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Impact evaluation of Netherlands supported programmes in the area of Energy and Development Cooperation in Burkina Faso

The provision of solar energy to rural households through a fee-for-service system

Public Private Partnership DGIS-NUON
Implemented by FRES and the local company Yeelen Ba

- Baseline Report -

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This baseline report is part of an evaluation commissioned by the Policy and Operations Evaluation Department (IOB) of the Netherlands Ministry of Foreign Affairs. It belongs to a series of impact evaluations of renewable energy and development programmes supported by the Netherlands, with a focus on the medium and long term effects of these programmes on end-users or final beneficiaries. A characteristic of these studies is the use of mixed methods, being quantitative research techniques, in combination with qualitative techniques, to get insight in the magnitude of effects. The purpose of the impact evaluations is to account for assistance provided and to draw lessons from the findings for improvement of policy and policy implementation. The results of these impact evaluations will be input to a policy evaluation of the "Promoting Renewable Energy Programme" (PREP) to be concluded in 2014.

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1. Introduction

Burkina Faso faces a serious challenge to provide access to energy to its citizens. The country has no significant fossil fuel resources. Petroleum product consumption is entirely dependent on imports. The country's hydroelectric potential is estimated at 100 megawatt (MW) in five identified sites. This is considerable for African standards, but the required investment is huge. Two hydropower plants have been developed although the energy production is volatile due to erratic rainfall conditions. Total energy imports, representing between 10 and 20 percent of the country's gross imports over the past ten years, are now increasing (World Bank 2007).

Therefore, it is not surprising that the electrification rate amounts to mere 18 percent for the total population, 40 in urban areas and only 3 percent in rural areas. Per capita consumption is 44 kilowatt-hours (kWh) in Burkina Faso, compared to 100 kWh in Cameroon and 270 kWh in Ivory Coast, for example (6,694 kWh in the Netherlands). The majority of the population, about 90 percent, relies on traditional energy sources such as firewood and charcoal for cooking and kerosene for lighting (World Bank 2007).

The country is facing four main challenges in the energy sector. The first and main challenge is to increase the power generation in order to meet the growing energy demand. A second challenge is to bring down the considerable transmission losses in the electricity grid that is largely operated by the state owned 'Société Nationale d'Electricité du Burkina' (SONABEL). One consequence of these losses is that electricity prices are among the highest in Sub-Saharan Africa. The third challenge is to increase the access to electricity in rural areas. The fourth challenge is to introduce alternatives to wood fuels – one of the most important causes of deforestation, which in turn induces several further problems such as soil erosion (World Bank 2007).

This report presents the baseline survey results of an intervention supported by the Dutch Ministry of Foreign Affairs that provides Solar Home System (SHS) to rural households using a market-based approach. The project is being implemented by the Dutch NGO 'Foundation Rural Energy Services' (FRES), which has set up a local company called Yeelen Ba. Yeelen Ba has obtained the authorization by the national regulation authority to market SHS on an exclusive basis within rural areas in the Kénédougou province. The SHS that are distributed can provide electric light and allow for the usage of small electric appliances including b/w or colour television depending on the service package chosen by the household. In particular, for low consumption households SHS are by many seen as a promising alternative to the investment intensive extension of the electricity grid fed by centralised electricity generation from fossil fuels. It is expected that this intervention provides benefits such as improved living conditions, time savings, increased security, better health conditions, and educational attainment trough extended study hours. However, the magnitude of these impacts is likely to vary greatly across households and with the intensity and duration of exposure. On the other hand, so far according to our experience in the field, SHS are a relatively expensive electricity source that often only wealthier households can afford.

The objective of this report is to describe the intervention, the context of the intervention, and the chosen evaluation strategy as well as to outline main results from a baseline survey that was undertaken in November 2010. Baseline data has been collected on virtually all household-specific socio-economic characteristics with a focus on energy-related issues. This information will constitute the benchmark against which we will compare the data to be collected two years later in 2012 when

households in the area targeted by the programme will have taken up the offered energy services. In the present report, the baseline data is used mainly to present the socio-economic situation in the project area, people's energy consumption as well as their opinion on and attitudes toward electricity before the roll-out of the programme. In presenting the baseline results we furthermore check the quality of the collected data by, first, testing its internal coherence, and, second by comparing it to other sources, in particular the last population census, to check its external coherence.

This report is structured as follows. In Section 2 we describe the intervention to be assessed in more detail and provide more information about the regional context in particular with respect to energy access and use. Section 3 presents the methodology and evaluation approach that will be used. Section 4 presents the collected baseline data with respect to key socio-demographic and economic information about the targeted households and their attitudes and habits with respect to energy use. Section 5 briefly discusses some evaluation risks. Section 6 concludes.

2. The Intervention in its Regional Context

2.1. Regional context

Burkina Faso has a population of 13.4 million inhabitants that is increasing at a rate of 3.1 percent per year. The project area is located in the region of 'Hauts-Bassins', which is the second largest region out of 13 in Burkina Faso (in terms of population) and situated in the West of the country. In the rural part of that region live today about 951,000 people. In the Yeelen Ba project area – the rural part of the province of Kénédougou – live about 278,000 people representing 89 percent of the total population in that province (Table 1).[2]

Table 1: Rural population and number of households in the provinces of Hauts-Bassins

Province (rural areas)	Rural population 2006	Share of total population in prov./region	Households 2006	Rural population 2009 (Projection)
Kénédougou	254,063	88.9	43,048	277,828
Hauts-Bassins	*871,007*	*59.3*	*144,307*	*951,336*

Source: Burkina Faso census data and official population projections 2006.

Table 2 shows that farming is the main activity in the project area. In 2003, when the last publicly available household survey was undertaken, 28 percent of all households were pure food crop farmers, while 69 percent of the households also cultivated cotton. Food crop farmers do typically not produce for export markets, but sell parts of their production on local markets to earn cash income. The share of cotton farmers is high compared to other parts of Burkina Faso. Cotton farmers are on average better-off than pure food crop farmers (see Grimm and Günther 2007a, b), although they are on the other hand more exposed to variations in weather conditions and cotton prices on the commodity markets.[3] Other activities such as formal and public sector wage works employ a negligible percentage of households in the project area.

[2] In total there are 45 provinces in Burkina Faso.

[3] One advantage of cotton farmers is that they have access to a marketing board and thus have access to fertilizer and pesticides that can be bought on credit. Usually farmers employ parts of these inputs for their food crops and thus often obtain higher yields than pure food crop farmers.

Table 2: Socio-economic structure of households in Kénédougou and Hauts-Bassins in 2003, in percent

Economic activity	Kénédougou rural			Hauts-Bassins rural	Hauts-Bassins (total)	National (total)
	Total	Bottom 50%	Top 50%			
Wage earner public sector	1.0	0	2.0	2.7	7.6	4.8
Wage earner private formal sector	0	0	0	0	4.9	3.0
Wage earn./self-empl. informal	1.0	0	1.9	2.7	17.3	10.0
Food crop farmer	27.8	35.0	20.4	26.1	20.9	57.4
Cotton farmer	68.6	65.0	72.3	65.2	38.6	15.3
Inactive	1.7	0	3.4	3.3	10.6	9.4

Notes: The bottom/top 50% refers to the position in the distribution of total household expenditure per capita. The socio-economic group is coded according to the main activity of the household head. Cotton farmers are farmers that produced at least 1kg of cotton during the last 12 months. Note that cotton farmers usually grow also food crops. Note that statistics on the level of the *département* are not fully representative.
Source: EP 2003, own computation.

In terms of educational indicators the Yeelen Ba project region performs slightly better than the rest of the country. School enrolment rates (net enrolment), for example, are higher at 37 percent than the national average of 31 percent. In terms of educational attainment, 14 percent of children aged between 15 and 19 years and living in Yeelen Ba project region have completed the primary education compared to a national average of 10 percent. The under five mortality rate, in contrast, is slightly worse for the rural part of the Kénédougou region. Again, all these figures are drawn from the *Enquete Prioritaire* 2003 and are likely to have improved over time, at least for education.

2.2. Market-based distribution of solar home systems

The project is being implemented by the 'Foundation Rural Energy Services' (FRES), a Dutch NGO that is aiming to provide electricity produced by solar energy to private households and small businesses. FRES is currently active in three African countries: South Africa, Mali, and Burkina Faso. Projects are currently planned in Benin, Guinea Bissau and Uganda. In Burkina Faso, FRES has set up a local company called Yeelen Ba, in which FRES also has a share of 20 percent via its involvement in Yeelen Kura, which is a similar company in Mali. The remaining 80 percent are held by NUON, a large Dutch energy provider. 'Yeelen Ba', which means in the local language 'Big Light', has been founded in 2008 and obtained the authorization from the national regulation authority to supply energy on an exclusive basis within rural areas in the Kénédougou province in 2008. The solar home systems it provides are subsidised by EU and Dutch funds. In July 2009, the first customer had been connected. Today, Yeelen Ba customers are located in villages ranging up to 4,000 inhabitants, although most villages are in the range of a few hundred inhabitants. The way for Yeelen Ba was paved by Yeelen Kura's operations in Mali. Yeelen Kura is a successful company providing solar-based electricity to an estimated 24,000 people living in rural areas in the Sikasso region in Southern Mali next to the Burkina Faso border. The living conditions in Burkina Faso and Mali are similar and households in the target area in Burkina Faso expressed on several occasions their wish to have access to similar energy service as their neighbours in Mali.

Yeelen Ba offers different types of solar home systems (SHS) on a fee-for-service basis. The fee-for-service system has been chosen to ensure sound maintenance of the solar panels by local businesses, which eventually should be self-sustaining in the long term without any donor involvement. In principle, a standard SHS comprises an accumulator, a charge regulator, and a solar panel. The number of light bulbs and sockets as well as the power that can be used is determined by the size of the SHS. Yeelen Ba offers three different packages at different fees. This is shown in Table 3. All

systems provide enough electricity to feed three to four light bulbs, and a television for around four to five hours. Alternatively, low consumption appliances like radios, fans, or mobile phone chargers can be used. Running a fridge, for instance, is not possible and requires taking several solar panels.

The idea of the fee-for-service approach is that the customer rents the SHS, while Yeelen Ba remains to be the owner and assumes responsibility for the maintenance. Customers typically go to a sales shop in their area to subscribe to the service. They pay connection costs plus a monthly fee. If they pay for a year upfront they get a month for free. Most customers do not pay the connection costs through a single instalment since these costs can be stretched over three months. As an example, Package 1 in Table 3 costs 10,130 FCFA (15.50 Euro) per month for the first year. The fees to be paid by customers were reduced in November 2010, since Yeelen Ba obtained government exemption for VAT on electricity consumption for the customers. If customers do not pay, the SHS is removed. By the end of 2010, this had happened 17 times. Moreover, a number of clients have been suspended temporarily until they settle their current bills. Yeelen Ba accepted delayed payment of up to six months conditional on signing a letter of commitment. This policy will be changed to two months in the near future.

Yeelen Ba visits customers on a monthly basis to check the correct maintenance of the SHS and for billing purposes. Marketing activities typically include radio spots and village sensitization campaigns in addition to small surveys to assess the market potential and the willingness to pay of households. The main selling arguments by Yeelen Ba are that SHS are clean and that they provide regular energy. Try-out periods are also possible for customers. A recurrent challenge for Yeelen Ba faces is to solve the customers' confusion about the SHS property status: People are not used to rent, but not own, something they use.

Table 3: Services packages and costs offered by Yeelen Ba (all amounts in FCFA; 1Euro = 656 FCFA)

	Package 1		Package 2		Package 3	
	2 bulbs and 1 socket (e.g. for b/w TV) or 3 bulbs		3 bulbs and 1 socket (e.g. for b/w TV) or 4 bulbs		3 bulbs 1 socket for colour TV	
	2010	2011	2010	2011	2010	2011
Connection costs	43,660	41,600	54,280	51,500	74,980	70,230
Annual fee (in case of advance payment)	77,880	66,550	103,840	88,550	178,750	152,625
Monthly costs first year	10,130	9,012	13,177	11,671	21,144	18,571
Monthly costs second year onwards	6,490	5,546	8,653	7,379	14,896	12,719
Rate per day (second year)	216	185	288	246	497	424

Source: Yeelen Ba, February 2011.

Currently customers can be found in about 40 different villages. Out of Kénédougou's 151 villages, a total number of 120 villages have been targeted by Yeelen Ba's marketing activities. These villages accommodate about 25,500 households. The remaining 31 villages in Kénédougou are either already served by a different operator, for example the state-owned SONABEL, or will be assigned to a different operator in the near future. By February 2011, Yeelen Ba had installed some 320 panels. Yeelen Ba's objective is to reach 2,600 clients, households and small businesses, by the end of 2012 (which implies a penetration rate of about 10 percent) and 3,000 clients by the end of 2013 (see Table 4).

Table 4: Yeelen Ba's sales objectives

Years	Number of installed SHS	Average growth
Realized		
August 2009	1	Average # of new clients per month
December 2009	104	(since January 2010):
April 2010	172	15.4
October 2010	249	
December 2010	282	
February 2011	320	
Target		Average # of new clients per month needed
End of 2010	600	to meet target in 2012:
End of 2011	1,600	103.6
End of 2012	2,600	
End of 2013	3,000	

Source: Yeelen Ba and FRES (see also FRES webpage[4]) February 2011.

Yeelen Ba went through a difficult year 2010 due to internal management problems and a case of fraud caused by some personnel and due to the fact that Yeelen Ba obtained very late the VAT exemption. A new director has been appointed by FRES by the end of 2010. The focus is now clearly on increasing as fast as possible the number of clients and to establish Yeelen Ba as a reliable electricity provider. Focus group discussions with villagers and a few expert interviews suggest that the fees for the SHS services for many households in the project area are prohibitive. The activities by Yeelen Kura in Mali are financed through a similar funding scheme, but the smallest service package that is offered is smaller than in Burkina Faso.[5] The lower price may explain that there the number of clients increased steadily in the past.[6] Yeelen Ba, instead only acquired 178 new clients in 2011. To reach the initial target of 2,600 customers at the end of 2012, Yeelen Ba needs to acquire about 100 new clients every month, which seems to be ambitious given the dissemination results so far.

2.3. Access and use of energy in the project area

In 2003, the official electrification rate in rural Hauts-Bassin was at 0.3 percent, while in the Kénédougou region no household was officially connected (Table 5). The connection rate in Hauts-Bassins (rural and urban together) was at 22 percent. About 75 percent of all households in Kénédougou owned a radio, but only few had a TV set. Kerosene was clearly the dominating energy source for lighting, as it is used by 99 percent of all households in Kénédougou. Figures in Table 5 again, show marked differences between rural and urban areas.

[4] www.fres.nl/en/how-fres-works/fres-in-burkina-faso.html

[5] In Burkina Faso the smallest package is larger, because, according to FRES, the households in Kénédougou have a higher preference for TV than their counterparts in Mali.

[6] However, the project area in Mali is relatively poor compared to the cotton-growing region of Kénédougou, therefore there might be other reasons for the difference in the performance of the business model in Mali and Burkina Faso.

Table 5: Access to electricity and ownership of electric appliances in project area in 2003, in percent

Access to electricity	Kénédougou rural	Hauts-Bassins rural	Hauts-Bassins (total)	National (total)
Access to Electricity	0.0	0.3	22.3	10.4
Possession of Radio	74.5	82.7	85.1	67.8
Possession of TV	2.3	3.5	19.0	10.0
Main source of energy used for light				
Kerosene	99.4	97.9	76.6	71.4
LPG	0	0	0.3	0.1
Electricity/Solar energy	0	0	21.7	10.4
Flashlight	0	1.6	0.9	13.2
Fire wood	0.6	0.5	0.4	4.3
Other	0	0	0.1	0.5

Note: Statistics on the level of the *département* are not fully representative. We checked consistency of these statistics with the results from the DHS 2003.
Source: EP 2003, own computation.

Table 6 shows household expenditures for energy in the province of Kénédougou, in Hauts-Bassins, and in Burkina Faso as a whole. Households in rural Kénédougou spend about eight percent of their budget on energy. Wood, which is mainly used for cooking purposes, is the most important item accounting for more than 75 percent of the total energy expenditure. The second most important item is kerosene, 21 percent, which is mainly used for lighting purposes. The energy share of total expenditures is much higher in the bottom quintile of the income distribution compared to the top quintile. However, in absolute terms there is almost no difference between the bottom and top quintile - poorer households even seem to spend slightly more which can be explained by larger household sizes - suggesting that what is spent probably covers for many households just the basic needs. Comparing the poorer with the richer quintile shows some substitution of wood by charcoal.

Table 6: Socio-economic structure and yearly energy expenditure in 2003 (local currency in 2009 prices)

Type of expenditure	Kénédougou rural			Hauts-Bassins (rural)	Hauts-Bassins (total)	National
	Total	Bottom 20%	Top 20%			
Household expenditure	663,347	344,125	1,373,554	983,828	1,108,997	1,009,722
Household expenditure for energy						
Charcoal	154	52	97	2532	3724	2912
Wood	27,106	31,975	28,306	31,597	36,902	34,198
LPG	150	0	0	439	3,905	2,261
Electricity	0	0	0	0	20,788	10,459
Kerosene	7,598	7,705	8,170	9,279	8,276	8,064
Candles and other	552	143	371	1,828	1,355	2,983
Total expenditure for energy	35,561	39,875	36,945	45,675	74,950	60,877
Share energy expenditure, in %	7.8	11.3	4.0	6.6	7.9	7.1
Household size	5.3	6.7	3.8	6.3	6.1	6.4
Household expenditure per capita	156,525	51,313	424,634	199,010	239,071	206,601

Notes: The bottom/top 50% refers to the position in the distribution of total household expenditure per capita. Household expenditure includes expenditure on food and non-food items (including auto-consumption), education, health and transfers given to other households. Values are in prices of Ouagadougou end of 2009. Regional prices are adjusted on the basis of price difference observed in 2003. The price deflator between Ouagadougou and the region Hauts-Bassins was estimated by the INSD to be 1.042. Prices have been adjusted to end of 2009 using the general consumer price index (1.22 between end of 2003 and end of 2009). Note that statistics on the level of the *département* are not representative.
Source: EP 2003, own computation.

3. Evaluation Approach

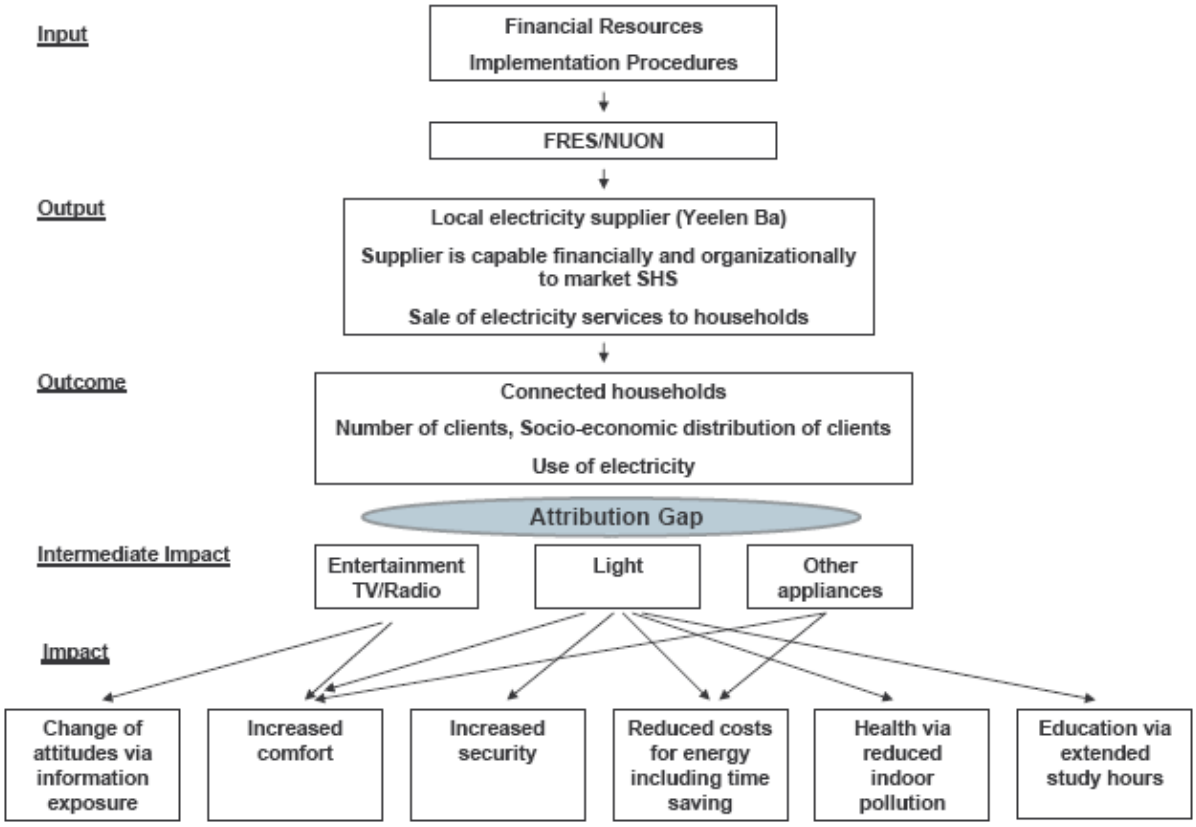
3.1. Evaluation objective

The objective of this evaluation is to assess all positive and negative effects – intended or not – related to the market-based distribution of SHS via Yeelen Ba in the province of Kénédougou. Our focus is on connected households and we will address questions on both outcome and impact level.

On the outcome level: (i) To what extent has access to electricity changed? (ii) How reliable is the electricity supply through SHS? (iii) Which socio-economic groups (incl. income groups) benefit from increased access?

On the impact level: (i) For what purpose and by whom in the household is electricity used? (ii) How have expenditures for energy changed? (iii) To what extent has safety/protection changed? (iv) To what extent has comfort/convenience changed? What monetary value do households attribute to this increased convenience, disaggregated by gender? (v) To what extent do activities during evening hours change? Have study hours/reading time of children changed? Do women and children enjoy more or less rest for physical recuperation? (vi) To what extent has indoor air pollution been reduced (according to the perception of dwellers)? (vii) How have, in response to the possibly increased media exposure, attitudes and behaviours, such as women's status, fertility, children's school enrolment changed? This is further illustrated in the result chain shown in Figure 1.

Figure 1: Results chain



Source: Own representation.

We expect that for beneficiaries the major impact is on 'softer' levels such as increased convenience and comfort, i.e. using electric lighting and appliances such as radio, TV, or a mobile phone charger. The questionnaire that has been designed covers virtually all socio-economic aspects that characterise the household's living conditions. A particular focus is put on the use of appliances and expenditure on energy before and after the SHS was installed. Not least, two additional features address the convenience and comfort aspects: (a) Direct questions on satisfaction and perceived convenience. These questions are similar to those used in the happiness and subjective poverty literature and in the marketing/business school literature. (b) A willingness-to-pay analysis (WTP), i.e. households have been asked how much they would be willing to pay to get a well-defined package of electricity services (see Box 1). The WTP approach has been designed in line with the WTP and contingent valuation literature.[7]

Box 1: Willingness to pay

The willingness to pay (WTP) of a household for a good (or a service) reflects the "true" value that this person assigns to this good. In the case of electricity the true value includes not only economic benefits in the narrower sense such as kerosene savings or income generation potentials, but also convenience factors or subjective security issues. Likewise, the household faces costs related to electricity usage, again not only costs in a narrower sense like monthly fees but also non-monetary costs such as kids who watch too much TV. Hence, implicitly the household sums up the benefits and contrasted them with the sum of costs, which is then aggregated in its WTP.

If sufficient variation in the price of the good is observable in a market, the WTP can be obtained from the *revealed* preferences of households in this market. If, for example, the price of fruits varies over time and across regions, the response in demand to price changes of fruits can be used to derive the WTP for fruits of different household groups. However, people might also assign a value to goods for which no market exists, for example clean water in rivers. In order to elicit this value, so called *stated* preferences techniques have been developed. These techniques can as well be applied to goods for which – in principle – a market exists, but no sufficient variation in market prices can be observed. Although SHS can be purchased on markets in rural Burkina Faso, the market is too small and prices do hardly vary. In addition, the particular fee-for-service product offered by Yeelen Ba is new and no market exists so far for this service. Therefore, stated preferences techniques can be used to scrutinize the value people assign to electricity from SHS in general and provided by Yeelen Ba in particular.

In principle, such stated preferences techniques simply ask respondents for their WTP. The most straightforward approach is the dichotomous choice method, for which the respondent is asked if s/he is willing to pay a certain price. For the double bounded dichotomous choice method, respondents are confronted with a follow-up question after the first response (e.g. if they are willing to pay 50 percent more/less depending on the first answer). If open-ended questions are applied, respondents are asked to state their WTP without any concrete offer.

[7] Refer to the following sources to see how this approach can be used to assess benefits from access to energy: Devicienti et al. (2004), Abdullah and Jeanty (2009) and FAO (2000).

Beyond the convenience and comfort level we will examine impacts on the activities after nightfall patterns of households, which might change in the wake of electrification due to increased usage of lighting and television. Here, the time children dedicate to home studying is an indicator. As the result chain shows, in principle also effects on health due to reduced indoor air pollution are possible. However, even if this impact exists it can be expected to be rather small given the short time horizon covered by the analysis and taking into account that indoor air pollution is largely induced by cooking fuels, although cooking largely happens outside.[8] A possible unintended effect associated with the replacement of kerosene lamps is that these lamps also protect against mosquito bites if some neem oil was added to the kerosene.[9]

In addition, the impact will be studied on behaviour and attitudes resulting from increased media exposure, such as on women's status, reproductive behaviour, and children's school enrolment. Some studies have demonstrated that the information and exposure provided by radio and in particular television can influence a wide range of attitudes and behaviour. Grentzkow and Shapiro (2004), for instance, find that television viewership in the Muslim world affects attitudes towards the West. Olken (2006) shows that television decreases participation in social organizations in Indonesia. La Ferrara, Chong and Duryea (2008) find that exposure to soap operas in Brazil reduces fertility and increases the divorce rate (Chong and La Ferrara, 2009). Peters and Vance (2011) find for Côte d'Ivoire a positive association between electricity and fertility for urban households, contrasted by a negative relationship for rural households. They provide two potential explanations for the negative correlation in rural areas: First, a modernizing effect could contribute to a different attitude towards fertility and more family planning instruments; second, people might reduce the frequency of intercourse because of "alternatives to sex". Jensen and Oster (2008) find that the introduction of cable television is associated with significant decreases in the reported acceptability of domestic violence towards women. The frequently observed preference for having male children seems to be as well affected (negatively) as the women's autonomy (positively) or fertility (negatively). They also find suggestive evidence that exposure to cable television increases school enrolment for younger children. The authors speculate that this latter effect is due to increased participation of women in household decision-making.

3.2. Identification strategy

The major problem faced in evaluating the programme is that the take-up of Yeelen Ba's services is not random, and hence households that get an electricity connection might systematically differ from those that do not. The characteristics that differ may be time constant or time variant and specific to the household or the village the household resides in. Not taking into account these differences bears the risk of falsely attributing changes to the programme that are in fact related to those differences. For example, 'smarter' household heads might be more aware of SHS advantages and, hence, are more inclined to obtain an SHS. At the same time, they take more care about their children's education – just because they are 'smarter'. If we then look at educational outcomes not taking into account that SHS users are smarter, we attribute the differences in educational outcomes to the SHS usage although they are just due to 'smarter' household heads among the SHS users.

[8] Electrification may also lead to fewer accidents with burning candles or with other lighting sources. Moreover, light may reduce the incidence of snake or scorpion bites. However, we doubt that these aspects while important for the perceived security can be measured in a quantitative way. These issues had been raised in focus group discussions, and the results as far as relevant can be found in the analysis part of this report (chapter 4).

[9] Neem oil is a vegetable oil pressed from the fruits and seeds of the neem, a tree in the mahogany family.

We can account for these factors in regression models as long as they are observable (smartness, for example, might be reasonably captured by the educational level of the household head, although this is far from evident). If unobservable differences remain, this can be taken into account by a difference-in-difference (DD) approach combined with a propensity-score matching procedure (PSM). Based on the role-out plan of Yeelen Ba's activities we collected baseline data in a random sample of villages that are in the programme's catchment-area. In two years (November 2012) we will re-visit all households and then compare the difference in the changes in outcome variables between users ('treatment group') and non-users ('control group') of the SHS. It is important to revisit households exactly in the same period two-years later to avoid any bias due to seasonality.

This DD approach removes unobservable differences – as long as they are time invariant. With data on users and non-users households before and after the SHS installation, therefore, the fixed component can be differenced out, i.e. all confounding factors that may have an impact on the outcomes of interest and that are constant over time are controlled for. The key assumption of the DD method is that unobserved characteristics affecting programme participation do not vary over time with treatment status. To further reduce the potential impact of a bias due to systematic differences between users and non-users, we will account in addition for as many as possible observable time-variant observables. We will also control for period-specific village effects. This is for instance relevant if weather conditions and thus harvest outcomes vary across locations in the project area or if farm-gate prices for agricultural goods are different, although we do not expect major differences in this respect, given the geographically narrowly defined project area.

Moreover, we consider combining the DD approach with a PSM approach (see Box 2) to better match control and treatment households on pre-programme characteristics (e.g. education, socio-economic status, income, asset-ownership, characteristics of the villages they live in). A high degree of similarity on pre-programme characteristics may reduce the risk of potential time-varying selection bias attributable to differences in initial observable characteristics. With PSM the treatment impact is calculated across users and matched control units within the common support, i.e. households that share many common characteristics and are hopefully equally likely to use an SHS. This is important since, the intervention relies entirely on a market-based approach and given the cost of the SHS, we expect that we will be confronted with selection effects which need to be addressed. A research assistant from our team on the ground helped to assess what factors determine the decision to install an SHS, in particular aspects that get unnoticed in a structured questionnaire, such as being particularly economical or open to new technologies. At the end it may turn out that the bias stemming from selection may not be very important as take up may be driven mainly by income, which is observable and recorded in the household survey.

The survey will also have to gather information on how many months a household made use of the SHS. Although we expect that in most cases a user remains at least a few years with the SHS given the high fixed cost in year one, it may happen that households take up the technology but drop out again, before the follow-up survey has been undertaken. Other surveyed households may have taken up the programme late. Hence, we could have comparisons on the one hand in terms of user/non-user and, on the other hand, amongst those who have chosen given that there shall be variation in outcomes that is due to the length of electricity exposure.

Box 2: Propensity Score Matching

When treatment participation is not by random assignment but depends on a set of observable characteristics, *X*, the concept of propensity scores is useful. In our case the subscription to a Yeelen Ba solar home system (SHS) on a user fee basis clearly falls into this category of treatment. Users are probably not just a random group of households in the project area, but rather households that are for example a bit richer and better educated than the average household. Put differently, households are likely to select themselves, according to some observable characteristics, *X*, into the group of users.

The idea of Propensity Score Matching (PSM) is then to compare the actual users with a group of non-users that are based on the observable characteristics, *X*, equally likely to be a user than the actual users. Hence, the comparison is limited to a very homogenous group of households. The implicit assumption is that the users that are observed would behave - in case they would not use an SHS – in the same way as the non-owners – the matches - to which we compare them.

Key to the application of this approach is the co-called common support condition, i.e. there should be enough non-users of SHS that share the same characteristics than the users. This ensures that we have untreated matches for the treated observations for every *X*. The propensity scores can be obtained by estimating econometrically the latent probability of being a user of an SHS on a set of observed variables, *X*. Given that the latent probability is unobserved the binary information of use/non-use is used as dependant variable. Such a model can be estimated using for instance a probit or logit model and the estimated regressions coefficients can then be used to predict conditional on *X* the hypothetical probability of using an SHS. This is then called 'propensity score'.

Propensity score matching does not work if the characteristics that explain selection into treatment are unobserved. If for instance astuteness of the household head is a key determinant in the decision to use an SHS and if astuteness cannot be observed, PSM is not a solution. However, if astuteness is only one of the many characteristics explaining the selection process and if astuteness is strongly correlated with other observable characteristics such as education and income the PSM approach would indirectly also reduce a potential bias through unobservable characteristics and can be seen as a valid approach to increase the efficiency of the impact assessment.

For a more detailed presentation and the underlying mathematics of this approach see, for instance, Cameron and Trivedi (2009). Note also that the literature proposes a number of other matching estimators.

Finally, and to further test the robustness of the obtained results, the analysis may also include an identification of effects via instrumental variables, i.e. variables that determine take-up of an SHS but do not directly affect the outcomes of interest. Distance to the selling point or the intensity of marketing efforts in a given area could serve as such variables. The closer a household lives to a selling point the more likely it might be to take up the technology, but distance should not be correlated with kerosene consumption; hence this variable can be used to identify the effect of having an SHS on kerosene consumption.[10] The qualitative work that had been done before and during the surveys were implemented helped to find such variables and to integrate the corresponding questions in the survey tool.

[10] Using the sub-sample of households that use already an SHS, we do not find any systematic relationship between distance and take-up. However, the number of users is still too small to conclude on the validity of this instrument.

To assess broader questions related to the sustainability of the programme on the household level and on the level of Yeelen Ba, we will in the follow-up survey investigate whether households are satisfied with the service provided by Yeelen Ba, whether the SHS are working without major interruption, whether repairs are done appropriately and in due time and whether they intend to maintain their subscription to the service. This assessment will be, first, based on some specific questions in the household surveys and, second, on semi-structured interviews with households. Moreover, focus group discussions will be conducted to learn more about the factors why some households do not take up the technology. These additional tools are discussed in more detail below. At the Yeelen Ba level, we will check whether customers usually make a valid assessment of their own capacity to pay the monthly fee. This can be done qualitatively, but also by looking at the share of customers that is not able to pay the monthly fee. In addition, we will look into the financial concept and assess whether Yeelen Ba can maintain the program even after the funding has ended. The quality of these parts of the evaluation depends obviously a lot on the collaboration then offered by FRES and Yeelen Ba. Finally, at the level of the Government we will investigate whether a regulative framework emerges that allows private operators like Yeelen Ba commercializing SHS or other decentralized electricity sources.

3.3. Survey tools

In order to achieve the evaluation objectives outlined in Section 3.1 several survey tools were applied: household surveys based on structured questionnaires, expert interviews, semi-structured interviews on the community level and focus group discussions. The principal tool is structured questionnaires. Given that the survey included a number of questions in particular related to fertility preferences, contraceptive methods as well as attitudes towards female decision making, we designed two questionnaires: (i) a household questionnaire to be answered by the household head and his/her spouse (see Appendix 1 (file) for the original French version of the questionnaire) and (ii) a women's questionnaire to be answered by all female spouses (see Appendix 2 (file)). This ensured that women could answer the questions without "feeling observed" by their husband. The general socio-economic parts of the questionnaire include questions on demographics, health, financial situation, security, and gender relevant issues.

Furthermore, the questionnaire included two additional sets of questions as mentioned before: (a) direct questions on the satisfaction and the perceived convenience and security; (b) a willingness-to-pay section (WTP, see Box 1). In combination, (a) and (b) help to assess the effects of electricity use on convenience and security in more detail. Further it also gives us an indication on how much people would be willing to pay for the Yeelen Ba service.

In addition, the complementary women's questionnaire seeks information on women's perception and usage of electricity, on contraceptive usage, and women's attitude towards domestic violence. These questions help us, as mentioned in Section 3.1, to analyse whether electricity in general and TV or radio usage in particular trigger new views and norms in terms of family planning and women's empowerment. As outlined in Section 3.1, this might be a softer but in the long-term extremely important channel of how electrification translates into poverty alleviation in a broader sense.

Obviously, some of the issues raised in the women's questionnaire, such as domestic violence, are sensitive topics. The concrete wording of questions has therefore been taken over from the Burkinabe Demographic and Health Survey Questionnaire 2003. Hence, these questions have already

been officially approved and asked in surveys in Burkina Faso. Like for all other parts of the questionnaire, answering these questions was voluntary. These interviews were planned to be done by female interviewers only. Since our Burkinabè partner organisation responsible for the implementation of interviews did not consider these questions that gender-sensitive, both male and female enumerators eventually conducted them. In most cases, interviewees were immediately willing to answer these questions. Only in some cases they asked for the relevance of questions about contraception to a survey about energy use. After the enumerators explained the intention behind these questions, the female household members also responded without any further scepticism.

The 'community questionnaire' (see Appendix 3 (file)) served to collect information about regional characteristics. This included questions on infrastructure access and quality, local economic conditions such as cash crops and employment opportunities, energy prices and general energy usage patterns in the village. This information captures the circumstances under which the households live and can therefore be linked to the household-specific data stemming from the household questionnaires. In addition, this information permits to cross-check certain household statements in the structured questionnaire.

Beyond these structured questionnaires, semi-structured interviews were conducted at schools and health centres to get inside information on their needs and consumption of energy, since these social infrastructure institutions represent the most important public services at local level as well as relevant potential future clients for Yeelen Ba.

Focus group discussions[11] (FGD) have been used to learn more about the reason why certain households do not intend to take up the technology and about their general attitude and knowledge about solar energy and electricity. FGD help to investigate the meaning of the survey results and bring them in a broader context (Schutt 2004). The FGD were held with women associations and men cooperatives. In total four FGD were held, one in the preparation phase of the survey and three during the survey, each in a village of a different department. All discussions were guided by the same list of open questions including the use of electricity for private consumption and for productive use in the group (see Appendix 4 (file)). For example, it was asked which electricity sources are prioritized and how electricity can improve their daily work. To ensure that all the opinions in the group were reflected in the FGD – between six and ten persons participated –, each person was included in the discussion by the facilitator, an ISS/RWI team member.

3.4. Sampling

A two-stage random sampling was applied with the first stage being on the village level and the second on household level. At the outset, all 120 villages targeted by Yeelen Ba in Kénédougou Province were eligible.[12] Among them, 40 were randomly drawn according to proportional-to-size probability sampling: the likelihood of each village to be in the sample was proportional to the number of households living in that village. In case the sampling yields a slightly biased (i.e. unrepresentative) sample, this bias can be redressed by computing appropriate weighing factors based on census data information on basic socio-demographic characteristics. Yeelen Ba provided the respective list of all 120 villages in the programme's catchment area including the number of

[11] A focus group is a group of individuals selected and assembled by researchers to discuss and comment on, from personal experience, the topic that is the subject of the research (Powell 1996).
[12] Or 'treated' in a sense that information campaigns have taken place and households can subscribe to the service.

inhabitants and households in each single village. The average population size of these villages was 1,940. The villages accommodate between 59 and 1,018 households.

The sampling at the second stage, i.e. at the household level, was done on site by the survey team (see Section 3.5). In each village 30 households were selected randomly. The strategy applied by the interviewers was the following: each village was divided into 5 sections with the help of a map and each interviewer was assigned to a section. In each section every n^{th} household was interviewed with the *n* depending on the number of households that lived in the respective part of the village. In virtually all cases we found the relevant household members and hence were able to conduct the interviews. If the household head and his spouse could not be found other household members were asked to fix an appointment for the same day with the household head. If no member at all could be found, then the household next door was interviewed. This happened very rarely. None of the households refused to answer the questionnaire.

In total, 1,200 households (30 households in 40 villages) were interviewed. This sample size was derived from statistical power considerations assuming that Yeelen Ba roughly meets its new clients targets before the follow-up takes place which is scheduled for the end of 2012. Applying the most direct impact indicators such as lighting hours shows that even a smaller sample size should be sufficient to detect the expected magnitude of the impact. For some other relevant outcomes such as indoor pollution and respiratory diseases the expected effect size is unknown, since we do not have information from other studies. Yet, the size of these impacts can be assumed to be rather small, and hence require a rather large sample size. Other intermediary impacts such as activities after nightfall (e.g. children studying at home) can be expected to lie somewhere in between in terms of the size of the expected impact. In order to capture as many of effects as possible while remaining within the limits of the available budget, we decided to sample 1,200 households.

Logistically, the implementation of the sampling faced some problems due to the inaccessibility of certain villages after the rainy season. Rainfall had uncommonly continued until October and in one case the bridges to access the village were not passable. As a result, not all villages from the original list of randomly selected villages for our evaluation could be surveyed. In total, seven sampled villages had to be replaced (see Annex 1). Based on general village information about schools, health stations, churches, and market places that we obtained from local authorities, we could verify that the replaced villages do not differ structurally from the sampled replacement villages, except that they are during some periods of the year not easily accessible (or not accessible by a vehicle).

As indicated in the Terms of Reference of this study, the option of undertaking additional baseline interviews with every new client of Yeelen Ba for a period of about three months after the survey was scrutinized. This procedure would have ensured that we end up with a higher share of users in the follow-up survey. Yet, this approach proved to be non-feasible for budgetary reasons. It would have required having a survey team in the region for three months. As an alternative, we discussed with Yeelen Ba whether their technicians could do the interviews. But this proved to be not feasible since Yeelen Ba was entering a period of organizational restructuring right after the survey, and hece the technicians unfortunately had not the time to administer the questionnaires on top of their actual tasks.

3.5. Survey implementation

For the implementation of the survey we teamed up with a local research institute, based in Ouagadougou and experienced in the field of energy surveys, called *Bureau d'Etudes des Géosciences, des Energies et de l'Environnement* (BEGE). BEGE was responsible for the logistical organization of the survey including, for example, the recruitment of the interviewers and the hiring of cars. Moreover they were responsible for the quality assurance of the survey, i.e. that the households were sampled properly, the questionnaires were completed consistently, and the data entry was done accurately. BEGE was supported by an ISS/RWI team member during the whole survey implementation.

The preparation of the baseline surveys was undertaken by ISS/RWI researchers in the beginning of October 2010 (see Annex 2). In order to account for potentially unintended impacts, open focus group discussions with a few target group representatives were done in the pre-test phase. A four-day training workshop was held by two ISS/RWI researchers to prepare ten interviewers and four operators for data entry. After a presentation of the study's objective and a discussion of the questionnaires, the role of the interviewer was discussed including how they had to present themselves when visiting a household. Afterwards, the interviews were practiced through role playing games in the local language (Dioula). Normal interviews, best-case and worst-case interviews were tested. In a two-day pre-test in the field the interviewers applied the theoretical content of the training. These pre-tests also served to verify the feasibility of the different questionnaires and to make further improvements regarding their content. A particular focus of the training was on data entry as a crucial part of the survey cycle. After the pre-test the enumerators were trained to enter the data in the Excel data entry sheet. As a final preparatory step, the route of the survey was planned by the supervisors, the ISS/RWI team member, and a Yeelen Ba staff member.

The interviews took place from November 1st until November 25th 2010. The survey was conducted by two teams, each consisting of five interviewers and one supervisor. Throughout the survey an ISS/RWI team member stayed with the survey team to ensure the proper implementation and to conduct interviews on the community level. The data entry took place in the regional centre of Orodara during the time of the survey. Three weeks after the survey, BEGE submitted the entered data to ISS/RWI. The accuracy of the entered data was checked and final revisions were made by BEGE in Ouagadougou. The final version of the data was handed over to RWI/ISS on 8 February 2011.

4. Baseline results

4.1. Assessment of data quality

This section presents some results of the baseline survey in order to illustrate the living conditions in the project area, but also to document the quality of the collected data. For this purpose we check the coherence of the data, for example by verifying if the correlation of certain socio-economic indicators and wealth is in line with expectation. Another instrument to check for the data quality is to compare our results with census data. Furthermore, we discuss the response rate to a few questions for which a certain rate of non-response could have been expected. For non-response, we additionally tracked whether the respondent did not know the answer or whether s/he was not willing to share it with the interviewer.

The 1,200 surveyed households are composed of 10,904 members; 2,489 members represent children aged less than six, while the remaining 8,415 members (77 percent) are older than six. For household members older than six, we collected individual level data on gender, age, relationship to the head of the household, educational attainment, main and second occupation and non-agricultural income. The response rate to this set of 'individual questions' has been very high: 'Age' and 'gender' do not show any missing values. For the variable 'years of schooling', nine percent of all respondents could not respond. However, in many cases we could impute the missing values using the response to the question about the highest educational level attained, for which we only have a non-response rate of 1.4 percent.

Even for income-related questions the rate of non response is negligible, although such information is generally considered very sensitive. Five percent of all household heads are engaged in non-agricultural wage work and almost all reported their earnings. For all other households the income information was collected in the agricultural module. In the agricultural module only about two percent of all households show missing values regarding the sales of agricultural products. All households were able to report the size of their land.

Enumerators were particularly vigilant when asking questions related to the household's source of electricity, energy use and costs, preferred electronic appliances, purpose of electricity and importance of electricity provision. The related questions were virtually answered by 100 percent of the respondents. Only very few questions were subject to non-response.

'Willingness to pay' (WTP) related questions which generally refer to hypothetical situations and, hence, require some ability to abstract to answer them. Nevertheless, they were handled very well by the respondents – also thanks to a careful training of the interviewers the information is missing for less than one percent of all households. Also with regards to the reliability of the answers there is no reason to be worried: The reported willingness to pay to have access to electricity is for 85 percent of the interviewed households less than 10 percent of their yearly expenditure. This suggests that respondents took into account their income and the inevitable expenditures before they stated their willingness to pay.

The highest rate of non-responses was encountered when households were asked about their expenditures (questions Q 128_1a to Q 129_14c, ref. Appendix 1). Here, on average 16 percent of the households could not respond to one or sometimes several of the listed expenditure categories. However, this is still moderate in comparison to other household surveys in African countries and even in comparison to OECD countries. The most difficult questions are typically those that relate to remittances sent to other family members. And indeed for this part of the questionnaire the highest non-response rate was encountered. Food or health expenditures, on the other hand, are almost complete.

In general, the data mirrors the information we intended to collect. Only few questions were not understood in the way we have expected. Question Q 75, for example, seeks to obtain information on which development project would be the most urgent in their village. Most households stated that electrification is the most urgent need; this surely reflects a bias, because people were aware that the survey was done for an electrification project. In interviews with village chiefs and other key persons higher priority was given to the construction of health centres and improvements of the infrastructure.

Another example is Q 91 by which we intended to capture perceived negative impacts of electricity. Yet, households did hardly refer to negative impacts such as higher TV consumption or later bedtimes, but rather mentioned inconveniences in the use of electricity, mostly the breakdown of electric appliances.

4.2. Village level comparison

The *'Village Questionnaire'* was designed to collect information at the community level. This type of information helps to better understand community aspects such as the quality of roads, the distance to the market, or the signal quality for media devices. Most of this information was obtained by observation and by interviewing the village chief and a few other key persons. Some of the data could also be drawn from administrative records available in the village.

The surveyed province of Kénédougou has 13 departments. In what follows, we describe the socio-economic conditions in the 10 departments that have been covered by our survey. We stratify the sample of villages into two groups: those located in the five departments in the North of the province (Banzon, Kayan, Morolaba, Samorogouan and Sindo) and those located in the five departments in the South of the province (Djigouera, Kangala, Koloko, Kourinion and Samogohiri). The two groups mainly differ in terms of road accessibility, TV signal coverage, type of crops produced as well as the presence and distance to markets.

During the rainy season (June-August), departments in the South of the province are better accessible. 37 percent of them have a 'good' road connection (not necessarily paved) to the main road that connects Bobo-Dioulasso and Mali, while in the Northern part of the province only 10 percent of the interviewed villages report to have a 'good' connection to the main road connecting to Orodara and Bobo-Dioulasso (see map in Annex 3). 19 percent of the surveyed villages in the North report to have no direct access to the main road during the rainy season (Table 7).

Table 7: Road accessibility during the rainy season, in percent

Village's location	Good	Average	Possible with difficulties	Possible in case of emergency	Inaccessible
North	9.5	0	23.5	48.0	18.7
South	36.8	5.2	31.4	26.4	0

Note: As reported by village head/source person.
Source: Solar Home System baseline dataset 2010.

While the radio and the mobile phone network do not show any substantial difference between Northern and Southern villages, TV signal quality does. According to the village chiefs, signal quality for radio is good in about 50 percent of the villages. 33 percent of the villages have a good mobile phone network signal. Television signal quality is bad in most villages in the South (Table 8).

Table 8: Mass media devices' reception, in percent

Village's location	Device	Good	Average	Bad
North	Radio	51.9	38.8	9.3
	Cell phone	33.1	33.8	33.1
	Television	38.3	28.3	33.4
South	Radio	50.0	16.6	33.4
	Cell phone	33.2	38.9	27.9
	Television	7.1	50.1	42.8

Source: Solar Home System baseline dataset 2010.

Although agriculture is the main income source, both in the North and in the South of the province, there are significant differences in the types of crops produced. The most important crop in the North of the province is cotton (55 percent), followed by food crops and fruits (27 and 18 percent). The two larger cotton factories of the state-controlled SOFITEX (Société Burkinabé des Fibers Textiles), which process the cotton into fibre for export, are located in the North of Kénédougou. In the South, cotton production does not dominate but still plays an important role (37 percent). Focus group discussions revealed that villagers in the South used to cultivate more cotton before, but given the recent price decline, they started to diversify their agricultural production. Vegetable production and food crops are cultivated by 23 and 22 percent, respectively (Table 9) in the South. Vegetables are not cultivated in the North.

Table 9: Main source of income, in percent

Type of crop	North	South
Cotton	55.2	37.5
Food crops	26.7	22.2
Fruits	18.1	8.3
Vegetables	0	22.7
Cash crops	0	9.3

Source: Solar Home System baseline dataset 2010.

In the South of the province, 73 percent of villages do not have an organized market. The average distance between villages in the South and the closest market (which can be in another village or nearby a road) is around seven kilometres, while in the North this distance is around four kilometres (Table 10).

Table 10: Market presence and average distance to the closest market

Village's location	Share of villages without a market (in %)	Distance from the closest market (in km)
North	47.9	4.5
South	73.8	7.2

Source: Solar Home System baseline dataset 2010.

Differences between villages in the North and in the South of the province also arise in terms of availability of various energy sources (Table 11). Batteries and kerosene are easy to purchase in both regions according to village chiefs. In the southern villages, charcoal, candles, and diesel are more difficult to purchase than in the North. It seems that firewood can also easier be found in the Southern than in the Northern villages. Liquefied petroleum gas (LPG) is hardly available in both regions.

Table 11: Availability of energy source, in percent

Village's location	Charcoal	Firewood	Candles	Batteries	LPG	Diesel	Petrol/ Kerosene
North	52.0	38.2	23.7	100	0	61.5	100
South	47.9	62.7	21.0	100	10.5	47.4	94.6

Source: Solar Home System baseline dataset 2010.

4.3. Household characteristics

In this section we present some descriptive statistics on the socio-economic structure of the households in the project area. A household is – in line with the official definition by INSD (National

Statistics) – defined as a community of individuals who live in the same house. These individuals pool their resources together to meet their basic food needs under the authority of a single person, called the 'head of the household'. In Burkina Faso, it is quite common that several individual households share the same dwelling with other households (Ministère de l'Èconomie et des Finances, 2009). The community of these households sharing the same premises is referred to as a *concession*. In Kénédougou province, 63 percent of households live in such a concession. The survey interviewed households.

In our sample, all households (except one) are headed by men. The average household size is 9.1. Household size decreases with household expenditures, i.e. richer households are on average smaller (Table 12). According to census data, the average household size in rural Burkina Faso is 6.3 (Ministère de l'Èconomie et des Finances, 2009). However, in cotton regions, such as Kénédougou, households are typically larger. The average share of children under seven is 22 percent. Only about 2.8 percent of all household members are above 65. These figures are all in line with census data (Ministère de l'Èconomie et des Finances, 2009).

Table 12: Household's structure variables, by expenditure quintiles

Household's Structure variables	Average	1st Expenditure Quintile	5th Expenditure Quintile
Household size	9.1	10.1	8.1
Share children 0-6 years, in %	22.3	23.2	20.2
Share of elderly (aged more than 65), in %	2.8	3.4	2.50

Note: Expenditures refer to total yearly household expenditures per capita and include expenditure for food (both consumed at home and in restaurants), clothing, health, energy, telecommunication, transportation, education, ceremonies and resources sent to other family's members, agricultural and livestock activities. Auto-consumption is not included in the expenditure aggregate.
Source: Solar Home System baseline dataset 2010.

The surveyed households belong to eight different ethnicities. The *Senoufo* represent the largest ethnic group (48 percent), followed by the *Toussian* (16 percent) and the *Bolon/Dafing* (12 percent). Ethnically mixed households represent nine percent of the surveyed households. There seems to be little correlation between ethnicity and household expenditure, even though the *Senoufo* and the *Bolon/Dafing* households are a bit more often represented among the richest expenditure quintiles.

The number of household with at least one emigrated person is quite high (33 percent). Almost 40 percent of the households in the lowest expenditure quintile have a close relative who emigrated. Most of the household's emigrated members went to Côte d'Ivoire (43.9 percent); 25 percent stayed in the same province or department. The main reasons for migrating are work (43 percent), followed by schooling and studying (35 percent) (Table 13).

Table 13: Destination and reason of emigration, in percent

Destination of migration	Share (in %)	Reason for migrating	Share (in %)
Côte d'Ivoire	43.9	Study related reason	35.0
Same province	17.3	Seasonal work	29.3
Same department	8.5	Regular work	14.2
Bobo	16.5	Lack of work	6.6
Ouaga	4.9	Lack of land	6.5
Other	8.8	Other	8.3

Note: Migration for wedding reason has been excluded from the table.
Source: Solar Home System baseline dataset 2010.

As highlighted already in the section about the villages above, agriculture is the main income source for the majority of the households. Slightly more than 90 percent of all households' heads are employed in the agricultural sector. There is only a slight difference across expenditure quintiles with richer households being slightly less often dependant on agriculture. The second most important occupation is an independent non-farm activity, relevant for a small share of the poorest households (2.5 percent) and a somewhat higher share among the richest households (6 percent). The household heads employed in the public sector or in the private formal or informal sector (1.2 percent) belong exclusively to the richest quintiles (Table 14).

Table 14: Sector of activity of the household head, in percent

Sector of activity	Share of household heads engaged in the sector		
	Average	1st Expenditure Quintile	5th Expenditure Quintile
Farmer	91.5	92.9	90.0
Independent non-farm	4.9	2.5	5.8
Public employee	0.4	0	0.4
Other dependant	0.8	0	0.8

Source: Solar Home System baseline dataset 2010.

98 percent of all households report to have land. The share of land dedicated to cash crops is much lower than to food crops. The most frequently produced food crops are cereals, with 89 percent of households producing maize, followed by sorghum and millet (54 and 42 percent respectively). As one would expect, wealthier households have larger fields and cultivate more cash crops. On average 50 percent of the surveyed households are cotton producers; though this share is significantly higher in the upper tail of the expenditure distribution (Table 15). On the national level the share of cotton producers is about 20 percent. 90 percent of households reported that they own livestock (Table 15), mostly cattle and poultries (70 percent in both cases). Ownership increases for richer households.

Table 15: Share of households owning land and keeping livestock and land size, by expenditure quintiles

Agricultural and livestock activities	Average	1st Expenditure Quintile	5th Expenditure Quintile
Land owners, in %	98.1	96.7	98.3
Size of land owned, in ha	12.3	8.5	16.8
Size of land used for food crops, in ha	8.8	6.7	11.5
Size of land used for cash crops, in ha	3.7	2.0	5.6
Cotton producers, in %	52.2	27.1	71.2
Livestock owners, in %	90.9	85.4	95.8

Source: Solar Home System baseline dataset 2010.

Educational and the literacy rate in depend largely on age. 64 percent of all household heads have received no formal education (again this is in line with census data, which also report 64 percent; Ministère de l'Èconomie et des Finances, 2009). The illiteracy rate is higher among women. 86 percent of all spouses to the household head do not have any formal education. The illiteracy rate is particular high among the very poor households. The share of household heads having received primary or higher education is on average around 28 percent; again this percentage decreases for poorer households (Table 16).

Examining primary-school enrolment rates for children between the age of seven and twelve, one notes that the situation has significantly improved over the last decade. Today about 65 percent of all children are enrolled in school. There are still differences, though, among children in richer and poorer households and between boys and girls (Table 16). These figures also corroborate the 2006

census, which reports a school enrolment rate for children between seven and twelve of 60 percent (61 percent for boys and 54 percent for girls) (Ministère de l'Èconomie et des Finances, 2009).

Table 16: School enrolment and educational attainment, in percent

School enrolment and educational attainment	Average	1st Expenditure Quintile	5th Expenditure Quintile
Head of the household (educational attainment)			
None	64.2	71.9	59.5
Primary education	23.9	17.0	24.5
Secondary education and more	4.3	2.4	8.0
Spouse of the household head (educational attainment)			
None	86.7	88.7	84.3
Primary education	9.4	7.8	11.3
Secondary education and more	1.7	1.3	1.3
Children aged 7-12 (school enrolment)			
All children	65.3	61.7	66.4
Boys	68.1	65.7	70.0
Girls	62.5	57.4	63.9

Note: Primary school starts officially at six (in practice often later) and lasts six years.
Source: Solar Home System baseline dataset 2010.

Considering the six main expenditure categories, the highest share of total income is spent on food (22 percent of total expenditures). This share decreases with total expenditures while the budget share spent on transportation increases with total expenditures. Expenditures for health are on average the second most important expenditure category for households, followed by transportation, clothing, and schooling (Table 17).

Table 17: Share of total expenditure spent for various expenditure aggregates and yearly per capita expenditure

Expenditure aggregate	Average	Expenditure Quintiles				
		1st	2nd	3rd	4th	5th
Food (including restaurants), in %	22.3	30.5	28.10	23.07	16.47	13.6
Health, in %	6.5	6.9	6.6	6.1	7.1	5.9
Transportation, in %	5.9	4.1	4.5	4.6	6.1	8.7
Clothing, in %	5.5	6.0	5.9	5.7	5.0	4.7
Schooling, in %	4.9	5.0	4.1	4.0	4.8	4.4
Telecommunication, in %	4.2	3.6	4.6	5.8	6.6	5.0
Total yearly per capita household expenditure, in FCFA	127,880	39,690	65,351	89,477	127,599	317,282

Note: Expenditures without auto- consumption.
Source: Solar Home System baseline dataset 2010.

Although expenditure levels are low, looking at subjective indicators of well-being (Table 18), one notes that the majority of households – even in the poorest quintile – considers their income as either appropriate or sufficient to cover the needs of the family. The share of households that consider their income as insufficient decreases, as expected, with expenditure levels.

Table 18: Perception on household's income by expenditure quintiles, in percent

Perception of household's income	Average	1st Expenditure Quintile	5th Expenditure Quintile
Sufficient	24.6	15.0	35.3
Appropriate	37.2	38.0	39.5
Insufficient	38.2	47.0	25.2

Source: Solar Home System baseline dataset 2010.

4.4. Energy Usage and Potential Impacts

The following section describes the households' current energy usage patterns and those socio-economic and behavioral characteristics that might be influenced by a change from traditional energy sources to electricity provided by solar panels. The energy usage of health stations and schools is briefly outlined in Box 3.

Box 3: Energy sources at health stations and schools

Health stations

Most of the health stations (14 out of 20) in the survey region have been equipped with a solar panel, but today only eight still have panels that are operational. The panels are mainly used for lighting, especially in the maternity sections, since most of the births occur during the night. Although the health stations are often fully equipped with electric appliances like fans and fluorescent tubes, the power of the panel usually does not allow more than the illumination of a few rooms. Of the seven health stations we interviewed in order to obtain more information on their energy usage, all confirmed that they use gas-run fridges to store vaccinations and medicaments. Health stations without solar panels use torches to work at night (write reports, consultations).

The respondents in the health stations were asked to name the health stations' main problem. Although the electrification background of our survey was revealed to the respondent, most health stations named the bad condition of the buildings and the poor equipment as the major problem. Electricity is mentioned as the second most pressing problem, especially for lighting. This would facilitate consultations at night and improve the nurses' living conditions as their lodging next to the health station is typically not equipped with electric lighting devices. Refrigeration, which is typically expected to be an important usage of electricity in health stations, has not been named.

Schools

Most schools in Kénédougou do not dispose of any electricity source. Only three out of 72 schools use electricity generated by a solar panel. One secondary school claims having observed a decline of graduations after the theft of the solar panel. A reason might be that pupils no longer benefit from the lighting to study together after classes in the evening. The energy source used at schools is fuelwood for cooking. Usually, the pupils bring one bundle of firewood per week for the preparation of meals. At primary schools meals are free of charge, at secondary schools pupils have to pay 75 FCFA per meal.

According to the teachers that were interviewed, the main problems for schools are the lack of class rooms and houses for the lodging of teachers, but also the lack of electricity. Respondents emphasized that electric lighting at schools would permit the pupils to study together at night after classes and teachers could prepare the classes for the next day. It would also pave the way for offering evening classes, which might be a solution to the problem of over-crowded class rooms. Apart from lighting, electricity could be used to run computers.

4.4.1. Energy sources and usage

The most surprising result of our baseline survey certainly is the high rate of electricity users. While the official electrification in rural Kénédougou in 2003 was still zero (see Table 5), in fact more than one third of the surveyed households are today using electricity. Even if one excludes car battery users, more than 27 percent of households can be considered electrified (mostly via SHS, see Chart 1).[13] Moreover, the baseline data confirms what can be observed in many rural areas in Africa: the advance of dry-cell battery-driven lamps as lighting sources in non-electrified areas. As a consequence, kerosene and candles are no longer the dominant fuel for lighting purposes. Candles have even vanished completely from the survey region. Instead, the most common energy sources are batteries and, of course, firewood for cooking that is used by virtually all households. Batteries are primarily used for lighting. 72 percent of batteries are used for battery-driven lamps, so called 'lampes chinoises' and only 26 percent for radios (see also Section 4.2.2.).

Collecting fuelwood is an essential part of every-day-life for virtually all households. 98 percent of the households stated that they collect firewood regularly, 13 percent of these households additionally buy firewood. Women are in most cases responsible for firewood collection (91 percent); children only in a few cases (6 percent). To collect the 18 bundles that are used on average per week, the average collection time amounts to seven hours. It has to be noted that rural Burkina is not an exception to the rule that electricity is virtually never used for cooking in (rural) Africa, which, in the case of SHS, for technical reasons is also hardly possible.

Table 19: Share of households using energy sources, by expenditure quintiles in percent

Energy Source	Average	Expenditure Quintile				
		1st	2nd	3rd	4th	5th
HH with access to electricity						
LPG	2.0	0	1.5	1.3	0.0	7.1
Kerosene	15.7	26.9	11.8	4.0	20.6	15.0
Firewood	98.7	100.0	98.5	98.7	97.9	98.2
Only collected	85.3	82.7	86.8	89.3	85.6	82.3
Collected and bought	13.3	17.3	11.8	9.3	12.4	15.9
Batteries	97.1	96.2	97.1	100.0	96.9	95.6
HH without access to electricity						
LPG	0.3	0	0	0	0.7	0.8
Kerosene	29.3	26.1	35.5	28.5	27.3	29.1
Firewood	97.0	93.6	96.5	97.6	97.9	99.2
Only collected	84.1	76.1	84.3	88.5	82.5	89.0
Collected and bought	12.9	17.6	12.2	9.1	15.4	10.2
Batteries	98.0	96.8	99.4	97.6	97.9	98.4

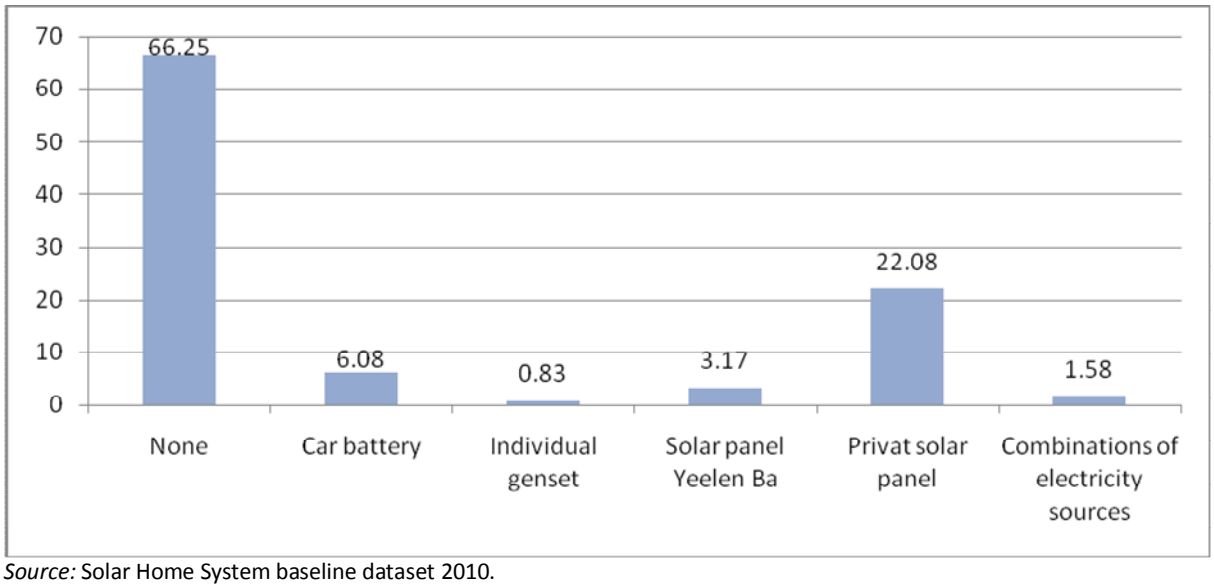
Notes: N=1200, Households using firewood are subdivided into those that only collect firewood and those who additionally buy firewood. In this group 1.4 percent of households are included who only buy firewood.
Source: Solar Home System baseline dataset 2010.

[13] The high penetration of private solar home systems was already stated in a short market analysis undertaken by Yeelen Ba. This study reports that 27% of all interviewed households in 47 villages of the project area owned a solar panel with battery. However, the report emphasizes that this high share is probably biased as a count across all households in the 47 villages visited would yield a penetration rate of 4.3 percent. It is not clear from the report how that count was obtained. The report further states that most of these solar panels are of weak quality and are mainly used for TV and less frequently for lightening (Yeelen Ba, 2010).

Households with and without access to electricity do not differ substantially in their usage of energy sources – except for kerosene (see Table 19). The share of households without electricity source using kerosene is almost twice the share of electrified households (29 percent versus 16 percent). This is not surprising since kerosene is mainly used for lighting and electrified households can substitute kerosene lamps with electric lamps. The average monthly consumption amounts to three litres per household. Remarkable is that these values differ considerably from findings in the last publicly available household survey, the EP 2003, where all households in rural Kénédougou referred to kerosene as the main lighting energy source. During focus group discussions villagers confirmed a substantial decrease in kerosene consumption in recent years, especially for lighting. This is mainly due to increasing kerosene prices and the availability of low-cost battery driven lighting devices imported from China (see section 4.4.4). LPG is only used by very few rich households, mainly for cooking. As mentioned in focus group discussions, especially the better-off civil servants use LPG stoves. Besides LPG usage there is no systematic difference between poorer and richer households regarding their usage patterns of energy sources.

While Yeelen Ba has been active in the region for about 15 months, two thirds of the surveyed households were found to possess no electricity source at the time of the survey by the end of 2010 (see Chart 2). Most of the electricity using households own a non-Yeelen Ba SHS (22 percent), which they bought on markets, mostly in Bobo-Dioulasso and across the border in Mali. There is no other provider or NGO that would distribute such panels in the villages we interviewed. Three percent are using a Yeelen Ba SHS (and, hence, are not the owner) and six percent possess a car battery to operate their electric appliances. Other sources like individual diesel generators or alike re rarely used. Ten village associations own individual generators, which are rented out for celebrations in their own or neighbouring villages. No household is connected to the national grid, which was the pre-condition for the government to give Yeelen Ba the licence for this area.

Chart 1: Electricity Sources



Source: Solar Home System baseline dataset 2010.

Most households have already been using their electricity source for some years (see Table 20). Since Yeelen Ba has just started its intervention in the area, their SHS have been in use for less than one year on average. Non-Yeelen Ba SHS are on average 4.5 years old. This information, though, does not necessarily refer to the year when households started to use electricity for the first time, but to the duration of the energy source by the time of the survey.

Table 20: Average years households have been using respective electricity source

Electricity Source	Car Battery (N=83)	Individual Genset (N=15)	Yeelen Ba Panel (N=35)	Private Solar Panel (N=280)
Age	3.6	7.2	0.8	4.5

Source: Solar Home System baseline dataset 2010.

Both households with Yeelen Ba and non-Yeelen Ba SHS largely use just one panel. A few (17 percent of Yeelen Ba SHS users and 10 percent non-Yeelen Ba users) installed two panels to increase the available power. Out of the 35 Yeelen Ba users, two stated that their SHS is not working. In comparison, the non-Yeelen Ba SHS seem to perform better with only four out of 267 SHS not working. Beyond these two anecdotes on non-working SHS, the small number of Yeelen Ba SHS in our sample makes it of course difficult to analyze reliability, maintenance services and customer satisfactory at this point.

82 percent of all households with SHS had no costs for repair last year. For Yeelen Ba clients this is due to the project's fee-for-service concept where the reparation costs are included in the monthly fee. Those households with non-Yeelen Ba SHS that needed a repair had to execute repairing in the last year paid on average 39,100 FCFA.

Households were also asked about potential previous electricity sources. This aspect becomes important in a future evaluation of Yeelen Ba, since it gives evidence on the share of households who actually received new access to a modern electricity source due to the project. Figures for current SHS owners may give indications on how pronounced the so-called pre-electrification will turn out to be. 75 percent of them declared that they had not disposed of an electricity source before receiving their current one. 15 percent had possessed a car battery before – a clearly inferior electricity source.

4.4.2. Appliances used for production

42 households (means 3.5 percent) are using their appliances for productive use, mainly non-electrical devices like fuel-run mills and mechanical sewing machines. Of the electricity using households, only thee use electrical devices for productive activities (one mobile phone, one video-TV system, and an electrical sewing machine). The video-TV-system is run by a household who possesses two Yeelen Ba SHS and has a subscription for a television package that allows him to show international football games. He usually takes 100 FCFA per game from the villagers. In busy months, he could pay the solar panels and subscription just by the entrance fees.

Table 21: Main source of information, in percent

	Female household member (N=1,146)	Head of the household (N=1,099)
Radio	55.4	67.6
TV	5.6	8.4
Neighbour/Friends	36.3	23.0
Town Crier	2.7	1.0

Source: Solar Home System baseline dataset 2010.

4.4.3. Appliances and lighting used for consumption

The most frequently owned electronic appliances are information and entertainment devices, led by mobile phones and followed by battery-powered radios, audio tapes, TVs and DVDs (see Table 21 and Table 22). Bivalent radios that can be used both with batteries and electricity are almost non-existent, even among electricity using households. Radios are of great importance since they are the main source of information for the households followed by conversations with neighbours and friends. TV plays a minor role in provision of information - at least until now. Women report to get more news from relatives and friends and less from radio than men.

Table 22: Appliance usage, in percent

Appliances	HH with electricity (N = 405)	HH without functioning electricity source (N = 795)
Mobile phone	87	59
Radio (battery only)	67	65
Audio tapes	44	14
TV (colour)	37	2
DVD	25	0
TV (black and white)	14	1
Fuel-run mill	7	2
Charcoal Iron	7	2
Radio (bivalent)	3	0
Fan	2	0
Landline telephone	2	1
Mechanical sewing machine	2	1

Source: Solar Home System baseline dataset 2010.

Beyond that, some households possess non-electric irons and only very few households own a fan, landline telephone, or a mechanical sewing machine. A few households (3 percent) without electricity own devices that need electricity for operation; mostly because they had an electricity source at one time that is now out of order.

Table 23: Appliances that would be purchased in case of Yeelen Ba electrification (for solar panel non-user) / higher electric capacity (for solar panel user), in percent

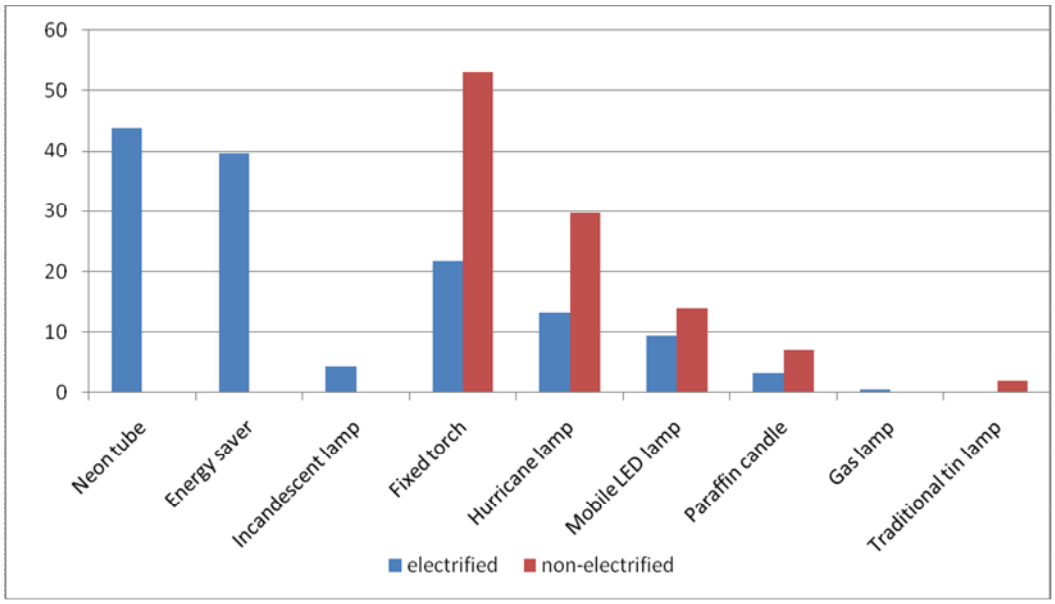
Wished appliances	Head of the household		Female household members	
	HH without solar panel (N=880)	HH with solar panel (N=320)	HH without solar panel (N=880)	HH with solar panel (N=320)
TV	66	57	60	47
Lamps	17	26	14	25
Cassette radio	6	11	2	8
Mill	3	6	6	8
Fridge	3	48	12	60
Mobile phone	2	1	1	3
Sewing machine	2	3	2	5
Fan	1	32	0	26
Radio	1	3	1	5
DVD Player	0	14	0	9
Video player	0	10	0	3
Iron	-	2	0	-
Computer	-	2	-	-
Other	-	2	-	-
Stove	-	1	-	2

Source: Solar Home System baseline dataset 2010.

Households without SHS have been asked which electronic appliance they would most likely buy in case of electrification with an SHS (see Table 23). The majority (66 percent) preferred to first buy a TV, followed by lighting devices (17 percent). Households that already dispose of an SHS have been asked which additional appliances they would like to use if the electric capacity was higher. The priority is also given to TV (57 percent), followed by refrigerators (48 percent), fans (32 percent), and more lighting devices (26 percent). Women were asked the same questions separately from the household head. The only difference in their answers lies in the higher ranking of refrigerators in comparison to their husbands. While service packages 2 and 3 of Yeelen Ba (see Table 3) allow for using a TV, the use of a fridge is until now not covered by the service packages offered.

Lighting is the most important service offered by SHS. All service levels of Yeelen Ba include compact fluorescent lamps (CFL) as lighting spots (see Section 2.2). Of the households which use an SHS, 95 percent use them for lighting. Households with access to an electricity source mainly use neon tubes and CFL as lighting sources (Chart 2 and Table 24). 54 percent of electrified households solely use electric lamps; the other 188 electrified households use additional torches and traditional lighting devices such as hurricane and paraffin candles. On average, almost the same amount of rooms is illuminated with electric lamps (1.9) as with traditional lamps (2.1). See Annex 4 for photos of the different lighting devices.

Chart 2: Primary lighting devices of households with and without electricity



Source: Solar Home System baseline dataset 2010.

Table 24: Lighting hours per day for different electric lighting devices

Electric lighting devices		**HH with electricity (N=405)**	
		Number of lamps used per household	Lighting hours per day (average for all HH)
Incandescent light bulbs ("normal light bulb")	Outside	0.1	3.5
	Inside	0.0	3.6
Neon/fluorescent tube	Outside	0.4	4.4
	Inside	0.7	4.9
Compact fluorescent lamps ("Energy saver")	Outside	0.4	5.0
	Inside	0.6	4.7
Total		2.1	10.0

Source: Solar Home System baseline dataset 2010.

The most common non-electric lamps are fixed torches and hurricane lamps (see Table 25). Fixed torches are modified torches equipped with a switch and usually fixed to the wall. Also mobile LED lamps and paraffin candles are used, very rarely LPG and traditional tin lamps. Candles are not used at all in the survey area. The reason for this surprising finding stated in focus group discussions was that they burn down very quickly, and, in consequence, are very expensive. Fixed torches and mobile LED lamps run with dry-cell batteries apparently are cheaper than candles. Furthermore, they are "cleaner" since they do not produce smoke and do not cause fire accidents. From an environmental perspective the disadvantage of battery driven lamps is the waste produced by used batteries. Households usually burn the batteries together with their waste; neither a suitable infrastructure for appropriate disposal nor the consciousness for its necessity exists.

Table 25: Non-electric lighting devices and consumption

Non-electric lighting devices	HH with electricity (N=405)		HH without electricity (N=795)	
	Number of lamps used per household	Lighting hours per day	Number of lamps used per household	Lighting hours per day
Fixed torch	0.5	5.4	1.1	5.9
Hurricane lamp	0.4	5.3	0.7	5.9
Mobile LED lamp	0.2	8.1	0.3	6.4
Paraffin candle	0.1	4	0.1	4.6
Total	1.4	6.8	2.9	13.0

Note: Gas lamps and traditional tin lamps are not included in the table since only few households use them.
Source: Solar Home System baseline dataset 2010.

Table 26 shows the total lighting hours by electrified and non-electrified households, calculated by summing up the consumption time of all lighting devices in the household per day. Electrified households clearly consume more artificial lighting than their non-electrified counterparts. If we also take into consideration the higher quality of electric lighting by measuring emitted lumen hours, the gap becomes even wider. Electricity users consume seven times more lumen hours than non-users.

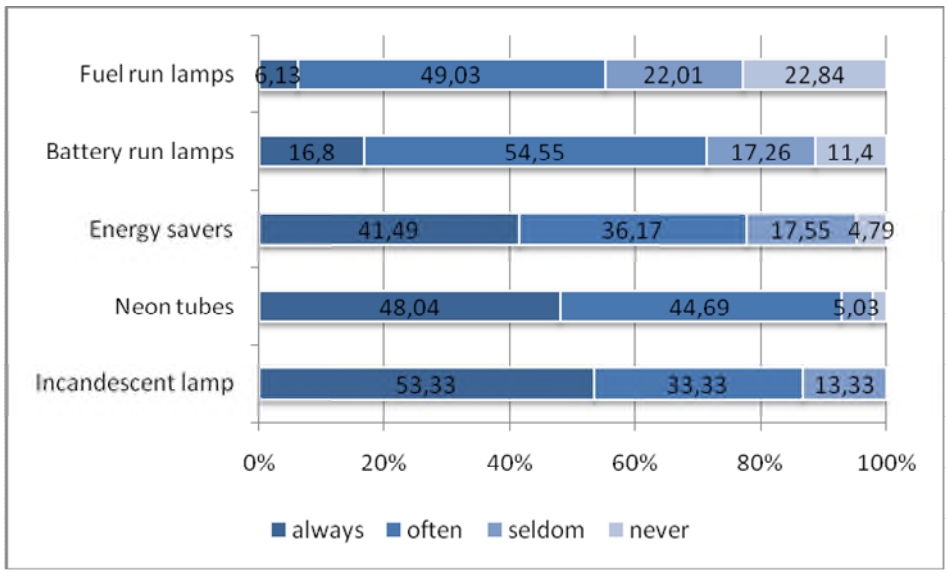
Table 26: Lighting hours and lumen hours consumed per day

	HH with electricity (N=405)	HH without electricity (N=795)
Lighting hours	17.0	13.3
Lumen hours	12,6	1,7

Note: Lumen hours are calculated based on lumen values for different lighting devices provided in O'Sullivan and D. Barnes (2006).
Source: Solar Home System baseline dataset 2010.

A softer indicator to capture lighting quality is to ask the respondents directly for their perception. In Chart 3, we differentiate between fuel run lamps, battery run lamps, and electric lamps. Not surprisingly, the comparison between the groups shows that the households in general are more satisfied with the quality of their electric light than with their fuel run or battery run lamps.

Chart 3: Satisfaction with lighting quality of different lighting devices



Note: Fuel-run lamps are paraffin candles, hurricane and traditional tin lamps. Battery-run lamps contain fixed torches.
Source: Solar Home System baseline dataset 2010.

4.4.4. Energy expenditures

Energy expenditures account for three to 13 percent of the total annual household expenditures. Table 27 shows the energy expenditures and their share in the total annual household expenditure.[14] According to the literature (Albouy and Nadufu 1999), energy spending is expected to increase less than proportionally with income growth. This relationship can be confirmed in our data: for households both with and without access to electricity richer households spend a lower share of their total annual household expenditures on energy than poorer households (see Table 27). This suggests that there is a basic incompressible energy need.

Table 27: Energy expenditures by wealth level, measured by expenditures

		Total	Expenditure Quintile				
			1st	2nd	3rd	4th	5th
HH with access to electricity	Yearly energy expenditures in FCFA	57,608	54,839	49,567	58,274	57,166	63,264
	Share of energy in total expenditures	0.06	0.12	0.07	0.07	0.05	0.03
HH without access to electricity	Yearly energy expenditures in FCFA	46,420	35,964	48,001	46,221	49,548	57,186
	Share of energy s in total expenditures	0.08	0.13	0.08	0.07	0.06	0.03

Note: Installation costs for the solar panels are not included in the energy expenditures.
Source: Solar Home System baseline dataset 2010.

The expenditures for energy sources (84 percent) and electricity (96 percent) are mainly paid by men. While the decision for the purchase of energy sources (89 percent) and electricity (92 percent) lies predominantly in the responsibility of women.

[14] The expenditures recorded in Table 27 are also in line with the results documented in the market analysis undertaken by Yeelen Ba. Yeelen Ba found an average spending for energy and lighting of FCFA 60,756 per year (Yeelen Ba, 2010).

Table 28: Average monthly expenditures per energy source by wealth level, in FCFA

Average monthly expenditures		Total	Expenditure Quintile				
			1st	2nd	3rd	4th	5th
HH with access to electricity	Batteries	2331.6	2323.2	2529.3	2196.3	2164.5	2326.5
	Wood	546.0	131.9	751.0	241.1	488.6	864.4
	Kerosene	297.3	502.4	368.0	50.7	378.9	248.8
HH without access to electricity	Batteries	2220.4	2054.8	2273.0	2146.3	2106.7	2633.3
	Wood	789.9	912.6	688.6	487.6	611.2	1349.8
	Kerosene	479.1	400.0	562.9	420.2	434.4	610.1

Note: Candles, Gas and Charcoal are rarely used and therefore not included in the table.

The average monthly expenditures on energy sources are highest for batteries (Table 28). This is not surprising since the consumption of batteries for fixed torches and radios is high among most households. Expenses for kerosene are lower, reflecting the lower total consumption of kerosene lamps. The expenses for wood are modest and vary across the income levels, since most households - even the richer - in the survey area collect firewood and do not buy it. In the upper three quintiles we see that non-electrified households spend clearly more on wood and kerosene than electrified households. Interestingly there is almost no difference across quintiles and between electrified and non-electrified households in terms of expenditures on batteries.

Without knowing at this baseline stage which energy sources are replaced by the SHS, energy cost savings seem not to be the driving force behind the decision to obtain an SHS, rather the desire for increased convenience. This can be confirmed by looking at the part of energy expenses that – technically – can be saved by owning an SHS. It might be expected that the consumption of batteries and kerosene for lighting decreases, since SHS users can use electric lamps and radios connected to a socket. These expenses (lighting plus radio) sum up to 29,664 FCFA (46 €) per year for electricity non-users and 30,768 FCFA (47 €) for electricity users. First, this suggests as shown in Table 28 that households owning an electricity source do not spend less on batteries than non electrified households – with exception of the highest income levels. Still, even for a total replacement of battery-run lighting devices and radios as well as kerosene lamps the savings potential would not be high enough to compensate the prices charged by Yeelen Ba. The potential saving would amount to 29,664 FCFA (46€) per year and household, which is less than half of the annual fee for the smallest service package offered by Yeelen Ba (66,550 FCFA (101€), see Table 3 for summary costs), installation costs not taken into account. Even the upper 20 percent in the expenditure distribution in our sample spend less on energy than this annual rate (Table 27).

However, an exact answer to the change of energy expenditures due to the possession of an SHS can only be given based on the follow-up data where we will observe the same households before and after they have access to the SHS. Comparing average installation, acquisition and maintenance costs of private SHS to the prices charged by Yeelen Ba, a similar picture emerges. While the initial costs of private SHS are as high as the connection fee for Yeelen Ba's service package 3 (70,000 FCFA), the average annual costs are much lower, even compared to the cheapest service package of Yeelen Ba (4,526 FCFA compared to 66,550 FCFA). By taking into account that private solar panels operate on average for 4 years, the gap becomes even wider (see Table 29).

Table 29: Initial and annual costs of private SHS and Yeelen Ba SHS, in FCFA

		Yeelen Ba SHS		
	Private SHS	Package 1	Package 2	Package 3
Initial costs	70,000	41,600	51,500	70,230
Annual costs	4,526	66,550	88,550	152,625
Total costs (1st year)	74,526	108,150	140,050	222,855
Total costs (4th year)	88,104	307,800	405,700	680,730

Note: For the private SHS the initial costs include acquisition and installation costs.
The annual costs of the private SHS are the maintenance costs (e.g. reparation costs).
Source: Solar Home System baseline dataset 2010.

Note that all this does not yet imply that households will not demand the Yeelen Ba SHS nor it would be irrational to do so. Compared to the no-electricity-at-all scenario the SHS allows for electricity services that are not available for SHS non-users (e.g. television, mobile phone charging). Compared to non-Yeelen Ba SHS the additional virtue is the maintenance service provided by Yeelen Ba and the possibility of stretching the connection fees over the first year. Hence, whether a household obtains a Yeelen Ba SHS or not depends on how the household values these new services, which, in turn, determine its willingness to pay.

4.4.5. Attitudes towards electricity

Almost all households (98 percent) stated that they were eager to get a Yeelen Ba solar panel. Only 19 households in the surveyed region revealed that they do not want to get an SHS and give financial restrictions as the reason. Households mentioned that the high prices and the monthly payment obligation are an obstacle to taking up an SHS from Yeelen Ba. The payment modalities have been adjusted by Yeelen Ba in the meantime. In discussions with women associations and men cooperatives, they all stated that they wish to have an electricity source, especially for the purpose of lighting. The costs were mentioned to be the main determinant to take up an electricity source.

57 percent of the interviewed households responded that they have heard about the service of Yeelen Ba. Most households have heard about them from friends, neighbours, or the family (48 percent), others from promotion campaigns (38 percent) or through radio (10 percent). Yet, the vast majority (90 percent) are not well informed about the price they charge for their services.

Electricity using households were asked for the purposes for which they use electricity. Likewise, electricity non-users were hypothetically asked what they would use electricity for. The coherence in statements between these two groups is striking: The factual purposes correspond fully to the hypothetical ones. The interviewed households name lighting as the most important purpose they (would want to) use electricity for (see Table 30). Studying at night is mentioned as the second priority. TV is most often mentioned as second and third most important purpose. Every fourth household uses or wants to use electricity to protect the household members, e.g. against wild animals.

Table 30: Purpose of electricity usage, in percent

	Households without solar panel			Households with solar panel		
	1. purpose	2. purpose	3. purpose	1. purpose	2. purpose	3. purpose
Lighting	58	15	7	58	15	8
Studying	21	24	13	23	29	10
TV	9	27	24	7	26	23
Security	4	9	10	1	10	13

Source: Solar Home System baseline dataset 2010.

Households with no electricity source have been asked about their willingness to pay for different electricity services (see Table 31). It can be seen that on average households are, as we would expect, willing to pay more for a higher capacity electricity provision.

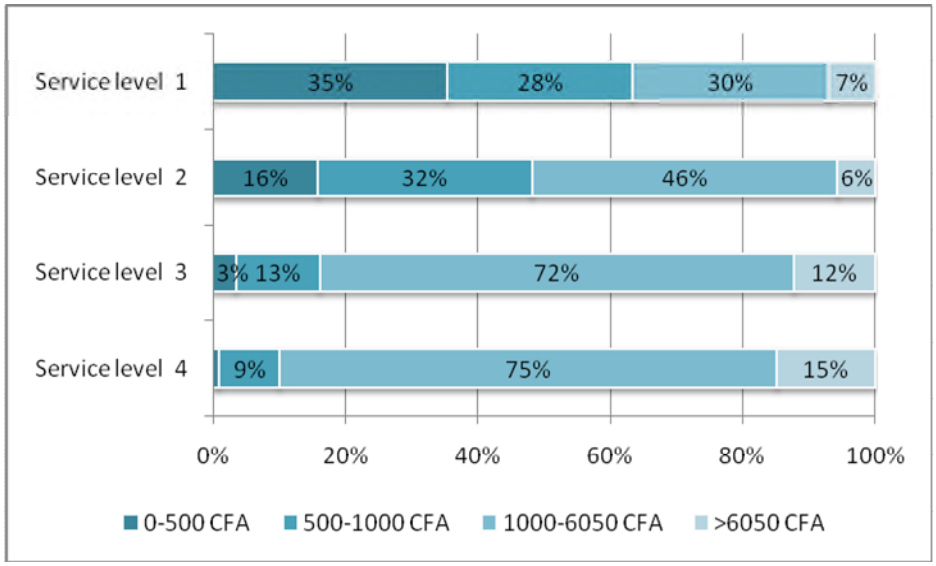
Table 31: Willingness to pay for electricity services, in FCFA

Average monthly willingness to pay for electricity that allows to use …	FCFA
…lighting inside the household (not outside)	2,103
…lighting inside and outside	2,225
…lighting, radio, TV and charging mobile phone	3,761
…lighting, radio, TV, charging mobile, fridge, and electric stove	4,446

Source: Solar Home System baseline dataset 2010.

The average monthly willingness to pay lies below the monthly prices charged by Yeelen Ba for their services.[15] Remember that Yeelen Ba's smallest service package costs 6,050 FCFA per month (in the second year). The service levels one and two in our questionnaire come close to the smallest service package of Yeelen Ba. Here, only seven percent indicated a willingness to pay higher than 6,050 FCFA (see Chart 4). The service level three in our questionnaire is comparable to Yeelen Ba's service package two, for which they charge 8,050 FCFA per month. Only nine percent indicated a willingness to pay of 8,050 FCFA or higher. It is interesting to see that even for the service level four in our questionnaire, which allows for using a fridge and an electric stove in addition to the lighting and TV devices, people are hardly willing to spend more than 6,050 FCFA. Note that these are stated willingness to pay for a hypothetical product. For various reasons it might deviate from the revealed willingness to pay, which can be observed only if the product is in fact available. The stated willingness might be biased because the respondents simply do not really grasp the idea of the question or because respondents answer strategically because they expect that their response influences the real product price later. This, in turn, can induce an upward or a downward bias (cf. Devicienti et al., 2004).

Chart 4: Willingness-to-pay for the different hypothetical service levels

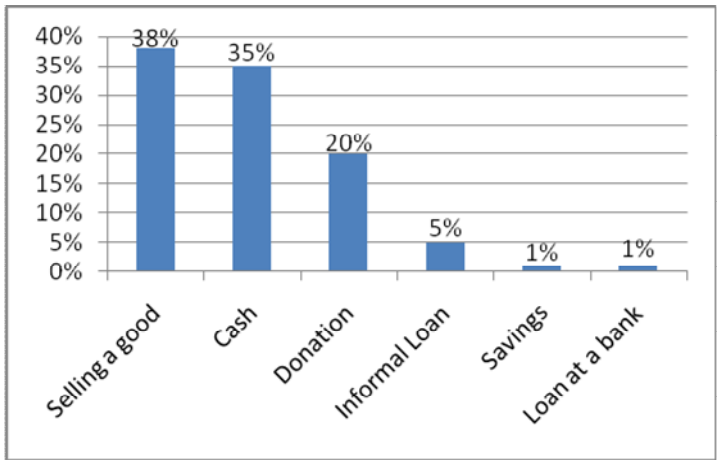


Note: Service level 1 = lighting inside (not outside), service level 2 = lighting inside and outside, service level 3 = lighting, radio, TV and charging mobile phone, service level 4 = lighting, radio, TV, charging mobile, fridge, and electric stove.
Source: Solar Home System baseline dataset 2010.

[15] Our findings are similar to those reported in the market analysis undertaken by Yeelen Ba. Yeelen Ba reports that the interviewed households declared to be willing to spend on average FCFA 3,460 per month for a solar kit (Yeelen Ba, 2010).

Chart 5 shows preferred ways to pay for the solar panel. Most households intend to finance the installation by selling a good or by paying cash. 20 percent mentioned that they would only be able to get an SHS if it was donated. Formal and informal loans, as well as savings are less important.

Chart 5: Source of finance for solar panel



Source: Solar Home System baseline dataset, 2010

Both households with and without electricity see only few negative impacts of electricity. This perception does not differ substantially between men and women: eight respectively six percent mention fire, electric shocks or damage of electric appliances as well as loss of time because of immoderate TV consumption.

31 percent of the households with electricity claim to have improved their work or other activities due to electricity. Electrified households alluded that electricity allows them to work at night, use electric appliances (e.g. for crop transformation) and to charge batteries or mobile phones. 13 percent of the households stated that they have created a new activity by virtue of electricity (note: not necessarily a business). These include the service of charging mobile phones or batteries.

A large share of 92 percent of both households with Yeelen Ba and non-Yeelen Ba SHS desire improvements in the existing electricity supply. 41 percent of Yeelen Ba clients and 62 percent with a non-Yeelen Ba SHS regard the capacity of their SHS as insufficient. 35 percent and 16 percent, respectively think that the SHS's installation costs are too high.[16]

Households were asked for their preferences concerning different electrification alternatives on the village level and their home (see Table 32). About 80 percent of the households think that lighting at primary schools is more important than street lighting. Electric appliances are considered to be more important in health stations than in secondary schools. Almost equal priority is given to electricity or water supply at home. When asked which projects they would welcome most to be implemented in their community, most households stated electrification of the village. 16 percent of the households wish to have an electric water pump in their village. Only few households consider the construction of schools and health facilities as priority. As we mentioned above, it could be that the answers are somewhat biased since the respondents may have said what they think is the anticipated answer in a survey about electrification.

[16] It should be noted that the number of Yeelen Ba clients in our sample is 35 while households with private panels amount to 245.

Table 32: Priority concerning lighting and appliances, in percent

Lighting at primary school is more important than street lighting	80%
Electric appliances at health stations are more important than at secondary schools	78%
Electricity at home is more important than private water supply	55%

Source: Solar Home System baseline dataset 2010.

5. Evaluation Risk

While this baseline survey could be implemented along the methodological requirements of this evaluation, risks may remain whether the identification strategy outlined in Section 3 will be realizable. For the present study, the main concern refers to the dissemination rates that Yeelen Ba will achieve in their target areas. This evaluation was actually designed on the basis of the customer projections of Yeelen Ba, hence, on the objectives of the projects.[17] In line with this, our evaluation requires a sufficient number of Yeelen Ba clients in our follow-up sample in 2012. If, however, take-up turns out to be much lower than expected, we will complement the intended difference-in-difference approach with a cross-sectional comparison in 2012. Apart from re-interviewing each household, we will then additionally interview a random sample of Yeelen Ba clients that will have been not yet included in the baseline sample. Since we would only dispose of 2012 data for these clients, comparisons could only be done in the cross-section. However, the baseline data could help as an approximation of the before-situation and will help to calibrate this comparison.

A low take-up, furthermore, could imply that selection effects in the take up of the technology are more pronounced. Since all findings on impacts conditional on having an SHS are only valid for households that share similar characteristics, the impact assessment cannot serve for predictions what the likely effects would be for population groups that are not represented among the observed actual users. In other words, these early adopters might be very different from the rest of the population.

However, obviously a very low take-up would in it-self be an indication of the program's failure and the quantitative evaluation of impacts would then only be of secondary importance. More attention should then be paid to the causes of low take up, for instance whether this is due to the quality, price, marketing etc. of the product. Lots of questions could be included in our follow-up survey that would allow answering these questions. In this respect already our baseline provides interesting insights as we asked for attitudes towards energy use, consumption habits and willingness to pay. The more qualitative sustainability assessment planned for 2012 would further complement this analysis.

Apart from the issue of take up, the evaluation may be more difficult than expected, in case of strong external shocks affecting the sampled villages, for example heavily changing cotton prices, a drought, a bumper harvest or possibly also other development interventions that are undertaken in the region. Strong seasonality (e.g. rainy vs. dry season) may endanger the transferability of findings to the rest of the year.

[17] It should be noted, though, that the projections are well beyond the 400 solar home systems that DGIS agreed to finance.

6. Concluding Remarks

This report presented the results of a baseline survey as the first step in the impact evaluation of the Solar Home System (SHS) dissemination project implemented by the Dutch 'Foundation Rural Energy Services' (FRES) in cooperation with a local company called Yeelen Ba. It described Yeelen Ba's fee-for-service approach, in which households basically rent the SHS and pay a fee for the hardware and maintenance services. Furthermore, the report outlines the evaluation strategy to assess the impacts of the project. The baseline data that we collected in late 2010 will serve as a yardstick after an end-line survey to be conducted in late 2012. We will then be able to use both surveys to conduct robust difference-in-difference estimation to identify the impacts of the intervention.

One major objective of the report is to verify the quality of the collected data. In fact, it turned out that the data is of high quality in terms of completeness and coherence with other sources of information. Even for questions that are frequently considered as sensitive (e.g. income) we have non-response rates clearly below 10 percent. The vast majority of questions is fully answered. Furthermore, the collected data is corroborated by information from the population census – as far as the information we collected is available there. Not least, the data has proven to be coherent "internally", i.e. we observe, for example, higher energy expenditures for wealthier households.

Although we are not yet in the impact analysis phase of the study, some interesting findings could be reported. Not surprisingly, the survey shows that the Yeelen Ba project is implemented in a poor region, also in comparison to other rural parts of Africa. Having said this, it clearly comes as a surprise that around 33 percent of the randomly selected households are already using individual off-grid electricity sources, mostly SHS. This indicates that the population in Yeelen Ba's target area has already access to SHS. Indicative findings on their sustainability do not suggest that these SHS are of bad quality. The other finding is in line with trajectories observed in other rural parts of Africa and, in consequence, less surprising, but still striking: Dry-cell battery driven lamps are crowding out kerosene and candles in non-electrified households.

Not least, the report provides information about attitudes towards energy and energy consumption as well as willingness to pay for energy analysis that no other previously undertaken survey could provide. The range of collected information will allow assessing not only direct impacts of SHS electrification, for example lighting usage and activities directly related to lighting such as study hours of children. In addition, it will allow for examining indirect effects and softer impacts such as possible impacts on fertility and women's empowerment through increased media exposure. We will also investigate if electricity will be used for small-scale production activities. All these aspects have never been studied for the Burkinabe context.

The main evaluation risk consists now in a low take up of the solar home system services offered by Yeelen Ba. However, this would bear of course new evaluation questions in its own, in particular regarding the causes of low take up on which our assessment would then focus on. Again, information on the household level would provide unique and highly useful information to give a well informed answer to this question.

References

Abdullah, S. and P.W. Jeanty (2009), Demand for electricity connection in rural areas: the case of Kenya. *Bath Economics Research Papers* 26/2009, Department of Economics, University of Bath.

Cameron, A.C. and P.K. Trivedi (2009), Microeconometrics Using Stata, STATA Press.

Chong, A. and La Ferrara, E. (2009), Television and divorce: evidence from Brazilian *novellas. Journal of European Economic Association*, 7(2-3): 458-468.

Devicienti, F., I. Klytchnikova and S. Paternostro (2004), Willingness to Pay for Water and Energy: An Introductory guide to contingent valuation and coping cost techniques. Energy Working Notes No. 3, World Bank, Washington, D.C.

FAO (2000), Applications of the contingent valuation method in developing countries: A survey. Food and Agriculture Organization.

Gentzkow, M. and J. Shapiro (2004), Media, education and anti-Americanism in the Muslim world. *Journal of Economic Perspectives*, 18: 117-133.

Grimm, M. and I. Günther (2007a), Growth and Poverty in Burkina Faso. A Reassessment of the Paradox. *Journal of African Economies*, 16: 70-101.

Grimm, M. and I. Günther (2007b), Pro-Poor Growth in Burkina Faso. The role of price shocks, In M. Grimm, A. McKay and S. Klasen (Eds.), *Determinants of Pro-Poor Growth: Analytical Issues and Findings from Country Cases* (pp. 135-163). London: Palgrave-Macmillan.

Jensen, R. and E. Oster (2008), The power of TV: Cable television and women's status in India. *Quarterly Journal of Economics*, 124(3): 1057-1094.

La Ferrara, E., A. Chong and S. Duryea (2008), Soap Operas and Fertility: Evidence from Brazil, *Bread Working Paper* No. 172.

Lee, Kyung H. and Hatcher, Charles B. (2001), Willingness to Pay for Information: An Analyst's Guide. *The Journal of Consumer Affairs* 35 (1): 120-140.

Ministère de l'Èconomie et des Finances (2009), Recensement general de la Population et de l'Habitation (RGPH) de 2006, *Institut National de la Statistique et de la Démographie*, Burkina Faso.

Olken, B. (2008) Do Television and Radio Destroy Social Capital? Evidence from Indonesian Villages. Harvard University. Mimeo.

O'Sullivan, K and D. Barnes (2006), Energy Policies and Multitopic Household Surveys: Guidelines for Questionnaire Design in Living Standards Measurement Studies. *Energy and Mining Sector Board Discussion Paper* No. 17, ESMAP, Washington, D.C.

Peters, J. und C. Vance (2011), Rural Electrification and Fertility – Evidence from Côte d'Ivoire. *Journal of Development Studies* (forthcoming).

Powell, Richard A. and Single Helen M. (1996), Methodology Matters V: Focus Groups. *International Journal for Quality in Health Care* 8 (5): 499-504.

Schutt, Russel K. (2004), Investigating the Social World: the Process and Practice of Research. Thousand Oaks, California: Pine Forge Press.

World Bank (2007), Burkina Faso Energy Access Project.

Yeelen Ba (2010), Etude de milieu. Unpublished document.

Annex 1: List of villages in the survey

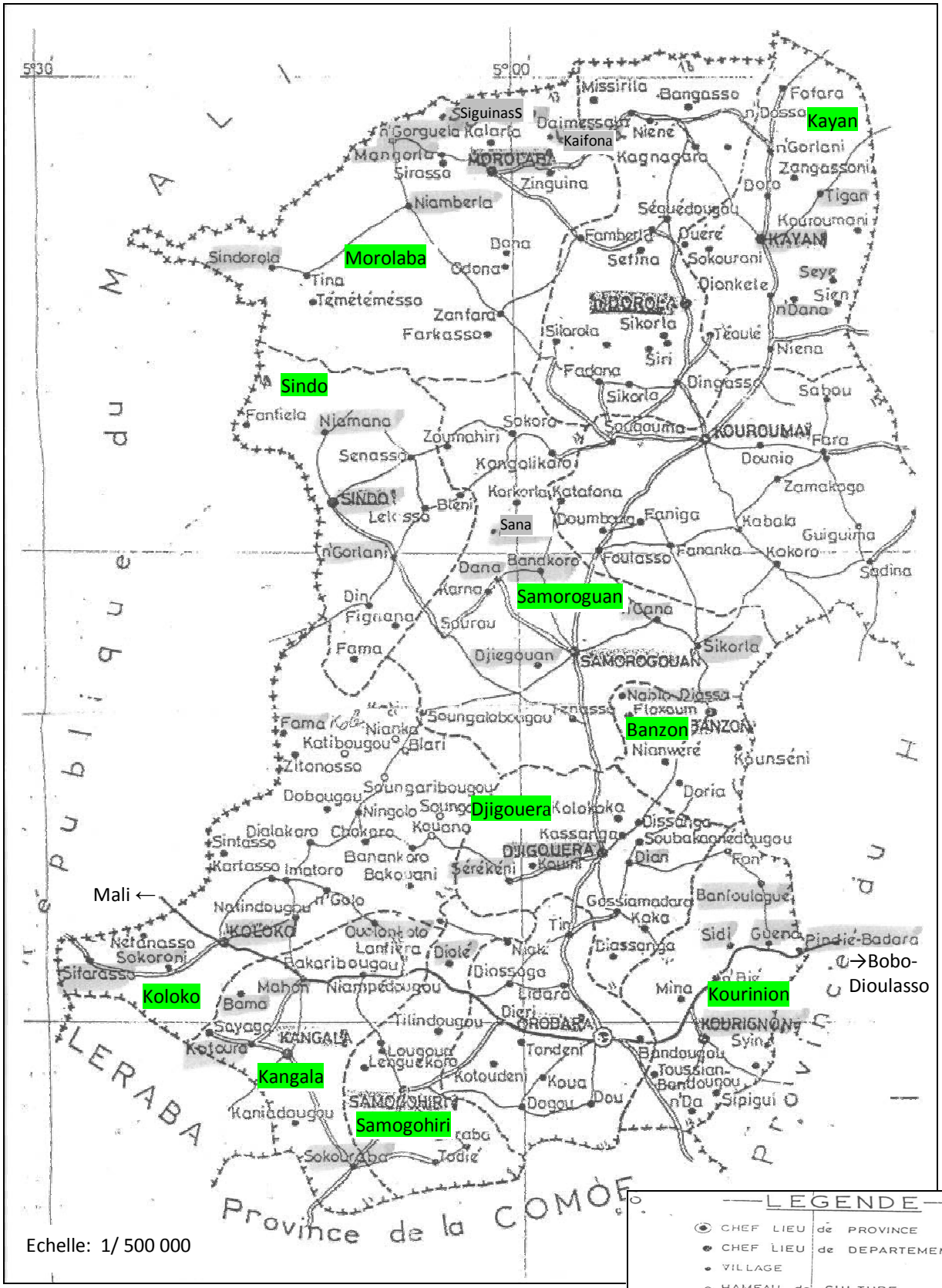
Department	Village	Population	Households	Date of the survey	Observations
Banzon	Nablo-Djassa	1.070	184	15.11.	30
Djigouera	Djigouéra (Chef-lieu)	3.580	556	12.11.	120
	Kouini	1.720	267	13.11.	
	Serekeni	3.212	499	12.11.	
	Dian	659	102	13.11.	
Kangala	Kotoura	2.345	387	08.11.	150
	Mahon	2.401	395	09.11.	
	Ouolonkoto	2.155	354	10.11.	
	Bama	661	109	09.11.	
	Sokouraba	3.100	509	10.11.	
Kayan	Kayan (Chef-lieu)	2.447	416	18.11.	120
	N'Dana	833	141	20.11.	
	Seye	960	163	19.11.	
	Tigan	2.171	369	17./18.11	
Koloko	Fama	760	128	06./07.11	120
	Koloko (Chef-lieu)	3.458	583	06.11.	
	Sokoroni	2.103	355	07.11.	
	Sifarasso	2.890	487	08.11.	
Kourinion	Kourinion (Chef-lieu)	2.861		01./02.11.	150
	Sidi	1.196	188	01./03.11	
	Banfoulagoue	1.980	312	03.11.	
	Guena	1.396	220	02.11.	
	Pindie-Badara	1.881	296	04./05.11	
Morolaba	Morolaba (Chef-lieu)	2.620	468	20.11.	210
	Sindorla	1.409	252	22.11.	
	N'Gorguerla	1.839	329	23.11.	
	Niamberla	3.050	545	23.11.	
	Siguinasso	588	105	23.11.	
	Kaifona	1.122	200	23./24.11	
	Nangorla	724	129	22.11.	
Samogohiri	Diole	360	59	04.11.	30
Samorogouan	Djigouan	1.485	249	16.11.	180
	Dana	874	147	14.11.	
	N'Gana	2.167	363	25.11.	
	Sikorla	4.208	706	24./25.11	
	Banakoro	1.342	225	15.11.	
	Sana	1.160	195	24.11.	
Sindo	Sindo (Chef-Lieu)	6.182	1.018	18.11.	90
	Niamana	1.415	233	18.11.	
	N'Gorlani	1.240	204	19.11.	

Note: Population and household figures provided by Yeelen Ba.

Annex 2: Study timeline

Pre-Departure Preparation of the Studies	*until October 1, 2010*
Desk Study of relevant project documents and literature; adaptation of existing survey methodology; questionnaire design in French; Excel matrix for data entry; coordination with local partner BEGE	
In-Country Preparation of the Studies (RWI/ISS Mission – Solar Home Systems and Improved Stove Study)	*between October 10 and 24, 2010*
▪ Coordination with local partner BEGE, project staff and national partners concerning both Solar Home Systems (Yeelen Ba) and Improved Stove (FAFASO) study; ▪ Field trips to Yeelen Ba sites not included in the sample; ▪ Choice on survey sites and planning of survey organisation and logistics, with the assistance of the supervisors and project staff; ▪ Design details of the study; ▪ Revision of the questionnaire; ▪ Training in Orodara of a survey team (including two survey supervisors, enumerators and operators for the data) for the survey including a pre-test of the questionnaire; ▪ Final review of questionnaire and survey organisation and logistics.	
Realization of the Yeelen Ba Survey	between November 1 and November 25, 2010
Survey implementation of the study of solar home systems by RWI research assistant and enumerators.	
Data Compilation	*until February 08, 2011*
Data entry by operators for the data	

Annex 3: Map of Kénédougou (survey region)



Note: Highlighted in green are the departments of the sample, marked in grey are the sampled villages.

Annex 4: Lighting devices

a. Ampoule électrique normale

b. Néon/ tube fluorescent

c. Ampoule à faible consommation

d1. Lampe à piles

d2. Torche fixe

d3. Lampe à gaz 	d4. Lampe tempête 
d6. Lampe à huile [Photo not available]	d5. Lampe artisanal 

Source: Own illustration

Electronic Appendices

Appendix 1 (file): Household questionnaire

Appendix 2 (file): Women questionnaire

Appendix 3 (file): Village questionnaire

Appendix 4 (file): FGD questionnaire