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Off-grid Rural Electrification and Fighting Poverty

A Comparative Impact Assessment of Solar Home Systems and Small Solar Home Systems in Rural Bangladesh

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Content

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Abbreviations

ADB	Asian Development Bank
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka
BMZ	German Federal Ministry for Economic Cooperation and Development
CBN	Cost of Basic Needs
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CO_2	Carbon Dioxide
DALY	Disability-Adjusted Life Year
DGIS	Directorate-General for International Cooperation of the Dutch Ministry of Foreign Affairs
EDI	Energy Development Index
EnDev	Energising Development
FEI	Food Energy Intake
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GDP	Gross Domestic Product
HIES	Household Income and Expenditure Survey
HDI	Human Development Index
HPI	Human Poverty Index
IDCOL	Infrastructure Development Company Limited
IEA	International Energy Agency
KfW	Kreditanstalt für Wiederaufbau Entwicklungsbank
LED	Light Emitting Diode
MDG	Millennium Development Goal
MPI	Multidimensional Poverty Index
NGO	Nongovernmental Organisation
OECD	Organisation for Economic Co-operation and Development
PDBF	Palli Daridro Bimochon Foundation
PO	Partner Organisation
PPP	Purchasing Power Parity
RCT	Randomised Controlled Trial
REREDP	Rural Electrification and Renewable Energy Development Project
RSF	Rural Services Foundation
SED	Sustainable Energy for Development Programme
SHS	Solar Home System
SSHS	Small Solar Home System
SMEs	Small and Micro Enterprises
TMSS	Thengama Mohila Sabuj Sangha
UN	United Nations
USD	United States Dollar
W	Watt
WHO	World Health Organization
Wp	Watt Peak

Abstract

As it is nowadays widely acknowledged that modern energy access plays an important role in promoting sustainable development and fighting poverty, the topic of (particularly rural) electrification has gained much attention among the international community throughout the last decade. One common approach for providing modern energy to rural areas is the dissemination of decentralised, small-scale photovoltaic systems – usually known as Solar Home Systems.

This study evaluates how exactly Solar Home Systems (SHS) and the less expensive Small Solar Home Systems (SSHS) contribute to fighting poverty in rural Bangladesh. Based on the multidimensional poverty concept of the OECD, the impacts of these solar systems are analysed and compared by applying a quasi-experimental evaluation design. During the field research both quantitative and qualitative data was gathered through a combination of methodological tools including a household survey, qualitative appraisals of (non-)users and local stakeholders, as well as focus group discussions.

The analysis of the different data sources indicates that both SHS and SSHS have positive impacts on most of the capability dimensions and thus indeed contribute to fighting poverty. However, they do not increase the economic capabilities of their users in the medium term and detrimental environmental effects due to inappropriate battery recycling are likely to occur in the near future.

Women benefit more than men from some of the determined outcomes including the improved indoor air quality and the overall working conditions in the house. Yet, such gender-specific differences could not be found for all capability dimensions and with regard to certain outcomes, men are the main beneficiaries.

Since many of the determined changes are essentially based on improved illumination conditions and the replacement of kerosene, the majority of impacts from SHS and SSHS are very similar. Yet, SSHS offer a higher poverty orientation and affect the economic capabilities less than the more costly SHS. In contrast to that, SHS have a more pronounced positive influence on the access to information, the recreational activities, and the general well-being of their users due to the possibility to use TVs as well as small fans.

The evidence from this study strongly supports the envisaged introduction of PicoPV systems into the national dissemination scheme. Furthermore, although the overall set-up can be considered as a role model for other countries, measures have be taken to mitigate the expected detrimental environmental effects from inappropriate battery recycling.

1 Introduction

1.1 Problem Statement

> *"Just as the spread of mobile phones in poor countries has transformed lives and boosted economic activity, solar lighting is poised to improve incomes, educational attainment and health across the developing world."*
>
> (The Economist Newspaper Limited 2012)

Albeit considerable progress has been made in the past years, 1.3 billion people around the globe still lack access to modern energy services[1] at the present day, which equals almost 20 % of the world's population (OECD/IEA 2012: 532). More than 80 % of these 1.3 billion human beings live in rural areas demonstrating that considerable differences exist between urban and rural spaces. Furthermore, 2.6 billion people (around 38 % of the global population) still depend on using traditional biomass for cooking, most of which live in rural areas as well (ibid., IEA 2013b).

In the face of these facts, it is not surprising that throughout the last decade the topic of (particularly rural) electrification has gained much attention among the international community. The reason for this, however, is not so much that access to modern energy itself is regarded as a goal worthwhile achieving but rather the widespread consensus that it plays an important role in promoting sustainable development and fighting poverty (Agbemabiese 2009: 151; Ilskog/Kjellström 2008: 2674; Kooijman-van Dijk 2012: 529; OECD/IEA 2010: 11-15).

The 2002 World Summit on Sustainable Development in Johannesburg was an important cornerstone in this regard, as it was formally acknowledged that modern energy is a crucial factor for achieving the Millennium Development Goals (MDGs) (e.g. GTZ/NL Agency 2010; Kooijman-van Dijk 2012; Rao et al. 2009). Recently, at the United Nations (UN) Conference on Sustainable Development held in Rio de Janeiro in June 2012, the „critical role that energy plays in the development process" (UN 2012: 24) was reiterated and the "need to address the challenge of access to sustainable modern energy services for all, in particular for the poor" (ibid.) was expressed. Additionally, the UN declared 2012 the International Year of Sustainable Energy for All, highlighting its importance for "internationally agreed development goals […] and sustainable development" (UN Foundation 2013). Hence, the problem of inadequate access to modern energy services not only has a

[1] The International Energy Agency defines modern energy services as „household access to electricity and clean cooking facilities" (OECD/IEA 2010: 8). This definition will be applied within the scope of this report.

very prominent place on the agenda of the international community, but it is also inextricably linked to the framework of sustainable development and multidimensional poverty reduction.

One large-scale activity within the international community facilitating modern energy access is the Energising Development (EnDev) programme. EnDev was launched in 2005 as an "impact-oriented global sector-wide initiative between the German Federal Ministry for Economic Cooperation and Development (BMZ) and the Directorate-General for International Cooperation of the Dutch Ministry of Foreign Affairs (DGIS)" (GIZ 2011: 1). Until the present day, several other donors have joined the EnDev initiative, which is why it can be regarded as a good example for donor harmonisation efforts. The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) constitutes the main implementing agency. The primary goal of this initiative is to provide sustainable access to modern energy services for people in the developing world. EnDev currently carries out activities in 19 countries. Whereas during the first phase (2005-2009) 5.1 million people were provided with modern energy access, the goal for the second phase (2010-2014) is to reach additional 8.61 million people. Since 2005, a total amount of 234 million Euros has been allocated to fulfil these targets (GIZ 2012a: 1).

One of the countries where activities are financed through the EnDev initiative is the People's Republic of Bangladesh. Within the scope of the countrywide Sustainable Energy for Development Programme (SED)[2], the GIZ promotes both the use of renewable energies and energy efficient technologies such as improved cooking stoves or rice parboiling systems (GTZ 2010a: 4-5). One component of this programme consists of the development of a self-sustaining market for decentralised, small-scale photovoltaic systems – commonly known as Solar Home Systems (SHS). SHS are designed for off-grid households with low energy demand. Their nominal power output depends on the system size and typically ranges from 30 to 130 Watt peak (Wp) (Komatsu/Kaneko/Ghosh 2011: 4022). The electricity generated from the photovoltaic panel is stored in a lead-acid battery and can be used for lighting devices and other small electrical appliances like mobile phone chargers, radios, or black and white televisions (Komatsu et al. 2011: 284). Figure 1 shows a rural household with a solar panel on its rooftop as well as a lead-acid battery that is frequently used for solar systems. A schematic overview of the typical SHS components is provided in appendix 1.

[2] This programme is financed through regular BMZ funding as well as the EnDev initiative.

Figure 1: Rural household with a solar panel on its rooftop | Lead-acid battery

Source: Own photographs 2012

Since experience has shown that the poorer sections of the rural population were mostly not able to afford the SHS despite receiving buy-down grants, in the past few years the focus has shifted towards the introduction of Small Solar Home Systems (SSHS) with a power output of 10-29 Wp as well as PicoPV systems (< 10 Wp) (GIZ 2013: 5-6). At the present day, SSHS constitute the most dynamic segment of the solar market in Bangladesh representing 35.9 % of the yearly sales in 2012 and already account for more than 20 % of the cumulated sales (IDCOL 2013b)[3].

The dissemination of SHS and SSHS is based on the above-mentioned understanding that modern energy access has a positive impact on different dimensions of poverty. However, recent country-specific studies of Blunck (2007) and Kürschner et al. (2009) have revealed that in the past not all of the anticipated impacts actually unfolded. Furthermore, despite the great success of the SSHS in terms of monthly sales, until now only anecdotal evidence is available that they actually offer a higher poverty orientation than the more costly SHS. Therefore, the question inevitably arises if the general optimism towards (S)SHS – strongly reflected also in the opening citation – is fully justified. Having identified this knowledge gap, the intention of this study is to examine how exactly SHS and SSHS contribute to fighting poverty in rural Bangladesh. Based on a multidimensional understanding of poverty, the impacts of these solar systems are analysed and compared. Before characterising the conceptual framework in detail, however, an overview of the structure of this report as well as a brief literature review are presented.

[3] By the end of 2012, the dissemination of PicoPV systems was still in the pilot phase, which is why these systems could not be included in the analysis.

1.2 Study Outline

Following this introductory section the theoretical conceptualisation underlying the study is explained in chapter two. After a characterisation of the understanding of poverty and the energy-poverty nexus, the concept of impact and its assessment is discussed. Subsequently, the main research objectives of this study are formulated. Chapter three deals with the overall evaluation framework and methodology applied during the fieldwork.
In chapter four, the dissemination of (S)SHS in Bangladesh is characterised in two steps: Firstly, an overview of the poverty and energy situation of the country is given. Secondly, the dissemination structure and progress is explained. Results are presented in chapter 5, which is structured according to the main research objectives formulated earlier. The report concludes with a summary of the main findings as well as recommendations for GIZ (chapter six).

1.3 Literature Review

The last 15 years have seen the evolvement of a growing multidisciplinary body of scholarly literature examining the relationship and causality between energy and poverty. As a consequence of the interdisciplinary nature of the scholarly literature, the research objectives and applied frameworks vary significantly. Referring to impact assessments of modern energy provision only, two broad categories can be identified: On the one hand, an econometric approach is frequently used to determine correlations and causalities between modern energy and – particularly, but not solely – economic indicators. This approach is usually applied on a macro-scale, i.e. on an international or global level (e.g. Akinlo 2008; Chontanawat/Hunt/Pierse 2008; Khandker/Barnes/Samad 2009; Shiu/Lam 2004).
On the other hand, several authors point out the importance of getting a better understanding of the causal linkages between modern energy and poverty and of acknowledging the multidimensional nature of the potential impacts. Therefore, they choose different research frameworks, which are commonly applied on the micro-level and include both qualitative and quantitative data collection as well as triangulation of information. The level of sophistication of the respective framework varies between the different authors (e.g. Bannister 2002; Cherni/Hill 2009; Diederich 2011; Kooijman-van Dijk/Clancy 2010).
While many of the scholarly papers concentrate on modern energy provision in general, specific literature on decentralised photovoltaic systems is also widely available. A multitude of country-specific studies (e.g. Laufer/Schäfer 2011; Lay/Ondraczek/Stoever 2012;

Rebane/Barham 2011; Sovacool/D'Agostino/Bambawale 2011) as well as critical reviews and cross-country analyses (e.g. Chaurey/Kandpal 2010; Karekezi/Kithyoma 2002; van der Vleuten/Stam/van der Plas 2007; Wamukonya 2007) have been published in the past years. With regard to the case of Bangladesh, the three studies of Blunck (2007), Kürschner et al. (2009), and Komatsu/Kaneko/Ghosh (2011) are the most recent ones analysing impacts of SHS in detail[4]. All of these studies investigated causal linkages on the micro-level and did not exclusively focus on the economic dimension. Other recent publications concentrated on specific aspects such as photovoltaic technology and productive use (Blunck 2008), the economic viability of solar systems (Chakrabarty/Islam 2011; Mondal 2010), or non-income factors behind the decision to purchase a (S)SHS (Komatsu et al. 2011). Additionally, drivers and structural obstacles for an effective dissemination of solar systems (and other renewable energies) as well as their possible integration into the Clean Development Mechanism (CDM) have been analysed (Mondal/Kamp/Pachova 2010; Schwan 2011; Uddin/Taplin 2009; Wong 2010).

It thus becomes apparent that the idea of assessing impacts of Solar Home Systems is not entirely new, considering that similar studies have been carried out in a variety of countries including Bangladesh. Yet, this study contains two innovative elements: Firstly, given that the dissemination of Small Solar Home Systems on a large scale did not start until 2008, none of the previously mentioned country-specific studies could include a methodologically sound comparison between the impacts of SHS and SSHS. In contrast to that, the *comparative impact assessment* of SHS and SSHS is an integral part of this study[5]. Secondly, by explicitly targeting both male and female household members as interviewees, using gender-disaggregated questionnaire forms, and addressing gender-related aspects directly in all appraisal techniques, this study consequently implements the respective recommendations from the GIZ Gender Strategy (GIZ 2012b: 10) and Gender in Reporting Guidelines (GTZ 2010b: 3-6). It thus offers a higher *gender-sensitivity* than most of the comparable studies. In addition to these two innovative aspects, it delivers detailed *up-to-date data*, which is very relevant for the monitoring and evaluation activities of SED in Bangladesh.

[4] Mondal/Klein published the results of another impact assessment in 2011. Yet, their findings are based on empirical data from the years 2004 and 2005.

[5] To the knowledge of the author, a similar approach has so far only been applied by Bond/Fuller/Aye (2012) in East Timor, where lighting-related impacts of 10, 40 and 80 Wp systems were compared.

2 Theoretical Conceptualisation and Framework

The theoretical conceptualisation and framework of this study are presented in three sections: Firstly, the understanding of poverty is explained. Secondly, the connection between modern energy and poverty is characterised by using the poverty concept presented beforehand. Thirdly, it is discussed how this connection can be assessed for a specific development intervention.

2.1 Understanding of Poverty

Within the international community, poverty eradication is nowadays regarded as the "overarching task" (GTZ 2007: 6) of all development policies. The well-known Millennium Development Goals, which were adopted by the UN at the Millennium Summit in the year 2000 in New York, constitute the respective frame of reference (ibid.). Yet, despite the overwhelming consensus to focus on poverty eradication, the understanding of what 'poverty' exactly means differs considerably among the relevant stakeholders (Ruggeri Laderchi/Saith/Stewart 2003: 243-244). This highlights the importance to make one's understanding of poverty explicit before assessing how a development intervention influences the poverty situation of the beneficiaries.

2.1.1 Poverty as a Multidimensional Phenomenon

Ever since the pioneering study of Rowntree (1902) at the beginning of the last century, questions of how poverty is defined and how it can be measured have been part of intense scientific debate. Traditionally, monetary approaches, which identify poverty as "a shortfall in consumption (or income) from some poverty line" (Ruggeri Laderchi/Saith/Stewart 2003: 247), are the ones most commonly used. Notwithstanding that these approaches are still highly relevant at the present day, during the last two decades more holistic concepts have gained much attention among scholars and practitioners alike that regard poverty as an essentially multidimensional phenomenon. Especially the seminal works of Sen (1985, 1997, 1999) contributed to the fact that "the multidimensionality of poverty is now widely accepted" (OECD 2001: 37).

However, in spite of the common denominator 'multidimensionality', various concepts and approaches compete with each other defining poverty in a very different manner. The most influential ones among them are Sen's capabilities approach, the social exclusion perspective on poverty, the participatory approach, and the chronic poverty framework (e.g.

Clark/Hulme 2010; Green/Hulme 2005; Ruggeri Laderchi/Saith/Stewart 2003; Sen 1999). Each of these approaches has its strengths and weaknesses and all of them deliver different results when applied to assess a country's poverty situation (Ruggeri Laderchi/Saith/Stewart 2003: 268-269). This underlines that "any definition of poverty is of a politically normative nature" (GTZ 2007: 13).

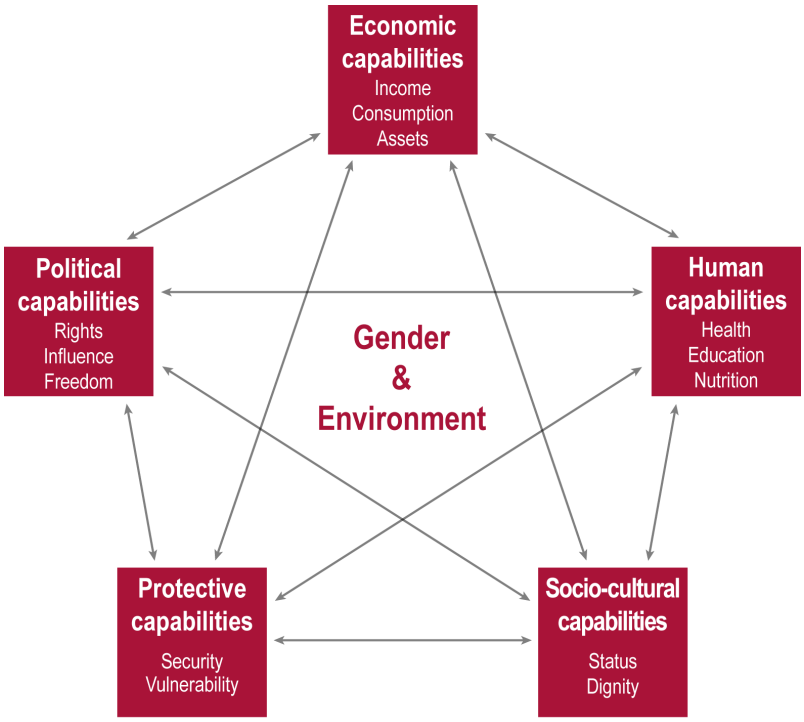
In this study, the multidimensional poverty concept of the Organisation for Economic Co-operation and Development (OECD), presented in its *DAC Guidelines* in 2001, is applied (OECD 2001). This concept draws heavily on Sen's capabilities approach, but it has a stronger focus on its application by development agencies. It was chosen because it offers a practical framework that allows to systematically relate the diverse effects that are expected from (S)SHS to the different dimensions of poverty. Additionally, as Kürschner et al. already stated in their study (2009: 12), it is in line with the poverty definition used in the German Government's Program of Action 2015 (BMZ 2001: II) and the Poverty Reduction Strategy Paper of Bangladesh (Government of the People's Republic of Bangladesh 2009: 3-4).

According to the concept proposed by the OECD, poverty is conceived as the deprivation of one's capabilities in five core dimensions: economic, human, socio-cultural, protective, and political. Whereas *economic capabilities* describe the ability to generate an income and purchase assets, *human capabilities* refer to aspects like health, education, nutrition, clean water, or shelter. *Socio-cultural capabilities* mean the "ability to participate as a valued member of a community" (OECD 2001: 38) referring to questions of social status, dignity, and inclusion in the community. *Protective capabilities* are enabling factors to withstand external shocks and are closely related to the aspects of insecurity and vulnerability. *Political capabilities* primarily include basic political freedoms, the possibility to influence political decision, as well as human rights. All of these five core dimensions are closely interrelated (OECD 2001: 38-39).

Furthermore, gender and environment are highlighted as being "mutually reinforcing, complementary and cross-cutting facets of sustainable development" (OECD 2001: 40), which concern all of the previously stated poverty dimensions. *Gender* is inextricably linked to every dimension, because poverty is not a gender-neutral phenomenon and men and women are oftentimes deprived of their capabilities to a very different degree. *Environment* is also closely related to poverty, since it can be both a cause for capability deprivation and a result (ibid.). Therefore, these two cross-cutting facets have to be integrated in

the analysis. Figure 2 provides an overview of the multidimensional poverty concept applied in this study.

Figure 2: The multidimensional poverty concept of the OECD



Source: OECD 2001: 39; modified | Graphic: Own elaboration

2.1.2 Aggregating Poverty Dimensions

As it has been noted earlier, despite the widespread consensus that poverty is a multidimensional phenomenon, monetary approaches to measure poverty are still of great importance for the international community. One of the main reasons for this is the difficulty to compare multidimensional poverty measures, which are oftentimes inconsistent due to different analytical frameworks. Additionally, some of the poverty dimensions are less tangible than others and can hardly be standardised (OECD 2001: 41-42).

Purely monetary approaches focus on the measurement of a household's income or consumption only, which is usually compared to a certain threshold defined as poverty line. This line is commonly determined by adding up the costs to meet the minimum nutritional requirements (food energy intake, FEI) or the costs for certain basic needs including non-food items as well (cost of basic needs, CBN) (Ravallion 2010: 8-11; Ruggeri Laderchi/Saith/Stewart 2003: 249-250).

The advantage of such an approach, upon which the World Bank's poverty statistics are based, is that the national poverty lines and the resulting poverty levels can easily be com-

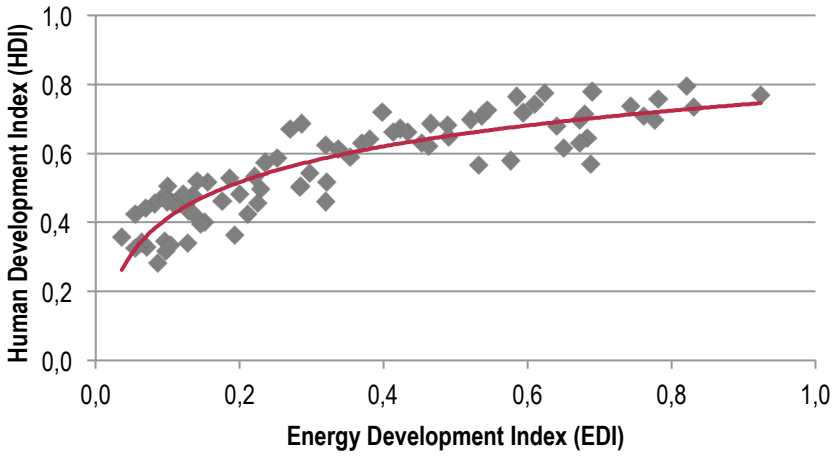
pared across different countries by translating the local currency into United States Dollar (USD) using Purchasing Power Parity (PPP) conversion factors. However, although income or consumption can be interpreted as a proxy for the other poverty dimensions, focusing on the economic dimension necessarily implies narrowing one's view on this multidimensional phenomenon (Ruggeri Laderchi/Saith/Stewart 2003: 248). Composite indices such as the Human Development Index (HDI), the Human Poverty Index (HPI), or the recently developed Multidimensional Poverty Index (MPI) integrate more than one dimension to reflect the multidimensional nature of poverty more adequately (Alkire/Santos 2011: 6; OECD 2001: 41-42). These indices are very valuable for cross-country analyses as well as to demonstrate the importance of a multidimensional understanding of poverty to both a wider public and the policy makers. Yet, their value for micro-level assessments is also limited, because every attempt to reduce poverty into a single index, be it one- or multi-dimensional, ultimately reduces the informational base.

Hence, within the scope of this study, only the analysis of the poverty orientation according to the definition of the BMZ is carried out by using income as a single indicator. The rest of the analysis is based upon the multidimensional poverty concept of the OECD described above.

2.2 Energy-Poverty Nexus

Nowadays, it is widely acknowledged that the access to modern energy offers several potential benefits for the poor (e.g. Agbemabiese 2009; Modi 2004; OECD/IEA 2010; The World Bank IEG 2008). This assumption is underpinned by strong evidence from a large number of cross-country analyses revealing a positive correlation between modern energy access and human development (typically expressed as gross domestic product (GDP) per capita or HDI) (e.g. Modi 2004: 11; OECD/IEA 2010: 12). One interesting approach in this regard is the introduction of the Energy Development Index (EDI) by the International Energy Agency (IEA). By taking into account indicators at the household level and the community level as well as considering not only access to electricity but also to clean cooking facilities, the informational base of this index is broader than the one underlying the usually stated electrification rates (OECD/IEA 2012: 541-542). Figure 3 provides a comparison between the EDI and HDI demonstrating the positive correlation between the two indices at a global scale.

Figure 3: Cross-country comparison between the Energy Development Index and the Human Development Index in 2010



Note: Every dot represents one country. A logarithmic trend line was used.
Data: UNDP 2011 & IEA 2012 | Graphic: Own elaboration

Zooming into the micro-level allows taking a closer look at the processes and causal relationships between modern energy and poverty. By using (S)SHS as an example for modern energy provision, the *potential benefits* for the poor become apparent: Traditional light sources like kerosene lamps can be replaced by electrical lamps resulting in lower expenditures on kerosene, better and easier lighting of the house as well as adjacent areas, and a reduction of indoor air pollution, which is assumed to improve the health situation of the household members. The electrical light can theoretically be used for a range of activities including home-based income generation in the evening and more comfortable and extended studying. Furthermore, household tasks such as cooking or cleaning are not constrained to daylight hours anymore. Other potential benefits include time savings from a decreased need to purchase kerosene and a higher perception of safety at home. Electrical appliances like mobile phone chargers, TVs, and small fans may contribute to easier communication, an improved access to information, and (more generally) to an elevated quality of life. Women and children are oftentimes assumed to be the main beneficiaries, as they spend most time inside the house. Furthermore, (S)SHS can be used in small and micro enterprises (SMEs) in order to save energy-related costs, run small appliances, and extend the opening hours (e.g. DFID 2002: 7; Modi 2004: 20-26; OECD/IEA 2010: 15)[6].

[6] This list is by no means exhaustive. It rather illustrates some important benefits for the poor that are commonly associated with modern energy provision in order to relate the macro level correlations to its underlying processes at the micro level.

The last few years have however shown that rural electrification projects did not always reach the anticipated results, especially concerning the economic dimension (Kooijman-van Dijk 2012: 530). Critical literature reviews on the relationship of energy and income point out that while at a global level evidence for definite correlations is strong, analyses at a national or regional level have yielded contradictory results (Karanfil 2009: 1193; Kooijman-van Dijk 2012: 530; Meadows et al. 2003: 5-6). Although these reviews mainly focussed on the economic dimension, one important result is applicable to all poverty dimensions: At a micro-level, evidence is largely of anecdotal nature and based on best cases only. The respective assumptions are oftentimes neither thoroughly questioned nor systematically tested.

Hence, three conclusions can be drawn for this study: Firstly, based on the strong correlations at a macro-level and the depicted processes and relationships at a micro-level, it is indeed fair to assume that providing modern energy access *can* achieve positive effects on various poverty dimensions. Secondly, the contradictory results at a micro-level demonstrate that modern energy provision may well be a necessary factor for effective poverty reduction, but it is not a sufficient one (Brew-Hammond 2010: 2291; van der Vleuten/Stam/van der Plas 2007: 1440). Therefore, these assumptions have to be rigorously tested. And thirdly, since there is no automatism between modern energy and poverty reduction, "[d]etails matter" (Banerjee/Duflo 2011: 243). Experience from a large number of impact assessments suggests that small and seemingly unimportant details can sometimes have a large influence on the success of a development intervention (ibid.). Therefore, the methodological instruments applied in this study not only have to be very comprehensive in order to reach a certain level of details but also open enough to grasp unexpected information.

2.3 Development Interventions and their Impact

After having outlined the poverty concept applied in this study and the connections between modern energy and poverty, two questions still remain: Firstly, what exactly is the 'impact' of a development intervention and secondly, how can we assess it?

2.3.1 The Concept of Impact Assessment

Triggered by the severe criticism of development assistance and its inadequate evaluation since the early 1990s, throughout the last 15 years the international community has at-

tributed a great deal of attention and significant financial resources to the topic of aid effectiveness[7] (Caspari 2009: 184; Faust 2010: 41-43). In this context, it has become increasingly important to determine the results that development interventions actually achieve rather than the financial resources spent on it. Additionally, the requirements to measure these results and shortcomings of the common evaluation practices have been intensively debated. As a consequence, the demand for methodologically sound impact assessments of such interventions has risen considerably (Caspari 2009: 186-188; GTZ 2008: 2; Reade 2008: 2).

According to the terminology of the OECD, the *results* of a development intervention include different causally interconnected levels, which are linked to form a *result chain*. At the beginning of the chain, the *inputs* of a development intervention are the "financial, human and material resources" (OECD 2009: 32) used to carry out certain *activities*, which in turn produce specific *outputs*. These are defined as the "products, capital goods and services which result from a development intervention" (ibid.: 36) and lead to the *effects*, which can be divided in short- and medium-term effects as well as long-term effects. While the former are usually known as the *outcomes* of a development intervention, the latter are defined as the *impacts*. These impacts can be positive or negative, intended or unintended, directly or indirectly produced (ibid.: 31). Furthermore, some development agencies (such as the German Technical Cooperation before its restructuring in 2011) complement this chain with two additional levels, namely the *use of output* as well as the *highly aggregated impact (GTZ 2008: 7-8)*[8].

Although at an international level there is a widespread consensus on the described terminology, the term *impact evaluation* (or *impact assessment*, which is used synonymously in this report) can have different meanings (Caspari/Barbu 2008: 5; White 2011: 3). Following Caspari/Barbu (2008: 5), in this study impact evaluation is understood as a systematic assessment of medium- and long-term effects that are directly attributable to development interventions. The term 'direct attribution' implies the "ascription of a causal link between the observed […] change and a specific intervention" (OECD 2009: 21). The stylised model of a result chain in figure 4 visualises the above-mentioned terms and interconnections.

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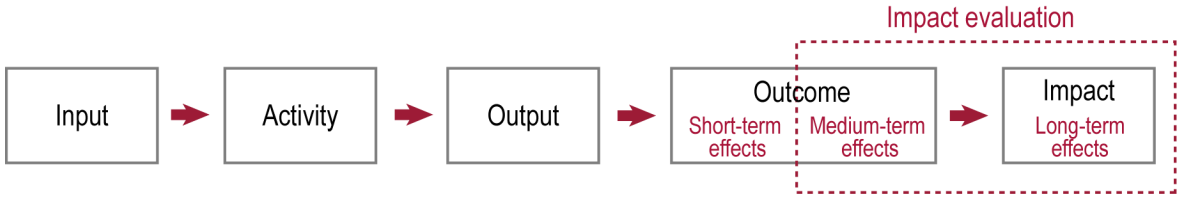
[7] The Paris Declaration on Aid Effectiveness (2005) was a particularly important step in this regard, because 'managing for results' and 'mutual accountability' were declared as core principles of the international development agenda.

[8] The GIZ currently carries out a reform of its results model and terminology. However, since this process was not yet completed at the time of writing, it could not be reflected in this report.

Figure 4: Stylised model of a result chain



Source: Caspari/Barbu 2008: 2; modified | Graphic: Own elaboration

2.3.2 Impact Assessment Frameworks

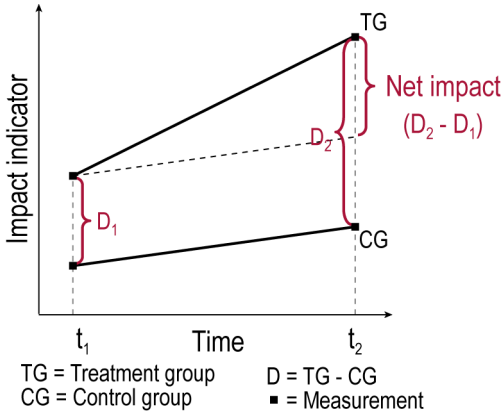
In line with the definitions mentioned above, the overall goal underlying all impact assessment frameworks is to determine the medium- and long-term effects that can be directly attributed to the development intervention. However, if one wishes to make robust statements, two aspects necessarily have to be included in the research design: Firstly, a 'before and after' comparison and secondly, a 'with and without' assessment (Caspari/Barbu 2008: 6-9; Reade 2008: 9-10).

Traditionally, many evaluations of development interventions only focused on the beneficiaries. By comparing baseline data (before the intervention) with survey data (after the intervention) or using survey data only, certain impacts were found and attributed to the intervention (Caspari/Barbu 2008: 6; Faust 2010: 43). However, this approach is problematic, because the same impacts could also have happened to non-beneficiaries. Theoretically, the intervention could even have had a negative impact, if the non-beneficiaries' situation had improved more than the beneficiaries'. Therefore, it is imperative to include not only the factual but also the counterfactual in the assessment. If the factual and counterfactual are compared after the development intervention only, it is referred to as a *single-difference method.* A comparison of both groups before and after the intervention is called *double-difference method*. By using this approach, the *net impact* of an intervention can be exactly determined (figure 5) (Caspari/Barbu 2008: 7-8; White 2011: 4).

Another important aspect is how both groups are being selected. In order to minimise the selection bias, the most sophisticated option is to randomly select 'units' (people, households, etc.) to be beneficiaries (*treatment group*) or non-beneficiaries (*control group*) before the development intervention has started[9]. Such a design is called an experimental design or a *randomised controlled trial* (RCT) (Banerjee/Duflo 2011: 14; Caspari/Barbu 2008: 9; White 2011: 6-7).

[9] This must not be confused with a randomised selection of the sample from the beneficiaries and non-beneficiaries after the intervention, because already the assignment to either of these groups (that is, the decision who participates in a project and who does not) is done on a randomised basis (White 2011: 7).

Figure 5: Schematic overview of a double-difference impact evaluation



Source: Caspari/Barbu 2008: 9 | Graphic: Own elaboration

Although commonly being referred to as the most rigorous within the class of evaluation techniques, in development practice RCTs are still not applied very often. This is due to the fact that they require careful planning over a relatively long period of time (the RCT-based evaluation has consequences for the project design as a whole), significant financial and time resources, as well as a certain level of especially econometric skills. Additionally, depending on the specific project characteristics, it can be very difficult (or even unwanted) to select the treatment group and control group on a purely randomised basis (Caspari/Barbu 2008: 10-11; White 2011: 13-15). As a consequence, a wide range of different impact assessment frameworks are frequently used for evaluations of development interventions offering a varying degree of methodological sophistication and robustness of the results. Their respective choice is based on the specific project setting, the scope of the evaluation, the available financial resources, as well as other determinants. (Bamberger/Rugh/Mabry 2008: 14-22; Reade 2008: 10; Stockmann 2006: 229).

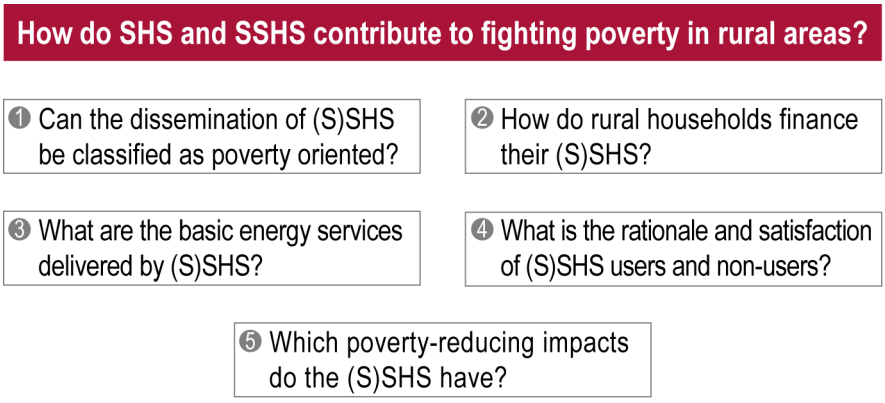
Thus, it can be concluded that the impact assessment framework used in this study should, on the one hand, contain as many elements of an RCT design with a double-difference comparison as possible. On the other hand, it has to be adapted to the circumstances of the evaluation to ensure that it is realisable in this specific context.

2.4 Research Objectives

It was stated in the introductory chapter that the main objective of this study is to determine how exactly SHS and SSHS contribute to fighting poverty in rural Bangladesh. Based on the conceptual framework introduced in the preceding chapter, it is now possible to further specify and explain this general objective.

The main research objective can be divided into five sub-objectives. Firstly, the poverty orientation of the (S)SHS dissemination is analysed, which addresses the question *who* actually benefits from the dissemination. In order to answer this, the per capita income levels of the (S)SHS users and non-users are compared to several poverty lines. Secondly, it is investigated how rural households finance their (S)SHS. That is, the acquisition of the (S)SHS and the respective payment modalities are examined. Thirdly, the basic energy services delivered by the (S)SHS are analysed to identify how the power output of the solar systems is used. This is an essential prerequisite to understand how the users benefit from their (S)SHS, because the nexus between energy and poverty is much more shaped by the specific energy services (e. g. the number of lighting devices as well as other electrical appliances) than by the nominal power of a (S)SHS (Wamukonya 2007: 8). Fourthly, the rationale and satisfaction of (S)SHS users and non-users are investigated. On the one hand, it is intended to determine the main reasons why rural dwellers did or did not purchase a (S)SHS. One the other hand, their satisfaction with the solar system is examined. Ultimately, the impacts of (S)SHS on the five dimensions of poverty according to the OECD framework as well as the cross-cutting facets gender and environment are assessed in detail. In line with the understanding of impact and its evaluation presented above, the focus lies on the medium- and long-term effects of the (S)SHS dissemination. Figure 6 summarises the research objectives of this study.

Figure 6: Main research objectives



Source: Own elaboration

Since (S)SHS are purchased by both rural households (domestic use) and SMEs (commercial use), in principle, the stated research objectives could be investigated for either type of usage. However, this study only focuses on the domestic use of (S)SHS, which is the most common application of solar systems in Bangladesh.

3 Methodology

As the previous chapters have shown, the methodology of an impact evaluation has strong influence on the findings that are produced. Therefore, in the following the overall framework as well as the methodological tools are explained and critically discussed.

3.1 Preliminary Methodological Considerations and Overall Framework

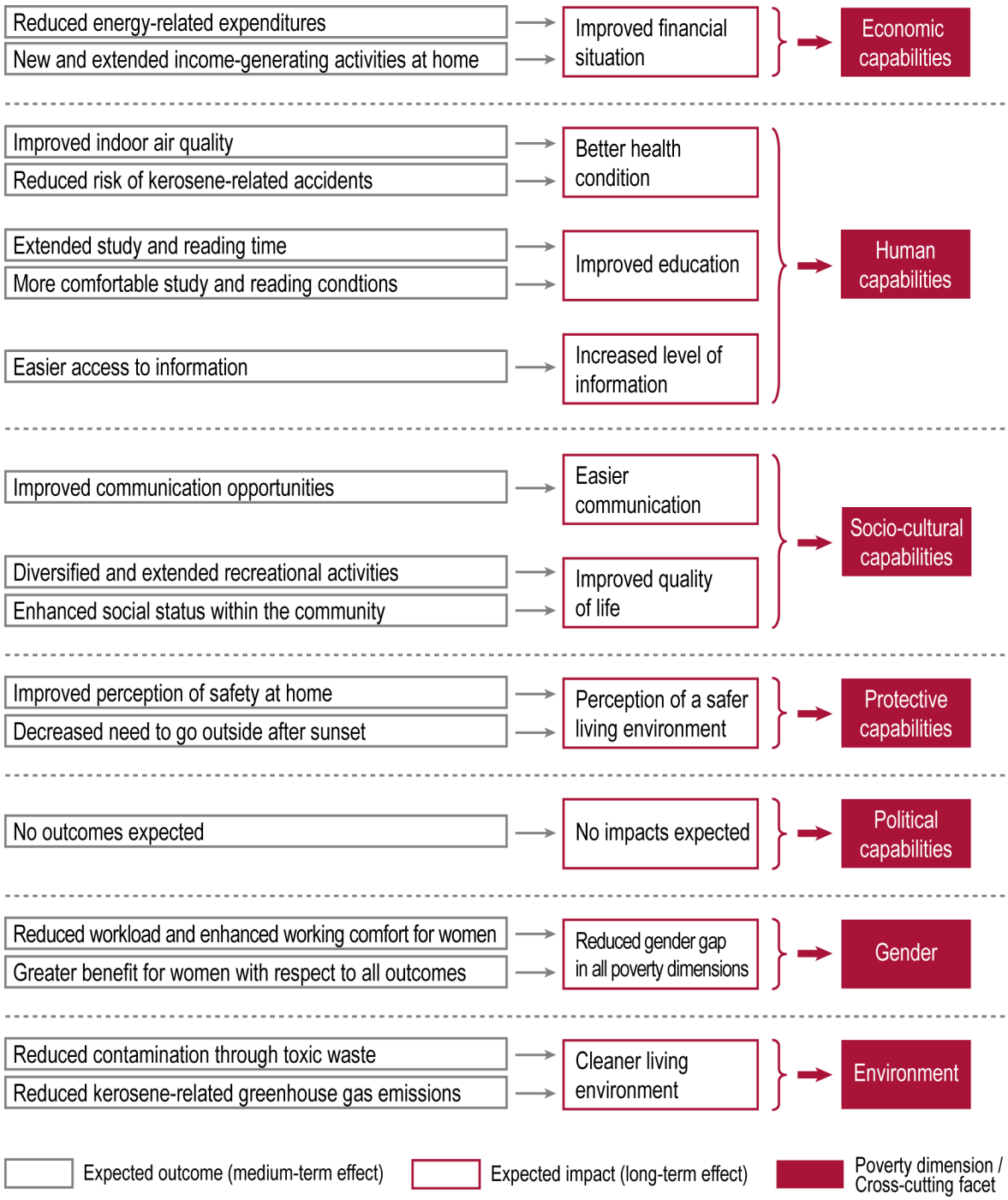
In order to ensure the 'appropriateness' of the evaluation framework applied in this study (Flick 2009: 53), particularly three aspects were taken into consideration.

Firstly, it was determined *which effects* are expected to be produced by the dissemination of (S)SHS. This refers to the need of a "theory-based approach" (Caspari 2009: 205), which means that every impact evaluation has to be based on a logical model specifying cause-and-effect hypotheses for the given development intervention. Without such considerations it would neither be possible to know *what* to assess nor *why* certain impacts did or did not unfold (ibid.).

Since the dissemination of (S)SHS is not a completely new approach anymore, many insights regarding the cause-and-effect relationships between (S)SHS and the different poverty dimensions could be gained from a detailed review of both scholarly papers and SED project documents. The latter included a result chain for the (S)SHS intervention in rural Bangladesh prepared by SED project staff members. An updated and modified version of this result chain is presented in appendix 2. On the basis of this result chain as well as the literature and project document review, the expected outcomes and impacts of the (S)SHS dissemination were determined and systematically allocated to the different poverty dimensions and cross-cutting facets according the OECD poverty concept (figure 7).

Many of the expected middle- and long-term effects have strong linkages and interconnections among each other, which could not be included in the figure for reasons of clarity. However, since particularly the cross-cutting facet 'gender' is relevant in all five poverty dimensions, gender-specific aspects were investigated with respect to all expected impacts. The respective section on 'gender' merely recapitulates and synoptically discusses these findings.

Figure 7: Expected outcomes and impacts of the (S)SHS dissemination



Note: As this study focuses on domestically used (S)SHS only, impacts on shop owners and employees in the solar business were not included in the overview.

Source: Own elaboration

Secondly, the *research design* to assess these impacts was chosen. Since the dissemination of (S)SHS was already on-going when this impact evaluation was planned, it was not possible to select beneficiaries and non-beneficiaries on a randomised basis, which is why a

RCT design could not be applied[10]. Instead, a *quasi-experimental design* was chosen. Both users and non-users were included in the framework to ensure a single-difference comparison. Since the non-users are the result of a self-selection process and were not randomly chosen *before* the intervention, they are referred to as a comparison group (and not a control group) (Bamberger/Rugh/Mabry 2008: 15; Caspari 2009: 197)[11]. Unfortunately, no data was available that could serve as a baseline for this impact evaluation, which is why a double-difference method could not be applied. However, users were asked in retrospect about changes with respect to the situation at the present day to overcome this shortfall. By using this 'recall-method', the difference between t_1 (before the intervention) and t_2 (after the intervention) could be measured, though with a lower precision than with baseline data (Caspari/Barbu 2008: 31). However, the method could not be applied for the comparison group, because without the purchase of a (S)SHS no clear point of reference was existent which could be 'recalled'. Thus, the quasi-experimental framework used in this study can be characterised as a *'one-and-a-half-difference'* research design.

Thirdly, the *methodological tools* were selected. Following the recommendations of Kooijman-van Dijk (2012), Ilskog/Kjellström (2008), Caspari (2008), White (2006), Reade (2008), and other related authors, both quantitative and qualitative methods were applied. Such a mixed-methods approach is regarded as vital for an impact assessment, because the triangulation of both types of data can yield important insights into the causal linkages of the result chain. While quantitative data is especially suitable to detect the direction and strength of a relationship, the more open qualitative methods can be applied to reveal the reasons behind such a relationship, to discover unintended impacts, or to identify new relationships which were previously not included in the result chain (Reade 2008: 16-17). It thus becomes apparent that "[b]oth quantitative and qualitative methods are necessary for a good evaluation" (Ezemenari/Rudqvist/Subbarao 1999: 28). The methodological tools applied in this study include a quantitative household survey among (S)SHS users and non-users, semi-structured interviews, as well as focus group discussions.

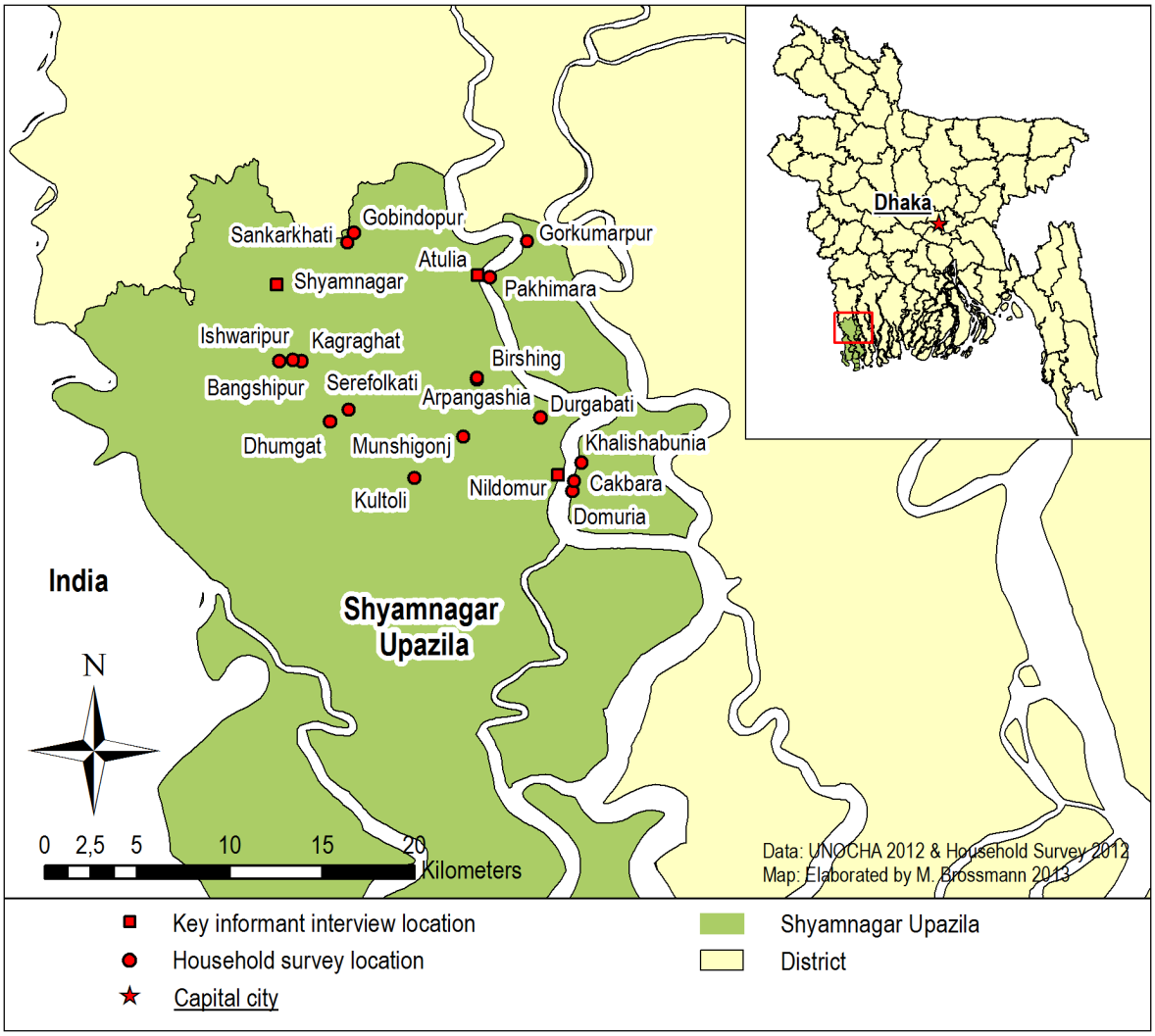
[10] It has to be noted that not only the timing of the evaluation prevented the application of a RCT design. As the (S)SHS dissemination in Bangladesh is market-based, in theory every person can freely choose whether to purchase a solar system or not. This makes it impossible to assign households to be either part of the treatment group or the control group on a randomised basis. However, a RCT design *is* possible in the pilot phase of such a dissemination, when only a limited amount of solar systems are sold or handed out for free in a specific area.

[11] This difference is not always taken into account in development research (e.g. Blunck 2007; Obeng et al. 2008). It is, however, very relevant with respect to possible biases in the sample and therefore influences the interpretation of the results (Caspari 2009: 197-198; White 2011: 6-9).

3.2 Study Area and Sampling

The field research was conducted in Shyamnagar Upazila within Satkhira District (Khulna Division). It is situated in the south-western part of Bangladesh, adjacent to the Bay of Bengal and the Indian border (figure 8). The Shyamnagar Upazila has an area of 1,968 km^2, of which the vast majority (1,623 km^2) is tree-covered with a mangrove forest that is scarcely populated (BBS 2012b: 24). The latest census results reveal that 94.5 % of the 318,254 inhabitants live in rural areas, which demonstrates that urban agglomerations only play a minor role in this region (ibid.). Data on modern energy access levels could not be retrieved on such a disaggregated level. However, earlier GIZ activities in this region indicated that it is predominantly an off-grid area.

Figure 8: Map of the study area



Source: Own elaboration

Within the Shyamnagar Upazila, a total number of 19,976 (S)SHS have been disseminated under the Infrastructure Development Company Limited's (IDCOL) solar programme (cf. chapter 4.2) until 24 September 2012. 3,772 of these solar systems (18.9 %) are SSHS with a nominal power of 20-29 Wp, the remaining 16,204 systems (81.1 %) are SHS with 30-130 Wp (IDCOL 2013b). By means of a list provided by IDCOL containing detailed information about every (S)SHS in the Shyamnagar Upazila, *stratified multi-stage sampling* was applied. At first, eight post offices were randomly selected from this target population by using a random number approach (*first stage*). The 2,993 solar systems within the selected post offices were then divided in two subgroups (*stratification*): SHS (2,421 systems) and SSHS (572 systems). Since the comparison between SHS and SSHS plays an important role in this study, a disproportional sample was selected from both subgroups with equal minimum targets of n = 100 (*second stage*) to ensure that enough SSHS would be surveyed to carry out statistical tests between the two groups. Yet, it is important to note that by applying such a sampling method, the results cannot be regarded as representative for the target population as a whole (Kromrey 2009: 284-286).

Originally it was intended to select the sample in this second stage with a random number approach as well. Unfortunately, it could not be determined from the list if a solar system is domestically or commercially used. Additionally, the ID numbers on the list very often did not match with the ones on the customer agreements and the information about the villages and post offices proved to be wrong at times. Since this prolonged the enumeration process considerably, it was decided to abandon this purely randomised approach and apply the random walk method instead: The enumerators were given instructions to cross the villages and survey the households according to a certain pattern, which was announced beforehand (Kromrey 2009: 290-292). This approach did not yield a purely randomised sample, but it ensured that the selection bias was as small as possible under the given circumstances. Additionally, only those (S)SHS users were interviewed possessing their panel for at least six months, because many of the effects of (S)SHS cannot be observed directly after the purchase of a solar system[12]. The non-users were surveyed in the same villages as the (S)SHS users by applying an identical random walk method.

The field research was carried out in two phases of 13 days each from 6 October to 18 October 2012 and from 3 November to 15 November 2012. Beforehand, a one-day pre-test of

[12] Originally this time limit was set to twelve months. However, particularly many SSHS were bought between nine and twelve months ago, reflecting the recent dynamics on the solar market. In order to reach a sufficiently high number of SSHS in the given timeframe of the fieldwork, the limit was reduced to six months.

the household survey was conducted in Singair Upazila within Manikgonj District (Dhaka Division) to apply the questionnaire under real-world conditions and enhance it according to the experiences gained on that day. During the fieldwork the author was supported by three local research assistants, which carried out the quantitative household survey. Additionally, in the first week a local GIZ staff member and a gender consultant joined the research team. In order to ensure the data quality, a two-days workshop was held preceding the field research to make the research assistants familiar with the study contents and the questionnaires. Furthermore, the completed questionnaires were checked after every day of enumeration and mistakes were discussed with the whole team. During both fieldwork phases at least one research assistant was female, which was crucial to be able to address those female interviewees as well feeling intimidated by a male enumerator.

The qualitative interviews were conducted by the author and translated by the local GIZ staff member or one of the research assistants. The interviewees of the qualitative user and non-user appraisals originated from the sample described above. The key informant interviews did not take place in the sample villages but mostly in Shyamnagar (town), the biggest urban agglomeration in the research area. Finally, the focus group discussions were carried out in three different villages by the gender consultant, who was supported by one female research assistant.

3.3 Methodological Tools

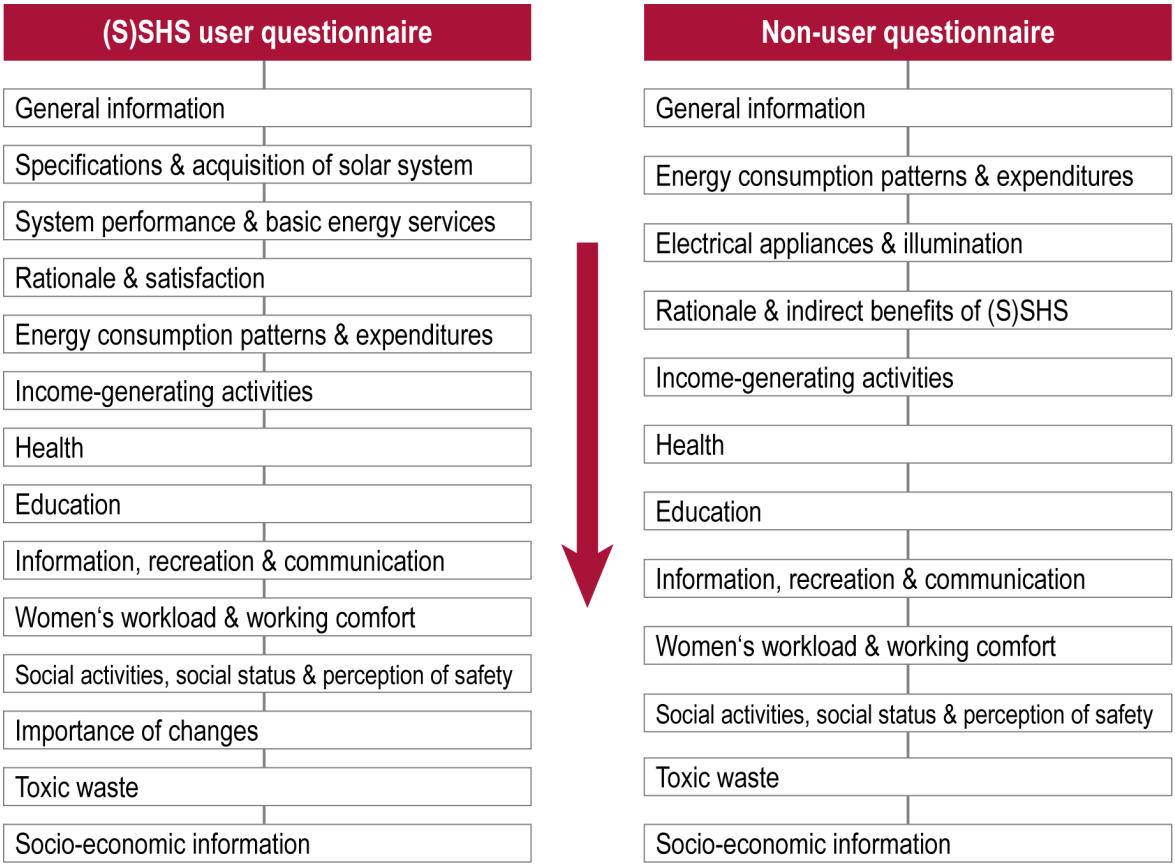
3.3.1 Household Survey

Questionnaire Design

The quantitative household survey was carried out on the basis of a standardised questionnaire, which was mainly composed of closed questions and semi-open questions, complemented by a few open questions (Reuber/Pfaffenbach 2005: 76-80). Two different questionnaire forms were used for (S)SHS users and non-users (appendices 3 and 4). Wherever possible, the same questions were used in both questionnaire forms to ascertain comparability. Yet, on the one hand, several user-specific questions like the system specifications or acquisition details as well as all ‘recall-questions’ (cf. chapter 3.1) were removed from the non-user version. On the other hand, a few questions towards the rationale and indirect benefits of non-users were added.

Both questionnaires were structured in several thematic blocks, which were derived from the literature and project document review[13]. These blocks and their order in the respective questionnaires are as follows:

Figure 9: Structure of the user and non-user questionnaires



Source: Own elaboration

As stated in the introductory chapter, the questionnaire was designed in such a way that most of the impact-related data could be gathered disaggregated by gender: A distinction was made between male adults, female adults and children under 16 years of age. Additionally, socio-economic information on the interviewee was collected to be able to assess all responses separately for male and female respondents (and take other aspects into account like the age or the relation to the (S)SHS owner).

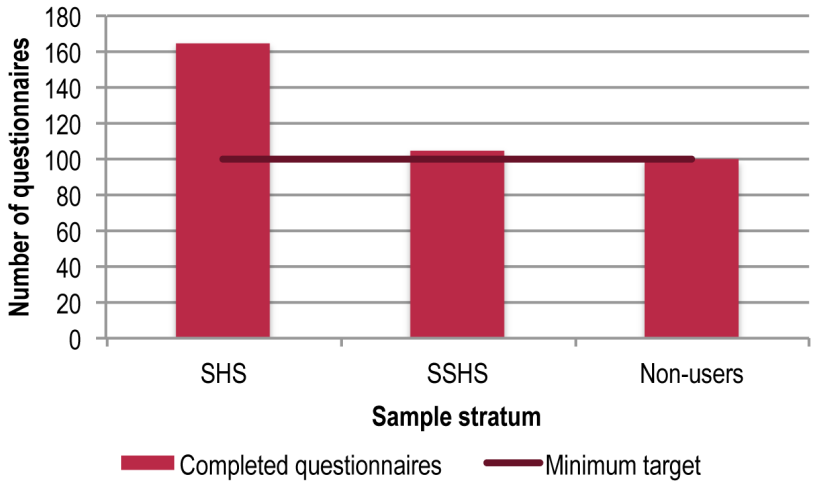
Description of the Survey Sample

During the fieldwork a total number of 370 valid questionnaires were obtained from 17 different villages belonging to the eight randomly selected post offices. 165 of the inter-

[13] In particular, several elements of the questionnaire forms developed by Kürschner et al. (2009) have been adapted for the current household survey.

viewees are SHS users, 105 SSHS users and 100 non-users. Hence, the minimum target for all three groups was reached (figure 10).

Figure 10: Questionnaire sample overview



n = 370

Data: Household survey 2012 | Graphic: Own elaboration

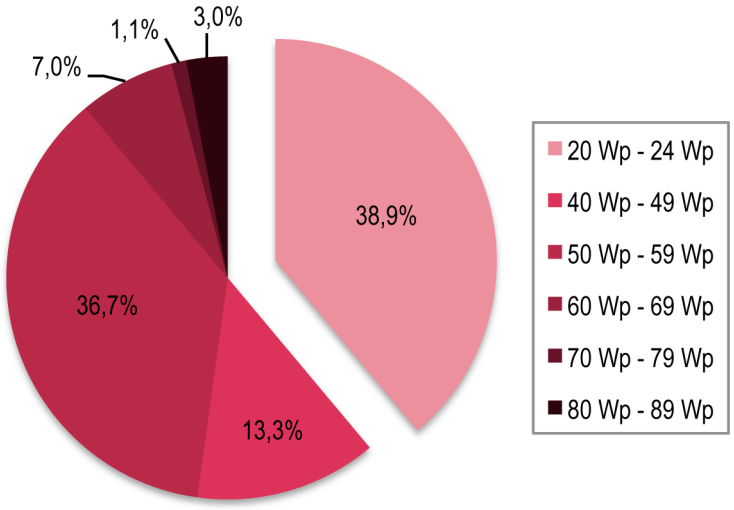
The average interview duration for (S)SHS users was 39 minutes with a standard deviation of seven minutes. The respective values for the non-users were 25 minutes and seven minutes. With a share of 52.7 % female respondents compared to 47.3 % male respondents, the sample is almost completely gender-balanced. In 37 % of the cases, the interviewee was the head of the household. The average household size was found to be 5.2 people, which is higher than the respective census results from 2011 (4.4 people per household) (BBS 2012b: 24). This is somewhat surprising, because in both cases "[p]ersons, either related or unrelated, living together and taking food from the same kitchen" (ibid.: 16) were counted as household members. An explanation for this difference could be that, despite this definition, especially in the case of joint families it is not always evident who still belongs to the same household. In such cases, the enumerators were instructed to count the respective persons as household members when they used the same (S)SHS in order to be able to determine the number of (S)SHS beneficiaries more precisely.

More than half of the sampled households mainly earn their living with day labour (32.2 %) or fishery and shrimp cultivation (20.4 %). Other common sources of income include agriculture and forestry (17.2 %) as well as small-scale activities in the trade

(15.8 %) and service sector (13.1 %)[14]. In about 97 % of the households, male adults earn the main part of the income. Only ten households stated that they would regularly receive remittances from family members working abroad.

The surveyed solar systems were provided by 11 different partner organisations (POs)[15]. Grameen Shakti holds the major share with 57.6 %, followed by SRIZONY (15.6 %) and the Rural Services Foundation (RSF) (7.4 %). Two (S)SHS were bought in private solar shops, nine were second hand purchases. A detailed overview of the (S)SHS providers in this sample is given in appendix 5. Over 50 % of the systems were bought in the last two years. In contrast, (S)SHS being older than five years account for a mere 13.3 %. While all 105 SSHS have a nominal power of 20-24 Wp, the SHS sample is more diversified. SHS with a power output of 50-59 Wp constitute the most frequent model with 99 units, compared to 36 SHS between 40 and 49 Wp as well as 19 SHS with an output of 60 to 69 Wp. Only 11 of the surveyed systems have a higher nominal power, the biggest SHS are in the range of 80 to 89 Wp (figure 11).

Figure 11: Distribution of sampled solar systems by nominal power output



n = 270

Data: Household survey 2012 | Graphic: Own elaboration

[14] Many interviewees stated that their main income-generating activity would change throughout the year according to the current job opportunities. Therefore, the given percentages can only serve as indication for the most common sources of income in the survey area.

[15] POs are private companies or nongovernmental organisations (NGOs), which sell and install the (S)SHS and which are responsible for the subsequent instalment collection (cf. chapter 4.2).

Furthermore, at the time of the interview 29 households (16 users and 13 non-users) were connected to the electricity grid. Although not being part of the target group of the EnDev initiative, they were not excluded from the sample in order to get a more complete picture of the *actual* beneficiaries from the market-based (S)SHS dissemination.

3.3.2 Qualitative Interviews

Two different types of qualitative interviews were applied in the field research: qualitative (S)SHS user and non-user appraisals as well as key informant interviews with local stakeholders.

The *qualitative user and non-user appraisals* consisted of semi-structured interviews covering the same thematic blocks as the quantitative survey as well as an additional part about 'daily routine'. In contrast to the questionnaire, however, these blocks served as a flexible interview guide only (Mikkelsen 2005: 169). During each interview the guide was adapted according to the responses of the interviewee and certain parts were discussed in detail, whereas others were left out completely. A set of open questions was prepared for each thematic block, which was flexibly complemented by additional questions coming up during the interviews (Mikkelsen 2005: 169-172; Reuber/Pfaffenbach 2005: 134-137). Special emphasis was put on questions directed towards the reasons for certain changes or behaviours. The complete (S)SHS user and non-user interview guides are attached in appendices 6 and 7.

Detailed notes were taken during each interview, reviewed and complemented after its conclusion. Additionally, a concise postscript was prepared to outline the author's impressions about the overall interview setting, the communication with the interviewee, and possible external influences such as the presence of other persons (Lamnek 2010: 335). This information was subsequently transferred into a matrix with the respective questions as column headings and interviewees as rows. The subjective impressions and other remarks were displayed in extra columns. In an additional step, the resulting matrix was searched for typical response patterns and related to the results of the quantitative analysis (Mikkelsen 2005: 185-186). In total, 20 interviews (15 users and five non-users) were conducted and included in the analysis (a detailed list is provided in appendix 8).

In addition to the interviews with (S)SHS users and non-users, several *key informant interviews* with staff from local PO offices were carried out. These were semi-structured interviews as well, based on an interview guide with open questions. Their content, however, differed considerably from the (non-)user interviews, because the intention of these inter-

views was to obtain expert knowledge that could not be gained from the (S)SHS users and non-users and complemented their statements (Mikkelsen 2005: 172). Therefore, the interviews focussed on aspects like financing schemes, local market development, job creation in the solar sector, and battery disposal mechanisms (appendix 9). The analysis was carried out analogously to the method described above.

Seven local branch officers were interviewed with this interview guide. Furthermore, another ten informal interviews were conducted in small solar shops and battery repair shops. The interview guides for these appraisals were developed during the fieldwork and were only loosely followed in the conversation. An overview of every interviewed key informant with the respective organisation and position is given in appendix 10.

3.3.3 Focus Group Discussions

Three *focus group discussions* were carried out with small groups of women (both users and non-users) in the sample villages to discuss gender-sensitive aspects without the presence of male household members. The rationale behind this was that the women would feel more confident in such a setting. Thereby, certain sensitive information could be retrieved, which would not have been communicated in regular interview situations due to the social-cultural context and other reasons (Gibbs 2012: 187; Mikkelsen 2005: 89). The qualitative (non-)user interview guides were used to set the general topics and create stimuli for the discussion (Reuber/Pfaffenbach 2005: 148). The analysis of the three discussions was also done by means of a matrix display, its interpretations were mainly used to complement the information from the quantitative and qualitative appraisals.

3.4 Critical Discussion of Applied Methodology

In retrospect, the applied methodology can be regarded as adequate to work on the five research objectives of this study. Especially the triangulation of quantitative and qualitative data led to important insights, which could not have been achieved by the application of either approach only. Furthermore, the recall method worked better than initially expected, because on the whole the (S)SHS users could remember the situation before they purchased the (S)SHS surprisingly well. Also, previous concerns that the very comprehensive questionnaire forms would be too time-consuming and could therefore not be used in such a study proved to be without cause.

Yet, like every impact evaluation, this study was also subject to a range of possible interference factors, which can lead to biases in the data set and thereby compromise the internal validity of the results. Three common biases that have to be taken into consideration in this regard are the time of the fieldwork, contagion effects, and a selection bias (Caspari 2009: 203-205). Since during the *time of fieldwork* the situation was not strongly influenced by a singular catastrophic event (such as a cyclone) and no other projects were carried out focusing on the provision of (S)SHS or a similar technology (*contagion effect*), the first two possible biases can be neglected here. However, due to the quasi-experimental design and the sampling method applied in this study, the *selection bias* is very relevant and has to be discussed.

The first and most relevant selection bias in the sample is inherent to the nationwide market-based (S)SHS dissemination in Bangladesh: It is very likely that people not possessing a (S)SHS are somehow 'different' to (S)SHS users due to observable (income, education, etc.) and unobservable factors (attitude towards new technologies, risk aversion, etc.) (Caspari/Barbu 2008: 15). These factors might correlate with the expected impacts of the (S)SHS, which has to be taken into account in the analysis. Yet, this 'difference' of the comparison group can be of advantage, because the non-users constitute the potential target group for future projects and therefore valuable information can be gathered for the respective project designs. Moreover, an additional selection bias exists, because the last stage of the applied multistage sampling approach was not entirely randomly selected.

Apart of these biases, another influencing factor is the need to rely on a translator to carry out the qualitative interviews. Although the translation was done to the best of the translators' judgements, such a step always constitutes an additional interpretation of both the researcher's questions and the interviewee's answers. Unfortunately, this influence can never be completely ruled out.

4 The (S)SHS Dissemination in Bangladesh and its Context

After having outlined the conceptual framework and methodology, this report now focuses on the results obtained on this basis. Yet, in order to be able to interpret these results correctly, a concise contextualisation of the (S)SHS dissemination in Bangladesh is given beforehand. The first part of this chapter casts light on the poverty and energy situation in Bangladesh, the second part explains the (S)SHS dissemination structure and progress.

4.1 Poverty and Energy Situation in Bangladesh

Bangladesh has a population of approximately 150 million inhabitants[16], distributed over an area of 147,570 km^2. The resulting population density of 1,015 people per km^2 is the highest of all territorial states worldwide. Approximately three out of four Bangladeshis (over 110 million people) live in rural areas. This demonstrates that the poverty and energy situation of the rural population determines to a large extent the overall picture (BBS 2012a: 10; 2012b).

According to the Human Development Report 2011, Bangladesh has a HDI of 0.500, which is equivalent to rank 146 out of 187 countries and the classification 'low human development' (UNDP 2011: 129). The (monetary) poverty headcount rate of the Household Income and Expenditure Survey (HIES) 2010 indicates that 31.5 % of the total population is considered to be 'poor' (BBS 2010: XXV)[17]. The poverty incidence in rural areas (35.2 %) is significantly higher than in urban agglomerations (21.3 %). Albeit remaining considerably high, these numbers have declined since the HIES 2005, when 28.4 % of the urban and 43.8 % of the rural population was found to be living below the upper poverty line (ibid.).

In 2005, the Government of Bangladesh has expressed its intention to reach universal electricity access by 2020 (Mondal/Kamp/Pachova 2010: 4626; MoPEMR 2008: 1). Yet, at the present day, large parts of the population still remain without such a connection. According to the IEA, 53 % of the total population does not have access to electricity. In rural areas,

[16] The respective estimates vary between 144 and 164 million inhabitants (e.g. BBS 2012b; IFC 2012; The World Bank 2013a).

[17] The Bangladesh Bureau of Statistics (BBS) applies the cost of basic needs method to determine the poverty incidence. Two different allowances for non-food items are used to calculate an upper and a lower poverty line. Furthermore, in order to reflect regional price differences, for each of the six divisions (Barisal, Chittagong, Dhaka, Khulna, Rajshahi, and Sylhet) the poverty lines are determined for rural, urban and metropolitan areas (appendix 11). Households with a monthly per capita expenditure below the respective upper poverty line are defined as 'poor' (BBS 2010: 181).

the electrification rate merely reaches 33 %[18] (IEA 2012; IFC 2012: 53). Where electricity is not available, kerosene is the predominant energy source for lighting. More than 90 % of the rural dwellers in off-grid and under-electrified areas have at least one kerosene lamp in use. Dry-cell batteries are frequently used to run torches, radios, and other small electrical appliances. Candles only play a minor role and are rarely found in rural households. The energy demand for cooking purposes is nearly completely met with biomass (firewood, tree leaves, crop residues, etc.) (Asaduzzaman/Barnes/Khandker 2010: 11-14; IFC 2012: 53-54). Apart of these 'traditional' energy sources, a growing number of people in rural Bangladesh use solar systems to meet their basic energy needs.

4.2 (S)SHS Dissemination Structure and Progress

The vast majority of the (S)SHS in Bangladesh have been disseminated under the IDCOL solar programme. IDCOL is a state owned financial institution established in 1997 in order to "provide financing for infrastructure and renewable energy projects in Bangladesh" (IFC 2012: 54). Its solar programme was launched in 2003 as part of the World Bank's Rural Electrification and Renewable Energy Development Project (REREDP).

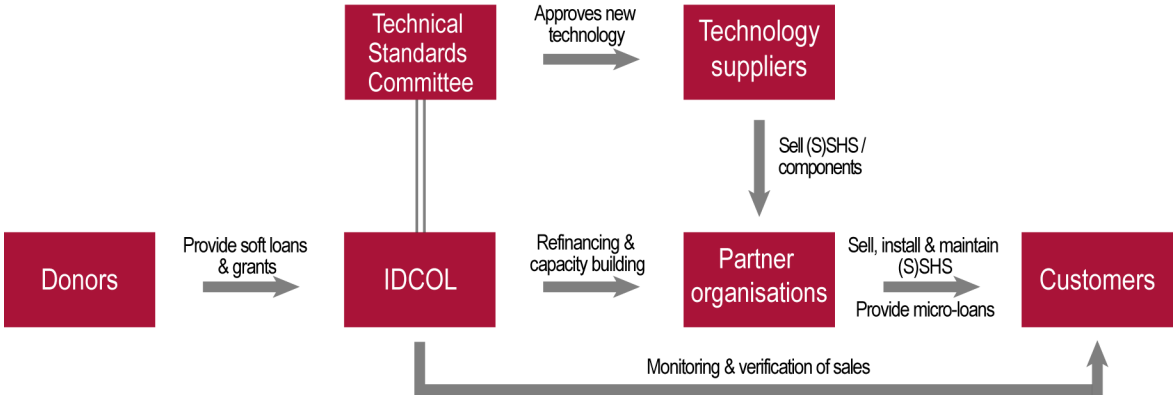
Within this scheme, IDCOL receives grants and soft loans from international donors such as the World Bank, the Asian Development Bank (ADB), or the Kreditanstalt für Wiederaufbau Entwicklungsbank (KfW). These funds are used for refinancing and capacity building of IDCOL's 46 POs, which sell, install, and maintain the (S)SHS through a network of small shops across the whole country[19] (IFC 2012: 54-55). Furthermore, the POs provide micro-loans to the customers and are in charge of the instalment collection, which is why this dissemination approach can be characterised as a *dealer credit model* or *one hand model* (IEA 2003: 7-10; SiNERGi 2009: 10). IDCOL carries out several monitoring activities including the verification of sales claimed by the POs as well as technical audits to ensure the performance of the systems (Schwan 2011: 52-54). Additionally, its Technical Standards Committee decides which solar system models are included in the dissemination scheme. Although POs are allowed to sell any solar system available on the market,

[18] The electricity access statistics vary considerably in different publications and therefore have to be treated with caution. One reason for this is that the informational base and methodology to calculate the electrification rate are not always the same. In its energy access database, the IEA only takes households into consideration with a first supply connection. Due to "general paucity of data on electricity access" (IEA 2012), the country-specific values are determined through a varying combination of sources (see also IEA 2013a).

[19] At the time of the field research the number of POs was 30 only. However, very recently IDCOL admitted 16 additional POs to participate in the (S)SHS dissemination (IDCOL 2013a).

they only receive refinancing and grants for (S)SHS that are approved by the Technical Standards Committee. Whereas various SHS models have been part of the IDCOL scheme since its launch in 2003, SSHS were not included until 2007[20] (GIZ 2013: 26-27). Figure 12 schematically illustrates IDCOL's solar energy programme.

Figure 12: Schematic overview of the IDCOL solar energy programme



Note: Some POs also construct (S)SHS components in their own manufacturing plants.
Source: IFC 2012: 55; modified | Graphic: Own elaboration

Among other activities, GIZ and other development agencies have supported the (S)SHS dissemination through IDCOL's solar programme with a subsidy scheme to reduce market entry barriers and enable the development of a self-sustaining market for solar systems in Bangladesh. The major share of the subsidies was used as a buy-down grant to make the (S)SHS more affordable for the rural population. Furthermore, a small grant for each disseminated (S)SHS was given to the POs for supporting their institutional development as well as to IDCOL for strengthening its management and monitoring capacities (GTZ 2009: 10-11; Kürschner et al. 2009: 21-24).

The subsidy scheme was designed in such a way that it would gradually phase out. The buy-down grants for SHS were as high as 70 USD when the programme was launched. After declining to 39 USD in 2008 they completely phased out at the end of 2012. SSHS received the same amount of buy-down grants as SHS since their introduction 2007. However, they are still subsidised by a buy-down grant of about 20 USD until the end of 2013 (GIZ 2013: 26; IFC 2012: 61; Schwan 2011: 51). In 2012, the customers had to pay about 160 USD for a 20 Wp system and 370 USD for a 50 Wp system[21]. A (S)SHS package typically includes a solar panel, a lead-acid battery, a charge controller, wires, and a small

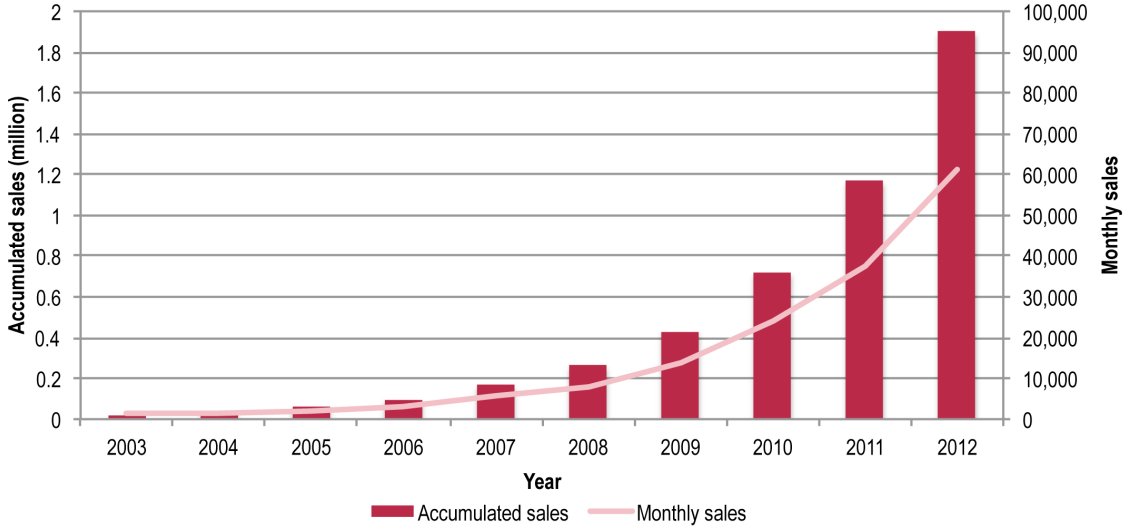
[20] PicoPV systems are not yet disseminated under the IDCOL scheme. However, it is expected that certain models will be approved by the Technical Standards Committee in the near future (GIZ 2013: 33-34).

[21] The official exchange rate from 31 December 2012 is used in the whole report (1 USD = 79.60 Bangladeshi Taka (BDT)).

number of lighting devices. Other appliances like TVs, radios, fans, or mobile phone chargers have to be purchased separately, if desired.

Despite the phasing out of the subsidies, IDCOL's solar programme is one of the world's fastest growing and most successful (S)SHS dissemination initiatives. Until the present day, 1.9 million (S)SHS have been distributed under the IDCOL scheme. Since 2003 the number of newly disseminated systems has steadily grown. Especially in the last few years the sales numbers have increased considerably and reached an average of about 60,000 (S)SHS per month in 2012 compared to only 8,000 in 2008 (figure 13). As a result, IDCOL revised its targets and set a new goal to finance four million (S)SHS by 2015, which is equivalent to 87,500 newly disseminated (S)SHS per month (IDCOL 2013a, 2013b).

Figure 13: Progress of the (S)SHS dissemination (2003-2012)



Data: IDCOL 2013a, 2013b | Graphic: Own elaboration

SHS account for 76.6 % of the cumulated sales. 50-59 Wp systems constitute the most popular system size among this group and reach a percentage of 28.2 %. Although only being disseminated since 2007, SSHS have steadily increased their market share and already represent 23.3 % of the total sales. In 2012, SSHS accounted for 35.9 % of the yearly sales, which underlines that Small Solar Home Systems currently constitute the most dynamic segment of the solar market in Bangladesh (IDCOL 2013b).

5 Results

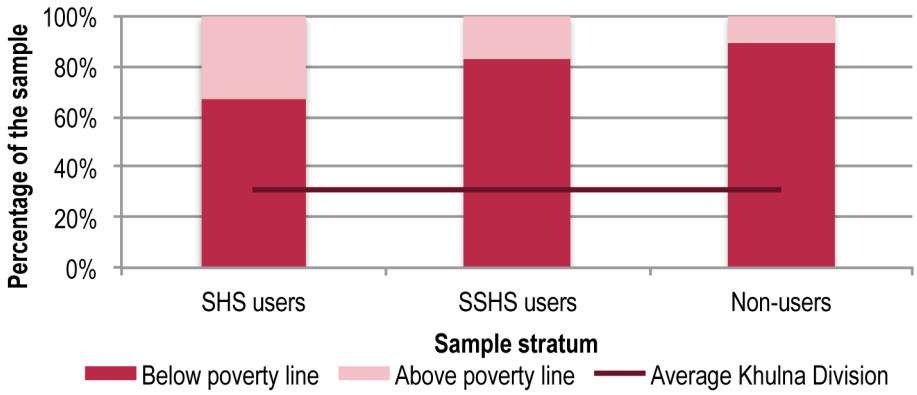
The preceding chapter has demonstrated that nowadays (S)SHS are widely spread across rural Bangladesh. But how exactly do these systems impact on the users' poverty situation? In order to answer this question, the poverty orientation of the (S)SHS dissemination is analysed first, followed by the financing modalities of the (S)SHS purchasing. Subsequently, the basic energy services delivered by the solar systems and the rationale and satisfaction of users and non-users are presented. Finally, the impacts on the different dimensions of poverty are investigated in detail. Unless otherwise stated, all presented results are based on primary data gathered during the fieldwork.

5.1 Poverty Orientation

The (S)SHS disseminated in the IDCOL programme are intended to be affordable for a high share of the rural population, including the rural poor. This is especially important for SSHS, which are believed to have a higher poverty orientation than the more costly SHS. According to the BMZ, a direct poverty orientation is given, if at least 50 % of the beneficiaries have a per capita income below the poverty line or the share of poor people is higher than the regional average (GTZ 2007: 31).

In order to assess if these thresholds are exceeded, the per capita income data for the different sample strata (SHS user, SSHS user, and non-user) is compared with the inflation-adjusted regional poverty line from the HIES 2010 (1,717 BDT per month)[22]. The resulting poverty headcount ratios are illustrated in figure 14.

Figure 14: Poverty orientation of the (S)SHS dissemination according to the regional poverty line



n (SHS users) = 165 | n (SSHS users) = 105 | n (non-users) = 100

Data: Household survey 2012 | Graphic: Own elaboration

[22] The upper regional poverty line for rural areas in Khulna Division was 1,435 BDT in 2010. This value was adjusted by the mean yearly inflation rate between 2010 and 2012 (9.4 %) (The World Bank 2013b).

The figure indicates that 67.1 % of the SHS user and 82.4 % of the SSHS users have a per capita income below the regional poverty line. In the case of the non-users this share is even higher and reaches 89.7 %[23]. Since the values for both user strata exceed the regional average and are higher than 50 %, it seems that the (S)SHS dissemination is indeed poverty oriented. However, acknowledging the arbitrary element and methodological limitations inherent to every poverty line (Lepenies 2010: 4-5), this result is crosschecked by determining the poverty headcount ratios according to several internationally used poverty lines as well. Table 1 shows the respective values for the 1 USD PPP poverty line used in the MDGs as well as the 1.25 USD PPP and 2 USD PPP poverty lines, which originate from a subsequent revision of the World Bank[24].

Table 1: Poverty headcount ratios according to different poverty lines

Income per day	SHS users	SSHS users	Non-users
< 1 USD PPP (1,078 BDT per month)	44.7 %	55.9 %	70.1 %
< 1.25 USD PPP (1,347 BDT per month)	55.9 %	74.5 %	81.6 %
< 1.59 USD PPP (1,717 BDT per month)	67.1 %	82.4 %	89.7 %
< 2 USD PPP (2,155 BDT per month)	76.3 %	90.2 %	94.3 %

Note: 1.59 USD PPP is equivalent to the inflation-adjusted regional poverty line.
Data: Household survey 2012

Apparently, even by taking the lowest poverty line as a reference, the share of poor SHS users almost reaches 50 % and the respective values for SSHS users never fall below this threshold. The non-users have a poverty headcount ratio of between 70.1 % and 94.3 %[25]. These results are a sharp contrast to the findings of Kürschner et al., which determined a poverty headcount ratio of only 23 % for their SHS sample (2009: 29). There are several possible explanations for this difference. Apart of biases related to the survey methodology, which can never be ruled out, especially one factor is very relevant: Although the divisional average for the poverty headcount ratio does not exceed 31 %, several of the surveyed villages seemed to have a much higher poverty incidence. Therefore, it is likely that

[23] The mean per capita income of SHS and SSHS users is 1,932 Taka and 1,438 Taka per month. Non-users earn on average 1,140 Taka per capita and month. The average income for rural dwellers in Khulna Division was 2,130 Taka in 2010 (BBS 2010: 28).

[24] Following the World Bank's database, a conversion factor of 1 USD PPP = 35.43 BDT was used to compare the local currency with USD PPP (The World Bank 2013b).

[25] Similar results are obtained when the regional poverty line from the HIES 2010 is applied without being inflation-adjusted. By taking 1,435 BDT as a threshold, 57.2 % of the SHS users, 75.5 % of the SSHS users and 83.9 % of the non-users are considered as poor.

in other rural areas where the poverty incidence is lower the share of poor (S)SHS owners does not reach the values obtained in this study.

Thus, what are the conclusions that can be drawn with respect to the poverty orientation of the overall approach? Since neither the sample of this study nor the one of Kürschner et al. is representative for all (S)SHS disseminated in Bangladesh, it cannot be inferred that a certain percentage of the total amount of users has an income below the poverty line. However, the high share of poor people among the (S)SHS users found in this study indicates that the framework conditions of the dissemination scheme are indeed suitable to reach the rural poor. Therefore, it can be concluded that the approach is directly poverty oriented. Another important finding is that SSHS indeed offer a higher poverty orientation than SHS[26]. This evidence supports the respective assumptions underlying their introduction into the IDCOL dissemination scheme.

5.2 Financing of (S)SHS

All of the interviewed POs offer potential customers the option to choose between a cash purchase and an instalment payment. Cash purchases are oftentimes advertised with a 4 % discount of the total price. The instalment option generally includes a 10-15 % upfront payment and a repayment period of 24 to 36 months with monthly instalment collection and a service fee of 7.5-12.5 % of the system price.

95.2 % of the surveyed households decided in favour of an instalment payment, of which the vast majority chose a repayment period of 36 months (94.5 %). This is not surprising considering the fact that the costs to purchase a (S)SHS are relatively high compared to the income levels of the rural population. According to the results of the qualitative appraisals, only few households would have been able to purchase a (S)SHS without the instalment option. Yet, this is not the only cause for the very high percentage of instalment payments. Some users reported that even if they had been able to purchase the (S)SHS at once, they would have chosen the instalment option. The reason for this is that as long as they have not yet completed their repayment period, they can stall their monthly payments and use this as a means of exerting pressure on the PO to carry out repairs quickly in case of problems with the solar system. Additionally, the PO staff member in charge of collecting the monthly instalments can check the (S)SHS and fix minor problems when visiting the household.

[26] The difference was found to be significant at a 99 % confidence level for all applied poverty lines but the 1 USD PPP poverty line by using a chi-squared test.

Sharing of solar systems between two or more households could theoretically lower the costs and thus make them affordable for poorer households as well (Kürschner et al. 2009: 31). Nevertheless, only one user stated to have bought his system together with someone who does not belong to his own family. This has to do with the fact that both households not only have to be situated in close vicinity but also need to have enough trust in the payment abilities of each other. As especially poor households cannot completely rule out the possibility of at least a temporary payment default, it becomes understandable that the option of sharing solar systems between several households is rarely used.

SHS users have to pay an average upfront amount of 4,872 BDT, whereas the respective amount for SSHS users was found to be 1,681 BDT. These values represent 15.6 % (SHS) and 11.6 % (SSHS) of the total systems costs. The monthly instalment payments are on average 747 BDT for SHS users and 363 BDT for SSHS users demonstrating that the instalments of a SHS pose a much heavier strain on the household's budget than in the case of a SSHS. Every fifth sampled household choosing the instalment option had already completed the repayment period, 78.6 % still had to pay the monthly instalments at the time of survey.

Despite the fact that instalment payment options are commonly regarded as a crucial factor to make solar technology affordable for poor people, concerns are sometimes raised that many households would run into debt to cover the upfront costs of the (S)SHS or would not be able to repay on time and eventually permanently default. Yet, in contrast to these apprehensions, only 17.5 % of the surveyed (S)SHS households used a loan to finance their solar system. Furthermore, in many of these cases purchasing a (S)SHS was not the main reason to take the loan but rather other major expenses such as a wedding or an urgent medical treatment of a household member. 38.1 % of the (S)SHS users reported to have faced temporary problems to pay their instalments on time. Not surprisingly, this share is significantly higher for users below the poverty line (47.2 %) than above (18.8 %) (chi-squared test, $p = 0.000$). The users generally stated that the variability of their monthly income was the main factor behind the temporary payment problems and at the time of the interview 78 out of 93 households (83.9 %) had already been able to solve the situation on their own[27]. The POs generally claimed that they would react flexibly to the users' financial situations and payment arrears of up to three months would not result in drastic

[27] Another important reason for temporary defaults was the cyclone 'Aila', which devastated the area in 2009 and heavily affected the livelihoods of many rural dwellers. Most of the POs responded to this state of emergency by suspending the instalment payments for six months.

measures such as the removal of the panel. 81.1 % of the users with temporary payment problems confirmed this assertion and stated that their respective PO usually accepts delayed payment. Yet, in a few cases, the (S)SHS users reported that PO members behave 'badly' and threaten them when they were not able to pay on time.

Thus, by and large, the financing modalities and informal arrangements between the POs and the (S)SHS users seem to be appropriate to ensure that many rural dwellers are able to purchase solar systems without defaulting permanently or running into debt. However, this does only apply for the purchase of a new (S)SHS. Additional components or replacements after the warranty period has expired can only be purchased in cash. While this is not a major problem for low-cost components such as lighting devices or mobile phone chargers, especially the replacement of the battery after its five-year warranty period poses a heavy financial burden for the (S)SHS owners. Particularly many SSHS users stated that they do not know how to afford a new battery without the possibility of an instalment payment[28]. Hence, if the POs do not start to offer such an option for the purchase of new batteries in the near future, it is possible that many of the disseminated (S)SHS lie idle after the old batteries stopped working.

5.3 Basic Energy Services

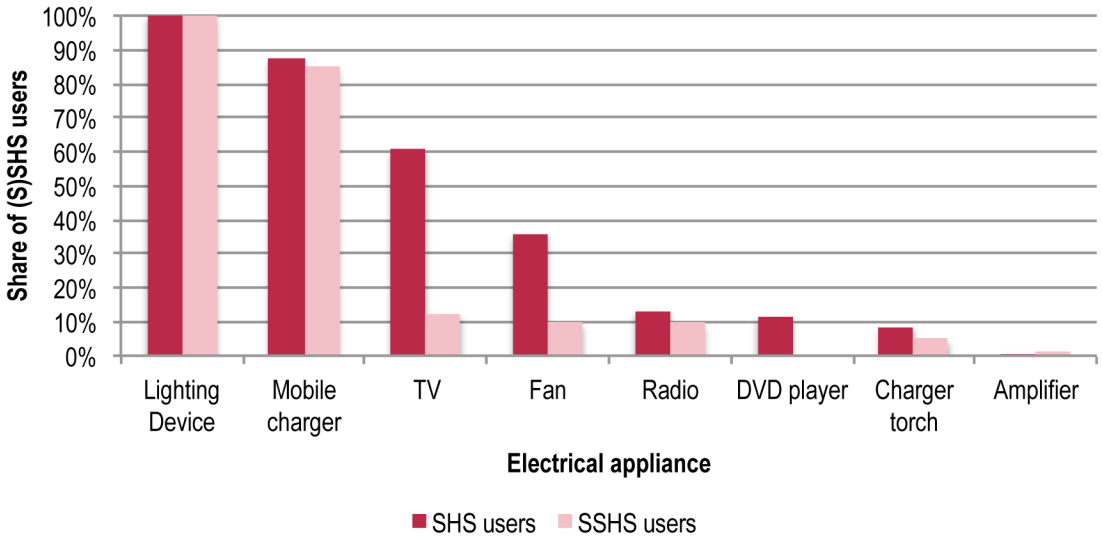
The basic energy services delivered by the (S)SHS are analysed in three parts. Firstly, the electrical appliances run by the solar system are examined. Secondly, the energy consumption patterns of (S)SHS users and non-users are compared. And thirdly, the performance and reliability of the (S)SHS and its appliances is investigated.

5.3.1 Electrical Appliances

Both SHS and SSHS can be used to power lighting devices and run small electrical appliances. On the one hand, their usage is determined by the system's nominal power output; on the other hand, they reflect the household's priorities and needs. Figure 15 shows the electrical appliances run by the (S)SHS in the surveyed households.

[28] SSHS with a nominal power of 20 Wp are generally sold with a 30 Ah lead-acid battery. The local price for such a battery is approximately 3,850 BDT, which is very high compared to the average upfront payment of 1,681 BDT and instalment rates of 363 BDT for such a system.

Figure 15: Electrical appliances in use with (S)SHS



n (SHS users) = 165 | n (SSHS users) = 105
Data: Household survey 2012 | Graphic: Own elaboration

Every solar system in the sample is used to run at least one lighting device, which indicates that light is the primary benefit generated from these systems. Additionally, more than four out of five (S)SHS are used to power a mobile phone charger. Since both lighting devices and mobile phone chargers require relatively low amounts of energy, it is not surprising that SHS and SSHS exhibit the same or very similar usage patterns. In contrast, considerable differences exist with regard to bigger appliances such as TVs, fans, or DVD players. Whereas 60.6 % of the SHS users have a TV in use, the respective share of SSHS users only reaches 12.4 %. Furthermore, one-third of all SHS users run a fan compared to only 9.5 % of the SSHS users. DVD players are not powered by any of the surveyed SSHS. Other appliances in use include radios, charger torches, and amplifiers.

On average, 3.7 lighting devices are powered by a SHS. The minimum amount of lamps was found to be one and the maximum nine lamps. The respective mean value for SSHS is considerably lower and only reaches 2.1 with a minimum of one and a maximum of seven light sources. In the case of SHS, tube lights are the dominant type of lighting devices with an average of 2.9 per household. Compact Fluorescent Lamps (CFL) and Light Emitting Diodes (LED) each account for 0.4 light sources per household. The most prevalent lighting devices for SSHS are CFLs (1.5 per household), followed by LEDs (0.4) and tube lights (0.2). Both SHS and SSHS households use about two-thirds of their lamps in the living areas. Other areas usually lit with the (S)SHS include the kitchen and outdoors, although the latter applies much more for SHS (0.9 lights placed outside on average) than for

SSHS (0.2 lights). Working areas and other locations are not frequently illuminated. The total wattage of all lights run with a SHS reaches an average of 32.9 Watt (W), SSHS are used to power a total wattage of 11.9 W. The distribution of the wattage over the different areas is similar to the distribution of the number of light sources. However, in the case of SSHS, the share of the wattage in the living area is somewhat higher (> 70 %) than the number of light sources would suggest, which means that the light sources in the living areas have a higher wattage per lamp than in the other illuminated locations. The average lighting time per day of the living area is between three and four hours for both SHS and SSHS users. Those households with lighting devices in the kitchen or outdoors frequently use them between one and three hours per day. The following table summarises the key information about the electrical appliances run by the solar systems.

Table 2: Key information about the electrical appliances run by (S)SHS

	SHS users	SSHS users
Most frequently used appliances	1. Lighting device (100 %) 2. Mobile charger (87.3 %) 3. TV (60.6 %)	1. Lighting device (100 %) 2. Mobile charger (84.8%) 3. TV (12.5 %)
Total number of lighting devices per household	3.7	2.1
Number of lighting devices per household by type	1. Tube light (2.9) 2. CFL & LED (0.4 each)	1. CFL (1.5) 2. LED (0.4) 3. Tube light (0.2)
Total wattage	32.9 W	11.9 W
Main illuminated areas	1. Living area 2. Outdoors 3. Kitchen	1. Living area 2. Kitchen (3. Outdoors)
Lighting time of the living area	3-4 hours	3-4 hours
Lighting time of other areas (if applicable)	1-3 hours	1-3 hours

Data: Household survey 2012

16 users and 13 non-users are also connected to the electricity grid. The grid-electrified (S)SHS users run on average five lamps with this power supply accounting for a total wattage of about 90 W. Tube lights are the most common light source. The non-users are equipped with an average of four lighting devices with a total wattage of 130 W. Apart of these light sources, TVs, fans, and mobile phone chargers are the most common electrical appliances powered by the grid. Both the grid-connected users and non-users stated that power cuts occur very frequently throughout the whole day and usually last about two hours.

5.3.2 Energy Consumption Patterns

Chapter 4.1 has shown that many rural dwellers heavily rely on kerosene and other energy sources like storage batteries or dry cells to meet their basic energy needs. (S)SHS are generally expected to reduce the energy consumption of these 'traditional' energy sources. Especially the demand for kerosene is assumed to decline, as kerosene-based light sources can be replaced by electric lighting devices. In order to assess if these effects actually materialise, the (S)SHS users were asked about their energy consumption of several energy sources before and after the purchase of the solar system[29]. Additionally, non-users were questioned about their current energy consumption patterns. The mean values for the monthly consumption of the different energy sources are presented in table 3.

Table 3: Energy consumption patterns before and after the (S)SHS purchase

Monthly consumption	SHS users			SSHS users			Non-users
	Now	Before	Change	Now	Before	Change	Now
Kerosene	0.34 l	3.65 l	-3.31 l	0.21 l	2.58 l	-2.37 l	2.46 l
Diesel (generator)	0 l	0 l	0 l	0 l	0 l	0 l	0 l
Storage batteries	0.01 chgs	0.09 chgs	-0.08 chgs	0.01 chgs	0 chgs	0.01 chgs	0.07 chgs
Dry-cell batteries	1.6 pcs	2.1 pcs	-0.5 pcs	1.8 pcs	2.4 pcs	-0.6 pcs	2.4 pcs
Candles	0.05 pcs	0.15 pcs	-0.1 pcs	0 pcs	0 pcs	0 pcs	0.19 pcs
Grid electricity*	N/A	N/A	N/A	N/A	N/A	N/A	N/A

*** Since only very few sampled households have a grid connection, the mean value for all surveyed users and non-users would be misleading and was therefore not included in this table.**

l = litres | chgs = charges | pcs = pieces

Data: Household survey 2012

The table demonstrates that the most important change in the energy consumption pattern is indeed the reduction of kerosene. SHS users reduced their monthly kerosene consumption from 3.65 litres to 0.34 litres, which is equivalent to monthly kerosene savings of 3.31 litres. In the case of the SSHS, this quantity was reduced from 2.58 litres to 0.21 litres, thus 2.37 litres are saved per month. Hence, the kerosene reduction induced by SHS exceeds the

[29] The related energy expenditures were also surveyed. These findings are discussed with regard to the impact on economic capabilities in chapter 5.5.1.

one of SSHS by approximately one litre. Both consumption values for the current situation lie far below the average kerosene usage of non-users (2.46 litres)[30].

The quantity of dry-cell batteries decreased by about half a battery per month. SHS users now consume 1.6 pieces per month, SSHS users 1.8 pieces. The respective non-user quantity at the present day is 2.4 pieces. Diesel generators, storage batteries, and candles only play a minor role as an energy source or were completely absent already before the (S)SHS was purchased (the same applies for the non-users now). Therefore, the respective changes due to the (S)SHS usage are negligible. Although 29 households stated to be connected to the electricity grid (both through official connections and side lines), only very few could quantify their monthly consumption. Furthermore, many of the grid-connected (S)SHS users only received their connection *after* purchasing the solar system. Thus, it was not possible to assess an effect of the (S)SHS on the grid electricity consumption.

Despite the fact that the (S)SHS have significantly reduced the consumption of kerosene, 102 users still regularly buy small amounts of this fuel. Additionally, 131 users still purchase at least two dry-cell batteries per month. Whereas kerosene is generally used to light kupis or hurricane lamps[31], dry-cell batteries are mainly applied in torches. Table 4 provides an overview of those lighting devices still being used every day.

Table 4: Light sources still in use every day

	SHS users	SSHS users	Non-users
Kupi	35.6 %	32.7 %	92.9 %
Hurricane	5.6 %	6.7 %	69.4 %
Torch	43.6 %	55.8 %	62.6 %
Candle	0.6 %	0 %	2.0 %

Data: Household survey 2012

At the present day, significantly more non-users apply kerosene-based lighting devices than (S)SHS-users. Yet, every third user claimed to use at least one kupi every day alt-

[30] A more detailed overview of the kerosene usage of grid and off-grid households is provided in appendix 12. In the case of grid-connected households, it could not be exactly determined how much of the kerosene reduction can be accounted to the (S)SHS and how much to the electricity connection. Yet, the comparison of the kerosene consumption in grid-connected user and non-user households at the present day indicates that (S)SHS reduce the monthly kerosene usage of grid-electrified households by at least one litre. Since the share of grid-connected households in the three sample strata never exceeds 15 %, however, this uncertainty only has a limited influence on the average values presented in table 3.

[31] Kupis (in the survey area also known as 'temis') are "uncovered lamps with a single handmade wick" (Asaduzzaman/Barnes/Khandker 2010: 27). Hurricane lamps have a glass chimney, its wick is thicker and oftentimes purchased. The light from the more expensive hurricane lamps is generally brighter than from kupis and the glass chimney makes it a somewhat safer light source (ibid.).

hough having a functional (S)SHS at home. Additionally, about 50 % of the (S)SHS users switch on a torch every day.

Torches are a convenient mobile light source the rural dwellers frequently use when being outside the house at night or in the early morning. Especially fishermen and owners of fish or shrimp cultivations stated that they would heavily depend on torches to carry out their work. Since (S)SHS only provides light in the immediate surrounding of the house (if at least one light source is placed outside), they cannot generate the same benefits as torches, which is why the observed reduction in dry-cell consumption only reflects the decreased need to use torches at home. Although solar-driven charger torches could theoretically fill this gap, many users reported that they would prefer torches with dry-cell batteries because they do not trust the charger torches available on the market.

The relatively high share of (S)SHS households having at least one kupi in use every day could possibly indicate that kerosene-based lighting devices are still an important light source for rural households. Yet, on average these lamps are only in use for 10 to 15 minutes per day. This is considerably less than the 3.5 to 4 hours before the purchase of the (S)SHS and the 3.7 hours kerosene-based lamps are lit in non-user households at the present day. Additionally, in many cases kupis are not even used for lighting purposes anymore but solely as a convenient way to ignite the fireplace for cooking. Table 5 shows the locations where kerosene-based light sources were used for illumination before and are still in use at the present day.

Table 5: Location of kerosene-based light sources

	SHS users		SSHS users		Non-users
	Now	Before	Now	Before	Now
Living area	4.3 %	100 %	5.8 %	98.0%	92.9 %
Kitchen	9.8 %	87.1 %	11.7%	79.4%	76.5 %
Outdoors	2.4%	73.0 %	2.9%	50.0%	46.9 %
Working area	1.8 %	7.4 %	0 %	2.0%	3.1 %
Other areas	0 %	0 %	1.0%	1.0%	1.0 %

Note: The percentages represent the share of households having at least one kerosene lamp in use every day in the respective locations. Kupis used to ignite the fireplace only are not included in this table.
Data: Household survey 2012

The table demonstrates that both SHS and SSHS users barely illuminate their homes with kerosene-based light sources anymore. While before purchasing the (S)SHS the living area was lit with kupis or hurricane lamps in almost every household, this percentage has now

dropped to about 5 %. The kerosene usage in the kitchen and outdoors has declined sharply as well. Furthermore, only three (S)SHS users reported to light a location with a kerosene lamp now where they did not use it before. The non-users have a similar illumination pattern at the present day as the SSHS users had before they bought the solar system.

Thus, in summary it can be stated that the decrease in the monthly kerosene consumption, the low average time of kerosene-based light sources in use every day, and the sharp decline of locations illuminated by these lamps strongly indicate that both SHS and SSHS successfully replace kerosene as the main energy source for illumination. Due to the higher number of electrical lamps, SHS have a somewhat greater potential for kerosene reduction than SSHS. However, the current kerosene consumption of the non-users only reaches about 2.5 litres per month and their kerosene usage pattern is similar to the SSHS users' pattern before purchasing the solar system. Therefore, the dissemination of SHS or SSHS to this group would probably result in approximately the same decrease of kerosene.

5.3.3 Performance of the (S)SHS

All of the sampled (S)SHS were functioning and in use when the household survey was carried out. However, despite that fact that only 13.3 % of the solar systems were installed more than five years ago, 49.3 % of the (S)SHS users reported to have encountered minor or severe problems since the purchase[32]. In the case of severe problems, the most common complaints are with regard to the battery and the charge controller[33]. Minor problems are usually associated with the light sources, switches, and wires. 68 interviewees stated that the problems had been solved already, whereas in 52 cases they were still persistent. It could not be exactly identified how many of these problems are caused by malfunctioning components and how often inappropriate use is the main reason. However, both the PO staff members and (S)SHS users claimed that the rural households would need a better training in order to use the solar system properly.

171 (S)SHS users (63.3 %) have already replaced at least one component of the system[34]. Lighting devices are by far the most frequently replaced parts. 44.6 % of all users have already substituted at least one light source because of malfunctions. Charge controllers

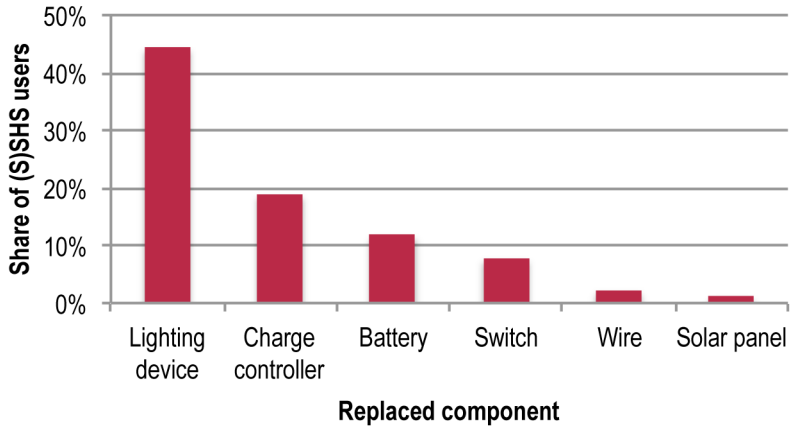
[32] As the SHS stratum contains a higher number of older systems, they are more likely to fail than recently installed SSHS. Therefore, a direct comparison between both sample strata with respect to the systems' performance would be misleading and is not carried out here.

[33] The users could not always express the exact nature of the problem. 'Low charge' as well as a general 'battery damage' (when the battery completely stopped working) are frequently stated issues.

[34] This value is higher than the share of users stating a problem, because not all of the users perceived the replacement of a lighting device as problem worthwhile reporting.

(19.0 %) and batteries (11.5 %) are the second and third most replaced components. Furthermore, 10 % of all (S)SHS users have substituted other small components such as switches or wires. Solar panels have been replaced in three households (1.1 %) (figure 16).

Figure 16: Replacement of (S)SHS components



n = 270

Data: Household survey 2012 | Graphic: Own elaboration

55.4 % of these replacements were stated as warranty cases, 44.6 % of the users had to pay for the new components. Yet, the share of warranty cases for the more expensive components such as solar panels, batteries, and charge controllers is much higher than for lighting devices, switches, or wires. As the warranty period for solar panels lasts 20 years, all three damaged panels were replaced free of charge. Moreover, 83.3 % of all replaced batteries and 82 % of all charge controllers were warranty cases. The median expenditure for replacements is 170 BDT reflecting the typical costs for new lighting devices and other small components. On the other hand, in the few cases where a new battery had to be purchased the replacement costs were very high (> 7,500 BDT).

Almost 60 % of the households with a warranty case stated that they have been very satisfied with the warranty service of the PO compared to 11.2 % being somewhat unsatisfied or very unsatisfied. These negative experiences are mainly linked to a very long response time of the PO or the use of second-hand components as replacements. Similar positive results were found for the regular visits of PO staff members. In 96.5 % of all households with an on-going repayment period the PO employee in charge of instalment collection visits the household regularly. 85 % of the users stated that he would check the (S)SHS always or sometimes during his visits, which is appreciated very much by most of the households. Only in a few cases the users expressed their discontent with the instalment

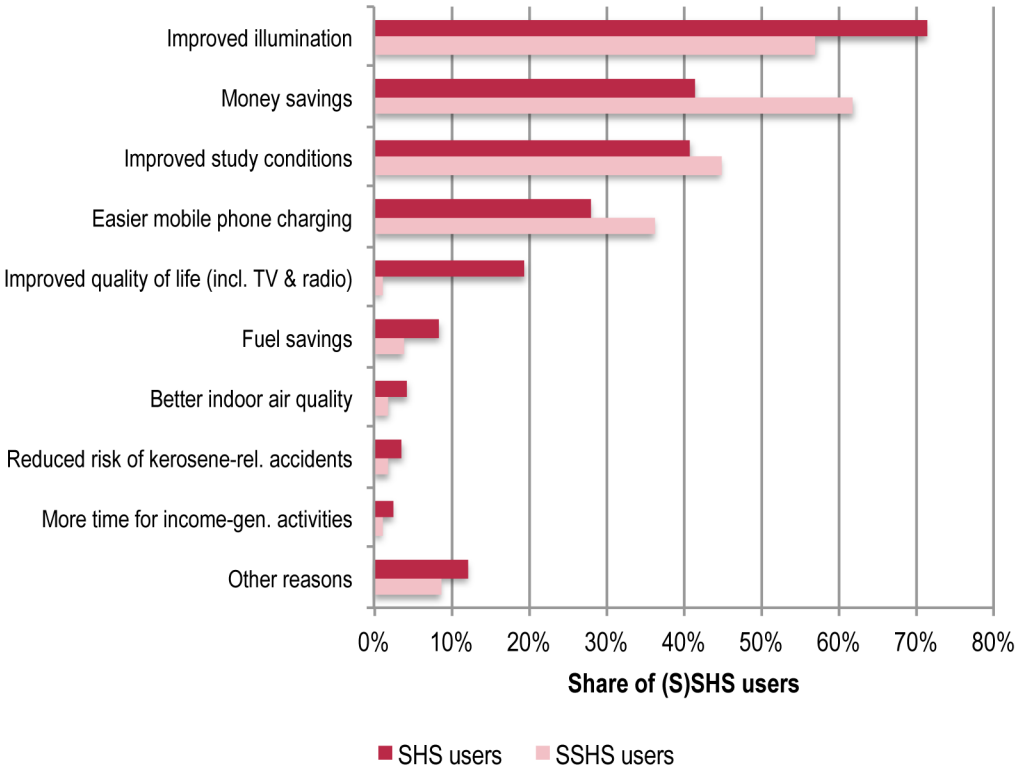
collector, which was related to the fact the he is either not capable of checking the (S)SHS due to insufficient training or he behaves impolitely and dismissively.
However, the maintenance situation changes drastically after the repayment period is completed. Less than one out of four users having finished the instalment payments stated to have some kind of (formal or informal) arrangement that would ascertain maintenance service and it could not be verified what these arrangements actually include. In many cases the users are not aware of such an option and it was oftentimes claimed that the PO does not offer any maintenance services subsequent to the instalment collection. Therefore, it can be concluded that maintenance services after the repayment period are only provided in exceptional cases.

5.4 Rationale and Satisfaction

As in many off-grid areas in rural Bangladesh, the density of (S)SHS in the surveyed villages is relatively high. Therefore, it is not surprising that 72.9 % of all users stated to know about the solar systems and their benefits because they had seen them in another household. 15 % were told about the benefits by another person (such as a relative or neighbour), 11.7 % were personally informed by PO staff members. In 46.2 % of all households the husband was the household member having the initial idea to purchase a (S)SHS, whereas 65 interviewees (24.6 %) reported that it was a joint idea of the whole family. Children came up with the idea in 17.8 % of all cases, the wife took the initiative in only 3.8 % of the interviewed households. The eventual decision to buy the solar system is even more dominated by the male household members. In 57.8 % of the households the husband took the final decision, followed by (usually the male) children (8.9 %) and the wife (2.6 %). Joint decisions were stated in 28.5 % of all cases.
Most of the (S)SHS users claimed that they were well informed about the benefits of a solar system and the differences between the various system sizes before buying one. Asked about their rationale to purchase the solar system, particularly four reasons appeared to having triggered the purchase decision of both the SHS and SSHS users: ‘improved illumination’, ‘money savings’, ‘improved study conditions’, and ‘easier mobile phone charging’. While the SHS users most frequently stated ‘improved illumination’ as one of the three main reasons (71.3 %), ‘money savings’ is the most common answer of the SSHS users (61.9 %). Another notable difference is that 19.5 % of the SHS users ranked ‘improved quality of life’ (which includes the use of TV and radio) as one of the top three

reasons. SSHS users, of which only very few run a TV with their solar system (cf. chapter 5.3.1), did only choose this answer once. Other reasons such as 'fuel savings', 'better indoor air quality', 'reduced risk of kerosene-related accidents', or 'more time for income-generating activities' were rarely given as an answer. Figure 17 provides an overview of the different reasons stated by the SHS and SSHS users.

Figure 17: Main reasons for the decision to purchase a (S)SHS



n (SHS users) = 165 | n (SSHS users) = 105
Note: Up to three reasons could be stated per household.
Data: Household survey 2012 | Graphic: Own elaboration

In addition, SSHS users were asked specifically about their motivation to buy a 20 Wp system instead of a bigger one. 72.8 % responded that they could not afford the higher costs of a SHS. 21.4 % stated that they do not need more power. This again demonstrates that the higher affordability of SSHS is an important advantage versus the SHS. 61.3 % of the SSHS users claimed that they would have tried to save more money to buy a bigger system, if the SSHS had not been available. Yet, many of them were not sure if they had been able to cover the upfront costs even after saving for a long time. If they had a bigger system in their home, 60.6 % of the SSHS users would use it to run a TV. Other appliances

that are commonly desired include fans (37.5 %) and additional lighting devices (32.7 %). Radios, DVD players, or charger torches only play a minor role.

All of the interviewed non-users are aware of the existence of (S)SHS in their villages and 79 % expressed the wish to purchase a solar system. Analogously to the users' answers, 'improved illumination' (70.5 %), 'improved study conditions' (55.1 %), 'money savings' (48.7 %), and 'easier mobile phone charging' (23.1 %) were stated most frequently as one of the three main reasons. All but one non-user wishing to buy a (S)SHS claimed not to have one because they could not afford it. A similar rationale was given by eight non-users that did not want to purchase such a system. They reported that they 'could not even dream' of purchasing a (S)SHS due to their financial situation. Hence, for 85 % of all non-users, financial constraints are the major reason for not having a solar system at home. Eight users do not want to purchase one, because they wait for or already have a grid-connection. Only three responded that a (S)SHS would not be worth its price.

The satisfaction level of SHS and SSHS users with their respective solar system is relatively high[35]. Almost 60 % of all (S)SHS users were 'very satisfied' and another 7.8 % claimed to be 'somewhat satisfied'. A mere 6 % of the users reported to be 'somewhat dissatisfied' or 'very dissatisfied'. The fact that only 11.9 % of the users reported at least one specific aspect that they dislike about the (S)SHS reinforces this positive impression. The main reasons for the dissatisfaction are the battery in general, its storage capacity, and a low charge after a few cloudy days[36]. 75.8 % of the (S)SHS users would recommend or have already recommended the solar system to someone else. The remaining 24.2 % either do not regard it as necessary to recommend the (S)SHS because 'everybody knows it already' or they are dissatisfied and therefore do not want to recommend it.

5.5 Poverty-reducing Impacts

The preceding chapters of the results section discussed to what extent the rural poor benefit from the (S)SHS dissemination, how the users finance their solar system, which basic energy services the solar systems deliver, and why the rural dwellers did or did not purchase a (S)SHS. On the basis of these results, the last part of the analysis now focuses on the

[35] The differences in the satisfaction level between SHS and SSHS users were not found to be significant (chi-squared test, $p = 0.509$).

[36] In some cases the users' discontent with certain aspects was revealed at another point of the interview, although s/he did not claim to dislike some specific aspect earlier. Therefore, the actual number of users with specific complaints can be assumed to be slightly higher than the 11.9 % stated above.

poverty-reducing impacts of the solar systems, which are assessed according to the results model developed in figure 7.

5.5.1 Economic Capabilities

The (S)SHS dissemination is assumed to enhance the economic capabilities of the users in two ways: through a reduction of the energy-related expenditures as well as new and extended income-generating activities at home.

Energy-related Expenditures

Chapter 5.3.2 has shown that both SHS and SSHS have caused a reduction in the consumption of kerosene, dry-cell batteries, and other energy sources previously used by the rural households. Analogously, the related expenditures have declined. At the present day, SHS users spend on average 44.3 BDT on energy sources per month, which is 156.1 BDT less than the average amount before the SHS purchase (200.4 BDT)[37]. SSHS users have reduced their energy-related expenditures from 166.1 BDT to 42.7 BDT being equivalent to monthly savings of 123.4 BDT. The major share of these savings originates from the reduction of kerosene consumption, followed by the decline in dry-cell batteries used per month.

Non-users pay an average amount of 221.2 BDT at the present day, which is higher than the (S)SHS users' energy-related expenditures before they bought their system. The reason for this is that in the past few years the kerosene price rose significantly and reached 68 Taka per litre in 2012[38]. As a consequence, those rural households still depending on kerosene for lighting purposes have to spend much more financial resources to buy the same amount of fuel than they did before. It is due to these additional expenditures that the saving potential of newly disseminated systems is considerably higher than it was several years ago.

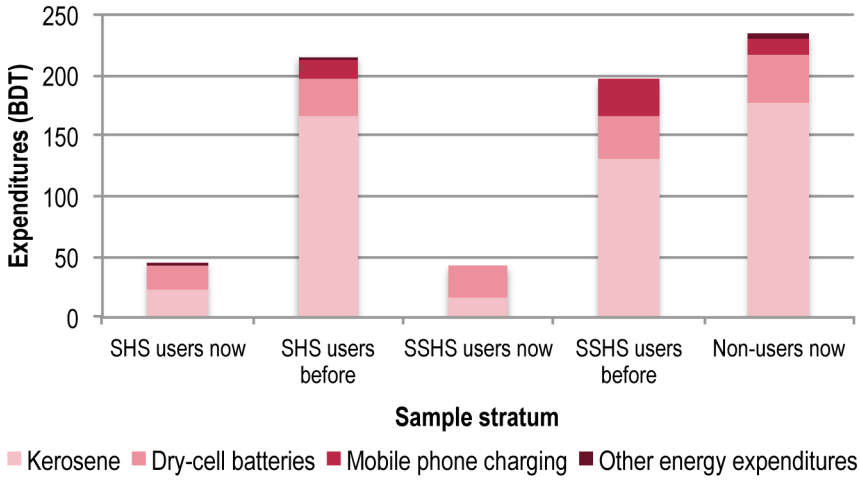
Another expenditure that is reduced by the (S)SHS is the cost for charging mobile phones. Before purchasing the solar system, SHS users paid on average 15.2 BDT per month, SSHS users had somewhat higher expenditures of 30.0 BDT. At the present day, the respective expenditures of (S)SHS users have dropped to 0 BDT, whereas non-users still pay on average 14.6 BDT per month. Figure 18 summarises the stated expenditures of the

[37] Expenditures on grid electricity (only applicable in grid-connected households) are not included in these values.

[38] This value represents the mean price the (S)SHS users and non-users have to pay at the location where they usually purchase their kerosene supplies.

(S)SHS users before and after the purchase of the solar system as well as the non-users' expenditures at the present day.

Figure 18: Energy-related expenditures of (S)SHS users and non-users



n (SHS users) = 165 | n (SSHS users) = 105 | n (non-users) = 100
Note: Expenditures on grid electricity (only applicable in grid-connected households) are not included in this figure.
Data: Household survey 2012 | Graphic: Own elaboration

In order to determine the net effect of the (S)SHS on the users' economic capabilities, the expenditure savings have to be compared with the total system costs. Obviously, the relatively high upfront costs and instalment payments result in a negative net effect in the first few years. Yet, since the expenditure savings continue after the payment is completed, a hypothetical break-even point will be reached after a certain period of time.

Based on the price of the solar system on the one hand and the stated expenditure savings on the other (thus neglecting potential replacement costs), the majority of SHS users will only have reached their break-even point after ten to fifteen years. The respective duration for SSHS is considerably lower. 50 % of the SSHS users will start to save money after a maximum of approximately seven years. The reason for this pronounced difference is that the price of a SHS is disproportionally higher than the additional expenditure savings compared to a SSHS.

Nonetheless, neither of the determined break-even points lies within the five-year warranty period of the battery. As it can be expected that most of the batteries have to be replaced or substantially repaired after five to seven years, the users face large additional investments before the expenditure savings outweigh the initial purchasing costs. Therefore, particularly in the case of the SHS, it is unclear when (or even if) most of the users reach their break-

even point, which is why a positive net effect on the economic capabilities through expenditure savings cannot be expected in the medium term. To the contrary, especially the bigger and more expensive systems among the group of SHS clearly decrease the economic capabilities of their users. Due to their lower price, SSHS are much more promising in this regard. Yet, despite the recent kerosene price hikes, also the break-even point of newly disseminated SSHS is rarely reached within five years.

Income-generating Activities at Home

Another potential effect of (S)SHS on the economic capabilities is that the solar systems can be used to start new or extend existing income-generating activities at home due to improved lighting in the evening hours. However, only about 30 % of the surveyed households stated to carry out such activities. The respective differences between the (S)SHS users and non-users are negligible, the same applies for the comparison of SHS and SSHS. 'Sewing and embroidery' is by far the most frequent activity in (S)SHS households (58.4 %), followed by 'small-scale livestock and poultry farming' (26.0 %) as well as 'teaching at home' (9.8 %) and 'processing of crops' (6.5 %). In 93.7 % of the cases, these activities were mainly carried out by adult women. Adult men participated in 19.2 % of all user households with on-going income-generating activities at home, children under 16 in only two cases.

In 56.8 % of the user households, the time female adults spend on these activities has increased since the (S)SHS was purchased. Nonetheless, the reported average time of 3.1 hours per day lies below the respective non-user value of 4.0 hours. 71.6 % of the user households with income-generating activities at home stated that women could carry out these activities more comfortably than before. It was difficult to obtain reliable information about the change of income from the home-based activities since the (S)SHS purchase. However, triangulation of the available quantitative and qualitative data indicates that the amount of additional income is low, if present at all.

Thus, the evidence suggests that the effect of (S)SHS on economic capabilities through income-generating activities at home is very limited. An important reason for this is that electric light is only *one* input factor for income-generating activities. Many (S)SHS users reported that other constraining factors such as insufficient training, not enough capital to purchase machinery, or the lack of middlemen or other mechanisms to sell the produced goods outside the own village prevent them from engaging in new or more productive activities. In addition, some rural dwellers stated that the male household members already

had a time-consuming and oftentimes arduous work and the female adults would not have enough time due to their other household duties.

5.5.2 Human Capabilities

The human capabilities of (S)SHS users are assumed to be positively affected by better health conditions, improved education, and an increased level of information.

Health

Asked about the effect of the (S)SHS on their health situation, only 50.6 % of the users stated that it would be positive. The other half of the sample (48.2 %) responded that they do not perceive any effect and three users reported a negative influence on their health status. Yet, interestingly, 62.9 % of the households claiming that there would be no effect of (S)SHS on their health stated that the use of kerosene would be harmful. Hence, they are aware of the connection between kerosene and their health condition but cannot immediately recognise how (S)SHS have an effect on this. The vast majority of users stating that (S)SHS would have an effect on their health explained it by an improved indoor air quality (80.5 %). 14.8 % responded that kerosene-related accidents would be less likely now. As both of these linkages had been anticipated beforehand, they were investigated in greater detail during the fieldwork[39].

According to the World Health Organization (WHO), indoor air pollution is causally linked to several respiratory diseases. Children under five years of age mainly suffer from pneumonia and acute lower respiratory infections, whereas adults are especially exposed to chronic obstructive pulmonary diseases (WHO 2007: 1). Although solid fuels used for cooking are clearly the main source for indoor air pollution (Duflo/Greenstone/Hanna 2008: 7-9), kerosene-based lighting is also a contributing factor.

With respect to their satisfaction with the indoor air quality, a significant difference was found between the (S)SHS users and non-users (chi-squared test, $p = 0.000$). Almost 70 % of both SHS and SSHS users are ‘very satisfied’ or ‘somewhat satisfied’ compared to a mere 30 % of the non-users. Dissatisfaction was only stated in less than 4 % of the user households. Furthermore, about 60 % of the (S)SHS users claimed that the indoor air quality had improved; only one user stated that it had worsened. Female adults are the household members suffering most often from illnesses such as ‘headaches’, ‘eye prob-

[39] The few households reporting a negative effect explained this by an increased number of mosquitoes due to the brighter illumination as well as higher temperatures inside the house caused by the electrical lights.

lems', or 'breathing problems'. Although about 80 % of the interviewees claimed that the respective household members would not suffer from illnesses more or less often than before the (S)SHS purchase, the prevalence of these illnesses is significantly lower in the case of both female adults (chi-squared test, $p = 0.000$) and children ($p = 0.045$) from user households than from non-user households[40].

Since the mentioned illnesses do not only depend on the indoor air quality and unobserved differences might exist between the treatment group and the comparison influencing their health condition (cf. chapter 3.1), it cannot be directly inferred that (S)SHS actually reduce their prevalence. However, the available evidence leans in the direction that the health condition of female adults and children – being the household members spending most time at home – is indeed positively influenced by (S)SHS.

Although not being such a prominent cause for diseases as indoor air pollution, the danger of kerosene-related accidents can negatively affect the health condition of rural dwellers as well. In fact, Mashreky et al. found in their large-scale study on childhood burns in Bangladesh that these accidents account for 23 % of all infant burns and 11 % in the age group of one to four years across the country (2008: 859). Additionally, kerosene lamps are a potential cause for fires, particularly when used close to a mosquito net or other easily flammable materials.

30.4 % of the (S)SHS users had suffered from at least one kerosene-related accident in their home before they purchased the solar system, which is very similar to the 29 % of non-users having experienced such accidents in the last few years. For both strata, fires are the most frequently stated type of accident (about 60 %), burnings account for the remaining 40 %. Only one household reported that a child had accidentally drunken kerosene, however, several interviewees claimed that they are very afraid of this possibility. Only 3.8 % of all (S)SHS users have experienced any type of kerosene-related accidents since they purchased the solar system, which is a significantly lower share than before. This demonstrates that (S)SHS successfully reduce the danger of kerosene-related accidents and thereby positively influence their users' health condition.

Education

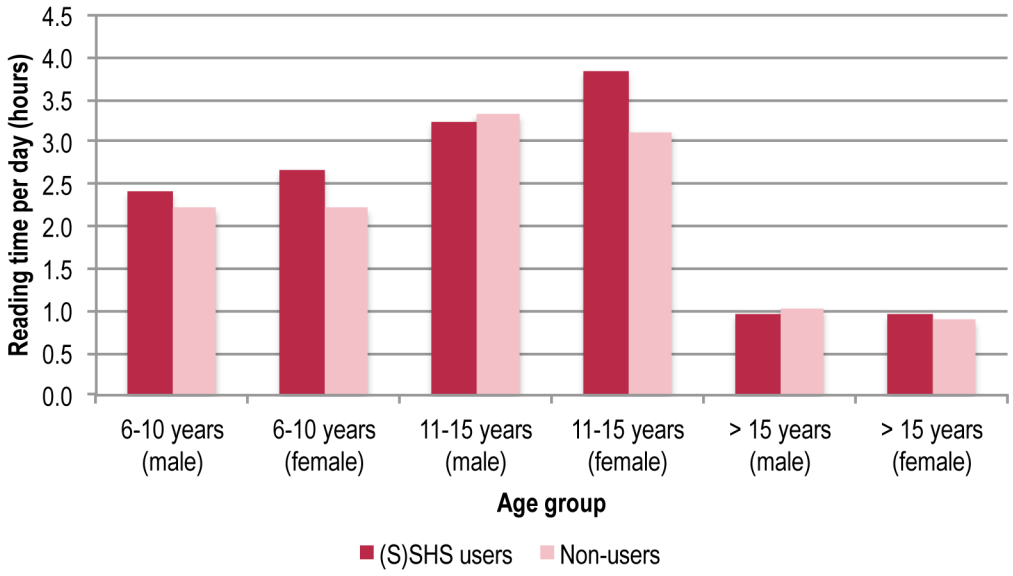
Over 40 % of the (S)SHS users stated that 'improved study conditions' was one of their main reasons to purchase a solar system. This is essentially linked to the advantages of electric lighting devices, which are brighter, easier to use, and cleaner than kerosene-based

[40] The respective chi-squared test for male household members yielded a non-significant result ($p = 0.425$).

lamps. In order to evaluate if these improvements also result in longer study and reading time, data on literacy, gender, age, and study hours was collected for every household member separately.

The literacy rate of all male household members was found to be 70.0 %, which is slightly higher than the respective rate of the female household members (65.8 %)[41]. In order to be able to interpret the average reading time per day of the literate household members more precisely, the sample was divided into three groups: primary school children (six to ten years of age), secondary school children (11 to 15 years of age), and adults (more than 15 years of age)[42]. Furthermore, all of these groups were analysed for male and female household members separately. Figure 19 provides an overview of the respective values for (S)SHS users and non-users[43].

Figure 19: Average reading time of literate household members in user and non-user households



n ((S)SHS users) = 270 | n (non-users) = 100
Data: Household survey 2012 | Graphic: Own elaboration

The figure illustrates that school children clearly spend more time reading at home than adult household members. In (S)SHS user households, 11 to 15 years old girls have the highest average value (3.8 hours per day), followed by their male coevals (3.2 hours). In the non-user households this order is reversed, as 11 to 15 year old males read on average

[41] The adult literacy rates of the sampled households according to the age threshold used by the UN (age 15 and above) are 69.6 % for male and 62.5 % for female adults.

[42] The respective age thresholds were adapted from the Bangladesh Bureau of Educational Information and Statistics (BANBEIS 2012).

[43] Since the differences between SHS and SSHS users were found to be very small, they are presented as one stratum.

3.3 hours per day compared to 3.1 hours of the respective female stratum. These absolute values, however, have to be treated with caution, because a tendency to overestimate the study and reading time of the household members was observed. Yet, since this applies for both (S)SHS users and non-users, the differences between the two strata are not affected by this bias.

The comparison of the different user and non-user strata reveals that – in contrast to adult household members – school children from households with (S)SHS indeed spend more time studying than the respective age groups from non-user households. Female children, especially those between 11 and 15 years of age, seem to benefit most from the improved study conditions. These results are underpinned by the fact that between 81 % and 90 % of the male and female school children were reported to having increased their study time since the (S)SHS purchase[44]. Yet, the differences between users and non-users are not very pronounced and in the case of 11 to 15 years old males, non-users even have a slightly higher average study time. Hence, it can be concluded that (S)SHS increase the average study time of school children, but the effect is not very strong. Furthermore, no conclusive evidence could be found that the (S)SHS would increase the study and reading time of male and female adults.

Even though the (S)SHS do not result in a strong increase of the average study time in every age group, the vast majority of interviewees reported that the study conditions had improved significantly. This was oftentimes regarded as a great relief particularly for the children and highly appreciated by all household members. Asked about the exact nature of the improvements, all three aspects mentioned above – brighter, cleaner, and easier illumination – were frequently stated.

Both the improvement of the study and reading conditions for all household members and the modest increase in the study time of school going children are valuable outcomes of the (S)SHS dissemination. However, it has to be clearly stated that these are not the only determinants for the level of education and other factors such as the teachers' qualification, their absence rates, or the didactic methods applied (to name only a few) seem to have a stronger influence in this regard. Therefore, the (S)SHS dissemination does not directly lead to significantly better educational attainments, but it rather enables the school children to harness the educational potential determined by other influencing factors more effectively and comfortably.

[44] The respective value for adult household members (both male and female) merely reaches about 30 %.

Information

(S)SHS are assumed to enable users to access information more easily through a TV or radio at home as well as improved lighting conditions to read the newspaper more frequently. As it has been shown earlier (cf. chapter 5.3.1), 60.6 % of the SHS users and only 12.4 % of the SSHS users run a TV with their solar system. Radios are much less common and are only used with 13.3 % of the SHS and 9.5 % of the SSHS[45]. Only 6 % of the non-users have a TV in their home, 9 % stated to have a radio in use[46].

(S)SHS households with a TV at their home use it on average 1.6 hours per day. The differences between the household members are not very large. Yet, somewhat surprisingly, female adults have the highest TV watching time with 1.7 hours per day, followed by male adults (1.6 hours) and children under 16 (1.5 hours). Considerable discrepancies exist, however, with regard to the programmes the different household members watch. While in all three groups 'entertainment' was stated in more than 90 % of the cases, 77.5 % of the male adults watch 'news' as well, which is a much higher share than for female adults (57.3 %) or children (33.0 %). Since in most households no TV was present before the (S)SHS was purchased, the vast majority of users reported that the TV watching time had increased.

The effect of (S)SHS on the radio use is much more diversified, because many interviewees stated that they already possessed a radio before or still run it with dry-cell batteries. Oftentimes the average time per day has not changed or has even decreased, because now the household members spend more time watching TV. Therefore, no clear connection between the (S)SHS and the radio usage could be observed. A similar finding applies for newspaper reading at home. Only in one-third of all (S)SHS households male adults regularly read the newspaper at home. The respective share of female adults is 12.6 %, children only reach a percentage of 7.4 %. Although the share of male adults from user households is higher than from non-user households (17.0 %), a mere 12.8 % of the interviewees reported that the male adults would read the newspaper more often now than before. Hence, it can be assumed that the major part of the differences between both groups already existed before the (S)SHS dissemination.

About 75 % of the SHS users and 50 % of the SSHS users stated that their knowledge on 'general news' as well as 'health-related issues' has improved since they bought the solar

[45] An equal amount of (S)SHS users power their radios with dry-cell batteries.

[46] Five of the six TVs are run in grid-connected non-user households, whereas one is powered by a storage battery. All radios were found in off-grid households and are powered with dry-cell batteries.

system. It is likely that the respective questions were sometimes answered very optimistically and the stated knowledge increase is rather small in many cases. However, the significant differences between the two strata (chi-squared test, p = 0.000) underpin the assumption that a TV represents the major source of knowledge gain. Hence, the effect of the solar systems on the level of information is stronger in SHS households.

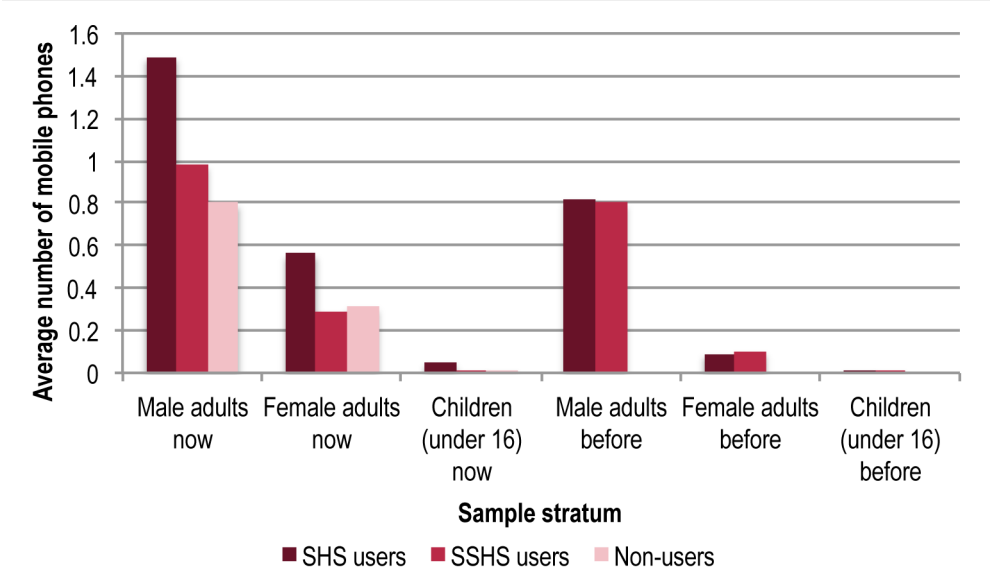
5.5.3 Socio-cultural Capabilities

As the socio-cultural capabilities primarily refer to the "ability to participate as a valued member of a community" (OECD 2001: 38), it is not straightforward to delimit this capability dimension. For the (S)SHS dissemination, easier communication opportunities and an improved quality of life have been identified as potential impacts.

Communication

The use of mobile phones is common among the rural dwellers in Bangladesh. Accordingly, the share of sampled households with mobile phones is very high. 98.2 % of the SHS users, 94.3 % of the SSHS users, and 78 % of the non-users stated to have one or more in use. Figure 20 illustrates the distribution of mobile phones over the different members of (S)SHS user and non-user households.

Figure 20: Mobile phones in use by the different household members



n (SHS users) = 165 | n (SSHS users) = 105 | n (non-users) = 100
Note: Non-user data was only gathered for the present day ('now').
Data: Household survey 2012 | Graphic: Own elaboration

The figure demonstrates that in both user strata the average number of mobile phones has increased since the purchase of the solar system and male adults are the household members possessing them most frequently. Children under 16 barely possess their own mobile phones. Furthermore, the average number of mobile phones in (especially SHS) user households at the present day is much higher than in non-user households.

Asked about the influence of the solar system on the mobile phone use, more than 70 % of both SHS and SSHS users stated that they would use it more often now. All but one interviewee reported that the reason for this would be that mobile phones could be conveniently recharged at home. Before purchasing the (S)SHS, more than 80 % of the user households had their mobile phone recharged in the same or a nearby village. They used the recharging service on average three times per week and had to pay between zero and seven BDT per charge. A similar pattern applies for the non-users at the present day. However, the average expenditures for recharging the mobile phone are slightly lower and more people recharge their phone in their own village, because many non-users benefit from the high density of solar systems and recharge their mobile phone with one of these systems (cf. chapter 5.5.8).

The qualitative appraisals revealed that the (S)SHS users highly appreciate the possibility to charge their mobile phone at home. Yet, money does not seem to play such an important role as rather the reduced need to go outside after sunset and the certainty that the mobile phone would not run out of charge. The latter has to do with the fact that many rural dwellers in the research area use their mobile phones to stay in contact with their relatives or coordinate small business activities and therefore value a reliable and convenient recharge option. Hence, it can be concluded that (S)SHS indeed improve the users' communication opportunities, which has a positive effect on their socio-cultural capabilities.

Quality of life

The 'quality of life' of the rural dwellers is potentially influenced by a myriad of factors and the blurry nature of the notion makes it difficult to determine specific outcomes and impacts to evaluate. In this report, however, 'quality of life' is understood in a narrow sense and with respect to socio-cultural capabilities primarily refers to the recreational activities of the (S)SHS users as well as their social status within the community.

The first aspect of the (S)SHS influence on the recreational activities has already been discussed with regard to the access to information (cf. chapter 5.5.2): All members from (S)SHS households with a TV at their home watch it on average 1.6 hours per day. 'Enter-

tainment' was stated as the most important programme and is watched by all household members and in almost every household. Therefore, watching TV is above all perceived as a recreational activity by the (S)SHS users.

Other frequent means of recreation include receiving visitors at home or meeting friends and relatives outside the own house. (S)SHS users receive visitors on average 6.5 times per month, which is slightly more often than the non-user households (4.3 times). Yet, only 27.6 % of the SHS users and 20.0 % of the SSHS users reported an increase since they bought the solar system. While a few users stated that their TV would be the reason for this increase, the difference between households with and without a TV was not found to be significant (chi-squared test, $p = 0.617$). Moreover, many interviewees regarded the question itself as awkward, because 'it it obvious that the solar systems do not have any influence on this'.

Similarly, no significant effect was found on the frequency the different household members visit other people outside their home. The respective averages for all three groups of households members oscillate between one and two visits per household member and month for both (S)SHS user non-user households. More than three out of four users stated that the solar system does not influence their visiting behaviour. In a few cases it was claimed that the solar system decreases the need to visit other people because electrical light or a TV is available at home now. Yet, the share of users reporting such a decrease does not exceed 15 % in any of the analysed strata. Therefore, it can be concluded that the influence of (S)SHS on these two types of social activities is very small.

56.6 % of the SHS users and 60.8 % of the SSHS users claimed that their social status has improved due to the solar system. The rest of the interviewees either experienced no change or did not understand the question correctly. In case of an improved social status, 36.4 % of the users stated 'improved illumination' as the main reason. Another 30 % responded that the 'SHS as a whole' and the 'improved wellbeing' related to it was responsible for the improvement of their status.

The qualitative appraisals revealed that (S)SHS influence the social status of user households mainly because they are visible for the whole community. While during the day the panels on the rooftops or in front of the houses can be seen even from some distance, at night the improved illumination immediately indicates who possesses a solar system and who does not. Yet, it was sometimes reported that due to the high density of (S)SHS in many villages ('everybody has one here'), a solar system would not improve the social status as much as it did a few years ago, when only few households had used such a sys-

tem. On the other hand, many non-users claimed that they would feel 'uncomfortable' or 'sad', because not having a (S)SHS at home stigmatises them as 'poor'. Yet, it seemed that the main determinant for this is not so much the share of (S)SHS in the whole village but rather in the immediate family.

5.5.4 Protective Capabilities

The main impact that is assumed to influence the protective capabilities of (S)SHS users is the perception of a safer living environment. 98.8 % of the SHS users and 99 % of the SSHS users from the sampled households stated that they would feel safe in their home and the surroundings, whereas the share of non-users is significantly lower and only reaches 76.3 % (chi-squared test, $p = 0.000$). Furthermore, 86.5 % of the (S)SHS users feel safer now than they did before they bought the solar system. More than 85 % of the users reporting an improved safety situation ascribed this to the improved illumination in their home. About 8 % stated 'fires are less likely to occur' as the main reason. Whereas a reduced need to go outside after sunset is highly appreciated in the context of mobile phone charging, only very few households claimed that this would be the main factor for their improved perception of safety. Hence, improved illumination is by far the most important outcome through which (S)SHS stimulate the perception of a safer living environment. It has to be noted, however, that it could not be evaluated if this subjective perception is justified by an actual improvement in safety.

Apart of the perception of a safer living environment, two more aspects seem to be relevant with respect to protective capabilities. Firstly, off-grid households without solar systems heavily depend on kerosene for lighting purposes and are thus very vulnerable to price variations. Since the rural dwellers are usually not able to substitute kerosene with other 'traditional' energy sources, the strong increase of the kerosene price in the past years led to considerably higher kerosene-related expenditures. These pose a heavy strain on the households' budget and many non-users reported that they try to limit their kerosene consumption because of the recent price hikes. As (S)SHS significantly reduce the monthly kerosene consumption, they limit the household's dependency on this fuel and vulnerability to future price hikes[47]. Therefore, they enhance the protective capabilities of their users against this specific economic shock.

[47] 99.6 % of the interviewed (S)SHS users and all non-users expect the kerosene price to increase notably in the future.

Secondly, during some of the qualitative appraisals and informal conversations the topic of *resilience* against catastrophic natural disasters such as cyclones was discussed. As this was not the main focus of the study, no conclusive evidence can be presented for the existence and exact nature of the linkages between solar systems and the users' resilience. Nonetheless, several possible connections were identified how (S)SHS (and other renewable energies) could potentially enhance the resilience of rural dwellers against natural disasters. Yet, additional research is needed to analyse these connections more in depth.

5.5.5 Political Capabilities

It was not assumed that the (S)SHS dissemination would have a direct impact on the political capability dimension. The fieldwork confirmed this assumption, as no direct linkages could be found between the solar systems and the basic political freedoms, the possibility to influence political decisions, or human rights. Indirectly, the increased level of information and the improved communication opportunities might positively influence the political capabilities of the (S)SHS users. However, no evidence is available to assess if these indirect linkages actually exist or how strong their influence is.

5.5.6 Gender

The previous chapters have shown that men and women benefit to a different degree from the (S)SHS impacts on the various dimensions of poverty. While in the first part of this section further information on the women's workload and working comfort is presented, in the second part the gender-specific differences of the (S)SHS outcomes and impacts are recapitulated and discussed.

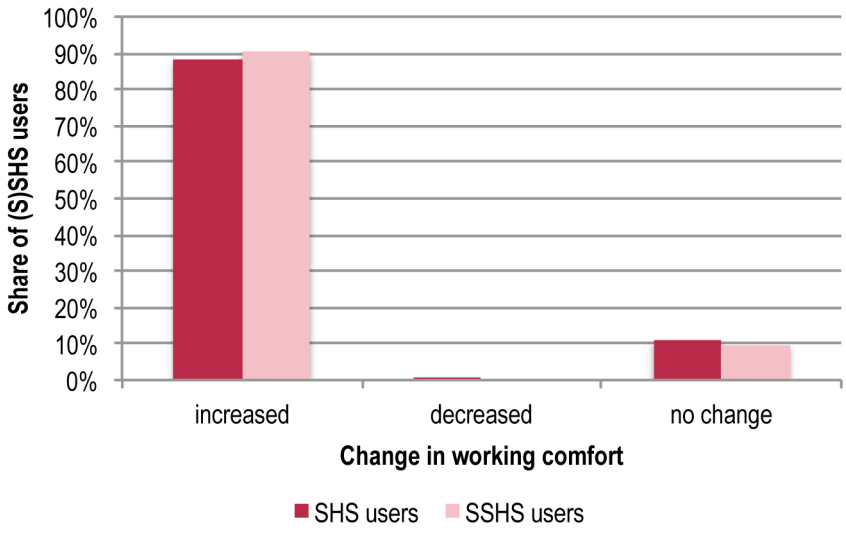
Women's Workload and Working comfort

Apart of the gender-disaggregated questions presented in the previous chapters, the interviewed households were also specifically asked about the workload and working comfort of the female household members. Adult women from (S)SHS user households spend on average 5.2 hours per day on housework such as cooking, cleaning, collecting firewood, or purchasing kerosene compared to 4.9 hours in non-user households. Yet, as more than 60 % of the user households stated that the (S)SHS had not induced any change in the working time, it is unlikely that this difference is causally linked to the solar systems. Furthermore, in the vast majority of cases male adults were reported to be the main responsible household members for purchasing kerosene and only very little time is spent on this

task. This underpins the assumption that the (S)SHS do not significantly influence the average working time of women, because time savings from reduced kerosene usage are oftentimes referred to as a major influencing factor in this regard. Additionally, a change in working time by itself cannot be directly interpreted as being positive or negative, because the interviewed women experience such change very differently. Whereas many appreciate the possibility to carry out some tasks after sunset as well, a few women also stated that they would like to rest more during the evening but now sometimes have to do additional work because of the available light.

With respect to women's working comfort, however, strong evidence was found that both the SHS and SSHS have a positive influence. 88.3 % of the SHS users and 90.4 % of the SSHS users reported an increase of the working comfort and only one user stated that the housework would be less comfortable now (figure 21).

Figure 21: Change in women's working comfort since the (S)SHS purchase



n (SHS users) = 165 | n (SSHS users) = 105
Data: Household survey 2012 | Graphic: Own elaboration

Two main reasons were frequently stated for the increase of the women's working comfort. Firstly, the improved illumination makes it easier to carry out many housework activities like sewing or processing of crops. Secondly, many women stated that they highly appreciate to be able to distribute their household duties more freely over the day. Since they are now able to finish their tasks after sunset, they experience less time pressure, which is generally perceived as a higher working comfort.

Cross-dimensional Benefits for Women

As women generally spend more time in the house and its immediate surroundings than any other household member, it is oftentimes assumed that they benefit comparatively more from most of the (S)SHS-related outcomes, which would eventually lead to a reduced gender gap in all poverty dimensions. In order to assess this assumption, the effects of the (S)SHS dissemination on the different capability dimensions presented above are now synoptically discussed with respect to the women's benefits.

The analysis has shown that women are not only the main responsible household members for the housework but also for income-generating activities at home, if such activities are carried out. Although the (S)SHS do not induce a major change in the time women spend on these activities per day, they clearly benefit from more comfortable working conditions. Furthermore, while the difference in the prevalence of illnesses between male adults from user and non-user households is only small, it was found to be highly significant for female adults. This finding suggests that female adults indeed benefit from the improved indoor air quality to a higher extent than their male coevals. Both male and female school children are the main beneficiaries from improved study conditions. While female adults rarely spend time on reading, particularly female children between 11 and 15 years seem to transform the improved illumination conditions into longer study hours.

In contrast, male adults make more use of the easier access to information through the TV than female adults or children do. Moreover, the share of women without a mobile phone in the (S)SHS user households still remains very high in comparison to the respective share of male adults. Although it was sometimes reported that female adults still have to carry out household work when the male adults and children watch TV at night, the average time of TV usage for all three strata is almost equal. This indicates that all household members benefit from this recreational activity to a similar degree. Additionally, the perception of safety of men and women is nearly the same.

Hence, in summary it can be stated that women benefit more than men from some of the outcomes such as the improved indoor air quality or the overall working conditions in the house. Yet, such gender-specific differences could not be found for all capability dimensions and in a few cases men are the main beneficiaries. Furthermore, notwithstanding these generally positive results in terms of gender equality, especially the focus group discussions and the qualitative appraisals revealed that pronounced gender-specific power disparities still persist in rural households, which cannot be substantially reduced by a (S)SHS dissemination only.

5.5.7 Environment

The dissemination of (S)SHS is believed to contribute to a cleaner living environment via two different outcomes: a reduced contamination through toxic waste and decreased kerosene-related greenhouse gas emissions.

Toxic Waste

Chapter 5.3.2 demonstrated that (S)SHS reduce the consumption of kerosene and dry-cell batteries. While the former is relevant in the context of greenhouse gas emissions, the latter are a source of toxic waste if not being recycled appropriately. Since such a recycling mechanism is not available in the research area (and most parts of rural Bangladesh), it is not surprising that two-thirds all of respondents stated that they throw the batteries away. The remaining share of the households sells them to hawkers, which means that eventually these batteries will also be disposed inappropriately. Therefore, the modest decline in dry-cell battery consumption slightly reduces the contamination through toxic waste.

Notwithstanding this positive effect, the (S)SHS dissemination also causes a pronounced increase in the usage of lead-acid batteries[48], whose disposal and recycling can have detrimental health effects. The Blacksmith Institute reports that informal lead-acid battery recycling, a common practice in many developing countries, is the main source of industrial pollutants in terms of the loss of disability-adjusted life years (DALYs) worldwide (Blacksmith Institute/Green Cross Switzerland 2012: 19-21)[49]. The processes of cutting the batteries open, smelting the lead plates, and disposing of the acid are described as the major exposure pathways through which lead particulates and fugitive dusts are deposited in the soil and nearby waterways (ibid.).

In order to prevent the informal recycling of the lead-acid batteries applied in solar systems, the POs are obliged to offer an environmentally sound disposal mechanism to their customers. However, while the replacement of malfunctioning or broken batteries within the warranty period works considerably well, only 7.8 % of the (S)SHS users are aware of the battery disposal mechanism of their respective PO. Almost 60 % of the households not having replaced the battery yet stated that they planned to sell it or have it repaired in a

[48] Only nine (S)SHS users stated to have used lead-acid batteries before they purchased the solar system.

[49] According to the WHO, "a DALY can be thought of as one lost year of 'healthy' life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability" (WHO 2012).

local battery shop when it is not working anymore[50]. Moreover, according to the interviewed PO staff members, many (S)SHS owners decide not to use the disposal mechanism after informing themselves about the exact conditions. Therefore, the actual share of users giving back their battery to the POs after the warranty period has expired is very low.

Three main reasons were identified for this behaviour: Firstly, the local battery shops generally offer more diversified services at lower prices than the POs do. While the latter usually refund the users for their old batteries only if a new battery is purchased, the former always pay for the old ones. Additionally, battery shops offer the option to 'repair' broken batteries by replacing lead plates and substituting the acid, which is much less costly than purchasing a new battery[51]. Most of the PO staff members are aware of this fact and some expressed their discontent about the unfavourable financial conditions of their own disposal mechanism, which are determined on a higher management level.

Secondly, many users claimed that they would trust the owners of the local battery shops more than the POs because they are believed to have a much higher expertise in the matter. The reason for this is that the POs generally send the broken batteries back to the manufacturers and do not carry out repairs by themselves. Furthermore, whereas PO staff members might change their employer or the local branch where they work after a certain period of time, the battery shop owners are perceived as being deeply locally embedded. Since they also provide warranty periods of two to five years on the repairs they make and products the sell and it is unlikely that they will move away in the short or medium term, the majority of (S)SHS users is very confident that they carry out their work more carefully than the POs do.

Thirdly, the POs do not inform their users well enough about the expected lifetime of the batteries and the possibility to give the battery back after the warranty period has expired. To the contrary, several users reported that PO staff members had even declined that such a possibility would exist. Although no conclusive evidence could be found if this is a common practice or only happens in few cases, most of the key informant interviews suggest that the POs are at least somewhat reluctant to generate an increased awareness of their own disposal mechanisms.

In the view of these facts, it becomes evident that the majority of lead-acid batteries used in the disseminated solar systems will most probably be recycled under environmentally

[50] As it is known among the rural dwellers that the lead-acid batteries still have a monetary value even when they do not work anymore, only very few users stated that they would throw it away.

[51] The replacement of all lead plates and the complete acid of an 80 Ah battery typically used for a 50 Wp system costs between 2,500 and 3,500 BDT. A new battery of this type has a price of about 10,000 BDT.

harmful conditions. As until the present day many of the disseminated batteries are still working and moreover covered by the warranty, this does not happen at a large scale yet. However, under the given framework conditions for the battery recycling a pronounced negative effect on the environment can be expected in the near future.

Kerosene-related Greenhouse Gas Emissions

Apart of the mentioned effects on toxic waste, which directly influences the living environment of the rural dwellers, the (S)SHS also cause a reduction of kerosene consumption and thereby also lower greenhouse gas emissions from the combustion of this fuel. Although this does not have an immediate impact on the living conditions in the area where the emissions are reduced, it contributes to a cleaner environment at a global level.

SHS were found to replace on average 3.31 litres of kerosene per month, the respective value for SSHS is 2.37 litres per month. It goes without saying that the higher kerosene reduction of SHS is equivalent to higher savings of carbon dioxide (CO_2). According to the UNFCCC, kerosene has an emission factor of 2.4 kg CO_2 per litre (2011: 6). Thus, the sampled SHS prevent 95.3 kg CO_2 from being released into the atmosphere per system and year, whereas a SSHS decreases the CO_2 emissions by 68.3 kg in the same period of time. Under the simplifying assumption that every (S)SHS disseminated under the IDCOL scheme is working and in use and by applying the mean kerosene reduction values found in this study for all (S)SHS in Bangladesh, the total emission savings from the (S)SHS dissemination at the present day are approximately 169,138 tons of CO_2 per year[52]. However, as not all (S)SHS are domestically used and no data is available about the percentage of broken or idle systems, this value can only be used as an indication.

5.5.8 Impacts on Non-users

Most of the previously stated results focused on the outcomes and impacts on (S)SHS users and the non-users were mainly taken into consideration as a comparison group to determine these effects more precisely. However, non-users might also be positively or negatively affected by the (S)SHS dissemination.

The first transmission channel for these indirect impacts is that households without solar systems sometimes make use of a (S)SHS close to their home. 54 % of the sampled non-

[52] The applied methodology yields much lower values of CO_2 reduction than calculations that are based average numbers of kerosene lamps and automotive batteries replaced by SHS and SSHS (Schwan 2011: 64-65). The application of such an approach leads to a total reduction of 406,025 tons of kerosene per year at the present day.

users confirmed that this would be the case. Furthermore, two-thirds of the SHS users and about half of the SSHS users stated that they let other people benefit from their system free of charge. Particularly direct neighbours were reported to be the main beneficiaries (about 85 %). In the remaining households, family members not living in close vicinity benefit most. Asked about the exact nature of the benefits, both the users and non-users reported that mobile phone charging is by far the most widely spread indirect use (stated in almost 90 % of the cases), followed by watching TV[53]. A few households also stated the use of improved illumination at night as an indirect benefit. Thus, the main outcomes of the indirect use of (S)SHS are improved communication opportunities and diversified recreational activities related to the use of a TV.

The second transmission channel for impacts on non-users is that they are influenced by certain effects of the (S)SHS dissemination, although they do not make of these systems. In this regard, the preceding analysis points towards two negative outcomes for non-users. The first concerns the stigmatisation of households without solar systems as 'poor'. (S)SHS represent prestigious assets, which not only provide several benefits for their users but also indicate whether the household is wealthy enough to cover the related costs. Thus, although (S)SHS do not considerably alter the income levels of users and non-users, they make this difference much more visible for everybody in the village and, even more importantly, in the own family. This, in turn, creates the subjective perception of some non-users that they are less valued members of the community than they were before, which negatively affects their socio-cultural capabilities. The second negative outcome is linked to the environmentally harmful battery recycling. Clearly, the detrimental health effects of the pollutants in the soil and waterways are not restricted to (S)SHS users. Therefore, improved battery recycling mechanisms would yield benefits for all members of the respective communities.

Hence, in summary it can be concluded that, on the one hand, about half of the non-users also make use of (S)SHS and therefore indirectly benefit from their widespread dissemination. On the other hand, they suffer from a stigmatisation as 'poor' to a higher degree than they did before and are as much affected by the inadequate battery recycling as the (S)SHS users.

[53] As only few SSHS households have a TV in use, this activity is mainly carried out at SHS users' homes.

6 Conclusion and Recommendations

6.1 Summary of Findings

The analysis of the primary data gathered during the fieldwork revealed that 67.1 % of the SSHS users and 82.4 % of the SSHS users have a per capita income below the inflation-adjusted regional poverty line. This demonstrates that the framework conditions of the (S)SHS dissemination are adequate to reach the rural poor, which is why it can be classified as directly poverty oriented. Furthermore, SSHS have a higher poverty orientation than the more costly SHS. This evidence supports the respective assumptions underlying the introduction of the SSHS into the IDCOL programme.

More than 90 % of the users choose an instalment payment to purchase their solar system. The reasons for this are both the comparatively high costs of a (S)SHS and the possibility to stall the payments as a means for exerting pressure on the PO to carry out repairs. Only few users take additional loans to cover (S)SHS-related costs or default permanently, whereas temporary payment defaults are common due to the variability of the users' monthly income. By and large, the financing modalities between the POs and the (S)SHS users seem to be appropriate. However, the lacking instalment payment option for new batteries poses a potential risk for the sustainability of the dissemination scheme, as many users reported that they would not be able to purchase a new battery at once.

In the vast majority of households, (S)SHS are used to run lighting devices and mobile phone chargers. While TVs and small fans are also commonly in use with SHS, they are not frequently run with SSHS due to the limited power output. The average number of lighting devices in SHS households was found to be 3.7, the respective value for SSHS is 2.1 lamps per household. In both cases the living area is illuminated between three and four hours per day. Lighting devices in other areas such as the kitchen or outdoors are used between one and three hours daily.

Both SHS and SSHS reduce the kerosene consumption of their users. The former induce a somewhat higher kerosene reduction of 3.31 litres per month compared to a decrease of 2.37 litres per month caused by the latter. (S)SHS users consume less than 0.4 litres of kerosene per month at the present day and mainly use their kerosene lamps to ignite the fireplace for cooking purposes. Although the consumption of dry-cell batteries is reduced as well, between 1.6 and 1.8 pieces of these batteries are still in use every month. In the majority of households the main application of these batteries are torches.

Approximately half of the users stated to have experienced minor or severe problems since they purchased the solar system. In most of the cases where replacements had to be carried out, lighting devices were substituted. Furthermore, every fifth user has already replaced the charge controller and in 11.5 % of the cases the battery had to be changed. The majority of these more expensive replacements were stated as warranty cases. Only few users have a maintenance contract after the initial warranty period has expired.

With respect to the rationale for purchasing a solar system, 'improved illumination', 'money savings', 'improved study conditions', and 'easier mobile phone charging' are the reasons most frequently stated by the (S)SHS users. In more than 70 % of the cases, limited financial resources are the determining factor why SSHS users did not buy a bigger system. Furthermore, the vast majority of non-users expressed the wish to have a (S)SHS at home. Yet, 85 % are not able to purchase one due to monetary constraints. The overall satisfaction level of (S)SHS users was found to be high.

The second part of the analysis has shown that both SHS and SSHS have several impacts on the different capability dimensions of their users. In terms of *economic capabilities*, the decrease of energy-related expenditures is the most important outcome and it was found that the overall monthly expenditure savings induced by SHS (171.3 BDT) are somewhat larger than in the case of SSHS (153.4 BDT per month). Yet, due to the high purchasing costs, particularly the bigger systems among the group of SHS clearly decrease rather than increase the economic capabilities of their users in the medium term. SSHS are much more promising in this regard. However, despite the recent kerosene price hikes, also the break-even point of newly disseminated SSHS does rarely fall into the five-year warranty period of the battery.

Neither SHS nor SSHS significantly influence the economic capabilities of their users through new or extended income-generating activities at home. It was found that the share of users and non-users carrying out such activities is nearly equal (about 30 %) and the additional income due to the purchase of a (S)SHS is negligible. An important reason for this is that electric light is only one among several input factors needed to carry out income-generation at home. Other critical factors such as adequate training or a distribution mechanism to sell the produced goods are oftentimes lacking and prevent many rural dwellers from engaging in these activities.

In contrast, various impacts were found that positively influence the *human capability dimension*. With regard to the health situation, the perception of the indoor air quality in both SHS and SSHS households has significantly improved. Although this is not the only factor

influencing the users' health condition, the prevalence of illnesses commonly associated with the indoor air quality was found to be significantly lower among women and children from user households than from non-user households. Furthermore, the risk of kerosene-related accidents in user households has been considerably reduced. Despite these positive findings, only half of the (S)SHS users know about the connection between solar systems and their health, which indicates that the awareness among the rural dwellers concerning this matter is not very high.

Both SHS and SSHS considerably improve the study and reading conditions in the user households. Whereas male and female adults do not seem to use these improved conditions to read more than before, the study time of school children has moderately increased. Girls between 11 and 15 years of age seem to benefit most from the enhanced illumination, as both the absolute study time and the difference between users and non-users were found to be the highest in this age group. However, it has to be clearly stated that the modest increase in study hours does not directly lead to significantly better educational attainments. The (S)SHS rather enable the school children to harness the educational potential determined by other influencing factors (such as the teachers' qualification, their absence rates, or the didactic methods applied) more effectively and comfortably.

In terms of access to information, the TV was found to be the major source of knowledge gain in the user households, whereas the effect through increased radio usage or newspaper reading at home is negligible. Male adults are the household members watching the 'news' most frequently. It could not be exactly determined to what extent the users increased their knowledge base, yet it can be assumed that the increase is not very pronounced in many cases. Since only few TVs are run with SSHS, the effect of SHS on the access to information is significantly higher.

With regard to the *socio-cultural capabilities*, the (S)SHS cause both an increase in the average number of mobile phones per household and the frequency of their usage. The possibility to recharge the mobile phones at home was stated as the most important reason for this change in the majority of cases. Male adults were found to be the main beneficiaries from these improved communication opportunities. Furthermore, the effect of (S)SHS on the recreational activities seems to be restricted to a more widespread TV usage. No conclusive evidence could be found that social activities are significantly influenced by the solar systems. More than half of the users reported that their social status has improved because of the (S)SHS.

Due to improved lighting conditions, the perception of safety in (S)SHS user households is significantly higher than in non-user households, which represents a positive effect of the (S)SHS on the *protective capability dimension*. Moreover, these capabilities are positively influenced by a reduced vulnerability against kerosene price shocks and several possible connections were identified pointing towards a slightly higher resilience against natural disasters. Yet, further research is needed to provide conclusive evidence in this regard. No direct impact of the (S)SHS dissemination on the *political capabilities* of the users could be found.

Women benefit more than men from some of the presented outcomes including the improved indoor air quality and the overall working conditions in the house. Yet, such *gender-specific differences* could not be found for all capability dimensions and with regard to certain outcomes, men are the main beneficiaries. Furthermore, pronounced power disparities between men and women still persist in rural households, which cannot be substantially reduced by a (S)SHS dissemination only.

While (S)SHS slightly reduce the toxic waste from dry-cell batteries, the introduction of lead-acid batteries at a large scale poses a major threat for the *environment*. Only few users give their battery back to the POs after it stopped working, whereas the majority rely on the services of informal battery shops due to three reasons: They offer diversified and less expensive services, (S)SHS users trust the battery shop owners more than they trust the PO staff members, and the POs do not inform the users well enough about their disposal mechanisms. Hence, under the given framework conditions for the battery recycling the majority of batteries from the (S)SHS will most probably be recycled under environmentally harmful conditions. A second outcome indirectly influencing the living environment of the users is the reduction of kerosene-related greenhouse gas emissions. SHS were found to prevent 95.3 kg of CO_2 per system and year from being emitted, whereas a SSHS reduces the respective emissions by 68.3 kg per year.

Finally, several *impacts on non-users* were determined. On the one hand, approximately half of the households without a solar system charge their mobile phone at a nearby (S)SHS or regularly go to user households to watch TV, thus benefitting from improved communication opportunities and diversified recreational activities. On the other hand, many non-users have the perception to be stigmatised as ‘poor’ because they are not able to purchase a (S)SHS. Furthermore, the negative environmental effects from informal battery recycling affect users and non-users to the same degree.

In summary it can be stated that although neither SHS nor SSHS increase the economic capabilities of their users in the medium term, they positively influence most of the other capability dimensions and thus indeed contribute to fighting poverty in rural Bangladesh. Yet, this contribution is not as strong as the opening citation might suggest and detrimental environmental effects due to inappropriate battery recycling are likely to occur in the near future.

Since many of the determined outcomes are essentially based on improved illumination conditions and the replacement of kerosene, the majority of impacts from SHS and SSHS are very similar. However, SSHS offer a higher poverty orientation and affect the economic capabilities less than the more costly SHS. In contrast to that, SHS have a more pronounced positive influence on the access to information, the recreational activities, and the general well-being of their users due to the possibility to use TVs as well as small fans.

6.2 Practical Implications and Recommendations for GIZ

The findings of this study support the assertion of Kürschner et al. that the overall set-up of the (S)SHS dissemination in Bangladesh can be considered as "a role model for approaches in other countries" (2009: 38). Notwithstanding this positive result, several points of entry were determined to further improve the impacts of the dissemination of solar systems in rural Bangladesh.

Firstly, the analysis has shown that 85 % of the sampled non-users would like to have a solar system at home, but financial constraints prevent them from purchasing one. Therefore, it is highly recommendable that the POs also *offer the less expensive PicoPV systems* in order to be able to reach this very poor target group. As these systems can power several small LEDs and a mobile phone charger, it can be expected that PicoPV systems yield important benefits despite their limited nominal power. Furthermore, due to the comparatively low system price, their break-even point will most probably be reached within the first few years. Hence, the evidence from this study leads to a very favourable opinion on the current EnDev initiative to include PicoPV systems in the IDCOL scheme and disseminate them at a large scale in the coming years.

Secondly, as the battery recycling mechanisms of the POs fail to ensure that the majority of lead-acid batteries is recycled appropriately, measures have to be taken to *mitigate the expected detrimental environmental effects due to widespread informal battery recycling*. On the one hand, it seems important to enter in a dialogue with IDCOL and the POs to

determine the problems of the current recycling mechanisms and encourage the POs to enhance their mechanisms accordingly. On the other hand, since many users probably prefer local battery shops even when the recycling mechanism of the POs is designed appropriately, it should be considered to enhance their abilities for an environmentally sound battery recycling and include them in the recycling mechanisms of the POs. Furthermore, in order to reduce the amount of toxic waste in the future, it should be assessed if at least the lead-acid batteries of SSHS can be substituted by cleaner alternatives such as lithium-ion batteries in the medium term[54].

Thirdly, in order to ensure the sustainability of the disseminated solar systems, the POs should be strongly encouraged to *offer instalment payment options for new batteries*. As many users reported that they would not be able to purchase a new battery at once, such an instalment option is necessary to prevent that their solar systems lie idle after the battery reached the end of its lifespan. Furthermore, since the informal battery shops generally only accept cash payments, this would be a comparative advantage and thus an incentive for the (S)SHS users to make use of the official recycling mechanism.

Fourthly, many users stated that they would require *additional input factors to start income-generating activities at home*. Hence, the respective effect of (S)SHS could be enhanced, if complementary measures were provided that focused on the lacking factors. It is, therefore, recommendable to enable (S)SHS users to engage in such activities by providing trainings and supporting the development of simple distribution mechanisms for the produced goods. Since home-based income-generating activities are very often carried out by women, female household members would especially benefit from these complementary measures.

Fifthly, both PO staff members and (S)SHS users claimed that the households would need a *better training on the proper use of the solar systems*. Although certainly not all technical problems of the solar systems can be ruled out by such trainings, many common application errors can be avoided. This would not only lead to a better performance of the (S)SHS but indirectly also to enhanced outcomes and impacts. Therefore, the POs should be supported in scaling-up their respective training activities. Moreover, it should be considered to combine these user trainings with awareness campaigns about the different benefits that can be gained from the (S)SHS, because this awareness does not always seem to be very pronounced.

[54] This battery technology will be used in the envisaged PicoPV dissemination (GIZ 2013: 9).

Ultimately, although the topic of resilience against natural disasters was only marginally addressed during the fieldwork, several possible connections to the (S)SHS dissemination and other renewable energies could be identified. Particularly for those areas where climate change adaptation strategies are needed in the future these connections seem to be highly relevant. Further research should therefore be carried out to systematically *assess the linkages between several renewable energy technologies and the resilience of individuals and communities against natural disasters*.

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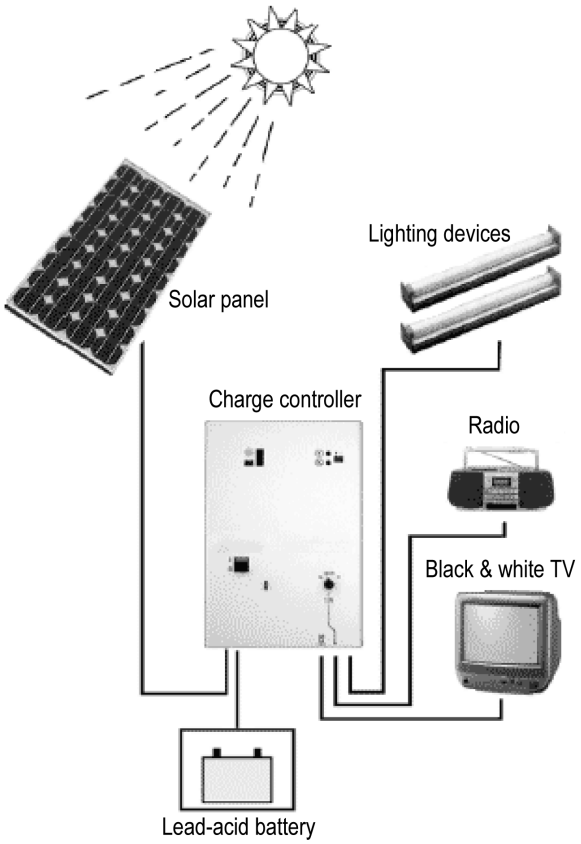
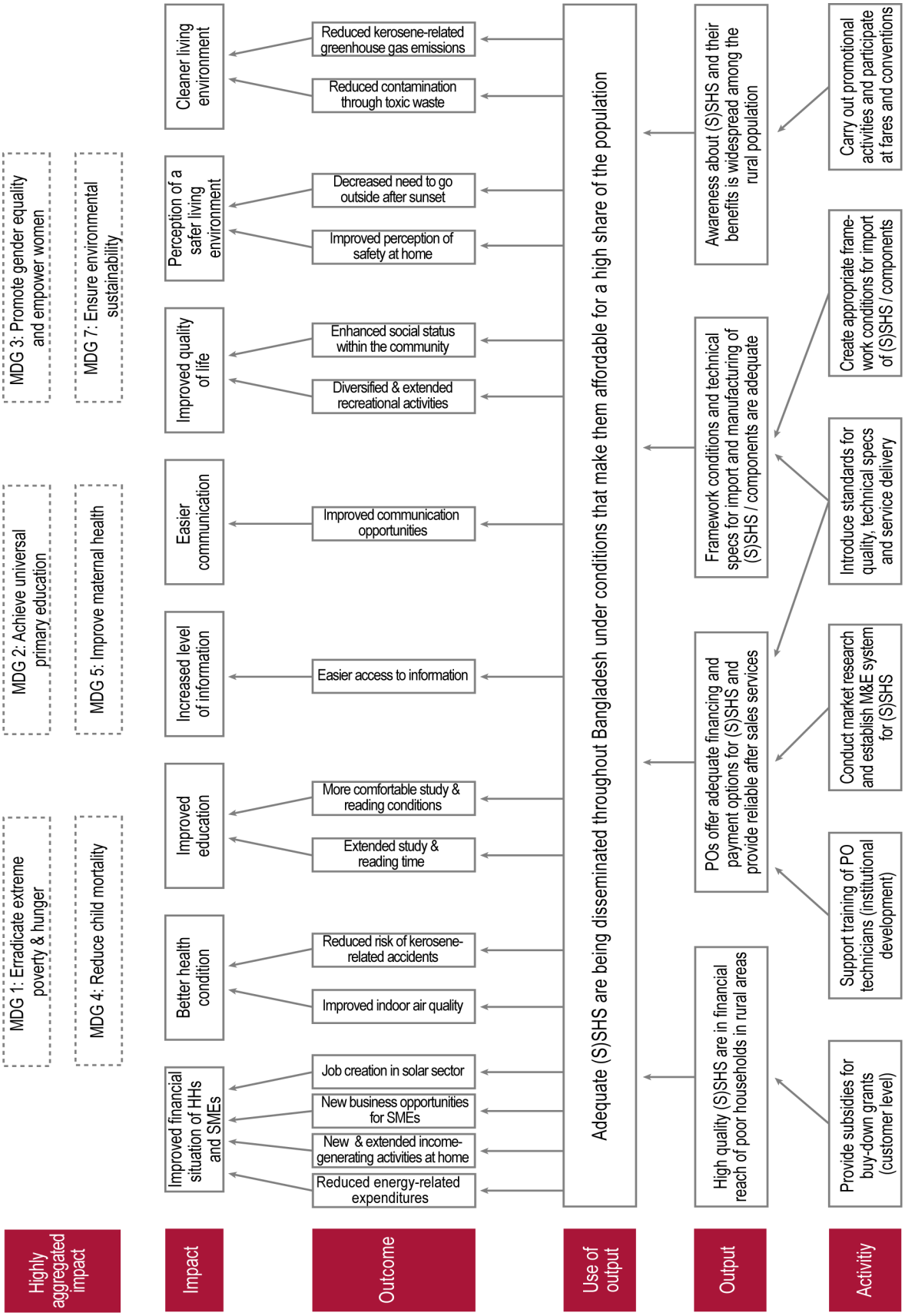
Appendix

Appendix 1: Schematic overview of the typical SHS components



Source: Enolar 2003; modified

Appendix 2: Result chain of the (S)SHS dissemination



Note: The two levels 'highly aggregated impact' and 'use of output' have been included according to the GIZ terminology used before the on-going reform. The 'inputs' are not displayed in this figure.

Source: Own elaboration based on SED project documents

Appendix 3: (S)SHS user questionnaire form

Questionnaire for **(S)SHS users**

Code: Name: Date: No. of interview on that day:	***Note: Some data should be gathered by observation and not by questioning!***	ID-No. ***(DO NOT FILL THIS OUT)***

General Information ***[to be completed before the interview]***

A	Post Office [***check IDCOL list***]	
B	Village [***check IDCOL list***]	
C	Name of the owner of the (S)SHS [***check IDCOL list***]	
D	Customer ID [***check IDCOL list***]	
E	Provider of the (S)SHS [***check IDCOL list***]	☐ ADAMS ☐ BRAC ☐ BRIDGE ☐ Grameen Sh. ☐ PDBF ☐ RDF ☐ RISDA ☐ RSF ☐ Shakti Found. ☐ Shubashati ☐ SolarEn ☐ SRIZONY ☐ TMSS ☐ Upokulio ☐ other [*specify*]:
F	Name of the interviewed person [***ask***]	
G	Relation of the interviewed person with respect to the owner [***ask***]	☐ owner ☐ wife ☐ husband ☐ father ☐ mother ☐ son ☐ daughter ☐ other [*specify*]:
H	Start of the interview [*hh:mm*]	End of the interview [*hh:mm*]

Introduction

Good Morning, my name is ***[NAME]***.Thank you very much for welcoming me to your home. On behalf of the GIZ (German Development Cooperation) we are currently carrying out a research project on the use and the benefits of Solar Home Systems. Your feedback is very important for us to further improve the dissemination of these systems. Therefore, I would like to ask you some questions. In total it will take between 45 and 60 minutes.

There are no right or wrong answers. We are only interested in your personal opinion. All information will be treated confidentially. This means that all personal details (e.g. your name & address) will be separated from the other answers. Thereby we will know who has been interviewed, but it will not be possible to know which answers were given by you or by someone else.

If you have not understood a question properly, please feel free to interrupt me and ask for clarification. We will not force you to respond to any of the questions. If, for any reason, you need to leave or feel uncomfortable during the interview, you can end it any time you want to.

Are there any questions you have before we start the interview?

[***wait for possible questions and respond to them***].

Okay, then let's start!

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Off-grid Rural Electrification and Fighting Poverty
A Comparative Impact Assessment of Solar Home Systems and Small Solar Home Systems in Rural Bangladesh
(S)SHS user questionnaire
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Specifications & Acquisition of Solar System
[Please ask if it is possible to see the customer agreement and payment card copy. Many of the following questions will be easier to answer with this document]

1	Solar system specifications [***If copy is not available: Check the label at the backside of the panel (if possible) and the battery***]	Wp Ah @ Volts
2	Time of purchase [***If copy is not available: ask***]	☐ less than 1 year ago ☐ between 1 and 2 years ago ☐ between 2 and 3 years ago ☐ between 3 and 4 years ago ☐ between 4 and 5 years ago ☐ more than 5 years ago
3	Did you have a (S)SHS before the one that is currently in use?	☐ yes ☐ no, it's the first one *If yes* ☐ the old one is still in use, this is an additional (S)SHS ☐ the old one was broken and we bought a new (S)SHS ☐ the old one was broken and was replaced by the PO free of charge (warranty case)
4	Are you also connected to the electricity grid?	☐ yes ☐ no *If yes:* How many hours per day does the grid supply electricity? _____ hours per day How often do power cuts normally last? _____ hours When do they usually occur? ☐ 6 a.m. – 12 p.m. ☐ 12 p.m. – 6 p.m. ☐ 6 p.m. – 6 a.m. ☐ I don't know
5	Do you share the electricity from your (S)SHS with nearby households?	☐ yes, I sell electricity to nearby households ☐ yes, I share electricity free of charge with nearby households ☐ yes, I bought the (S)SHS together with someone and share its electricity now ☐ no
6	How do or did you finance your (S)SHS?	☐ at once (upfront payment only) ☐ by monthly installments How high was the upfront payment? ____ Taka *If financed by installments:* ***[Please check if payment card is available]*** How high is the monthly payment rate? ____ Taka per month How long is the repayment period? ____ months
7	Did you use an additional loan to cover the upfront costs and/or the installments of your (S)SHS?	☐ yes ☐ no *If yes:* How high was the loan? ____ Taka

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8	Have you faced any problems in the past to pay your installments?	☐ yes ☐ no *If yes:* What kind of problems? _____ How did you and/or the PO handle this situation? _____ Have you been able to solve these problems by now? ☐ yes ☐ no
9	Have you already completed your repayment period?	☐ yes ☐ no *If yes:* Do you have a maintenance contract with the provider of your (S)SHS? ☐ yes ☐ no *If no:* Does the PO personnel in charge of installment collection visit you regularly? ☐ yes ☐ no Does he check the (S)SHS when he collects the installments? ☐ yes, always ☐ yes, sometimes ☐ no ☐ I don't know
10	Do you also possess an Improved Cooking Stove (Bondhu Chula)?	☐ yes ☐ no *If yes:* If you had to choose between the (S)SHS and the ICS (Bondhu Chula), which one would you keep? ☐ (S)SHS ☐ Improved Cooking Stove

System Performance & Basic Energy Services

11	Is your (S)SHS still functioning?	☐ yes ☐ no
12	Have you encountered any problems since you bought the (S)SHS?	☐ yes, I have encountered severe problems ☐ yes, I have encountered minor problems but the system was working the whole time ☐ no *If yes:* What kind of problems? _____ Have these problems been solved? ☐ yes ☐ no
13	Did you have to replace parts of the system?	☐ yes ☐ no

EBERHARD KARLS UNIVERSITÄT TÜBINGEN
Off-grid Rural Electrification and Fighting Poverty
A Comparative Impact Assessment of Solar Home Systems and Small Solar Home Systems in Rural Bangladesh
(S)SHS user questionnaire
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

	[***Multiple answers possible***]	*If yes:* Which part(s)? ☐ battery ☐ solar panel ☐ lamp / tube ☐ charge controller ☐ switch ☐ other [*please specify*]: How much money did you spend on the replacement(s) in total? ☐ _____ Taka ☐ nothing (warranty case) *If warranty case:* How satisfied were you with the service of the PO? ☐ 1 (very dissatisfied) ☐ 2 (somewhat dissatisfied) ☐ 3 (so so) ☐ 4 (somewhat satisfied) ☐ 5 (very satisfied)
14	Which electrical appliances do you run with the (S)SHS? [***Multiple answers possible***]	☐ lighting devices ☐ mobile phone charger ☐ TV ☐ radio ☐ DVD player ☐ fan ☐ other [*please specify*]:
15	How many lamps do you run with your (S)SHS?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ other: _____
16	Lamp specs and location [***Do NOT ask! Check the lamps and fill in the table!***] ***Type: CFL, LED, ICL, Tube*** ***Codes for location*** *L = Living area* *K = Kitchen* *W = Working area* *O = Outdoors* *X = Other [specify below]*	**Type No. Watt Loc.** / **Type No. Watt Loc.** x W / x W x W / x W x W / x W x W / x W x W / x W
17	How many **hours per day** do you normally light your home?	living area ____ hours / working area ____ hours kitchen ____ hours / other [*specify*]: ____ hours outdoors ____ hours

Rationale & Satisfaction

18	What were your **main reasons** to buy a (S)SHS? What did you expect to change? ***[Do NOT read out the answers]*** ***[Mark and prioritize up to three reasons with '1', '2', '3']***	☐ money savings ☐ fuel savings ☐ improved illumination ☐ easier mobile charging ☐ more time for income generating activities ☐ improved quality of life [*incl. TV and radio use*] ☐ improved study conditions ☐ better indoor air quality ☐ reduced risk of kerosene-related accidents ☐ easier access to information ☐ improved safety ☐ less prone to power cuts ☐ improved status ☐ other [*please specify*]:

19	How did you know about the (S)SHS and its benefits?	☐ I saw (S)SHS in other households ☐ someone (friends, relatives, neighbours, ...) told me about the (S)SHS and its benefits ☐ PO staff members informed me personally ☐ other [*please specify*]:
20	Did you have any concerns or doubts when you bought the (S)SHS? ***[Do NOT read out the answers]*** ***[Multiple answers possible]***	☐ yes ☐ no *If yes*: What kind of concerns or doubts? ☐ I was afraid the (S)SHS would not be worth its price ☐ I was afraid that the price would suddenly be higher than stated when I bought the (S)SHS due to loan arrangements ☐ I was afraid that I couldn't always pay the installments on time ☐ I wasn't sure if the (S)SHS would work well ☐ I wasn't sure if the customer service would be reliable ☐ other [*please specify*]:
21	***If the HH is NOT connected to the grid (qu. 4):*** Would a grid connection have been available in your location when you bought the (S)SHS? ***[Only mark the most important reason]***	☐ yes ☐ no *If yes*: Why did you chose a (S)SHS instead? ☐ the electricity grid is not reliable (power cuts) ☐ someone (friends, relatives, neighbours, ...) recommended me to buy a (S)SHS ☐ I couldn't afford a grid connection ☐ there was an electricity grid in the area, but I could not get a connection [*other than economic reasons*] ☐ I thought I would save more money with a (S)SHS in the long run ☐ the (S)SHS improves my status in the village more than a grid connection ☐ other reason [*please specify*]:
22	**Whose idea** was it initially to buy the (S)SHS?	☐ husband ☐ wife ☐ children ☐ whole family ☐ other: ☐ don't know
23	**Who decided** to buy the (S)SHS in the end?	☐ husband ☐ wife ☐ children ☐ whole family ☐ other: ☐ don't know
24	*If the solar system is smaller than 30 Wp:* Why did you buy a small system instead of a bigger one? ***[Do NOT read out the answers]***	☐ I wanted to buy a bigger system but I couldn't afford it ☐ I could afford a bigger system but I didn't want to spend more money ☐ I could afford a bigger system but I didn't need more power ☐ someone (friends, relatives, neighbours, ...) recommended me to buy a SSHS instead of a bigger system ☐ other reason [*please specify*]:

25	*If the solar system is smaller than 30 Wp:* Which appliances would you use in addition if you had a bigger system? [***Do NOT read out the answers***]	☐ additional lighting devices ☐ mobile phone charger ☐ TV ☐ radio ☐ DVD player ☐ fan ☐ other [*please specify*]:
26	*If the solar system is smaller than 30 Wp:* If a small system had not been available, would you have bought a bigger system instead?	☐ yes ☐ no ☐ I don't know
27	How satisfied are you with your (S)SHS in general?	☐ 1 (very dissatisfied) ☐ 2 (somewhat dissatisfied) ☐ 3 (so so) ☐ 4 (somewhat satisfied) ☐ 5 (very satisfied)
28	***If concerns were stated (qu. 20):*** What about your concerns and doubts? Have any of them been fulfilled? ***[DO ONLY read out the concerns stated in qu. 20 and tick if they have been fulfilled]***	☐ the (S)SHS was not worth its price ☐ the price was suddenly higher than stated when I bought the system due to loan arrangements ☐ I couldn't always pay the installments on time ☐ the (S)SHS didn't work well the whole time ☐ the customer service was unreliable ☐ other [*please specify*]:
29	Is there anything that you dislike about your (S)SHS?	1st: _____ 2nd: _____
30	Which household member benefits most from the (S)SHS?	☐ husband ☐ wife ☐ children ☐ all equal ☐ other: ☐ don't know
31	Does anybody else benefit from the (S)SHS? ***[Multiple answers possible]***	☐ yes, my neighbour(s) ☐ yes, my relatives ☐ yes, others [*specify*]: ☐ no, nobody else ☐ I don't know *If yes*: How? ☐ they charge their mobile phones here ☐ they come here to watch TV ☐ they come here to listen to the radio ☐ they come here to use the illumination at night ☐ other reason [*please specify*]:
32	Would you recommend the (S)SHS to your friends, relatives, neighbours, ...?	☐ yes ☐ no

Energy Consumption Patterns & Expenditures		
33	Do you still use other energy sources than solar energy **for illumination and other electrical appliances at home**?	☐ yes ☐ no
34	***[If the answer is 'no', skip question a) and ask directly for the energy sources before the purchase of the (S)SHS (question b). Then ask if none of these energy sources are used anymore to assure that the answer given before was correct.]***	

a) What kind of energy sources do you use **now for illumination and other electrical appliances at home**? How much money do you spend on each of them per month?

b) What kind of energy sources did you use **before** you bought the (S)SHS? How much money did you spend on each of them before?

***[Both the quantities and the expenditures are important for the study!** If the interviewee is unable to indicate some of the values of the table below, try to calculate them together with him/her (e.g. multiply the quantity with the price per item for each energy source).]*

	Now		**Before**	
	Quant/month	Taka/month	Quant/month	Taka/month
Kerosene	litres		litres	
Diesel (generator)	litres		litres	
Grid [***indicate 'x' for grid connection without bill***]	unit / kWh		unit / kWh	
Storage batteries (e.g. automotive batteries)	charges		charges	
Dry-cell batteries	pieces		pieces	
Electricity bought from neighbours or other persons	---		---	
Candles	pieces		pieces	
Other [*please specify*]:				

35	***If repayment period is not yet completed (question 9):*** Do you think that you will save money after you have completed the payment of your (S)SHS?	☐ yes ☐ no ☐ I don't know
36	How many of the following lighting devices do you have in use **every day**?	_____ kupis _____ hurricanes _____ candles _____ torches
37	Where do you use your kerosene lamps [***kupis + hurricanes***]?	☐ living area ☐ working area ☐ kitchen ☐ other [*specify*]: ☐ outdoors
38	Where did you use them before you bought the (S)SHS?	☐ living area ☐ working area ☐ kitchen ☐ other [*specify*]: ☐ outdoors
39	Do you use your kerosene lamp(s) at any location now **where you didn't use them before**?	☐ yes [*specify location*]: _____ ☐ no
40	How many hours per day do you usually use your kerosene lights?	_____ hours per day
41	How was it before you bought the (S)SHS?	_____ hours per day
42	How much does one litre of kerosene cost at the moment?	_____ Taka per litre
43	Has the kerosene price changed significantly since you bought the (S)SHS?	☐ yes, increased significantly ☐ yes, decreased significantly ☐ no ☐ I don't know
44	Do you expect the kerosene price to change significantly in the future?	☐ yes, it will increase significantly ☐ yes, it will decrease significantly ☐ no ☐ I don't know

Income-generating Activities					
45	Does any HH member usually carry out income-generating activities **at home**? ☐ yes ☐ no ***[If the answer is 'no', please continue with question 52]***				
46	What kind of activities? [***Multiple answers possible***]	☐ sewing / embroidery ☐ handicrafts ☐ home-based shop ☐ processing of crops (e.g. assortment of seeds) ☐ small-scale livestock farming ☐ other [*please specify*]:			
47	Which of the HH members are involved?		☐ Male adults	☐ Female adults	☐ Children (under 16)
48	How much time per day do they spend on it on average?	**Hours per day**			
49	Has the amount of time changed since you bought the (S)SHS?	**Change in time**	☐ increased ☐ decreased ☐ no change ☐ no change but shifted ☐ don't know	☐ increased ☐ decreased ☐ no change ☐ no change but shifted ☐ don't know	☐ increased ☐ decreased ☐ no change ☐ no change but shifted ☐ don't know
50	Has it become more or less comfortable to carry out these activities?	**Change in comfort**	☐ increased ☐ decreased ☐ no change ☐ don't know	☐ increased ☐ decreased ☐ no change ☐ don't know	☐ increased ☐ decreased ☐ no change ☐ don't know
51	Do you earn more or less money since you bought the (S)SHS?	☐ yes, more money ☐ yes, less money ☐ no ☐ I don't know *If yes*: How much? _____ Taka per month ☐ I don't know			
52	***If question 45 is answered with 'no':*** Have you ever thought of carrying out income-generating activities **at home**?	☐ yes ☐ no *If yes*: Why don't you do so?			

Health		
53	Do you think the (S)SHS has any effect on your health?	☐ yes, a positive effect ☐ yes, a negative effect ☐ no ☐ I don't know If *yes*: How? [***Do NOT read out the answers***] ☐ kerosene-related accident are less likely now ☐ the indoor air quality is better now ☐ I know more about hygiene and other health-related issues now ☐ other [*please specify, also mention negative effects here*]: *If no*: Do you think the use of kerosene has any effect on your health? ☐ yes, a positive effect ☐ yes, a negative effect ☐ no ☐ I don't know

54	Do you remember any kerosene-related accidents in your home before you bought the (S)SHS?	☐ yes ☐ no *If yes:* What kind of accidents? ☐ burnings of HH members ☐ other [*please specify*]: ☐ fire(s) *If no:* Do you know of kerosene-related accidents in other households? ☐ yes ☐ no			
55	Have any similar accidents occurred since you bought the (S)SHS?	☐ yes, even more frequently than before ☐ yes, as frequently as before ☐ yes, but less frequently than before ☐ no ☐ I don't know			
56	How satisfied are you with the air quality inside your home	☐ 1 (very dissatisfied) ☐ 2 (somewhat dissatisfied) ☐ 3 (so so) ☐ 4 (somewhat satisfied) ☐ 5 (very satisfied)			
	Has the indoor air quality changed since you bought the (S)SHS?	☐ improved ☐ worsened ☐ no change ☐ don't know			
57	***[If the interviewee only answers for himself/herself, explicitly ask for the other HH members]***	HH member	male adults	female adults	children (under 16)
58	Has any HH member suffered from illnesses like headache, breathing problems or eye problems since you bought the system?	Situation **now**	☐ yes, often ☐ yes, sometimes ☐ no ☐ don't know	☐ yes, often ☐ yes, sometimes ☐ no ☐ don't know	☐ yes, often ☐ yes, sometimes ☐ no ☐ don't know
59	*If yes:* What kind of illnesses? [***Multiple answers possible***]	**Type of illness**	☐ headache ☐ breathing problems ☐ eye problems ☐ other:	☐ headache ☐ breathing problems ☐ eye problems ☐ other:	☐ headache ☐ breathing problems ☐ eye problems ☐ other:
60	How often does this happen now compared to the time before you bought the (S)SHS?	**Comparison** to situation before	☐ more often ☐ less often ☐ no change ☐ don't know	☐ more often ☐ less often ☐ no change ☐ don't know	☐ more often ☐ less often ☐ no change ☐ don't know

Education	
61	a) How many **hours per day** do the different HH members spend reading and studying at home **now**? b) **Has this changed** compared to the **situation before** you bought the (S)SHS? ***[Collect all the information on one HH member before asking for the next one. Only ask the exact age for children younger than 16. For older children and other HH members fill in ">16"]***

62	Literate?	Gender	Age	Studying + reading **hours per day** (**now**)	Studying + reading time per day (**comparison**)
Husband	☐ yes ☐ no	☒ male ☐ female	>16		☐ increased ☐ decreased ☐ no change ☐ no change, but shifted ☐ don't know
Wife	☐ yes ☐ no	☐ male ☒ female	>16		☐ increased ☐ decreased ☐ no change ☐ no change, but shifted ☐ don't know
Child 1	☐ yes ☐ no	☐ male ☐ female			☐ increased ☐ decreased ☐ no change ☐ no change, but shifted ☐ don't know
Child 2	☐ yes ☐ no	☐ male ☐ female			☐ increased ☐ decreased ☐ no change ☐ no change, but shifted ☐ don't know
Child 3	☐ yes ☐ no	☐ male ☐ female			☐ increased ☐ decreased ☐ no change ☐ no change, but shifted ☐ don't know
Child 4	☐ yes ☐ no	☐ male ☐ female			☐ increased ☐ decreased ☐ no change ☐ no change, but shifted ☐ don't know
Child 5	☐ yes ☐ no	☐ male ☐ female			☐ increased ☐ decreased ☐ no change ☐ no change, but shifted ☐ don't know
Other:	☐ yes ☐ no	☐ male ☐ female			☐ increased ☐ decreased ☐ no change ☐ no change, but shifted ☐ don't know
Other:	☐ yes ☐ no	☐ male ☐ female			☐ increased ☐ decreased ☐ no change ☐ no change, but shifted ☐ don't know

63	Have you noticed any change in the children's school outcomes?	☐ yes, the children's school outcomes have improved ☐ yes, the children's school outcomes have worsened ☐ no, I haven't noticed any change ☐ I don't know

Information, Recreation & Communication					
64	*If TV is present:* How many hours per day do the different HH members spend watching TV	HH member **TV hours per day** (**now**)	male adults	female adults	children (under 16)
65	Has this changed compared to the situation before you bought the (S)SHS?	TV time per day (**comparison**)	☐ no TV before ☐ increased ☐ decreased ☐ no change ☐ no change but shifted ☐ don't know	☐ no TV before ☐ increased ☐ decreased ☐ no change ☐ no change but shifted ☐ don't know	☐ no TV before ☐ increased ☐ decreased ☐ no change ☐ no change but shifted ☐ don't know

66	Which TV programmes do they watch? [***multiple answers possible***]	**TV programmes** (**now**)	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:
67	*If radio is present:* How many hours per day do the different HH members spend listening to the radio?	**Radio hours per day** (**now**)			
68	Has this changed compared to the situation before you bought the (S)SHS?	Radio time per day (**comparison**)	☐ no radio before ☐ increased ☐ decreased ☐ no change ☐ no change but shifted ☐ don't know	☐ no radio before ☐ increased ☐ decreased ☐ no change ☐ no change but shifted ☐ don't know	☐ no radio before ☐ increased ☐ decreased ☐ no change ☐ no change but shifted ☐ don't know
69	Which radio programmes do they listen to? [***Multiple answers possible***]	**Radio programmes** (**now**)	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:
70	Does any HH member regularly read the newspaper?	**Newspaper** (**now**)	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
71	Has this changed compared to the situation before you bought the (S)SHS?	Newspaper (**comparison**)	☐ more often ☐ less often ☐ no change ☐ no change but shifted ☐ don't know	☐ more often ☐ less often ☐ no change ☐ no change but shifted ☐ don't know	☐ more often ☐ less often ☐ no change ☐ no change but shifted ☐ don't know
72	Do you think your knowledge on general news has changed since you bought the (S)SHS?	☐ yes, it has increased ☐ yes, it has decreased ☐ no change observed ☐ I don't know			
73	And your knowledge on health-related issues?	☐ yes, it has increased ☐ yes, it has decreased ☐ no change observed ☐ I don't know			
74	Does any HH member possess a mobile phone?	☐ yes ☐ no			
	If yes: Who and how many phones?	HH member Mobile phone (**now**)	male adults ☐ yes: ___ ☐ no	female adults ☐ yes: ___ ☐ no	children (under 16) ☐ yes: ___ ☐ no
75	*If yes:* Did they have their mobile phone(s) already before you bought the (S)SHS?	Mobile phone (**before**)	☐ yes: ___ ☐ no	☐ yes: ___ ☐ no	☐ yes: ___ ☐ no

76	Does the (S)SHS influence your mobile phone use?	☐ yes, I use it more often now ☐ yes, I use it less often now ☐ no, there is no influence ☐ I don't know *If yes: Why?* ☐ I can charge it in my home now [*time savings + comfort*] ☐ I don't have to pay for recharging my mobile phone(s) [*money*] ☐ other [*please specify*]:
77	Where did you charge your mobile phone(s) before? How often and for how much money?	☐ in a nearby village ☐ within my village ☐ at my home ☐ other [*specify*]: _____ times per week _____ Taka per charge

Women's Workload & Working Comfort		
You said that **the adult women in the HH** spend ____ **hours per day** [***question 48***] on income-generating activities at home?		
78	How much additional time per day **do the adult women in the HH** spend on other housework? (cooking, collecting firewood, ...)	*[Get up at: _____ Go to bed at: _____]* ____ hours of work per day
79	Has the overall workload of **the adult women in the HH** changed since you bought the (S)SHS?	☐ increased ☐ decreased ☐ no change ☐ don't know
80	Has it become more or less comfortable to carry out these tasks since you bought the (S)SHS?	☐ yes, it's more comfortable now ☐ yes, it's less comfortable now ☐ no, no change in comfort ☐ I don't know
81	***If kerosene is still in use [qu.34]:*** Who **are** the **main** responsible HH members for purchasing kerosene?	☐ male adults ☐ female adults ☐ children (under 16) ☐ other [*specify*]:
82	***If kerosene is NOT in use anymore [qu.34]:*** Who **were** the **main** responsible HH members for purchasing kerosene **before** you bought the (S)SHS?	☐ male adults ☐ female adults ☐ children (under 16) ☐ other [*specify*]:
83	How much time do they spend on purchasing kerosene per week **now**?	_____ hours per week
84	Has this changed compared to the situation before you bought the (S)SHS?	☐ increased ☐ decreased ☐ no change ☐ don't know

Social Activities, Social Status & Perception of Safety		
85	How often do you receive visitors at your home?	_____ times per month
86	Has this changed compared to the situation before you bought the (S)SHS?	☐ increased ☐ decreased ☐ no change ☐ don't know

		HH member	male adults	female adults	children (under 16)
87	How often do the different HH members meet other people in their leisure time outside of their home?	**times per month (now)**			
88	How often does this happen compared to the situation before you bought the (S)SHS?	times per month **(comparison)**	☐ more often ☐ less often ☐ no change ☐ don't know	☐ more often ☐ less often ☐ no change ☐ don't know	☐ more often ☐ less often ☐ no change ☐ don't know
89	Do you think the (S)SHS has changed your reputation in the village?	☐ yes, my reputation is better now ☐ yes, my reputation is worse now ☐ no, it has not changed my reputation ☐ I don't know			
		If yes: Why?			
90	Do you feel safe in your home and the surroundings?	☐ yes, I feel safe ☐ so so ☐ no, I don't feel safe			
91	Has this changed since you bought the (S)SHS? [***Multiple answers possible***]	☐ yes, I feel safer now ☐ yes, I felt safer before ☐ no, I feel as safe as before ☐ I don't know *If yes: Why?* ☐ improved illumination of my home ☐ No need to go out at night anymore [*mobile charging, etc. possible at home*] ☐ other [*please specify*]:			

Importance of Changes

92	Which of the different changes we talked about so far do you regard as the most important ones? ***[Mark and prioritize up to three changes with '1', '2', '3']***	☐ money savings ☐ improved illumination ☐ more time for income generating activities ☐ improved study conditions ☐ reduced risk of kerosene-related accidents ☐ improved safety ☐ improved status	☐ fuel savings ☐ easier mobile charging ☐ improved quality of life [*incl. TV and radio use*] ☐ better indoor air quality ☐ easier access to information ☐ less prone to power cuts ☐ other [*please specify*]:

Toxic Waste

93	*If dry cells are still in use*: You said that you use ____ [***number from qu. 34***] dry cells per month? What do you do with them when they are empty? ☐ I throw them away ☐ I don't know ☐ other [*specify*]:

Now I would like to know a bit more about the **battery of your solar system.**

[If the solar battery has not been replaced yet (qu. 13), please ask questions 94-96]
[If the solar battery has been replaced already (qu. 13), please ask questions 97-99]

94	*If not replaced:* Do you know that you will have to replace your battery after a certain amount of time?	☐ yes ☐ no
95	*If not replaced:* What do you plan to do with your battery when it's not working anymore? ***[Do NOT read out the answers]***	☐ I will throw it away ☐ I will give it back to the PO ☐ I will sell it ☐ other [*please specify*]: ☐ I don't know
96	*If not replaced:* What do you think a new battery will cost?	_____ Taka
97	*If replaced:* How many **years after you bought the (S)SHS** did you replace your battery?	☐ less than 2 years ☐ between 2 and 3 years ☐ between 3 and 4 years ☐ between 4 and 5 years ☐ between 5 and 6 years ☐ between 6 and 7 years ☐ more than 7 years ☐ I don't know
98	*If replaced:* What have you done with your old battery after replacing it with a new one?	☐ I threw it away ☐ I gave it back to the PO ☐ I sold it ☐ other [*please specify*]: ☐ I don't know
99	*If replaced:* How much money did you spend on the new battery?	_____ Taka
100	Do you know the battery disposal mechanism of your PO?	☐ yes ☐ no *If yes & battery won't be / wasn't given back to the PO:* Why don't you make use of this mechanism?

Socio-economic Information

S1	Gender of the interviewed person [***observe***]	☐ male ☐ female
S2	Age of the interviewed person	☐ up to 20 ☐ 21 to 30 ☐ 31 to 40 ☐ 41 to 50 ☐ older than 50
S3	Is the interviewed person the head of the HH?	☐ yes ☐ no
S4	How many people regularly live in this HH?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ other:
S5	Do any HH members live abroad or have lived abroad in the past 5 years?	☐ yes ☐ no *If yes:* How many? _____ still abroad _____ abroad before

S6	Who earns the main part of the income?	☐ male adults ☐ female adults ☐ children (under 16) ☐ other [*specify*]:
S7	Where do you get most of your income from?	☐ agriculture ☐ trade ☐ service sector ☐ day labour ☐ labour migration within Bangladesh ☐ labour migration outside of Bangladesh ☐ other [*please specify*]:
S8	How high is your monthly family income?	_____ Taka per month
S9	Has the HH received remittances from HH members abroad in the past 5 years?	☐ yes ☐ no *If yes*: What is or has been the average amount of remittances per month? _____ Taka per month [***Check if this amount was already part of the calculation above. If not, please add it!***]

Concluding Remarks

X	Is there anything else you would like to tell us regarding your (S)SHS we have not talked about so far?

Conclusion of the Interview

Now **I** have asked **you** a lot of questions. Is there anything that **you** would like to ask **me**?

[***Wait for possible questions of the interviewee and respond to them***]

Thank you very much again for taking your time and answering all of our questions. Goodbye!

[***Note: Please fill in the time when you concluded this interview on the first page now and answer the questions on the last page afterwards***]

Interviewer's Observations
Please take some time after completing the interview to answer the following questions

What was your general impression of the conversation?	☐ everything went well & open atmosphere ☐ it was difficult to obtain the information
Do you think that the answers given to you were consistent and faithful?	☐ yes, the answers seemed plausible ☐ no, many answers seemed doubtful

Are there any aspects that were particularly difficult to talk about/ to get information on?
Please indicate the topics and the respective questions

Are there any aspects that went particularly well and proved especially fruitful?
Please indicate the topics and the respective questions

Are there any other impressions from the interview that you would like to share?

Researcher's declaration

I have personally conducted the interview and collected the information above to the best of my knowledge.

Name: **Signature:**

Source: Own elaboration

Appendix 4: Non-user questionnaire form

Questionnaire for **non-users**

Code: Name: Date: No. of interview on that day:	***Note: Some data should be gathered by observation and not by questioning!***	ID-No. ***(DO NOT FILL THIS OUT)***

General Information [*to be completed before the interview*]		
A	Post Office [***according to IDCOL list***]	
B	Village [***according to IDCOL list***]	
C	Name of the interviewed person [***ask***]	
D	Relation of the interviewed person with respect to the head of HH [***ask***]	☐ head ☐ wife ☐ husband ☐ father ☐ mother ☐ son ☐ daughter ☐ other [*specify*]:
E	Start of the interview [*hh:mm*]	End of the interview [*hh:mm*]

Introduction

Good Morning, my name is ***[NAME]***.Thank you very much for welcoming me to your home. On behalf of the GIZ (German Development Cooperation) we are currently carrying out a research project on the use and the benefits of Solar Home Systems. Your feedback is very important for us to further improve the dissemination of these systems. Therefore, I would like to ask you some questions. In total it will take between 30 and 40 minutes.

There are no right or wrong answers. We are only interested in your personal opinion. All information will be treated confidentially. This means that all personal details (e.g. your name & address) will be separated from the other answers. Thereby we will know who has been interviewed, but it will not be possible to know which answers were given by you or by someone else.

If you have not understood a question properly, please feel free to interrupt me and ask for clarification. We will not force you to respond to any of the questions. If, for any reason, you need to leave or feel uncomfortable during the interview, you can end it any time you want to.

Are there any questions you have before we start the interview?

[***Wait for possible questions and respond to them***].

Okay, then let's start!

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Energy Consumption Patterns & Expenditures		
1	Do you have a (S)SHS in your home?	☐ yes [***If the answer is 'yes', CHANGE the questionnaire form and use a USER-questionnaire***] ☐ no
2	Are you connected to the electricity grid?	☐ yes ☐ no *If yes:* How many hours per day does the grid supply electricity? _____ hours per day How often do power cuts normally last? _____ hours When do they usually occur? [***Multiple answers possible***] ☐ 6 a.m. – 12 p.m. ☐ 12 p.m. – 6 p.m. ☐ 6 p.m. – 6 a.m. ☐ I don't know
3	What kind of energy sources do you use **for illumination and other electrical appliances at home**? How much money do you spend on each of them per month? ***[Both the quantities and the expenditures are important for the study!*** *If the interviewee is unable to indicate some of the values of the table below, try to calculate them together with him/her (e.g. multiply the quantity with the price per item for each energy source).]*	

	Quant/month	Taka/month
Kerosene	litres	
Diesel (generator)	litres	
Grid [***indicate 'x' for grid connection without bill***]	unit / kWh	
Storage batteries (e.g. automotive batteries)	charges	
Dry-cell batteries	pieces	
Electricity bought from neighbours or other persons	---	
Candles	pieces	
Other [*please specify*]:		

Electrical Appliances & Illumination		
4	Do you have any electrical appliances in your home?	☐ lighting devices ☐ mobile phone charger ☐ TV ☐ radio ☐ DVD player ☐ fan ☐ other [*please specify*]: ☐ none
5	How many electrical lamps do you possess?	☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ other: _____

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6	*If at least 1 electr. lamp:* Lamp specs and location [***Do NOT ask! Check the lamps and fill in the table!***] ***Type: CFL, LED, ICL, Tube*** ***Codes for location*** *L = Living area* *K = Kitchen* *W = Working area* *O = Outdoors* *X = Other [specify below]*	**Type**	**No.**	**Watt**	**Loc.**	**Type**	**No.**	**Watt**	**Loc.**
			x	W			x	W	
			x	W			x	W	
			x	W			x	W	
			x	W			x	W	
			x	W			x	W	
7	How many of the following lighting devices do you have in use **every day**?	_____ kupis _____ candles				_____ hurricanes _____ torches			
8	Where do you use your kerosene lamps [***kupis + hurricanes***]?	☐ living area ☐ kitchen ☐ outdoors				☐ working area ☐ other [*specify*]:			
9	How many **hours per day** do you normally light your home [***both electrical and non-electrical lamps***]?	living area ____ hours kitchen ____ hours outdoors ____ hours				working area ____ hours other [*specify*]: ____ hours			
10	How many hours per day do you usually use your kerosene lights?	_____ hours per day							
11	How much does one litre of kerosene cost at the moment?	_____ Taka per litre							
12	Do you expect the kerosene price to change significantly in the future?	☐ yes, it will increase significantly ☐ no				☐ yes, it will decrease significantly ☐ I don't know			

Rationale & Indirect Benefits of (S)SHS		
13	Do you know that (S)SHS are available in your village?	☐ yes ☐ no
14	Would you like to have a (S)SHS in your home?	☐ yes ☐ no [***if answered with 'no', continue with question 17***] ☐ I don't know
15	*If yes:* Why would you like to have a (S)SHS? What are your main reasons and expectations? ***[Do NOT read out the answers]*** ***[Mark and prioritize up to three reasons with '1', '2', '3']***	☐ money savings ☐ fuel savings ☐ improved illumination ☐ easier mobile charging ☐ more time for income generating activities ☐ improved quality of life [*incl. TV and radio use*] ☐ improved study conditions ☐ better indoor air quality ☐ reduced risk of kerosene-related accidents ☐ easier access to information ☐ improved safety ☐ less prone to power cuts ☐ improved status ☐ other [*please specify*]:

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16	*If yes:* Why don't you have one? ***[Do NOT read out the answers]*** ***[Multiple answers possible]***	☐ I cannot afford the price of the (S)SHS ☐ I am afraid that the price will suddenly be higher than stated initially due to loan arrangements ☐ other [*please specify*]:
17	*If no:* Why not?	☐ I don't believe the (S)SHS is worth its price ☐ I don't believe that the (S)SHS works well ☐ I don't believe that the customer service is reliable ☐ other [*please specify*]:
18	How far away is the (S)SHS that is closest to your home?	_____ m / km _____ minutes (walking time)
19	Do you sometimes make use of any (S)SHS close to your home? [***Multiple answers possible***]	☐ yes ☐ no *If yes:* How? ☐ I charge my mobile phone there ☐ I go there to watch TV ☐ I go there to listen to the radio ☐ I go there to use the illumination at night ☐ other reason [*please specify*]:
20	Have you experienced any disadvantages due to the fact that other villagers have a (S)SHS?	☐ yes ☐ no *If yes:* What kind of disadvantages?

Income-generating Activities					
21	Does any HH member usually carry out income-generating activities **at home**? ☐ yes ☐ no [***If the answer is "no", please continue with question 25***]				
22	What kind of activities? [***Multiple answers possible***]	☐ sewing / embroidery ☐ handicrafts ☐ home-based shop ☐ processing of crops (e.g. assortment of seeds) ☐ small-scale livestock farming ☐ other [*please specify*]:			
23	Which of the HH members are involved?		☐ Male adults	☐ Female adults	☐ Children (under 16)
24	How much time per day do they spend on it on average?	**Hours per day**			
25	***If question 21 is answered with 'no':*** Have you ever thought of carrying out income-generating activities **at home**?	☐ yes ☐ no *If yes:* Why don't you do so?			

Health

26	Do you think the use of kerosene has any effect on your health?	☐ yes, a positive effect ☐ yes, a negative effect ☐ no ☐ I don't know *If yes:* How? [***Do NOT read out the answers***] ☐ danger of kerosene-related accidents ☐ kerosene negatively affects the indoor air quality ☐ other [*please specify, also mention positive effects here*]:
27	Do you remember any kerosene-related accidents in your home during the last few years?	☐ yes ☐ no *If yes:* What kind of accidents? ☐ burnings of HH members ☐ other [*please specify*]: ☐ fire(s) *If no:* Do you know of kerosene-related accidents in other households? ☐ yes ☐ no
28	How satisfied are you with the air quality inside your home	☐ 1 (very dissatisfied) ☐ 2 (somewhat dissatisfied) ☐ 3 (so so) ☐ 4 (somewhat satisfied) ☐ 5 (very satisfied)

29	***[If the interviewee only answers for himself/herself, explicitly ask for the other HH members]***	HH member	male adults	female adults	children (under 16)
30	Has any HH member suffered from illnesses like headache, breathing problems or eye problems during the last few years?	**Occurrence of illnesses**	☐ yes, often ☐ yes, sometimes ☐ no ☐ don't know	☐ yes, often ☐ yes, sometimes ☐ no ☐ don't know	☐ yes, often ☐ yes, sometimes ☐ no ☐ don't know
31	*If yes:* What kind of illnesses? ***[Multiple answers possible]***	**Type of illness**	☐ headache ☐ breathing problems ☐ eye problems ☐ other:	☐ headache ☐ breathing problems ☐ eye problems ☐ other:	☐ headache ☐ breathing problems ☐ eye problems ☐ other:

Education

32	How many **hours per day** do the different HH members usually spend reading and studying at home? ***[Collect all the information on one HH member before asking for the next one. Only ask the exact age for children younger than 16. For older children and other HH members fill in ">16"]***

33		Literate?	Gender	Age	Studying + reading **hours per day**
	Husband	☐ yes ☐ no	☒ male ☐ female	>16	
	Wife	☐ yes ☐ no	☐ male ☒ female	>16	
	Child 1	☐ yes ☐ no	☐ male ☐ female		
	Child 2	☐ yes ☐ no	☐ male ☐ female		
	Child 3	☐ yes ☐ no	☐ male ☐ female		
	Child 4	☐ yes ☐ no	☐ male ☐ female		
	Child 5	☐ yes ☐ no	☐ male ☐ female		
	Other:	☐ yes ☐ no	☐ male ☐ female		
	Other:	☐ yes ☐ no	☐ male ☐ female		

Information, Recreation & Communication

34	*If TV is present:* How many hours per day do the different HH members spend watching TV	HH member **TV hours per day**	male adults	female adults	children (under 16)
35	Which TV programmes do they watch? ***[Multiple answers possible]***	**TV programmes**	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:
36	*If radio is present:* How many hours per day do the different HH members spend listening to the radio?	**Radio hours per day**			
37	Which radio programmes do they listen to? ***[Multiple answers possible]***	**Radio programmes**	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:	☐ news ☐ educational programmes ☐ entertainment ☐ other [*specify*]:
38	Does any HH member regularly read the newspaper?	**Newspaper**	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no

39	Does any HH member possess a mobile phone?	☐ yes ☐ no
	If yes: Who and how many phones?	HH member / male adults / female adults / children (under 16) Mobile phone: ☐ yes: ___ ☐ no
40	Where do you charge your mobile phone(s)? How often and for how much money?	☐ in a nearby village ☐ within my village ☐ at my home ☐ other [*specify*]: _____ times per week _____ Taka per charge

Women's Workload & Working Comfort

You said that **the adult women in the HH** spend ____ **hours per day** [***question 24***] on income-generating activities at home?

41	How much additional time per day **do the adult women in the HH** spend on other housework? (cooking, collecting firewood, ...)	*[Get up at: _____ Go to bed at: _____]* ____ hours of work per day
42	Who are the **main** responsible HH members for purchasing kerosene?	☐ male adults ☐ female adults ☐ children (under 16) ☐ other [*specify*]:
43	How much time do they spend on purchasing kerosene per week?	_____ hours per week

Social Activities, Social Status & Perception of Safety

44	How often do you receive visitors at your home?	_____ times per month			
		HH member	male adults	female adults	children (under 16)
45	How often do the different HH members meet other people in their leisure time outside of their home?	**times per month**			
46	Do you feel safe in your home and the surroundings?	☐ yes, I feel safe ☐ so so ☐ no, I don't feel safe			

Toxic Waste

47	*If dry cells are still in use:* You said that you use ____ [***number from qu. 3***] dry cells per month? What do you do with them when they are empty? ☐ I throw them away ☐ I don't know ☐ other [*specify*]:

Socio-economic Information

S1	Gender of the interviewed person [***observe!***]	☐ male ☐ female
S2	Age of the interviewed person	☐ up to 20 ☐ 21 to 30 ☐ 31 to 40 ☐ 41 to 50 ☐ older than 50
S3	Is the interviewed person the head of the HH?	☐ yes ☐ no
S4	How many people regularly live in this HH?	☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ other:
S5	Do any HH members live abroad or have lived abroad in the past 5 years?	☐ yes ☐ no *If yes:* How many? _____ still abroad _____ abroad before
S6	Who earns the main part of the income?	☐ male adults ☐ female adults ☐ children (under 16) ☐ other [*specify*]:
S7	Where do you get most of your income from?	☐ agriculture ☐ trade ☐ service sector ☐ day labour ☐ labour migration within Bangladesh ☐ labour migration outside of Bangladesh ☐ other [*please specify*]:
S8	How high is your monthly family income?	_____ Taka per month
S9	Has the HH received remittances from HH members abroad in the past 5 years?	☐ yes ☐ no *If yes:* What is or has been the average amount of remittances per month? _____ Taka per month [***Check if this amount was already part of the calculation above. If not, please add it!***]

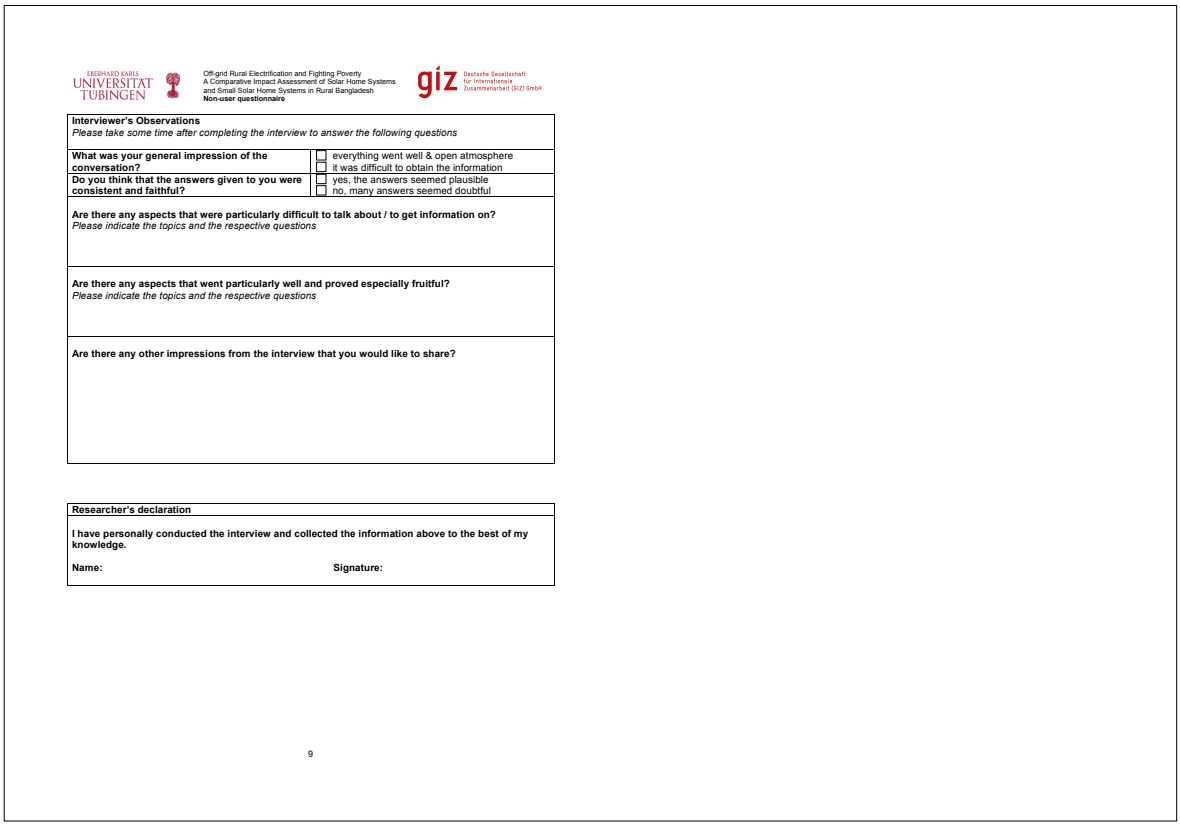
Concluding Remarks

X	Is there anything else you would like to tell us regarding your (S)SHS we have not talked about so far?

Conclusion of the Interview

Now **I** have asked **you** a lot of questions. Is there anything that **you** would like to ask **me**?
[***Wait for possible questions of the interviewee and respond to them***]
Thank you very much again for taking your time and answering all of our questions. Goodbye!

[***Note: Please fill in the time when you concluded this interview on the first page now and answer the questions on the last page afterwards***]



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Interviewer's Observations *Please take some time after completing the interview to answer the following questions*	
What was your general impression of the conversation?	☐ everything went well & open atmosphere ☐ it was difficult to obtain the information
Do you think that the answers given to you were consistent and faithful?	☐ yes, the answers seemed plausible ☐ no, many answers seemed doubtful
Are there any aspects that were particularly difficult to talk about / to get information on? *Please indicate the topics and the respective questions*	
Are there any aspects that went particularly well and proved especially fruitful? *Please indicate the topics and the respective questions*	
Are there any other impressions from the interview that you would like to share?	

Researcher's declaration
I have personally conducted the interview and collected the information above to the best of my knowledge. **Name:** **Signature:**

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Source: Own elaboration

Appendix 5: Overview of the (S)SHS providers of the sampled households

	SHS		SSHS		Total	
	Amount	Per cent	Amount	Per cent	Amount	Per cent
ADAMS	0	0.0 %	2	1.9 %	2	0.7 %
BRAC Foundation	3	1.8 %	0	0.0 %	3	1.1 %
BRIDGE	5	3.0 %	1	1.0 %	6	2.2 %
Grameen Shakti	95	57.6 %	60	57.1 %	155	57.4 %
PDBF	8	4.8 %	1	1.0 %	9	3.3 %
RSF	7	4.2 %	13	12.4 %	20	7.4 %
Shakti Foundation	1	0.6 %	0	0.0 %	1	0.4 %
Shubashati	1	0.6 %	0	0.0 %	1	0.4 %
SRIZONY	30	18.2 %	12	11.4 %	42	15.6 %
TMSS	8	4.8 %	10	9.5 %	18	6.7 %
Upakulio	0	0.0 %	1	1.0 %	1	0.4 %
Solar shop	1	0.6 %	1	1.0 %	2	0.7 %
Second hand	5	3.0 %	4	3.8 %	9	3.3 %
Unknown	1	0.6 %	0	0.0 %	1	0.4 %
Total	165	100 %	105	100 %	270	100 %

Data: Household survey 2012

Appendix 6: Qualitative (S)SHS user interview guide

Daily Routine
• What are your main daily activities? How do your normal workdays look like? • *If talking to the husband*: *W*hat about your wife? How do her workdays normally look like? • And your children? • What does it mean for you to have electricity in your daily life? What importance does it have?
Specifications & Acquisition of Solar System
• What type of solar system do you have? When did you buy it? • Do you share the electricity from your (S)SHS with nearby HH? How exactly? *[selling, sharing without charge, ...]* • How do or did you finance your (S)SHS? • Did you use an additional loan to cover the upfront costs and/or the instalments of your (S)SHS? *[Where? Conditions?]* • Are the monthly instalments a strain on the HH budget or easy to afford? • *If repayment period is completed already*: Do you have a maintenance contract with the provider of your system? Why (not)? • *If repayment period is not yet completed*: Does the PO personnel in charge of instalment collection visit you regularly? Does he check the (S)SHS when he collects the instalments? • Do you also possess an Improved Cooking Stove (Bondhu Chula)? Why? / Why not? • *If no*: Why do you think a (S)SHS is more important than an ICS? Why did you prefer a (S)SHS?
System Performance & Basic Energy Services
• Have you encountered any problems since you bought the (S)SHS? What kind of problems? • Have the problems been solved? How? *[Within what time? Solved to your satisfaction?]* • Which electrical appliances do you run with the (S)SHS?
Rationale & Satisfaction
• How did you find out about the (S)SHS? • Why did you buy a (S)SHS? • Did you have any concerns or doubts when you bought the (S)SHS? • Whose idea was it initially to buy the (S)SHS? Who decided to buy it in the end? • *If solar system ≥30 Wp*: Why did you decide to buy a solar system of [the above mentioned size] Wp? • *If solar system <30 Wp*: Why did you buy a small system instead of a bigger one? • Were you aware of the differences in the appliances and the time you could use them before you chose your system size? • *If yes*: How did you get information on this? • If you had been more affluent at the time of purchase *[more money!]*, would you have bought a differently-sized system? Why? • *If solar system <30 Wp*: If a small system had not been available, would you have bought a bigger one instead? Why? • Are you satisfied with your (S)SHS? • Have your expectations *[see main reasons]* been met? Did anything else change you didn't expect when buying the (S)SHS? *[also negative changes]* • What about your concerns and doubts? • Has the (S)SHS changed the daily life of your family in a significant way? What are the most important changes for you? • Is there anything that you dislike about your (S)SHS? • Have you experienced any disadvantage due to the (S)SHS so far?

- *If yes*: What kind of disadvantage?
- Do you think that any of the HH members especially benefits from the (S)SHS? Why?
- Does anybody else benefit from your (S)SHS? Why?
- Would you recommend the (S)SHS to your friends, relatives, neighbours, ...? Why? / Why not?

Energy Consumption Patterns & Expenditures

- Which energy sources did you use for illumination and electrical appliances before use bought the (S)SHS?
- Do you still use other energy sources than solar energy for these purposes? Why?
- Where do you still use kerosene lamps? Why?
- Do you use your kerosene lamps at any location where you didn't use them before? Where and why?
- Have you noticed any change in your energy expenditures since you bought the (S)SHS?
- Has the kerosene price changed significantly in the last few years? Did this somehow influence your kerosene expenditures?
- Do you expect the kerosene price to change significantly in the future?
- Is it important for you to be less prone to kerosene price variations *[especially price hikes]*?

Income-generating Activities

- Does any HH member carry out income-generating activities at home? Who? What kind of activities?
- *If yes*: Does the (S)SHS have any influence on this? How? *[time and/or comfort]*
- *If no*: Why not? *[improved lighting conditions not important?]*
- *If no*: Would you like to carry out such activities at home? What would you need to do so? *[independent from the (S)SHS]*

Health

- Do you think the (S)SHS has any effect on your health? *[kerosene-related accidents, indoor air quality, health-related information]*
- *If yes*: Why and how exactly?
- *If no*: Do you think the use of **kerosene** has any effect on your health?
- *If not yet answered*: Are you afraid of fires in your home because of kerosene lamps? Why / why not?

Education

- What about reading and studying? Did you observe any difference in time and/or comfort since you bought the system?
- Do you think your children learn more now? Have their school outcomes changed?
- Do you know how your children think about this? Are they more or less satisfied with the study conditions now? Why?

Information, Recreation & Communication

- Do you think it is easier or harder to get information now? [with the (S)SHS] Why?
- *If TV is present*: Which TV programmes do you regularly to watch?
- *If radio is present*: And which radio programmes to do you regularly to listen to? *[entertainment/news/education/...]*
- Do you think that you learn something from these programmes? *[general news + health-related information]*
- Do you read the newspapers regularly? More or less often than before you bought the (S)SHS? Why?
- Do you have a mobile phone?
- *If yes*: Do you use it more or less often since you bought the (S)SHS? Why?
- *If yes*: Where did you charge your mobile phone before you bought the (S)SHS?
- *If yes*: Why is it so important to have a mobile phone? What are the benefits?

Women's Workload & Working Comfort
• Has the overall workload of the female adults in the HH changed since you bought the (S)SHS? *[income generating activities + housework]* • *If yes*: How? Why? • Has it become more or less comfortable to carry out these tasks since you bought the (S)SHS? • *If change is present*: Why? • Who is/was the main responsible HH member for purchasing kerosene? How does/did he or she normally do that *[Where? How often? ...]* • Does he or she spend more or less time on this since you bought the (S)SHS? • Are there any (other) time savings due to the (S)SHS for the different household members? • *If one of the former two answers was yes*: Do you think this is a positive or negative change? Why? • *If one of the former two answers was yes*: What does he or she do with this extra time now?
Social Activities, Social Status & Perception of Safety
• How often do you receive visitors at your home? • Did the purchase of the (S)SHS influence on this? How? • Is this a good or a bad change? • How often do the different HH members meet other people in their leisure time outside of their home? • Did the purchase of the (S)SHS influence on this? How? • Do you think the (S)SHS has changed your reputation in the village? How? • How important is your reputation in the village to you personally? Do you care a lot about it? • Do you know what your neighbours think about your (S)SHS? • Do you feel safe in your home and the surroundings? *[daytime + night time]* • What does light mean for you with regard to safety? • How did the (S)SHS influence on this?
Toxic Waste
• Have you replaced your solar battery already? • *If not replaced*: Do you know that you will have to replace your battery after a certain amount of time? Did anybody explain this to you? • *If not replaced*: What do you plan to do with your battery when it's not working anymore? Why? • *If replaced*: How many years after you bought the (S)SHS did you replace the battery? What happened to the old battery? • Do you know that throwing your battery away is harmful to the environment and your health? Did anybody explain the negative consequences to you? • Do you know the battery disposal mechanism of your PO? • *If applicable*: Why didn't/don't you use it?

Source: Own elaboration

Appendix 7: Qualitative non-user interview guide

Daily Routine
• What are your main daily activities? How do your normal workdays look like? • *If talking to the husband*: *W*hat about your wife? How do her workdays normally look like? • And your children? • What would it mean for you to have electricity in your daily life? What importance does it have?
Energy Consumption Patterns, Electrical Appliances & Illumination
• Which energy sources do you use for illumination and electrical appliances? • Do you possess any electrical appliances? Which ones? • How many lamps do you have in use every day? What kind of lamps? • Where do you use these lamps? • If you had more lamps, would you illuminate other locations as well? Which ones? • Has the kerosene price changed significantly in the last few years? Did this somehow influence your kerosene expenditures? • Do you expect the kerosene price to change significantly in the future?
Rationale & Indirect Benefits of (S)SHS
• Would you like to have a (S)SHS in your home? • *If yes*: Why? What would you expect to change? • *If yes*: Why don't you have one? *[money or other reasons?]* • Do you sometimes make use of any (S)SHS close to your home? • *If yes*: How? • Have you experienced any disadvantages due to the fact that other villagers have a (S)SHS and you don't?
Income-generating Activities
• Does any HH member carry out income-generating activities at home? Who? What kind of activities? • *If yes*: Would an improved illumination help you with these activities? • *If no*: Would you like to carry out such activities at home? What would you need to do so?
Health
• Do you think the use of kerosene has any effect on your health? • *If yes*: Why and how exactly? *[kerosene-related accidents, indoor air quality, health-related information]* • *If not yet answered*: Are you afraid of fires in your home because of kerosene lamps? Why / why not?
Education
• Are your children able to read/study at home? When do they normally study? For how long? • Do you think it would help the children to have better lighting conditions at home? Why? • Do you know how your children think about this? Do they want to study more?
Information, Recreation & Communication
• *If TV is present*: Which TV programmes do you regularly to watch? *[entertainment/news/education/...]* • *If radio is present*: And which radio programmes to do you regularly to listen to? • Do you think that you learn something from these programmes? *[general news + health-related information]* • Do you have a mobile phone? • *If yes*: Where and how often do you charge it? • *If yes*: Why is it so important to have a mobile phone? What are the benefits?

Women's Workload & Working Comfort
• How much time do the adult women in the HH normally spend on housework? • Who are the main responsible HH members for purchasing kerosene? How do they normally do that *[Where? How often? ...]*
Social Activities, Social Status & Perception of Safety
• How often do you receive visitors at your home? • How often do the different HH members meet other people in their leisure time outside of their home? • Do you think the fact that other people possess (S)SHS in your village has changed your reputation? How? • How important is your reputation in the village to you personally? Do you care a lot about it? • Do you feel safe in your home and the surroundings? *[daytime + night time]* Why? • What does light mean for you with regard to safety?

Source: Own elaboration

Appendix 8: List of qualitative interviews conducted with (S)SHS users and non-users

ID-No.	Date	Surname	First name	Description	Duration (minutes)	Location (village)
Q1	10.07.12	Mondal	Kushum Rani	User	45	Arpangashia
Q2	10.07.12	Mondal	Suchandan	Non-user	36	Arpangashia
Q3	10.07.12	Mondal	Babashindu	User	38	Arpangashia
Q4	10.07.12	Mondal	Shubangshu Kumar	User	39	Arpangashia
Q5	10.08.12	Sana	Md. Shirazul	User	49	Cakbara
Q6	10.08.12	Rahman	Md. Aminur	User	44	Cakbara
Q7	10.08.12	Islam	Anorwa	User	48	Cakbara
Q8	10.08.12	Islam	Shahina Shirazul	User	36	Cakbara
Q9	10.08.12	Khatun	Ms. Asma	Non-user	29	Domuria
Q10	10.08.12	Haque	Md. Mozammel	Non-user	29	Domuria
Q11	10.09.12	Islam	Josna Begum	User	27	Serefolkati
Q12	10.09.12	Das	Brindaban	User	27	Serefolkati
Q13	10.09.12	Begum	Anora	User	36	Serefolkati
Q14	10.09.12	Gazi	Shorkat	User	26	Serefolkati
Q15	10.11.12	Mondal	Baburam	User	53	Durgabati
Q16	10.11.12	Mondal	Kobita	Non-user	23	Durgabati
Q17	10.11.12	Mondal	Pintu Kumar	User	32	Durgabati
Q18	10.11.12	Mondal	Subita Rani	User	25	Durgabati
Q19	10.11.12	Mondal	Shaducharam	User	30	Durgabati
Q20	13.11.12	Begum	Insia	Non-user	22	Gorkumarpur

Source: Own elaboration

Appendix 9: Qualitative key informant interview guide

Introduction
• What organisation do you work for and what is your current position? Since when do you have this position? • What are you main responsibilities? How does your workday normally look like?
System Specifications, Types & Costs
• How many (S)SHS do you sell per month? • Which different types of (S)SHS do you sell? • What is the price range of the (S)SHS?
Financing Schemes
• How do the customers pay for their (S)SHS? Do you offer instalment payment? • What are the conditions for the instalment payments? • How high is the (permanent and temporary) payment default on average? • What do you do when customer are unable to pay on time?
Local Market Development
• How did the market for (S)SHS develop in the last years in this area? • Do you think that the (S)SHS market will continue to grow in the near future? • Which system sizes do you sell most? • How did the prices develop in the last few years? • In your opinion: How will they develop in the near future?
Job Creation in Solar Sector
• Are jobs being created in this area due to the dissemination of (S)SHS? • What kind of jobs? What do the people do exactly? • What educational background is needed for these jobs?
Gender
• How relevant is 'gender' in your work? • What are the challenges of integrating 'gender' in the (S)SHS dissemination? • In your opinion, what are possible entry points / opportunities for addressing 'gender' in your work?
Battery Disposal
• Do you have a battery disposal mechanism in place? • *If yes*: Which incentives are provided for the (S)SHS user? • *If yes*: How many users make use of this mechanism? • What do you think the rest of the users do with their battery after it is broken? • Do you consider the battery disposal mechanism as appropriate? • What are the most important flaws?
User Satisfaction & Feedback
• What are the most common problems the user face? • How do you respond to a user complaint about a technical problem? • In your opinion, what is the overall user satisfaction?

Source: Own elaboration

Appendix 10: List of qualitative interviews conducted with key informants

ID-No.	Date	Surname	First name	Name of organisation	Type of organisation	Position	Location (village/town)
K1	10.10.12	Rahman	Ziaur	Grameen Shakti	PO	Unit Manager	Shyamnagar
K2	10.10.12	Halder	Dipak	RSF	PO	Unit Manager	Shyamnagar
K3	10.10.12	Hasan	Imram	ADAMS	PO	Unit Manager	Shyamnagar
K4	10.10.12	Bilcha	Md. Masum	SRIZONY	PO	Unit Manager	Shyamnagar
M-10-10-X1	10.10.12	Chandro Mondal	Babu Jogesh	One Solar Power	Solar shop	Manager	Shyamnagar
M-14-10-X1	14.10.12	Gazi	Mostafa	Mostafa Battery	Battery repair shop	Owner	Shyamnagar
M-14-10-X2	14.10.12	Rahman	Jela	Jabar Sorosokte	Solar shop	Owner	Shyamnagar
M-14-10-X3	14.10.12	Haque	Mozammel	Khan Battery	Battery repair shop	Owner	Shyamnagar
M-14-10-X4	14.10.12	Islam	Saiful	REPA Foundation	Solar shop	Executive Director	Shyamnagar
M-16-10-X1	16.10.12	Rahman	Azir	Imran Battery Service	Battery repair shop	Owner	Munshigonj
M-06-11-X1	06.11.12	Hossein	Farhad	Sundarbarn Battery	Battery repair shop	Owner	Atulia
M-06-11-X2	06.11.12	Raptan	Ponkaz	Gazi Battery	Battery repair shop	Owner	Atulia
M-06-11-X3	06.11.12	Hossein	G.M. Shaminul	M & S Enterprise	Battery repair shop	Owner	Atulia
K5	08.11.12	Hasan	Alumgir	Bridge	PO	Community Promoter	Shyamnagar
K6	08.11.12	Islam	Toriqul	BRAC Foundation	PO	Sales & Service Assistant	Shyamnagar
K7	08.11.12	Roy	Paraj	SolarEn	PO	Technician	Shyamnagar
M-10-11-X1	10.11.12	Islam	Md. Rofiqul	Shirin Electronics	Solar shop	Owner	Nildomur

Source: Own elaboration

Appendix 11: Regional poverty lines according to the HIES 2010

Division	Area type	Lower poverty line (BDT)	Upper poverty line (BDT)
Barisal	Rural	1,284	1,485
	Urban	1,419	1,963
Chittagong	Rural	1,404	1,687
	Urban	1,495	1,825
	Metropolitan	1,479	1,876
Dhaka	Rural	1,276	1,497
	Urban	1,314	1,793
	Metropolitan	1,406	2,038
Khulna	Rural	1,192	1,435
	Urban	1,262	1,680
	Metropolitan	1,348	1,639
Rajshahi	Rural	1,236	1,487
	Urban	1,312	1,585
	Metropolitan	1,223	1,556
Sylhet	Rural	1,240	1,311
	Urban	1,286	1,558

Source: BBS 2010: 185; modified

Appendix 12: Monthly kerosene consumption of households with and without a grid connection

Monthly kerosene consumption	Off-grid households			Grid-connected households		
	Now	Before	Change	Now	Before	Change
SHS users	0.36 l	3.61 l	-3.25 l	0.08 l	4.21 l	-4.13 l
SSHS users	0.22 l	2.42 l	-2.20 l	0.05 l	6.50 l	-6.45 l
Non-users	2.65 l	N/A	N/A	1.18 l	N/A	N/A

Note: The number of grid-connected households in the sample is very small. Therefore the displayed average values have to be treated with caution.

l = litres

Data: Household Survey 2012