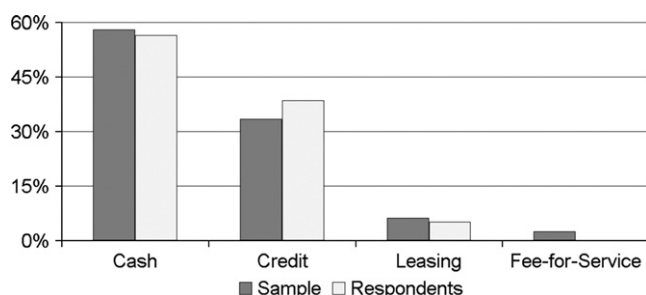


Fig. 3. Comparison of the applied PSSs of 55 companies in the whole sample and 27 companies of the respondents of the survey (multiple PSSs are possible per company).

Table 4
Description of the sample characteristics.

	N	%
<i>Years of professional experience</i>		
Up to 5 years	14	45
5–10 years	8	26
More than 10 years	9	29
<i>Area of responsibility</i>		
Owner/CEO	18	58
Top management	7	23
Other	6	19
<i>Focus regions (aggregated)(multiple answers possible)</i>		
South America	6	14
Africa	20	45
Asia	18	41
<i>Number of employees</i>		
up to 20	14	45
20–50	10	32
More than 50	7	23
<i>Number of SHSs sold</i>		
up to 1000	14	45
1000–10,000	8	26
More than 10,000	9	29
<i>Refinance of organisations (multiple answers possible)</i>		
Venture capital/private equity	15	48
Corporate venture capital	2	7
Debt	14	45
Social venture capital	12	39
Donations	8	26
Public grants & loans	13	42

The respondents reveal that their respective organisations rely on private funding, such as venture capital, private equity and bank loans, as well as on financial sources with a broader social scope, such as social venture capital and public grants and loans. One quarter of the organisations relied at least partly on donations as an additional source of revenue. Interestingly, only two organisations benefited from corporate venture capital and are found to be subsidiaries of the same multinational company.

5. Findings

In the survey, responses regarding a total of 1550 decisions are gathered. This number corresponds to 50 choice tasks per respondent. Other conjoint studies that apply non-adaptive survey techniques already suggest that this number of decisions is sufficient for conducting rigorous analysis (Patzelt et al., 2008; Loock, 2012). Beyond, the advantage of adaptive survey techniques (such as Adaptive Choice Based Conjoint) is the ability to ask more accurate questions that result in a lower number of decisions required; in other words the adaptive nature in our survey selects more relevant items from the overall choice set based on earlier decisions in the course of the survey on the part of the respondents. Based on the survey, HB estimation is able to extract utility values for every level (Table 5). Furthermore, the utility values are used to conduct simulation studies on the preference of the sample regarding a number of defined PSS.

5.1. Experimental results of the HB estimation

The utilities of different levels of attributes are zero-centered in order to facilitate the discussion of the results (Fig. 4). In general, utility values can be interpreted as follows: A positive utility means that this specific level is reasonable, attractive or useful for the respondent. Correspondingly, a negative utility indicates that this specific level is not attractive or even not reasonable.

Regarding maintenance, it appears that both no maintenance and 5 years of maintenance are not reasonable, but the high standard deviation found shows that there is no general agreement among the respondents. However, the respondents agree that one year of maintenance as well as maintenance services during the payment period are both reasonable from the business perspective of respondents. In addition, the quantitative results fit with qualitative statements by experts who had emphasised – prior to the survey – the link between regular repayments and proper maintenance of the product. One entrepreneur specified that “end-users stop paying their instalments whenever the SHS is not functioning as expected”.

Down payments of 0% are evaluated not to be reasonable from a business perspective. Interestingly, the utilities of a 30% down payment and a 100% cash payment are evaluated to be equally reasonable. However, the standard deviation shows that the respondents agree on the first evaluation but have different perceptions regarding the 100% cash payment. The overall results regarding the payment fit with previous studies that highlight the importance of the end-user’s showing real commitment by buying into the SHS as an asset (Vleuten et al., 2007). Our interview partners report that if the consumer does not take responsibility of and make a commitment to the SHS – a challenge in many donor-funded projects – then the system is likely to malfunction after a short period of time. One entrepreneur in India explained during an interview that “to create a sense of responsibility at the consumer side, down payments are absolutely necessary”.

The levels related to sales service indicate that SHSs are difficult to sell without any advisory service. In fact, respondents recommended including on-site installations into the services that a successful

Table 5
Average utility values of attribute levels and standard deviation.

Attribute	Level	Average part-worth	Standard deviation
Maintenance service	No	-0.79742	2.40575
	Included during payment period	0.94105	0.60095
	1 year included	1.24954	0.72625
	5 years included	-1.39316	2.25627
Down payment	0%, regular instalments	-2.20251	1.57125
	10% & regular instalments	0.12358	1.32459
	30% & regular instalments	0.97241	0.98232
	100% (cash)	1.10651	2.16143
Sales service	No	-1.44892	1.20345
	Advisory service	0.03962	0.93952
	Advisory service plus on-site installation	1.40930	1.08807
	1000 US\$/year	0.21391	0.84115
	3000 US\$/year	0.34124	0.65559
Ownership of the SHS	Private household	0.82112	1.04571
	Your organisation, after repayment: private household	0.48727	0.56545
	Your organisation	-1.30840	0.79094

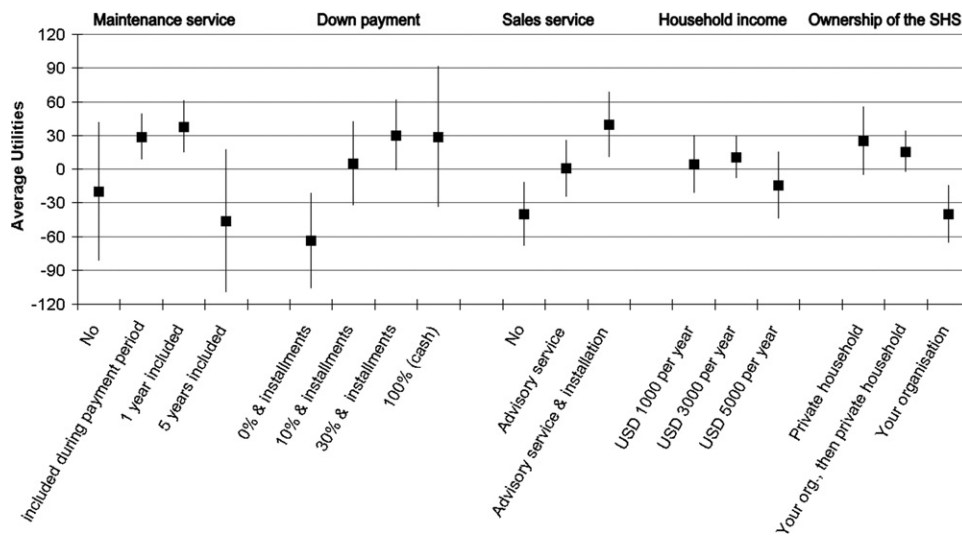


Fig. 4. Visualisation of the utility values (zero-centered) and standard deviation.

organisation should offer. In addition, one entrepreneur clarified that “consumers want to experience the product before they buy it—this is what we are doing to boost the market”.

Regarding ownership of the SHSs, respondents evaluated an intermediate transfer of ownership as well as a transfer of ownership after the completion of repayment, as beneficial. Maintaining the ownership of the SHS rather than handing it over to the customer appears to generate difficulties from the private sector point of view, as one social entrepreneur highlighted: “If the customer knows that at some stage he will own the system, it increases his motivation to pay instalments on time.”

Interestingly, household income has the lowest difference in part-worth utility, which means that all three income levels are of interest from a private sector perspective. This finding indicates that household income levels above USD 1000 per year do not represent a barrier for organisations in the context of SHSs and low-income markets.

5.2. The business perspective vs. limited financial resources of consumers

The individual preference data are combined to reveal the preference for the four different PSSs. In this way, the share of

preference can be observed as a response to the question: “What percentage of entrepreneurs in the field of SHSs would choose this PSS for their business?” and always sums to 100%. Considering each PSS, we take the levels that result in the maximum individual share of preference within their respective boundaries (e.g., the Cash PSS requires ownership transfer and a 100% down payment). The described approach results in the “Business preference” scenario (Fig. 5; for the specifications, please refer to, Table 6). If the four “best” PSS compete for the share of preference of the respondents, two effects can be observed. First, almost half of the respondents would prefer a Cash PSS, which is very reasonable from a business perspective. Second, the Fee-for-Service PSS remains marginal, as Credit PSS remains twice as attractive and Leasing PSS approximately three times as attractive.

The “Income adjusted” scenario is built on the assumption that more complex PSSs such as Leasing and Fee-for-Service are designed for lower household income levels, which also correspond to a reduced availability of cash for down payments. This adjustment results, on the one hand, in an almost equally high preference for both Cash (35%) and Credit (36%). On the other hand, the preference for the Leasing PSS did not have relevant changes in preference (26%), whereas the Fee-for-Service PSS has marginal relevance in the “Income adjusted” scenario.

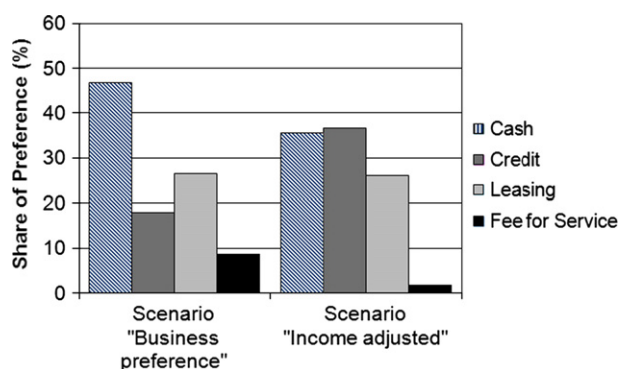


Fig. 5. Preference of the respondents regarding the two scenarios "Business preference" and "Income adjusted", the sum of the share of preferences equals 100% (for the definitions of the PSS, see also Table 6).

Table 6

Definition of the different attribute levels for each scenario; levels with bold and underline numbers change from one scenario to the other (please also refer to Table 3).

Scenario	PSS	No. of levels
1 Business preference	Cash	1.3 2.4 3.3 4.1 5.2
	Credit	1.3 2.3 3.3 4.1 5.2
	Leasing	1.3 2.3 3.3 4.2 5.2
	Fee-for-Service	1.2 2.3 3.3 4.3 5.1
2 Income adjusted	Cash	1.3 2.4 3.3 4.1 5.3
	Credit	1.3 2.3 3.3 4.1 5.2
	Leasing	1.3 2.2 3.3 4.2 5.2
	Fee-for-Service	1.2 2.1 3.3 4.3 5.1

6. Discussion and conclusion

This study demonstrates the relevance of linking products and services in low-income markets. By analysing the case of SHSs, we can show that comparatively expensive products must be combined with services such as advisory services, maintenance, finance and capacity building. The bundling of products and services has been investigated in mature and developed markets, particularly in the context of customised durable goods, such as buildings, trains, airports and hospitals, but has been largely absent from extant research in low-income markets. This explorative study is a first attempt to quantify these effects. In this way, this study explores common patterns of success across national borders and beyond regional differences.

In the context of all four PSSs, the Cash variant appears to be an entry point for new companies due to its simplicity and the comparably low capital requirements (Krause and Nordström, 2004), a claim that is supported by current business activities of the sample (Fig. 3). As our survey shows, the very same companies evaluate Cash, Credit and Leasing as being almost equally reasonable, which can be interpreted as an indicator for the emergence of more complex PSSs in the near future (Fig. 5). Based on the literature and on our interviews, we conclude that this shift towards more complex PSSs results from the motivation of companies to reach significantly more customers beyond the current demand (Terrado et al., 2008; Lemaire, 2009). This claim is in line with the traditional PSS literature such as Mont (2002). Pursuing more complex PSSs implies the entrepreneur's taking more risk—either financial risk or asset risk (in case the ownership of the SHS is still with the company). When the entire sector approaches maturity, we expect companies to sell fewer SHSs on a cash basis and pursue Credit and Leasing mechanisms to a

significantly greater extent, which would consequently result in an inverted-U shape of preferences.

Interestingly, the current trend towards more complex PSSs does not include the Fee-for-Service mechanism. In fact, our survey shows that the low preference of companies for low or zero down payments and the lack of transfer of ownership to the customer are the reasons why Fee-for-Service is not evaluated as a feasible option for purely private companies. This finding resonates with the existing literature in the field of Fee-for-Service models, such as the study of Lemaire (2009), who analysed this mechanism as part of a public-private partnership in Zambia. The joint conclusion is that the risks for purely private companies are too high to implement this mechanism.

Regarding the broader context of diffusion of innovation, this study contributes to a refined understanding of low-income markets. Existing studies focus on either the "high-level" (modelling the entire sector such as Hammond et al. (2007)) or specific case studies (Lemaire, 2009; Mukherji and Jose, 2010). This study aims to bridge the gap between the two camps by drawing from the combined understanding and experience of successful entrepreneurs (micro) across the low-income markets in different countries (macro). This study evaluates how entrepreneurs enable access to energy services in constructive and profitable ways. More specifically—and counterintuitive given prior findings on the market potential of SHSs (Terrado et al., 2008)—our results show that entrepreneurs evaluate the Cash PSS to be reasonable and the Fee-for-Service approach not to be feasible without any type of risk sharing or reward, e.g., by public policy or development aid. In addition, this study provides a baseline for future research on "micro" phenomena in the SHSs sector in low-income markets, e.g., through case study research or consumer surveys.

Regarding the method and the sample selection, several implications can be drawn for researchers and policy makers. The method – conjoint analysis – was initially developed for revealing the preferences of consumers regarding new product developments. In line with other studies (Shepherd and Zacharakis, 1999; Patzelt et al., 2008; Patzelt and Shepherd, 2009), this study focuses on entrepreneurs and not the end-users of a product. Conjoint analysis is particularly useful, as it reveals underlying preferences of decision makers for different elements of a PSS and also offers the possibility of conducting simulations with product service combinations that are not explicitly part of the survey. Regarding the sample, a selection process was established to identify the most suitable organisations and decision-makers for the survey. Interestingly, it was not possible to identify any multinational corporation that fits within the selection criteria. Only one multinational company was indirectly involved in the survey, as it owns shares in two small local organisations that match our criteria. One conclusion could be that large multinational companies have not yet managed to overcome the barriers in low-income markets, whereas clever, determined and often socially motivated entrepreneurs are able to set up commercially successful companies in the very same contexts.

6.1. Policy implications

The study identified a large gap between supply and demand indicating market failure and thereby scope for policy intervention. Although the study did not explicitly include the policy framework, it has high relevance for the design of public support mechanisms. Both the literature review and the interviews prior to the survey clearly indicate that public support mechanisms such as cash grants can significantly distort a functioning market. One interview partner from India argues that "cash grants add fuel to the fire of corruption". Therefore, more indirect measures,

such as cheap refinancing conditions for companies and consumers, appear to be more reasonable for addressing market failure. Beyond financial support that could be provided by favourable refinancing conditions or well-targeted guarantees, capacity building and technical assistance for both policy makers and private sector companies may act as a major lever driving the diffusion of renewable energy technologies. Interestingly, this study also shows that household income levels above USD 1000 per year in principle allow the private sector to deliver SHSs on a commercial basis.¹

Beyond, three aspects of this study may influence national and international policy makers. First, developing low-income markets with products that are comparatively expensive, such as SHSs, entails designing policy support in a way that focuses not only on the product and its (technical) specifications but also on including services such as advisory pre-sales services, on-site installations and training as well as maintenance and suitable financing services that balance down payments and regular instalments. This study suggests that these aspects are not just important but absolutely essential for successfully developing the private sector in low-income markets. In this way, failures of past public programmes for developing the national off-grid energy sector that are discussed, e.g., by Acker and Kammen (1996) and Vleuten et al. (2007) can at least partly be explained.

Second, the World Bank (Terrado et al., 2008) found that the market potential increases when PSSs become more complex. However, this study suggests that more complex PSS mechanisms are not always more suitable from a private sector perspective. In fact, more complex PSSs face additional risks regarding finance and ownership. Therefore, one key conclusion is that the Fee-for-Service PSS could be feasible for the very poor but requires policy intervention to become reasonable for private sector decision makers. In other words, public policy could attempt to correct for a market failure stemming from a mismatch between supply and demand.

Third, because it was not possible to identify large multinational corporations in the SHS space, there is doubt that they are currently able to deliver SHSs to end-users in low-income markets on their own. In fact, entrepreneurs are currently at the forefront to develop the market. One suggestion for policy makers could be to support these organisations in teaming up with local entrepreneurs. Large multinational companies could support local entrepreneurs through their access to the formal (international) market – for example, access to finance and better procurement conditions – but might require a policy “push” to do so.

6.2. Future research directions

This study had some limitations that may inspire additional fruitful research. First, a (explorative) quantitative study can only investigate a limited set of aspects. Future research could either refine the aspects covered in this study, such as a differentiation between down payments and collateral, or evaluate other influencing factors that go beyond the scope of this study, such as cultural aspects. Many issues have already been raised and discussed in case studies, and with this study, we would like to encourage other researchers to start quantifying these aspects.

Second, only indirect effects of national and international policies on the preferences of the decision makers have been studied. Public policy mechanisms may have a relevant impact on the entire SHS sector (Sebitosi and Pillay, 2005; Wamukonya,

2007; Vleuten et al., 2007) as well as on the design of the PSS of an individual company, e.g., if public support is only available under certain conditions, such as in the case of Zambia (Lemaire, 2009).

Finally, due to the nature of this nascent sector, the sample size of the survey is comparatively small. Therefore, it is not possible to analyse different sub-groups of the sample. Exploring the variance between different types of companies, regions and decision-makers by quantitative measures will hopefully be possible in the future once more companies enter this market.

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¹ The slight preference expressed for lower household income levels (Fig. 4) can be explained by the fact that many socially driven organisations participated in the survey.

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