

Gender and intra-household dynamics of off-grid electricity access: insights from rural Tanzania



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1. Executive Summary

Introduction

Tanzania has become a hotspot of solar energy innovation in recent years, with social enterprises making the most of opportunities presented by mobile money and falling equipment costs to create business models which provide more affordable, sustainable energy access to off-grid communities. Nonetheless, two thirds of people in Tanzania still lack access to electricity which is most pronounced in rural areas, and the benefits of access are not equitably distributed between women and men due to structural inequalities that result in different societal roles for women and men.

This report presents a case study of how women and men in rural Tanzania are affected differently by the arrival of off-grid electricity in their homes, and the extent to which access contributes towards women's empowerment. The 3-year study was carried out by Ashden, with guidance from Institute of Development Studies at Sussex University and funding from IKEA Foundation and the Department for International Development (DFID). It aims to inform work by enterprises, as well as funders and policy makers so that women in Tanzania and beyond are meaningfully included in the sustainable energy transition. In order to do this, our study tests assumptions about the impact of household solar technologies on women's lives so that companies can ensure their products and services are inclusive and avoid reinforcing gender inequality.

Our area of interest is if, and how, electricity can benefit women as end-users of solar home systems and microgrids in rural Tanzanian households, whilst recognising that the energy value chain more broadly can influence women's empowerment, for example as leaders, business owners and employees of off-grid electricity enterprises. We acknowledge that a focus on the household level is just one piece of the puzzle towards understanding the extent to which the provision and supply of electricity contributes towards women's empowerment.

The benefits of household electricity on people's quality of life and economic standing are widely cited, which is why household electrification is considered as an important component of achieving Sustainable Development Goal 7 'universal sustainable energy access for all'. For example, bright electric light is said to provide extra hours of light to extend the 'useful' day, and power for television and phone charging can increase access to information. More powerful systems, like microgrids, can power appliances for productive activities. Yet evidence on how, or if, these benefits contribute towards women's empowerment is limited, as is our understanding of how these benefits affect women and men differently. The extent to which women are able to benefit from electricity access are dependent on a number of context-specific factors which relate to empowerment, such as cultural norms, access to resources and household decision-making dynamics¹.

¹ See Kabeer's definition of women's empowerment in: Kabeer, N, 1999, Resources, Agency, Achievements: Reflections on the Measurement of Women's Empowerment, Development and Change Volume 30, Issue 3, pages 435–464, July 1999

Methodology

An extensive review of academic and grey literature formed a part of this research (see annex 2) to inform our definition of women's empowerment, explore gender dynamics in Tanzanian society, and provide insights into gender differentiated impacts related to solar home systems and solar microgrids from studies across various contexts.

The fieldwork involved a two-part baseline/end line approach to develop a picture of life before households gained access to solar electricity, then the same communities were revisited once they had used solar over a substantial period. Overall, the study involved 1260 household surveys, 16 focus groups and 66 semi-structured interviews with, as far as possible, equal numbers of women and men. Fieldwork took place between March and June 2017 (additional data collection in December 2017), and between July and August 2019 in the Kagera and Morogoro regions of Tanzania.

The sample was drawn from customers of two solar enterprises and neighbouring communities. A treatment and control group were used for both solar home systems and solar microgrid regions to compare experiences of solar customers and non-customers with comparable socio-economic profiles. However, in practice, control groups were poorer than their respective treatment groups, which may have introduced some bias. Nevertheless, this approach deepened our understanding of some of the financial barriers to solar access for non-customers from less affluent backgrounds.

Partnerships

This piece of work builds on a desk study carried out by Ashden and Energia in 2015, funded by DFID, on the impact of the work of Ashden Award winning organisations on the lives of women and girls. The baseline study in 2017 was managed by Ashden in partnership with Institute for Development Studies at the University of Sussex (IDS), who supported on methodology design and data analysis. The end line report in 2019 was produced by Ashden with guidance from IDS on developing the end line research tools and invaluable feedback on the final report. The data analysis was carried out by Ashden and an independent consultant. The field research was carried out by the Economic and Social Research Foundation in Tanzania.

2. Research questions

Selecting research questions

The literature review demonstrated that a significant body of research exists on the impacts of access to electricity, but much less that is gender disaggregated. Across many impact categories, in particular impacts on women and men's time use and income generating potential, results vary widely between studies. Clearly, context is critical in determining the extent to which women can benefit from electricity access. Our study adds insight into how intra-household dynamics influence women and men's ability to benefit from off-grid electrification, as well as the extent to which electricity can have an impact on women's empowerment. We have drawn on Kabeer's definition, as the ability of people to make choices about their life (see 'contextual factors').

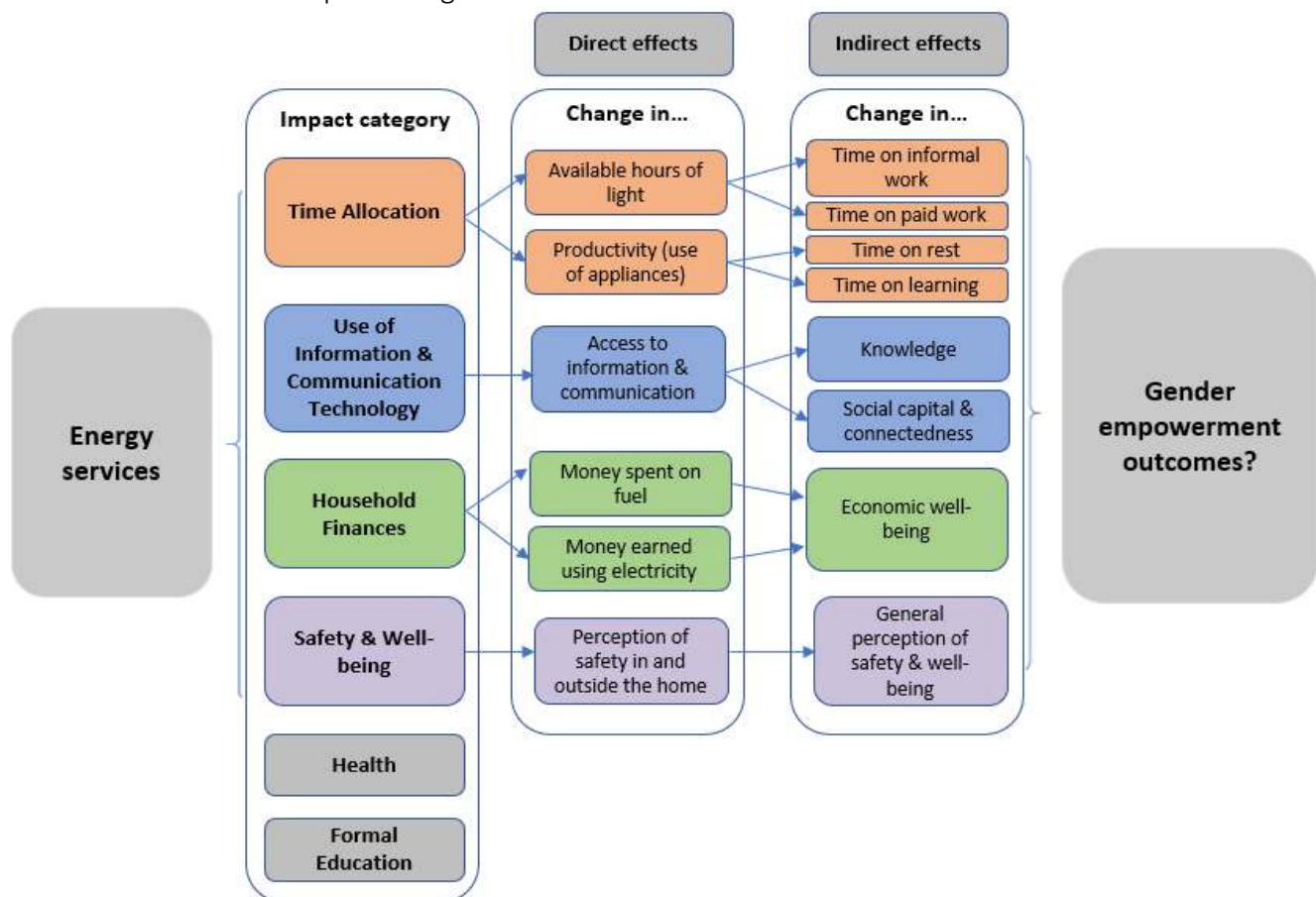
Research questions

1. How are the lives of women affected by access to solar home systems and solar microgrids in rural Tanzania?
 - 1.1 To what extent are the benefits of access to these technologies mediated by intra-household dynamics?
 - 1.2 To what extent does access to these technologies contribute towards women's empowerment?

To explore these questions, we have structured our research tools according to the following impact categories and contextual factors.

Impact categories

Based on the literature, the diagram below hypothesises some of the ways in which access to solar home systems and solar microgrids may have an impact on women and men. The key social impact areas of interest are time allocation, communication and information technologies (like phone charging, TV and radio), household finances (through a change in income or spending on expensive fuels such as kerosene) and perception of safety and well-being. Note: Children's education and empirical research into health are major themes, but constitute distinct research areas in themselves, requiring different methodology. We therefore consider them out of scope). The following diagram hypothesises possible impact of access to solar electricity and provides a framework for our impact categories:



Hypothesis of impacts of access to solar home systems and solar microgrids (Ashden's own elaboration)

Contextual factors

Factors affecting an individual's ability to benefit from access to electricity include intra-household dynamics as well as the wider context of social norms, institutions and markets. While in-depth analysis of some of the wider context is out of scope, our study adds insight into how intra-household dynamics and differences in empowerment influence women and men's ability to benefit from off-grid household electrification. We also explore the extent to which electrification, in addition to making life cleaner and easier, can influence the lives of women, for example by increasing empowerment and reducing gender inequality. Cross-cutting themes related to intra-household dynamics (based on Kabeer, 1999) are:

- Access to resources (i.e. money, time, social networks)
- Agency (which refers primarily to decision making, but also negotiation and resistance).
- What kinds of challenges and aspirations individuals experience in using, and benefitting from, these energy services?

Our findings also describe demographic characteristics and societal expectations that contribute towards a general understanding of women and men's roles in Tanzania.

Research themes

Combining the impact categories, and contextual factors, the following table sets themes explored through qualitative and quantitative methods. The quantitative part of our study focuses on direct and indirect impacts of access to electricity, whilst the qualitative part contributes insight into the influence of intra-household dynamics.

Time use and task allocation	Time spent on different types of household activities per day and who performs each activity. Hours of light per day in home. Distribution of activities throughout the day. If 'extra' time is available, what it is used for? Introduction of new activities in the day (e.g. through time saved or reallocation of activities) Access to and control over resources relating to nature and structure of day e.g. time-saving appliances. Ability to influence decisions on length and distribution of tasks during the day.
Household finances (including energy-related)	Sources of income; household assets. Energy sources most used by households?

expenditure and productive activities)	<p>Amount spent on various sources of energy per month.</p> <p>If there are savings, what is the money saved used for?</p> <p>Type(s) of income-generating activities undertaken. Time spent on each.</p> <p>Amount earned through these activities.</p> <p>How income is used.</p> <p>Ability to influence decisions on how income is used.</p> <p>Who decides type(s) of income generating activity undertaken and length of time spent.</p> <p>Access to and control over resources relating to productive activities – e.g. social networks, access to markets, time.</p> <p>Level of satisfaction with current situation and what individuals would want to be different. Barriers to change.</p>
Information and communication appliances	<p>Types of information/ communication appliances owned.</p> <p>When/for how long each type of communication technology is used for.</p> <p>Who made decision to buy appliance? Who decides when/ how each is used?</p> <p>Access to and control over resources relating to appliances e.g. access to information (e.g. market, health information) and how this information is used and ability to communicate with others via phone/internet.</p>
Perceived safety and well-being	<p>How satisfied are women and men with the nature and distribution of activities within their day? (General sense of subjective wellbeing amongst the studied groups).</p> <p>Reported incidences of burns and fires.</p> <p>Perception of cleanliness and comfort (e.g. indoor air quality).</p> <p>Perception of safety after dark.</p> <p>Aspirations and levels of satisfaction (see above).</p>

	Level of satisfaction with current situation and what individuals would want to be different. Barriers to change.
Energy use and appliance use	<p>Energy use patterns: energy sources currently used; energy expenditure; appliances used; decision making with regards to appliances used.</p> <p>What are energy sources most used by households and the electronic appliances these are prioritizing to buy?</p> <p>Decision-making in relation to energy expenditure and use including decisions around purchase of electronic appliances.</p> <p>Decisions around uptake of solar home system or microgrid connection.</p>
Demographic information	<p>Household characteristics: household members, dwelling characteristics.</p> <p>Demographic information of the sample: age, education, marital status, years living in the community, employment status.</p> <p>Gender roles: General understanding of the societal expectations of women and men and the issues of not complying with them.</p>

3. Methodology and research tools

Overview

This research employs a mixed-methods case study approach, combining quantitative surveys to obtain a breadth of data with qualitative methods, namely focus groups and semi-structured interviews, to explore intra-household dynamics in depth. The sample was drawn from the customer bases of two organisations - a pay-as-you-go solar home systems company, and a microgrid developer.

A two-part baseline/end line strategy was used to develop a picture of life before solar access, then revisit the same communities once they had used it over a substantial period. A treatment and control group were selected for both parts of the study to compare experiences of solar customers and non-customers with comparable socio-economic profiles. However, in practice, control groups were poorer than their respective treatment groups, and therefore it is not possible to draw direct comparisons between regions – refer to the ‘limitations’ section for more information. Despite these challenges, this approach deepened our understanding of the financial barriers to solar for non-customers from poorer backgrounds.

At the baseline, the treatment group had signed up to receive a microgrid connection or a solar home system, but had not yet been connected, and the control group were not scheduled to receive an electricity connection during the research period. The baseline work was carried out between February and June 2017, in the regions of Kagera and Morogoro. A total of 607 quantitative interviews were conducted, gathering contextual information and looking at impact areas (time allocation; household finances; information communication appliance; safety and well-being, as well as energy use and gender dynamics).

At the end line, the data collection was carried out between July and August 2019, in the same regions of Kagera and Morogoro. In the two treatment groups (region 1 and 3), the end line found there is now 100% coverage of solar electricity (or grid). Many people are now using solar home systems in region 2. A total of 653 quantitative interviews were conducted covering the two treatment groups and two control groups.

The key differences between the baseline and end line methodology and sampling strategy was a stronger focus on qualitative data collection at the end line, with 30 semi-structured interviews and 12 smaller focus groups at the end line, and fewer surveyed households in regions 2 and 4. As planned, the qualitative methods had a stronger focus on solar impacts and less on contextual information than the baseline.

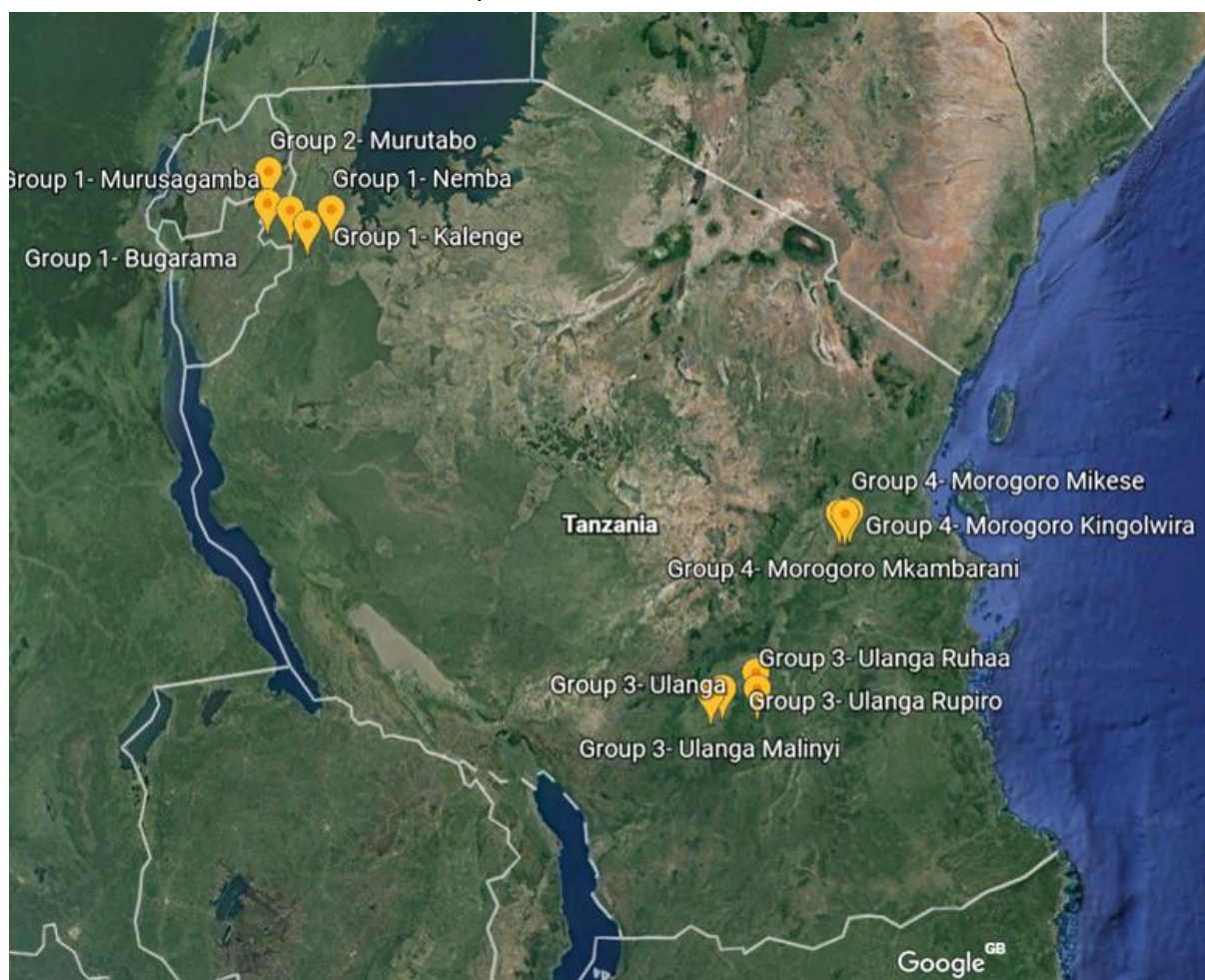
Household identification strategy

The following table summarises the key group characteristics and timeline for data collection. Please note that ESRF were sub-contracted by ACSRED to carry out the data collection, and the microgrid company carried out the quantitative data collection in region 1.

	Solar microgrid research region		Solar home system research region	
	REGION 1 Treatment	REGION 2 Control	REGION 3 Treatment	REGION 4 Control
Definition of groups	M and F who were connected to microgrids in 2017	M and F not exposed to microgrids	M and F recruited to get SHS in 2017	M and F not exposed to SHS
Region and district	Kagera region Ngara district (villages: Murusagamba, Bugarama, Kalenge, Mavota and Nemba.	Kagera region, Kyrushia district, village: Murutabo	Morogoro region Ulanga and Malyinyi districts	Morogoro region, Rural district.
Quantitative research team				
Baseline	Microgrid company	ACSRED & IDS	ACSRED & IDS	ACSRED & IDS
End line	Microgrid company	ESRF	ESRF	ESRF
Quantitative sample size and date				
Baseline Sample size	Total: 258 Men: 197 Women: 54	Total: 121 Men: 60 Women: 61	Total: 122 Men: 59 Women: 63	Total: 117 Men: 61 Women: 56
Date of fieldwork	May 2017	Mar 2017	May-Jun 2017	Feb-Mar 2017
2nd visit sample size		Total: 121 Men 61 Women 60		Total 121 Men: 59 Women: 62
2nd visit	n/a	Dec 2017	n/a	Dec 2017

End line sample size	Total: 354 Women: 46 Men: 308	Total: 80 Women: 48 Men: 32	Total: 139 Women: 85 Men: 54	Total: 80 Women: 53 Men: 27
Date fieldwork	June 2019	July 2019	July 2019	July 2019
Qualitative survey sample sizes and dates				
Baseline focus group	1FG with 12F and 1FG with 12M prospective customers, run by ACSRED & IDS		1FG with 12F and 1FG with 12M prospective customers, run by ACSRED & IDS	
Baseline Semi-structured interview	9F and 9M may/may not be customers		9F and 9M may/may not be customers	
Date of baseline fieldwork	March 2017		March 2017	
End line focus group	2FG with 6 F customers, 2FG with 6 M customers run by ESRF		2FG with 6 F customers, 2FG with 6 M customers, run by ESRF	
End line Semi-structured interview	8F and 7M, interviewed by ESRF		8F and 7M, interviewed by ESRF	
Date of end line fieldwork	July/August 2019		July/August 2019	

Location and characteristics of surveyed communities



The map above shows the location of the treatment and control communities within Tanzania. The Kagera region, where villages in Region 1 and 2 are located, is very close to Burundi and characterized by plateaus, steep slopes and streams. The area supports the cultivation of coffee, beans, bananas, cassava, maize as well as poultry, cows and pig keeping. The area has rainy seasons and dry, cold weather seasons, with trees and greenish vegetation. The community is mixed with people from both Tanzania and Burundi. Most of the latter do not speak Swahili. Villages have dirt roads, no national grid, poor mobile phone network system.

The Ulanga District in Morogoro region, where villages in Region 3 are located, has lowland areas and river valleys, supporting the growth of paddy, maize, sugarcane, traditional fishing and cattle keeping. The area has poor roads, prone to flooding. Other wards are in highlands with limestone plateaus and forests. These areas support cultivation of maize, vegetables, fruits, beans, coffee and cocoa and also support poultry, pig, goat and sheep keeping. Coal and ruby extraction are also available in the region. In this area there are banks, tarmac roads in some parts, district hospitals and some secondary schools. Most people speak Swahili.

The rural district of Morogoro, where villages in Region 4 are located, is mainly lowland based on agriculture, supporting growth of maize, beans, vegetables, watermelon, sunflower, sweet potatoes and mangoes and also keeping animals. These wards are crossed by the highway from Dar es Salaam to central Tanzania, which enables farmers to sell their crops along the roads.

Research tools

1. Qualitative

The qualitative component used two methods for gathering the data: semi-structured interviews (SSI) and focus group discussions (FGDs). The qualitative data was analysed by using Excel and Nvivo software to identify patterns. These patterns were then cross-referenced with the quantitative data and the findings synthesised.

a. Focus group discussions

The FGDs sought to understand women and men's roles and responsibilities, decision-making abilities in a group context, access to resources and choices regarding power sources. The discussions were digitally recorded, then transcribed and translated from Swahili to English. The focus groups were carried out with women and men separately and led by a researcher of the same gender where possible.

b. Semi-structured interviews

Semi-structured interviews were carried out by enumerators of the same gender as the participant, except in more remote parts of the region where the team of enumerators had to break up into smaller groups. Each interview lasted between 30 minutes and one hour. It was important to build rapport and create a relaxed environment, in addition to the standard practice of informed consent to being interviewed. A set of questions guided the interview however these were not fixed, and the researcher could add or omit ones depending on the interest and reaction of the respondent.

2. Quantitative survey

The survey was based on a tool used by one of the solar companies as part of its customer recruitment procedure. This was adapted to include questions related to our impact areas. The questionnaire was edited at the end line to focus more on aspects that might elucidate gender differences.

For the data collection, questionnaires were translated and transformed into an electronic format. For this, ESRF used the Census and Survey Processing System (CSPPro) operating on a handheld device. The use of computer assisted personal interviewing techniques (CAPI) for the data collection meant that checks could be built in to avoid enumerators entering inadmissible data values and allow in-the-field validation of each questionnaire. Each day the field teams sent their data files back to the ESRF survey team and the assistant data manager, and Ashden also validated and checked the quality of the data received.

Enumerator training and piloting

At the baseline, IDS was commissioned to design the methodology for the study and trained ACSRED and ESRF field researchers over four days. This included carrying out a pilot in Morogoro to test the research tools and approach. After studying the questionnaire and brief, the team pre-tested the quantitative tools at Mpiji Magohe and Msumi at Mbezi ward in Ubungu district - Dar es Salaam. The pretesting exercise helped the team to discuss their experiences and develop common understanding of the task. The microgrid company conducted their own training, but the supervisors joined ACSRED training via video link for one session.

At the end line, Ashden worked with the same core team of enumerators from ACSRED and ESRF, carrying out a 4-day refresher training in Dar es Salaam. Two researchers were new to the study. The endline research tools were adapted by Ashden with guidance from IDS.

Limitations

Points on sampling

Region 1: The overall sampling approach sought to interview equal numbers of women and men, however in region 1 (microgrid treatment group) only 20% of the sample were women at both the baseline and endline. Effort was made to rectify this imbalance at the endline by interviewing more women across the remaining 3 regions. The reason for the gender imbalance in region 1 is that the microgrid company could not recruit enough female customers. This was because the team used an opportunistic sampling method, carrying out the survey with the householder present at the time.

Region 2: This region was proposed by the microgrid company as a control on the basis of its similarity to region 1. The sample was drawn randomly from a list of households in the community provided by the headman. It is worth noting that this region presents lower socio-economic conditions than Region 1. The sampling strategy for Regions 1, 3 and 4 involved women and men that had self-selected as customers of solar products. These are likely to be of a different profile to those who do not purchase these products. As at the baseline, the end-line data shows that the control group in Region 2 is considerably poorer than Region 1, the treatment group.

Region 3: This region consists of customers who had signed up to receive a solar home system from the SHS company. We had hoped to carry out the baseline in the very brief window between sign-up and installation. In fact, a significant number already had the system installed by the time the baseline data was collected. Whilst acknowledging this, at the end-line we were satisfied that these customers were very new to solar home systems therefore we could make useful comparisons.

Region 4: This was originally intended to consist of existing SHS customers, who had been using solar products for approximately one year (so effects could be observed over a longer period time). However, a different sampling frame was followed and none of the sample were shown to be already using solar home systems. This group, therefore, constituted a more traditional control – nevertheless, region 4 was notably poorer than region 1 and 3.

Points on data collection

Whilst contact details of participants were recorded, it was not possible to survey and interview all of the same people at the endline as those contacted during the baseline survey in 2017: a number of participants across all regions had moved away, were no longer customers, or were uncontactable. The control groups were also poorer than their respective treatment groups, and therefore, it is not possible to draw direct comparisons between regions. This means that some of the data cannot be compared directly between the endline and baseline and it is also not possible to directly link any changes in survey data of the control group directly to the connection of solar electricity. Nevertheless, all of those involved in the focus group discussions

and semi-structured interviews were asked to compare differences between life before and after getting access to solar.

We also do not know from those surveyed or interviewed who were from the same household – for example the husband and wife. If this has occurred, then the data will include some duplication. We also did not seek to interview other members of the household beyond the head and spouse of the family. Including other members of the household including grandparents, adult children and additional spouses would have provided richer insights into intra-household decision-making dynamics.

The focus groups and SSIs for the baseline were conducted in the farming season, in March 2017, and in the dry, non-farming season, in July and August 2019 for the end-line. This may have led to more focus on farming at the baseline than at the end-line. Although the format and topics were similar for the men and women's focus group discussions there was a significant focus on household chores in the women's discussions with less focus on their activities outside of the home, such as farming. This may also be because it was outside of the farming season.

4. Ethical considerations

This study upholds the principles cited in IDS' Research Ethics Policy (2015). The policy outlines how all research is conducted with integrity and minimises physical, mental, legal or financial risk for the Institute or any of its members, partners or participants.

Regarding the data collection for this study specifically, ACSRED and ESRF requested and was granted permission to conduct research in survey areas by the government of Tanzania. The permit was given by Regional Administrative Secretary (RAS) of the respective regions. It is mandatory in Tanzania to have such a permit before carrying out research activities. The second level of permit was then obtained from the (district level) Local Government Authority. Research firms need to be cleared at regional level as well before going to the wards. The permit must be shown to be allowed to continue with the research activities.

Before interviewing participants, consent was requested by reading the consent information to the researcher. The participant was then free either to accept or to decline to be interviewed and reminded they could withdraw consent and stop the interview at any time. At the baseline, the respective village leaders explained the intention of the study in a language that was clear to potential participants. During the training, researchers were reminded to be respectful, honest and patient with participants.

5. Summary of findings

Gender roles, time use and structure of the day

Solar brings flexibility to women's daily routines – they spend more time undertaking activities in the evening or early morning

The introduction of solar did not alter the most time consuming daily activities carried out by women and men. Domestic chores including cooking, childcare, cleaning and collecting fuel and water still took up much of women's time, whilst men's typical activities remained as

farming, carpentry and tailoring, as well as running smaller side-enterprises (with support from spouses). These side-enterprises included bike rental, cutting hair, welding, and running small shops. A handful of men also helped with household chores.

Yet household solar did alter the typical structure of the day for women, and there was a perception of increased flexibility: more than 90% of women survey respondents said they now use evening hours to continue with household chores, help children with homework, watch television or work on income-generating activities. For a breakdown of livelihood activities see this report's income generation and household finances section. The reported flexibility suggests that more well-lit hours in the day from solar can give women a sense of control over how they structure their daily routine – choice being one aspect of Kabeer's (1999) definition of empowerment.

There was less evidence, however, of solar technologies enabling women to meet strategic needs such as educational or entrepreneurial aspirations. Half of the women interviewed wanted to spend less time on household chores so they had more time to earn money or relax, a change their current system or grid access could not deliver. As one woman microgrid customer explained: "I would like to spend more time cooking and selling food; the activities that give income." This echoed the qualitative findings from our baseline research, where most women felt that they had control over how they managed their schedules regardless of solar access but would prefer to spend more time on their businesses than domestic chores.

Fewer men mentioned solar had created change in their daily routine, although seven in the qualitative element of the end line study spent more time on income generating activities in the evening. This included carpentry and tailoring work, as well as keeping small businesses open for longer due to having better quality light. Several men also reported spending more time with their families watching television in the evenings, rather than seeking entertainment outside of the home.

Incremental time savings from solar access were cited by six interviewees (three women and three men) primarily from reducing the time needed to go and charge a mobile phone elsewhere. In two specific cases, one woman and one man mentioned that purchasing an electric iron has made the task faster than previously when a charcoal powered iron was used. Yet these were general comments, so it was unclear who in the household was responsible for this domestic chore and therefore who benefited from time savings.

Yet more hours of productive time, without a change in existing gender norms, increases the double burden (domestic chores coupled with paid work) on women's time

The baseline findings revealed that all women with income-generating work structured their working day to accommodate a 'double-burden' (domestic chores coupled with paid work). Some delayed the start of their working day or finished early to carry out chores, while others devoted an entire day to them, in which they were unable to earn an income.

In the areas covered by our study collecting water is often the responsibility of women and girls, and this was the most time-consuming chore for women survey respondents. Over a third of households walked over 100m to fetch water. This task is unlikely to be affected by

household-level energy access. Childcare, cleaning, and fetching firewood were other arduous tasks carried out by women.

The end line results found little evidence that access to solar had shifted the double time burden, altered existing gendered work or eased the most arduous tasks listed above – except for introducing a small amount of choice as to when tasks were carried out. Here it is worth bearing in mind Mukherjee's (1999) point that if unequal gender norms do not change, for many women the introduction of solar only increases the number of hours they are expected to work.

Socio-economic status is a greater determinant of women's free time than access to solar by itself

Women who reported to have more leisure time, regardless of solar access, were in the minority and tended to be of a higher socio-economic status, suggested by their ability to hire a housekeeper or farm labourers. This allowed time for other activities such as reading or watching television in the evenings. In both the solar home system and microgrid regions, women who could afford appliances such as irons, refrigerators or blenders, appeared to appreciate and benefit the most from electricity, compared to those who could not afford them, or had not yet purchased appliances.

This was particularly true in the microgrid regions, where more energy intensive equipment could be powered. As one man put it: "everyone has their own equipment depending on their living standards." Overall, there was a strong call from men and women solar home system customers for more appliances, and demand for solar companies to offer more loans that make appliances affordable.

Access to solar isn't necessarily equally distributed among members of the household

Five women interviewed in the solar home system and microgrid treatment regions wanted extra bulbs to light their kitchens or commented on how useful a bulb in their kitchen would be, as currently the bulbs available are placed in communal spaces. If lightbulbs are not prioritised in rooms which are regularly frequented by women, such as in the kitchen area, women will continue carrying out chores in poorly lit rooms with polluting fuels.

There are also trade-offs in who can use electricity, and the time they can use it, because of the limited number of hours solar is available – particularly via solar home systems. One woman, a solar home system customer, explained: "the problem I have is battery power gets weak quickly so you cannot watch television at daytime with freedom. If you watch during daytime you cannot watch at night."

Reasons for these limitations are not clear and could be due to faulty batteries or that electricity is being used heavily for other purposes, meaning that the full benefits of the system are not experienced. Solar home system customers taking part in the study also used different sized systems, starting from a basic 40Wp system, so this issue may only have affected those with smaller systems.

Income generation and household finances

Solar power has allowed some customers to increase their income, with activities such as mobile phone charging and TV screening

Around 20% of survey respondents noted they had started new businesses since getting access to solar, such as charging people to watch TV series at their homes or phone charging. Another 10% of those surveyed are planning to open businesses, including a salon and a welding workshop, but have not done so yet. Women with solar home systems, in particular, have started businesses charging phones or screening television series to neighbours, with half of those interviewed (10 women) now earning from these businesses. Most importantly, the women who were asked said they were able to keep this additional income. Where stated, this was typically spent on food or household expenses. Three men with solar home systems had also started similar businesses.

Solar had improved existing entrepreneurial and leisure activities, either by increasing in productive hours or unlocking new services

Women had extra better-lit hours to carry out existing income generation activities such as cooking food to sell and making textiles. One woman now spends more time reading the Quran into the evening, another woman, a dress maker, said she can no longer destroy a customer's dress by working in the evening with dim candlelight. Two male microgrid customers mentioned that they now own electric sewing machines which allow them to work more productively. A solar home system customer used solar for his barber shop business, and a tailor now spends more time sewing and hires labourers to work on his farm.

More than a third of participants had reservations about starting new activities because of the reliability, expense and price of solar

Many women and men (35% of interviewees: 10 women and 18 men) were stopped from starting businesses by concerns about the reliability, capacity, expense and future of the services offered. Half of the focus group decision participants from the solar home system group had experienced some increases in prices since first getting connected.

There were calls for more flexibility in payments for solar home systems - particularly during the rainy (farming) season, when there is less income available. One woman from the microgrid region explained: "I started an ice and ice cream selling business, but I have stopped it because of high costs of electricity compared to the profit I was making. I did this business for two weeks only and I decided to leave it because I was getting a loss." Four women and men also stopped offering mobile phone charging or screening television due to neighbours not paying for the service.

Gender differences in financial inclusion were most stark in the poorest region – and across the regions studied, gender inequalities impacted ownership of energy systems

Survey respondents in the solar home system control group, the poorest region studied, showed the starkest gender difference in mobile money account ownership (31% of women, 84% of men) and bank account ownership (4% of women, 34% of men). There was also a large

difference in mobile phone ownership in the region (46% of women, 90% of men). Mobile ownership is often a pre-requisite for buying solar home systems, and mobile money is often the only payment option.

These findings support the argument that gender inequality and socio-economic status are inextricably linked – here it is worth considering that women will not always have equal access to certain financial mechanisms, such as mobile money. Such inequalities help explain why solar accounts were also owned almost exclusively by men, and therefore most of the interaction between the companies and customers was with the man of the household, even if men and women in the same household were equally responsible for paying bills and deciding when to top up. Interviewees said the payee was normally the family member who was available at the right time, and in some cases the person, man or woman, who had money available. Reasons given for men's account ownership were because the man was the head of the household and therefore was responsible, but also in a few cases because he owned a mobile phone.

There were strongly varying views of what constitutes 'joint decision-making', and energy types have different gendered decision-making dynamics

The household survey results suggested that energy related decision making was relatively balanced (on average 55% reported making energy related decisions together). However, the interviews and focus groups support a more nuanced perspective: 60% of women said that the husband tended to have the final say, as the main earner, even where decisions were made together. In other households (see page 47 for full list of responses) women felt decisions were absolutely mutually agreed. By contrast, some women who were told they were getting solar by their husbands (who had heard about the service from friends) later accepted and appreciated having the electricity connection.

The qualitative findings also shed light on decision making dynamics around energy. For example, acquiring energy for cooking (charcoal and firewood) is usually undertaken by women and paid for with cash. However, acquiring solar, making payments and maintaining the system or microgrid connection in this context were considered to be a man's responsibility – men overwhelmingly put forward the idea of getting solar, and while they often involved their families in the decision-making process, they generally had the final say. Clearly, then, responsibility for energy in the household rarely falls exclusively to men or women. Nor does the widely used term 'joint-decision making' capture the complex intra-household bargaining process that shapes the purchasing of solar.

[Access to information and communication appliances](#)

Marketing and outreach were more likely to be targeted at places frequented by men, and no one interviewed had come across a woman sale's agent

Men were more likely to be the first in the family to have learned about solar electricity. There were also several comments (see page 47) about men finding out about solar then signing up for a system without consulting the wider family first, even though women significantly contributed towards household income and picked up solar bills when their husband could not afford to pay.

There is certainly scope for more marketing targeted at women, potentially through women's groups, at places women visit such as food markets, or through house to house visits, the latter of which is frequently used in the microgrid region. House-to-house visits have the advantage of reaching women who are based at home. Two interviewees mentioned they found out about solar from women's groups. Membership of women's groups varies considerably, though; in Region 1 only 11% of women were part of a women's group and this rose to 29.4% in Region 3.

No one interviewed had come across a woman sales agent, although the solar home system's remote customer service team was more gender balanced. A third of interviewees mentioned they had heard about the microgrid company working in their area at a village meeting, which in this context tended to be male dominated spaces.

Fewer women than men were trained on how to maintain their systems

Rudimentary training was provided to customers by solar agents, which was targeted at the man of the household, the solar account holder. Only 31% (5 of 16) women interviewed received any training. There is a clear gap in training women on their solar connection, meaning women sometimes relied on the man or adult children in the household to fix or top up the system.

Other benefits – enhanced status and wellbeing

Women and men generally satisfied with their lives and levels of autonomy, but this varies according to intra-household dynamics

Men with a new solar home system or microgrid connection said that having solar had strengthened social ties and improved relationships with their neighbours, largely because these men could now offer them phone charging and television viewing services. Household light also made both genders feel safer because it was seen to deter potential thieves and signal someone was at home. Men were more at ease when away from the house, as they felt that their spouses would be safer.

There was also a sense of pride from women with a solar home system or microgrid connection. Four of the women interviewed mentioned that they are in better social standing because when the national grid has power cuts neighbours can use their solar home system to charge phones. One said: “[we are] perceived that we have very good life and well organised with what we do”.

Conclusion

This study set out to explore how off-grid electricity access for customers in Tanzania contributes towards women's empowerment, and the extent to which this is mediated by intra-household dynamics. The data revealed that household solar access alone does provide some practical benefits to women, such as increasing the number of well-lit hours in the day, which in turn gave women more choice in how they structured their daily routine. Some women also cited time saving benefits from appliances and having readily available mobile

phone charging facilities, and there were economic benefits for women who were able to supplement their incomes or use solar to support existing livelihood activities.

Yet, because of reliability and cost issues, it is unclear if these practical benefits could lead to a sustained rise in income. Also, solar did not reduce the most arduous tasks carried out by women, such as collecting fuel and water. There was limited evidence of women using solar to meet their strategic needs – such as gaining education from watching television. However, the extent to which this activity led to positive educational outcomes is unknown.

Other factors, notably the socio-economic status of the household, played a central role in amplifying the benefits of solar electricity: women from more affluent households were more likely to be able to purchase more powerful appliances which could be used to generate income and save time, as well as afford farm labourers or help with housework. Women who could only afford smaller systems with a limited number of bulbs were also more likely to de-prioritise their own needs by rationing solar power for times when the family could use it together.

The causes of these issues are largely the patriarchal societal structures that lead to women and men's unequal roles. These cannot be erased by a single intervention. As such, access to solar technologies at the household level by themselves can only have an incremental impact on women's lives. Instead, women need enough time, finances and power to fully benefit from their systems and grid access. This adds nuance to the widespread belief that household electricity access can act as a catalyst for more time, finances and power.

Clearly, off-grid electricity providers cannot provide goods or services that solve deeply rooted structural inequalities. Yet our findings uncovered ways that the provision of solar, without taking gender and intra-household dynamics into consideration, can reinforce existing unequal gender roles.

6. Recommendations

We propose the following recommendations based on gaps and opportunities identified in this case study, as well as from feedback from a practitioner focused workshop held in Nairobi in November 2019. The suggestions are targeted towards practitioners working in off-grid electrification. Following them recommendations will empower women, deliver deeper market insights and attract new customers, creating benefits for businesses and communities.

They are also relevant to policy makers and funders that are looking to support projects that incorporate gender into their business models and operations.

Context is key to understanding intra-household dynamics, and therefore not all recommendations will be applicable to every business and geography. Nevertheless, embracing the underlying principles behind them can guide best practice for organisations around the world.

1. Training and HR

Create spaces where the whole household can negotiate the decision to buy a system or grid connection

On several occasions, men bought solar technologies without discussing the decision with their spouse beforehand, excluding women from the decision-making process. Companies should prioritise household visits in place of signing individuals to contracts on the same day. This would encourage purchasing decisions to be made jointly within the household. Visits could also be used by agents to share product information, discuss the benefits of various appliances and their financial implications, and the benefits of flexibility in lifestyle that result from solar access. This would make clear how the connection will meet the needs and aspirations of women and men. As a result:

- women would be better informed about the system and its full range of benefits before contributing their income to the bills;
- there would be a stronger commitment from the entire household to paying off the system or grid connection, which could reduce risk of customers defaulting on payments.

Guide agents to suggest installing lightbulbs in the living area and kitchen as the standard option for customers.

Women's energy needs were de-prioritised when available electricity was limited, and many women participants would have appreciated access to lightbulbs in spaces where they spend time, in this case, the kitchen area. Agents generally followed a standard installation plan for lightbulbs, which often neglected such areas. This left women carrying out chores in poorly lit rooms to benefit other household members, despite having household electricity access. As a 'light touch' solution to this problem, companies should encourage agents to suggest lightbulbs in areas of the house most frequented by women.

Promote appliances that directly benefit women and offer more appliances on credit

Women with greater access to appliances had more opportunities to save time, complete chores more easily and generate income. Women aspired to buy a greater variety of appliances such as fridges, blenders and irons that would help them achieve these goals. Phone charging and TV screening were popular business opportunities for women, and enterprises should develop offers and services that can support these ventures.

In many cases the key barrier to accessing appliances was affordability and lack of availability in the local market. Companies could offer more appliances on credit and agreeable rates or discounts on appliances most likely to benefit women, to enable those from less affluent households to benefit from time-saving appliances.

Ensure training is provided to all members of the household

Many women relied on their husbands or adult children to maintain the system or top up, reducing their control over how and when solar was used. Providing training for the whole family would ensure that women and men can more equally use and manage the technology.

Build multidisciplinary, diverse teams that understand intra-household and gender dynamics

Overall this research demonstrates that a better understanding of gender and intra-household dynamics can lead to more inclusive services and deeper market insights.

Companies should:

- Employ women at every level of the organisation.
- Involve women in decision making processes throughout the company to mainstream women's needs as customers.
- Use existing insights and research on household dynamics research by other's (e.g. local NGOs);

2. Marketing and partnerships

Increase women's mobile phone ownership and use of mobile money

Women, particularly in poorer regions, were less likely to own a mobile phone or use mobile money. As mobile money is often a prerequisite for setting up and managing an account, unequal access risks shifting solar related decision making to men. Services that rely on mobile based payments should consider working more closely with mobile phone providers by:

- promoting MPESA/mobile money account opening as part of the sales package and work with local mobile companies to boost phone ownership and mobile money access and use for women;
- providing training on use of mobile money learning from local service providers;
- offering flexible payment methods to improve inclusivity. These could include promoting community cash or lending groups.

Widen marketing and outreach for women

Men in our study were likely to have learned about solar technologies before women did, and none of the interviewees had encountered a woman sales agent. Male-dominated marketing channels and agent teams are likely to result in a male customer bias, reinforce unequal decision-making dynamics, and exclude women-headed households from off-grid technology access. Evidence suggests that women agents are more likely to reach women customers than male agents, as women are in a better position to understand the product's benefits and limitations for other women in the community.

Woman champions (existing solar customers) could promote solar solutions to other women in their community. Greater use of other marketing channels, including women's groups, places women visit regularly such as food markets and house-to-house visits, would ensure women are more actively engaged in the purchasing decision.

Carry out a gender needs assessment to find out women's needs and aspirations

Women's needs vary widely according to context and intersect with other factors such as socio-economic status. Gender disaggregating company data is an important first step in understanding the lives of local women. Enterprises should carry out further research on current women customers to understand how the company's technology, appliances and payment schemes meet their needs. Enterprises should also carry out research with potential women customers. This body of knowledge can help reveal women's aspirations and the barriers they face in accessing off-grid solutions.

Building partnerships to maximise benefits for women and broaden customer reach

There are clear limitations to how much solar can meeting the needs of women, in that the greatest time-saving impacts are seen when electricity can power cooking appliances or can impact water collection. These issues cannot be tackled by household electricity access alone; however, companies should work more closely with clean cooking providers and suppliers of water pumps and other agricultural equipment, to offer a package of services or products that would have a greater impact on women's lives than single interventions.

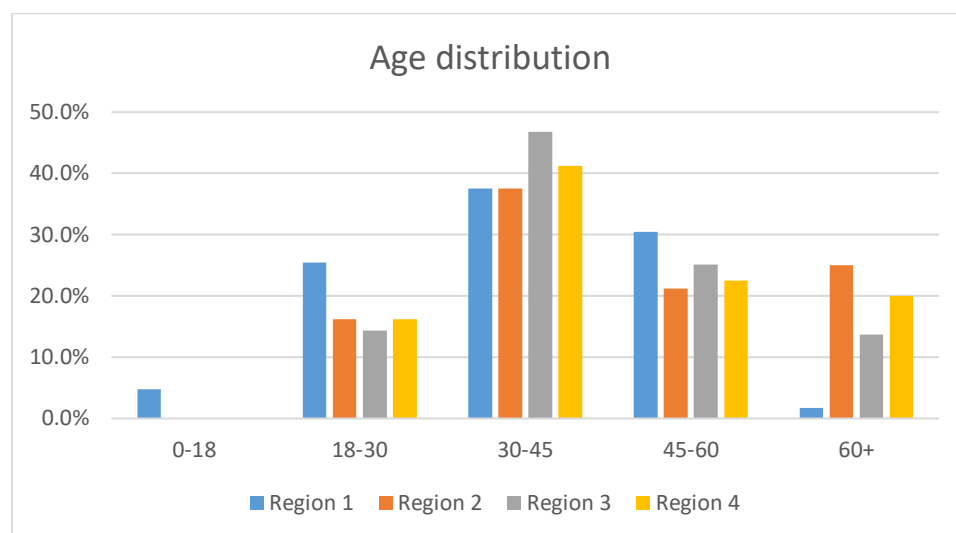
Solar companies could also establish creative relationships with other organisations and people sharing parallel development or gender objectives. These might include social enterprises, community leaders, women's groups and entrepreneurship training programmes. Such alliances would broaden the enterprise's reach and could maximise the benefits of access to solar energy.

Annex 1: Findings in full

Demographic characteristics

Demographic and educational attainment

The age distribution shows older respondents in Regions 2 and 4 and younger respondents in Region 1. Under 18-year olds were not targeted in Regions 2, 3 and 4. The largest group of respondents were between 30 and 45.



Respondents were predominately married in all regions. Widows/widowers and separated respondents are predominately women with the highest proportion in Region 2 with 14 widows (29.2%), which means they are more likely to be heads of households. It is also the region where more older women (25%) were interviewed.

	Region 1	Region 2	Region 3	Region 4
single	13.0%	2.5%	4.3%	16.3%
married	84.5%	75.0%	87.1%	67.5%
widow	0.8%	18.8%	5.0%	8.8%
separated	1.7%	3.8%	3.6%	7.5%

Men are typically the head of the household. In line with the marital status, the proportion of women headed households is higher in Regions 2 and 4 where the higher number of widow, separated and single women live. This information was not collected from Region 1. The number of women headed households is lower than reported at the baseline across all regions even though the figures for women who are separated and widowed were similar.

	Region 1	Region 2	Region 3	Region 4
Head	na	33.3%	20.0%	35.8%
Spouse	na	66.7%	77.6%	58.5%
Daughter	na	-	1.2%	5.7%
Other	na	-	1.2%	-

In all regions less than 30% of respondents have any education beyond primary school. There is higher educational attainment in Region 1 with 29.6% having education beyond primary school. It appears the question was posed differently in Region 1 and the other regions as it is odd that no respondents finished primary school in Region 1 when in the other regions this accounted for the largest number of respondents. The number of respondents with no education in region 4 was high, at 20%, of which the majority were women. In fact, in Regions 2, 3 and 4 the majority of those with no education were women, often, but not exclusively, older women. In Region 2 only 1 woman had gone beyond primary school. Otherwise gender differences in educational attainment were not significant.

	Region 1	Region 2	Region 3	Region 4
No education	15.5%	8.8%	5.0%	20.0%
Some primary school	54.8%	15.0%	7.9%	17.5%
Finished primary school		63.8%	69.8%	47.5%
Some secondary school	13.0%	2.5%		5.0%
Finished secondary school	9.9%	6.3%	10.8%	7.5%
Some university-college degree	5.9%			
Finished university	0.8%	3.8%	6.5%	2.5%

Gender roles, time use and structure of the day

Occupations

Livelihoods across all four regions are most often linked to farming. Self-employment in agriculture is the predominant employment status across all four regions with Region 4 having the least reliance on farming at 50%. This includes both commercial and subsistence farming. The definition between commercial and subsistence farming seems to be blurred with some subsistence farmers earning more than commercial farmers, for instance. Also, unemployment in all regions includes respondents who carry out subsistence farming as well as small informal or retail businesses.

Region 1 and 3, the microgrid and solar home system treatment groups, have significantly more employees/wage workers than the other two regions at 11.6% and 12.2% respectively. This partly explains the higher socio-economic status of the two regions, as shown in the annual income figures. Self-employment in Regions 1 and 4 accounts for more than 20% with work including small businesses such as selling food, drinks, hairdressing, masonry and carpentry.

	Region 1	Region 2	Region 3	Region 4
Wage worker/Employee	11.6%	3.8%	12.2%	6.3%
Self-employed non-agriculture	22.3%	1.3%	6.5%	26.3%
Self-employed agriculture	65.8%	81.3%	64.0%	50.0%
Contributing family worker				
Unemployed	0.3%	13.8%	17.3%	17.5%

Gender differences are not that striking although men are more likely to be wage workers in Regions 2, 3 and 4 and women are more likely to refer to themselves as ‘unemployed’ than men in Regions 2 and 4. As mentioned above this includes those that are subsistence farmers and even women with a small business considered themselves unemployed, yet women make a significant contribution to household income in all four regions. In Region 1 more than 70% of women contribute more than 55% of the household income. Fewer women than men were in agriculture in Region 4 (but note this is where many considered themselves unemployed).

There are limitations to comparing the findings between the baseline and end line because the interviewees were not necessarily the same for the two surveys. For example, the data for Region 3 is significantly different from that at baseline when only 27% of respondents were self-employed in agriculture. At baseline self-employed in non-agricultural activities was 31.1% compared to 6.5% now. In Region 4 reliance on agriculture has decreased since the baseline, possibly because it was not farming season so people were suggesting how they currently bring in an income.

Occupations in the other regions are more similar to the baseline.

Disaggregation per occupation confirms that Region 2 is most reliant on agriculture. In Region 1 less than half of respondents are reliant on subsistence farming whilst there are a substantial number of professional workers and more than 30% involved in ‘other’ which is primarily made up of small businesses and services. Region 4 also has significant numbers not working in agriculture and working in small businesses.

	Region 1	Region 2	Region 3	Region 4
Commercial farmer	11.6%	23.8%	12.9%	6.3%
Subsistence farmer	47.7%	71.3%	70.5%	55.0%
Teacher	5.1%	3.8%	5.8%	
Nurse	2.5%			
Doctor	0.3%			
Police	0.6%			
Public Official	0.8%		1.4%	
Non-farm labourer	0.8%		0.7%	2.5%
Other	30.5%	1.3%	7.9%	36.3%

The data for Regions 1, 3 and 4 is quite different from that collected at baseline again because some of the cohort interviewed were different in the two surveys. The numbers involved in ‘Other’ has increased dramatically in Regions 1 and 4 (from 15% to 30.5% and from 12.8% to 36.3% respectively) and has decreased significantly in Region 3 (from 26.2% to 7.9%).

The differences between occupations by gender is not that marked. It is noteworthy that all women in Region 2 are working in agriculture when some men are otherwise occupied. This is a different situation from the baseline in all regions. At that time there were stark gender differences in occupation except in Region 3, whereas now it is Region 3 where there are larger differences between the numbers of men and women in subsistence farming.

During the Focus Group Discussions in Region 1 and 3 nearly all men mentioned farming as a main activity whilst fewer women focussed on it. This could be because more emphasis was

put on the household chores during the women's discussions and the interviews took place out of the farming season.

	Region 1		Region 2		Region 3		Region 4	
	W	M	W	M	W	M	W	M
Commercial farmer	13.0%	11.4%	25.0%	21.9%	16.5%	7.4%	3.8%	11.1%
Subsistence farmer	45.7%	48.1%	75.0%	65.6%	63.5%	81.5%	56.6%	51.9%
Teacher	4.3%	5.2%		9.4%	7.1%	3.7%		
Nurse	4.3%	2.3%			1.2%			
Doctor		0.3%						
Police		0.6%						
Military								
Public Official	2.2%	0.6%			2.4%			
Non-farm labourer		1.0%			1.2%		1.9%	3.7%
Other	30.4%	30.5%		3.1%	8.2%	7.4%	37.7%	33.3%

Daily activities

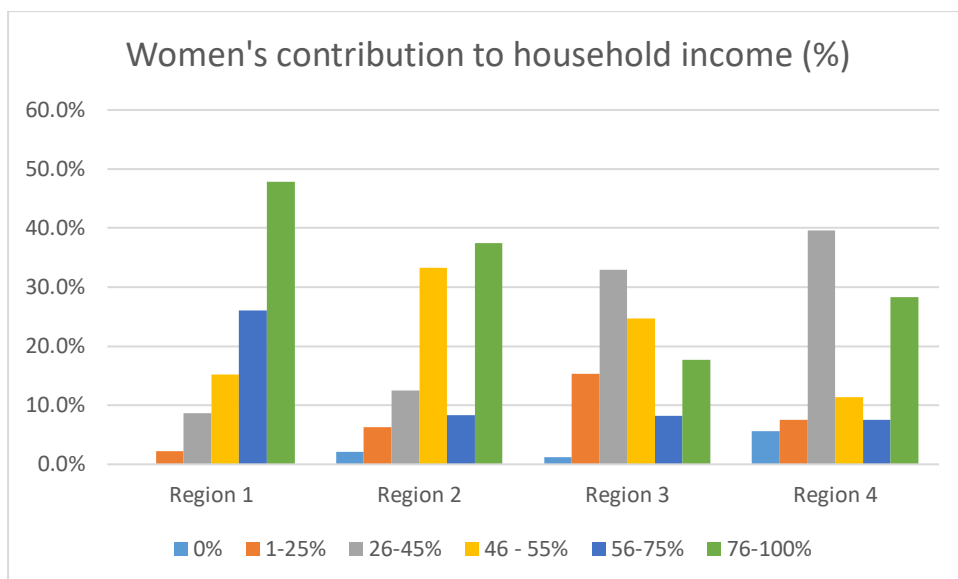
Many men and women respondents and discussion participants did not initially recognise that there was any change to their activities as a result of the SHS or microgrid, yet on further probing most did admit to changes in their daily routines or use of free time.

Almost all respondents felt good or happy about their new microgrid or SHS service and noticed the difference, primarily due to brighter and more reliable light and ease of mobile phone charging. Many had had solar lanterns before but still noticed the benefits of the new service as did those who had previously relied on kerosene, candles and torches.

The typical day of women participants across both the solar home system and microgrid groups involved household chores including cooking, cleaning and fetching water, childcare duties, farming, income generating activities and in two cases formal employment in the microgrid region. This is the same as the situation reported at the baseline and demonstrates the continued "double burden" for women; being responsible for both household tasks and income generation. This is typified by a woman respondent:

"When I wake up in the morning I sweep, mop, make tea, wash clothes, cook lunch, fetch water, bathe the kids, and cook dinner. Also if it is farming time in the morning I go to the farm when I return from there I continue with household work depending on the time I come back."

Women make a significant contribution to household income in all four regions. In Region 1 more than 70% of women contribute more than 55% of the household income, however this is also the region with the highest percentage of widowers and are therefore more likely to be the main earner.



In line with the survey data the FGDs and SSIs showed that women's livelihoods were linked to farming and most income generation was either household based (sewing, cooking) or small vending businesses, as shown in the activities table below. The time allocated to these activities seemed to vary between a few hours up to spending most of the day, and in some cases the introduction of an SHS or microgrid connection had extended these hours.

Women still included water and fuel collection as daily activities in line with the findings at the baseline. This was not investigated further at the end line but at the baseline it was worth noting that over a third of households in all regions walked over 100m to collect water. Though there was not a gendered breakdown, evidence indicates that this task often falls to women and girls. Water collection is a time-consuming activity that household-level solar electrification does not tend to influence. It is the same when it comes to gathering cooking fuel. The focus groups confirmed that it fell to women to obtain these. As at the baseline there is still a strong desire to move away from firewood due to the time it takes to collect and fumes it generates. This is not something that SHS or microgrid connections has been able to influence, because of the lack of appropriate, electrical cooking appliances on the market currently.

Half of the women participants wanted to spend less time doing household chores so they could free up time to make more money, either in a business or more farming. They would also appreciate more free time. This was similar to the findings at the baseline when most women felt that they had control over how they managed their lives but many who were involved in small businesses would prefer to spend more time doing this than household work.

woman, SHS: Interviewer: Why you want to spend more time in restaurant?

Respondent: If I do for longer time I will get money and expand my business

Interviewer: Which daily activities would you like to spend less time doing?

Respondent: washing dishes and cooking

woman, SHS: Interviewer: Which daily activities would you like to spend less time doing?

Respondent: Cooking and washing dishes

Interviewer: Why do you like to spend less time doing it?

Respondent: *Because they are simple tasks to perform*

The brighter light can also improve the experience of chores like cooking, or not destroying a customer's dress in the experience of one tailor - *"In dress making it help me a lot I can't not destroy customer dress"*.

"Before the light I was using when it is nighttime tend to be not bright they are very weak, but now I can cook any time"

"There is sufficient light that helps me do my activities sometimes at night like cooking and washing the dishes....another change is charging my phone for a long time because I do not pay hourly like I used to pay 300 to charge my phone to people who had powerful solar at the time."

Men's typical activities were also similar to those reported at the baseline and included farming, carpentry, tailoring as well as running smaller side-enterprises such as renting bikes, barber shop, welding, local brew or small shops. In a number of cases the men seemed to include the multiple activities of the whole household, rather than solely theirs, and hence included shops or mobile phone charging run by their wives. Most changes to routine were related to extended time in income generation and how they used their free time.

Three men mentioned that they also helped with chores - a similar number to the baseline. A couple of households had domestic help, or could afford farm labourers, so allowing the women more time for other activities. **Socio-economic status appears to have a greater impact on women's free time than solar by itself.**

Time savings were cited by six participants, primarily from reducing the time to go and charge a mobile phone elsewhere and for others that that using an electric iron is much faster than a charcoal iron and so saves time - *"I am happy with the use of an electric iron because when I am in a hurry it helps me unlike the charcoal iron which needed me to light fire up charcoal for a long time then I can use it."* A male teacher also appreciated the time saved in ironing and not worrying about running out of charcoal - *"sometimes I went to work with crumpled clothes because I did not have charcoal but now I use an electric iron."* All households which had not had solar previously mentioned the benefits of mobile phone charging at home so it is likely that the time savings are greater than reported.

One activity in the Kagera region mentioned in the baseline study which did not appear at the endline, was time spent processing maize: in 2017 drying maize was one of the top 12 areas where women spent their time, one of the top 3 activities women least enjoyed, and one sought after appliance was a maize shelling machine for both women and men. However, this was not mentioned at the endline, potentially because the fieldwork was not carried out in the farming season this time and some of the respondents were not the same as those interviewed at the baseline. Farming overall came up less often as a key task for women in the endline study.

Typical daily activities recorded	
Women	Men

House cleaning Preparing breakfast Making tea Preparing children for school Washing dishes Washing clothes Fetching water Collecting firewood Cooking lunch and dinner Bathing children Overseeing homework Farming (in farming season) Keeping livestock Cooking food for sale Food vendor/Shop keeping/Restaurant Mobile phone charging Local brewing Sewing and knitting Renting bikes Hospital/office work Eating Resting Sleeping Watching TV *Only one woman mentioned socialising – “ <i>chat with neighbours</i> ”.	Farming (in farming season) Carpentry Keeping livestock Tailoring Local brewing Welding Renting bikes Barber shop Builder Hotel owner Shop keeping Boda boda driving Bus ticket selling Pastor Photography Masonry Selling produce Teaching Mobile phone charging TV showcasing Labourer Watching TV (sport, football and news) Resting Sleeping Helping with household chores
Activities that would like to spend more time doing	
Restaurant business Shop keeping Farming TV watching	
Activities that would like to spend less time doing	
Fetching water Cooking and cleaning Finding firewood Washing dishes and clothes	Farming

Whilst the key benefits of solar such as phone charging, extra hours of light and television access were highly valued by participants, **solar home systems or microgrid access does not appear to have altered existing gender roles or reduced the most arduous tasks traditionally carried out by women** – domestic chores like cooking, child care, cleaning and collecting fuel and water still take up much of women’s time as demonstrated by this SHS customer who works in a café.

“Cooking takes a lot of time. Starting with preparing ingredients. Going to the market. So it’s difficult to save time. I use a lot of time... I would like to use less time in fetching water so that I can get time to rest”.

Flexibility

Whilst the introduction of solar has not altered the type of activities women and men carry out since the baseline, the majority of women respondents (more than 90%) across regions now spend **more time undertaking activities early in the morning and in the evening because of solar**, and they almost unanimously agreed that solar has increased the flexibility of their daily routines – women now spread chores in to the evening and can use evening hours to work, help children with homework or watch TV. Women mentioned they no longer feel rushed to complete all of their chores by nightfall and can choose to spend time on other activities during the day, including allowing themselves free time. The increased flexibility for women was also recognised by the men.

“I got many benefits, firstly I can make dress up to night , washing dishes at night even when am late, I can do mopping at night, we can do homework at night , washing clothes, fetching water at night so benefits are so many”

“I benefited through cooking in light, I can wash clothes at night or early morning in light, I can fetch water and washing dishes in light”

“[SHS company] solar helped us children they area happy they don’t get around in street also I can prepare doughnut and chapatti without any problem while doing other small activities so [SHS] has many benefits”

Interestingly in one case having electricity actually helped to fetch water – previously solar and water collection have not thought to be connected – *“Electricity has helped me to wake up at night and turn on lights and taking the phone to look at the time so I can fetch water early because it is found very far and if you are late you won’t get water. Before I was connected to [microgrid] electricity we waited till morning so we can go and fetch water most of the times we could not find it because of the lateness of the time we went especially in during the dry season when there is acute scarcity of water. For now we wake up at 3 am to go and fetch water but before we woke up at 5 am or 6 am in the morning. ”*

Increased flexibility also **helped with some entrepreneurial activities** – *“To me there is a big difference, I am a food vendor, before having solar I had to wake up at 7:00 am so that I go to the business place but now because I have solar I wake up at 5:00 am, I do my activities at home the I go to the business therefore solar power helps.”*

The **structure of men’s working day was impacted by solar to a lesser extent**, except for in the microgrid region, where some respondents used electricity to extend their working day. In the solar home system region, many men considered women to benefit most, because they spent more time at home.

Free time

More than 90% women use the increased flexibility to spend more time doing household chores or income generating activities. One woman said that she only rests when she is unwell and for those farming there was an understanding that there was more free time during the dry season compared to the farming season when *“there is not even time to watch TV”*. That

said most women with TVs mentioned that they **enjoyed resting with the TV and had some time in the day when they could watch TV (or listen to the radio)**. One woman mentioned she now spends more time reading the Quran into the evening. Another woman mentioned that before the TV “*we were chilling, making stories and sleeping*”. Some women also did their chores whilst watching the TV or listening to the radio:

“I watch television all the time; listen to the radio all the time. These are the benefits that I get from the solar home system.”

“It has helped with rest as I can rest in the day now knowing I can do washing etc. later”.

“Since I was connected with the home solar system what I like the most is watching television, especially series called “Sinema zetu” during the night until the time I feel that I am tired then I can go to sleep”

“[After 9pm after returning from shop] When I finish eating dinner I sit in the living room and watch TV and watching different programs or I turn on the radio to listen to music and different programs for an hour or an hour and a half then I go to sleep”

None of the women respondents claimed they had *more* free time because of the introduction of solar, nevertheless the element of choice it brings women in planning their schedule can allow free time of their choosing.

Whilst an increase in economic activity and flexibility can be considered as positive benefits, it is worth bearing in mind Mukherjee’s (1999) point that in fact, for many women the introduction of solar has only increased the number of hours they are expected to work.

Other than watching TV women spoke little about leisure, but they are slightly more likely than men to be involved in some types of community groups, which was a similar finding to the baseline findings. The majority of respondents are not engaged in any community group.

	Region 1		Region 2		Region 3		Region 4	
	W	M	W	M	W	M	W	M
Agricultural coop	4.3%	10.1%	6.3%		2.4%	3.7%		
Religious group		1.6%	8.3%			3.7%		
Women’s group	10.9%	1.0%	20.8%		29.4%	1.9%	18.9%	
Political org	6.5%	0.6%			0.0%			
Other	10.9%	18.8%	4.2%	21.9%	8.2%	18.5%	1.9%	14.8%
Vicoba				6.3%	3.5%	5.6%	3.8%	
Care					2.4%	3.7%	1.9%	3.7%
None	67.4%	67.9%	60.4%	71.9%	54.1%	63.0%	73.6%	81.5%

These observations tell us that by increasing the number of lit hours, solar can improve the sense of control a woman has over her day’s activities, improve productivity, and, sometimes, result in an increase in time spent on leisure activities. However, most women use the flexibility to spend more time doing household chores or earning money, thus increasing the ‘double burden’ placed on women.

In contrast to the women, men in both control regions focussed more on leisure activities and rest and appreciated the light and entertainment provided by solar as well as some using the

light for extending their income generation activities or work. Before many went to bed earlier. There was more family time with the TV rather than the men (and children) looking for football, news or other entertainment outside the home. Some men extended their working hours outside of the home in the knowledge that security was better at home.

"We watch television with my husband and my children together so my children don't get around in the street or sometime my husband used to go to town to watch football match but now he watch at home so those are the benefit we get we join together with my family."

"I used to come back home midnight. This caused quarrels with my wife. But now we are no longer quarrelling because I stay at home and watch television. "

"Before used to roam the streets looking for a TV to watch."

A woman participant mentioned her benefit is light, whilst the TV is beneficial for the children and her husband implying, she watches it less:

"Purpose for appliances I have first is to get entertainment at home also to make children not to get in the street regularly because most of the time they are home watching television also for instance others are football fan instead of going somewhere else he just remain home to watch football match. For light is for my own benefit at home"

On the other hand, some men feel they can stay out longer:

"Yeah there is such a thing; this has happened because of the situation I have because my house is isolated, before I was back home early at 17:00 or 18:00 pm evening but now I and back even at 22:00 pm because now at my home there is full bright light so even people scared to approach also my neighbours come to watch television until I get sleep they leave so now my wife can't fear anything"

Some claim that having solar has in some ways strengthened social ties with improved relationships with their neighbours.

"I have managed to improve my relationship with my neighbours because they come here to watch television and sometimes charge their phones for free".

"...Now friends come to watch news bulletins..."

"My things have changed a lot!!! I used to light candles to get light but now I use [the microgrid] electricity, my friends come with their PCs and connect the to the electricity and watch movies, my relatives come to my house to read, watch TV and charge their phones"

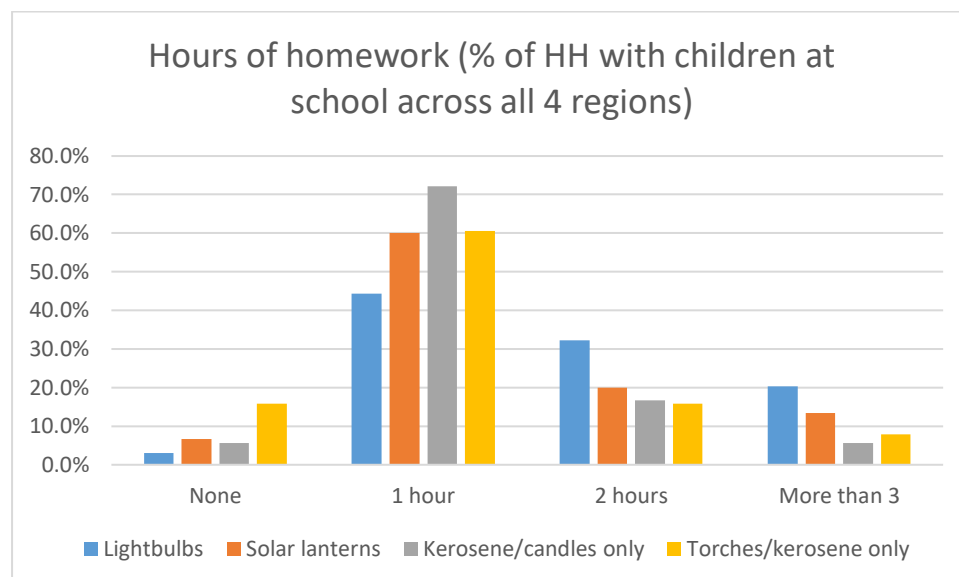
In contrast a couple of men respondents felt the pressure to earn more and spend less time socialising, as one man said *"[I] have stopped visiting friends and relatives and instead I make furniture to increase my income."*

Children's study time

Extra hours of light for children to carry out homework was a frequently cited benefit of off-grid electricity access from both women and men. Almost all respondents with children mentioned that their children were now able to study at night and were able to study more

comfortably due to the better light. Some mentioned that their children were now studying for more hours, for instance now studying for 2 or more hours rather than one. One woman said *“...it has helped my children study for more time for 2 hours more than in the past when they were using regular solar because the light was faint even sometimes they were not studying because the solar could not work due to battery problems or when it rains heavily”*. Two respondents commented that as a result of the extra study made possible by electricity they were performing better at school – *“They have improved because in the previous they were not studying at night they used most of their time to play around, so they could not perform well at school now that we have solar they settle and read during the night and we see them performing well”*.

The quantitative survey backs this up to an extent with more households with an SHS or microgrid connection (lightbulbs) reporting children studying for more than one hour than those households with other lighting sources. The following figure shows number of hours of homework reported by households with children across all four regions.



Limitations

Lightbulbs are not always installed where they may have the most benefit for women, such as in the kitchen. Five women requested extra bulbs to light their kitchens, as currently bulbs are placed in the communal spaces – this raises an important point that whilst women may have access in the household, **where the light is located and the choice women have in this decision making process defines the extent to which electricity, particularly small-scale electricity like solar home systems, can contribute towards women’s empowerment.**

“the solar power light does not reach every corner in the house that is why I am using my phone's torch. There is time for using solar light and time to use torch especially when am cooking”

Microgrid customer: “I am still cook in dark because I have one bulb in living room, I didn't put bulb either in rooms or kitchen “

Another interesting finding is that where there are limited number of hours of electricity available, particularly with the solar home systems, there are certain trade-offs in terms of who

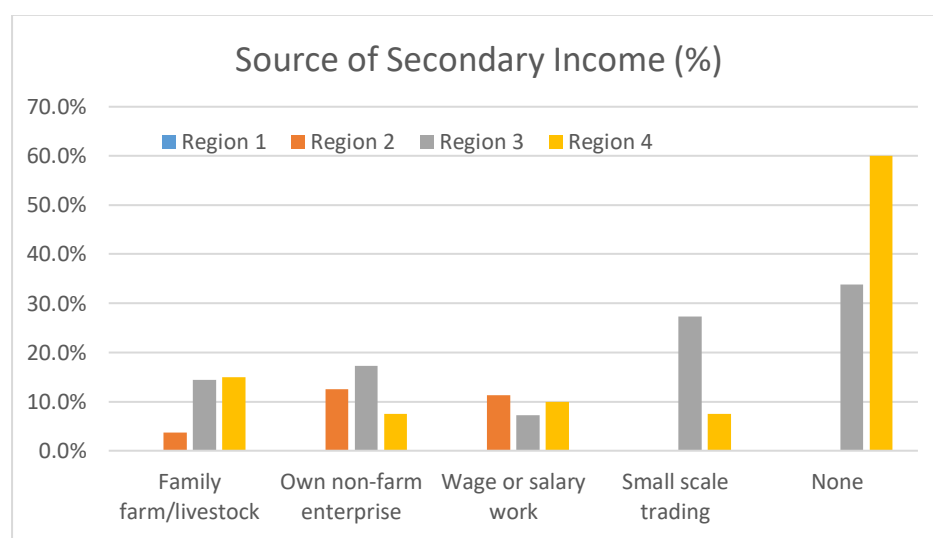
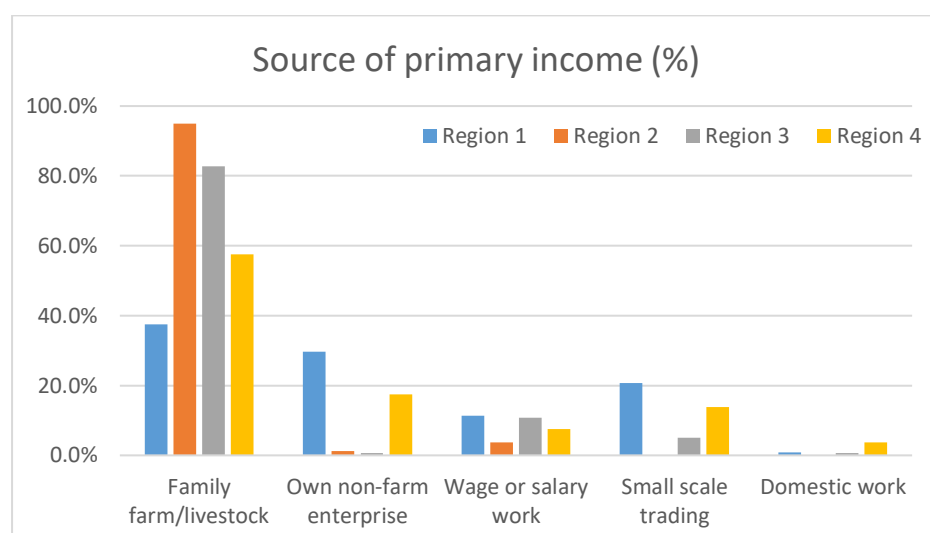
uses solar and when. As one woman said, *“The problem I have is a battery power to get weak quickly that you cannot watch television at daytime with freedom if you watch during day time you cannot watch at night.”* Consequently, if women de-prioritise their own needs, they may avoid using solar during the daytime to allow their children, spouses or other members of the household to benefit from it. The reasons for limitations are not clear and could be due to faulty batteries or that electricity is also being used for other uses.

The microgrid also has limitations in that it is not reliable in the evening and has been subject to frequent power cuts. If women are relying on the power and extra hours of light for their chores, income generation or TV and there is a power cut the potential benefits of the microgrid are nullified.

Income generation and household finances

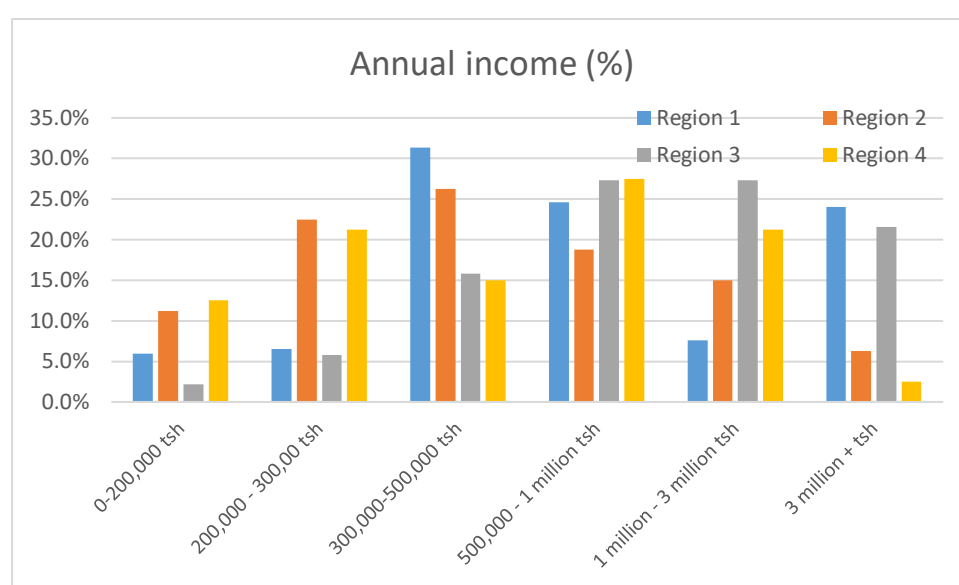
Household income generation

The main source of income in all areas is agricultural activities, in line with the occupations presented. Respondents in Region 2 rely most heavily on farming with 100% of women relying on farming. There is greater diversity of income in Regions 1 and 4. No-one in Region 2 was involved in small-scale trading and all respondents had some form of secondary income. Secondary income was not asked in Region 1.



Annual income was recorded in each region. **The two control regions (2 and 4) are notably poorer than their respective treatment regions (1 and 3).** For example, in Region 2 and 4, 33.8% earn less than 300,000 tsh a year. In contrast 24% and 21.6% of respondents in Region 1 and Region 3 respectively earn more than 3 million tsh. These regions also had the highest number of employees/wage workers.

	1	2	3	4
0-200,000 tsh	5.9%	11.3%	2.2%	12.5%
200,000 - 300,00 tsh	6.5%	22.5%	5.8%	21.3%
300,000-500,000 tsh	31.4%	26.3%	15.8%	15.0%
500,000 - 1 million tsh	24.6%	18.8%	27.3%	27.5%
1 million - 3 million tsh	7.6%	15.0%	27.3%	21.3%
3 million + tsh	24.0%	6.3%	21.6%	2.5%



At the baseline the results were relatively similar in Regions 1 and 2 with Region 2 (the control region) notably poorer than Region 1. At the baseline income distributions were similar in Regions 3 and 4 but at the end line there is now a difference with the control region (Region 4) which is notably poorer than Region 3 which can be explained by the fact that different people were surveyed at the end line.

New income generating activities and barriers

Around 20% of respondents noted they had **started new businesses since getting access to solar**, like charging people to watch TV series at their homes, or phone charging. Many others are planning to open businesses, like a salon and a welding workshop, but haven't done so yet. The most common new business was phone charging.

Women, in particular, have started mobile phone charging. New SHS customers were more likely to charge for mobile phone charging and this was mainly women's work since they were at home. Importantly they were able to keep the income. Where stated, it was normally spent on food or household expenses. Two microgrid customers mentioned that they charged for mobile phone charging whilst others offered it for free, possibly because more of their neighbours are connected.

Half of the SHS women focus group participants were charging for mobile phone charging at about 200 tsh a charge, and one had started charging for TV shows (at 200 tsh per episode) but has stopped as nobody paid. Two participants mention that they use the income generated from mobile phone charging to pay the SHS bills.

"I can get 1000 or 1500 shillings per day. This is because I do not charge money to all people who bring their phones"

"[phone charging] income is very small because we are using two pin a day you can get 600 to 1000 tsh due to two pins "

*"Interviewer: In general how has solar power helped you conduct your business?
Respondent: It has changed my life, now I can get 2000 per day"*

One man has started a business repairing and charging mobile phones earning 3000 tsh a day for 10 phones: *"I have started a business of repairing mobile phones and charging them. This activity has helped me to get income. Also I save money I used to pay to charge my phone. Also my children have managed to study during the night in anytime the wish, because there is enough light"*. Another man was earning 4-5000 tsh a day for charging phones and 1000 tsh per week for watching football and news: *"I have managed to start business of charging phones also I charge people who come to watch football matches and news"*.

A limitation mentioned by some respondents was that the phone chargers available with SHS are designed for smart phones which limits their ability to charge more customer's phones. A number of respondents also wanted more charge points to be able to earn more money.

Not all new entrepreneurial activities have proved to be successful with, for instance, more than one respondent stopping showcasing TV - *"After connected with [SHS] I was showcasing television but they don't pay money so I stop doing it then after I started phone charging"*.

One particularly entrepreneurial woman started making ice cream but stopped after two weeks due to the high costs - *'I started an ice and ice cream selling business but I have stopped it because of high costs of [microgrid] electricity compared to the profit I was making. I did this business for two weeks only and I decided to leave it because I was getting a loss.'*

More often than starting a new business solar power has allowed solar customers to *increase* their income generation; either from an increase in productive hours, an increase in productivity or from offering new services. For example, women microgrid customers have extended their drink range with blenders and fridges to include juices and cold drinking water and soda. *"electricity has helped me for now I can make juices by using a blender and cool it in the refrigerator and sell it to people I can also cool drinking water and soda for business so I can get an income for my needs and my family's"*. A woman shop owner and local brewer mentioned that the light and radio attracted more customers and allowed the shop to stay open later. *"I can turn on the radio and it attracts more customers and even when night sets in I can turn on the lights and I continue with my business without any problem."*

Women now have more and better lit hours to carry out their existing income generation activities such as cooking food for sale, making mattresses, handbags, bed sheets and sofa covers and knitting, as demonstrated here:

“There is a difference in time when doing activities because before having solar I used to end my activities at 18:00 hours but now that I have solar I do my activities anytime that I want like making local handbags and local mattress which I can even do during night hours something I couldn’t do before solar”

“Since connected with solar it has helped to do work at longer time especially during the night because I get light I can prepare doughnut even at 00:00 am and doing it without any problem so solar it has helped me a lot”

“Availability of solar power has helped me spend more time in doing my activities because I use to make knit fabrics even at night hours”

“Using [SHS] has brought a big change because I can cook and make local mattress at night even if I am late compared to the time before having solar I could not do that.”

Two men microgrid customers mentioned that they now have electric sewing machines which allows them to be much more productive and one SHS customer uses solar for his barber business. One tailor now spends more time sewing and hires labourers to work on his farm. This also has the potential to affect the woman’s daily activities if she is expected to visit the farm less frequently. At least one respondent who had farm labourers mentioned that their wives oversaw the work.

“[I] was unable to do some activities because I could not afford the costs but now I can afford the costs, I can hire [farm] labourers with the money I make from my barber shop”

“If I get money from tailoring I pay the [farm] labourers”

Microgrid male tailor: *“It has helped me because sometimes when I was not using [microgrid] used to running away and saying if you take it to Alani it will be late...clothes stay for a long time but now I can finish work in a short time and people are saying that I have started to change and I finish work on time, so it has helped me”*

“Yes!!! It has helped because of using electricity on my sewing machine. The way I used to sew before there were no electricity the machine had a slow speed and the clothes were not finished on time but now things are good” I have added another machine for just simple work.

“I do business and my wife goes to farm...When I get money, I give it to my wife for hiring a labourer to help her at least once a week because of the difficulties that exist in farming”

As with the women customers, men have been able to extend their working hours as this furniture maker describes: *“I can say yes, because solar power has helped me to perform my furniture making during the night. Like applying polish to the bed, fit soft angles in the bed. This*

is due to the fact that there is enough light... I keep chickens. So even if I am too busy to give my chicken food during the day, now I can do it during the night because there is enough light”.

Fridges and blenders were priority appliances for some women, who often mentioned they could be useful to start a small business. One woman said she was reluctant to buy these appliances even with microgrid access because... *‘I wish to have fridge, fan, iron and blender my fear is that I don’t know if solar power will have capacity to support those things.’* This comment coincides with comments from **men and women who mention SHSs are not powerful enough to run large appliances, and even within the microgrid regions**, people reported regular power cuts, particularly as the number of customers using the grid has increased. When someone in the community uses a piece of energy intensive equipment e.g. a local welder, the entire community can face a power cut.

These aspirations chime with those expressed at the baseline when women wanted to use electrical appliances to ease chores and develop business activities. Women would also like electric or gas cookers to ease cooking and irons to speed up the process. At the baseline, in contrast, men placed emphasis on equipment linked to livelihoods, particularly farming equipment, which solar is unlikely to be able to deliver.

There is a clear difference between the microgrid and SHS customers in that the microgrid allows for more power consumption and therefore a wider range of appliances which could be linked to productive uses. For example, the refrigeration for selling cold drinks and blenders for selling juices, electric sewing machines, photocopiers/printers and welding equipment. One SHS customer had an electric sewing machine but it cannot be powered by the SHS.

Even within microgrid customers there are differences between those customers who can afford appliances versus those on the minimum tariff powering just one light bulb and a mobile phone charger. **Those who can afford more appliances have the most benefit from solar access.**

There was a strong call for more appliances for solar home system customers from SHS men and women customers and there was a demand for the solar companies to offer more loans for more appliances. Men and women mentioned that they might be able to afford equipment in instalments (but not an up-front cost). Men were less concerned about the expenditure but also worried about the capacity of the system to power the equipment. At the baseline there was already a strong call from men and women to reduce prices and increase capacity of solar systems, so they can power more appliances.

It is also interesting to note that at the baseline for some women, particularly in Region 2 (the solar microgrid control region) access to energy-enabled appliances seemed out of their financial reach. For example, one woman said a bicycle to carry produce to market would be more useful.

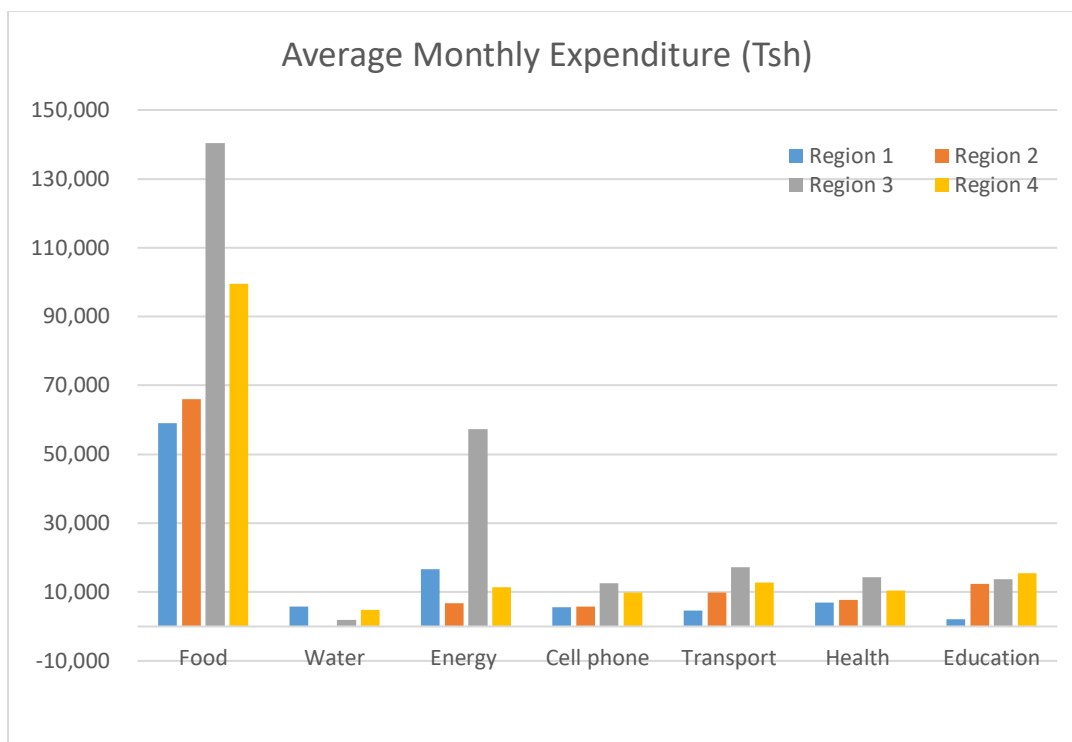
Many women and men (35% of participants) had concerns about the capacity of the system, reliability, cost or the future of the company which stopped them from starting businesses. Half of the FGD participants from the SHS group experienced an increase in prices and a change to the contract without sufficient warning.

In addition, there were concerns about the lack of flexibility in payments for the SHS systems. If a customer defaults on a payment, then they must pay a full month's tariff to be re-connected. This is difficult for many, particularly during the rainy (farming) season when there is less income available.

Household finances

Food is the largest monthly expense making up more than half of total monthly household expenditure in all regions; food represents between 53% and 61% of the total expenditure. Region 1, with the highest income, has the lowest monthly expenditure. All the figures are significantly different from those collected at the baseline. The end line shows less expenditure in all regions (Region 3 data was not provided at the baseline) in all categories except energy in Region 1 where the average expenditure has increased from 7,733 tsh to 16,615 tsh. Respondents in Region 3 reported significantly higher expenditure on energy than any other region. In Region 2 many respondents do not pay for water as they rely on fetching it locally.

	Region 1	Region 2	Region 3	Region 4
Food	59,011	65,989	140,403	99,543
Water	5,688	220	1,992	4,787
Energy	16,615	6,806	63,280	11,459
Cell phone	5,565	5,838	12,585	9,834
Transport	4,599	9,828	17,123	12,722
Health	6,901	7,646	14,219	10,427
Education	2,106	12,296	13,700	15,479
	100,484	108,622	263,302	164,251



In Regions 2, 3 and 4 men report higher expenditure in almost all categories except education. Overall differences are in the region of 9 – 17% however in Region 2 men reported spending more than 40% more than women on mobile phones, in line with ownership data. Region 4 also showed men, on average, spending more than 29% more than women on mobile phones. There were no appreciable differences between spending between men and women in Region 1.

Savings in Energy Expenditure

Mixed experiences were reported on whether energy cost savings had resulted following the introduction of an SHS or microgrid connection. Some felt they now spent more whilst others felt that the costs had gone down or were similar to before (9 felt they spend more compared to 18 spending less or the same). One woman appreciated that you couldn't 'waste' your money as you could if you spilt kerosene. Savings were recognised from less spend on kerosene, batteries and candles.

SHS, woman: I see the cost has gone down. Because we can use 50000shillings to pay for solar power for the whole month unlike previous days where we used 5000 to buy kerosene and candles

SHS, woman: :I think costs are high because 1000 tsh power I can use for 5 days while I have 1 bulb and phone charge so for month how will I use I like 4000 tsh and still I have low income so the cost is high but because you want to use for phone charging and light I have just to use

SSI 28: Expenses have increased because there is family expenses and solar so it has increased

Microgrid, woman: "Spend more money".

SHS woman: "Now spend less than torch batteries and candles before"

SHS male customer: Now spend more “is like I have married a second wife”.

A greater number of SHS customers thought their costs had gone up compared to the number who thought their costs had reduced (6 compared to 3). In some cases, there is a recognition that their energy now covers more services than before. SHS customers pay, on average, 50,000 tsh per month for their SHS system plus costs for cooking fuels taking the average monthly energy payment to more than 63,000 tsh. This is significantly higher than costs reported in the other three regions (see table below) but includes the loan repayment for a TV and radio.

In contrast a greater number of microgrid customers felt costs had reduced (9 compared to 3). However, the quantitative survey shows energy costs increasing in the microgrid region (Region 1) whilst reducing in the control areas. It is unclear why this is the case.

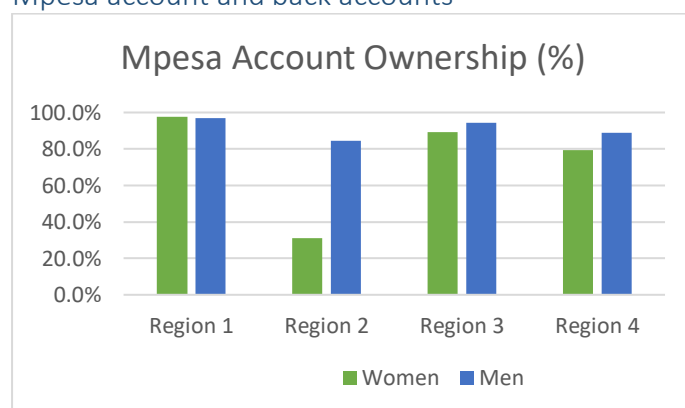
Data collected	Region 1	Region 2	Region 3	Region 4
Baseline	7,733	18,507	n.a.	36,128
End-line	16,615	6,806	63,280	11,459

In addition, the cost of mobile phone charging has reduced significantly for a number of households which are now able to charge at home rather than pay others.

Financial inclusion

Questions about access to finance references the use of mobile money, bank accounts and loans. **Gender differences in financial inclusion were most stark in the poorest region.** The use of mobile money is widespread although notably lower in Region 2 (microgrid control group) and particularly with women in Region 2 where MPESA account ownership was only 31% of women compared to 84% of men, and only 46% of women owned a mobile phone (90% of men owned a phone). This implies that gender inequality and socio-economic status are inextricably linked.

Mpesa account and bank accounts



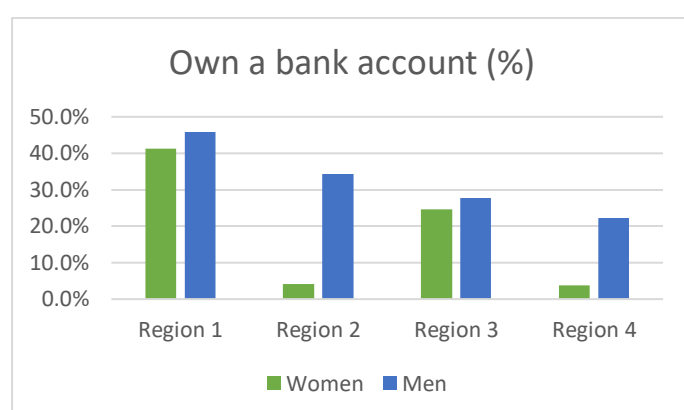
In Region 3 mobile money was a pre-requisite for the solar home system and all SHS customers pay through mobile money. Although this was also the case in Region 1, the majority of microgrid customers pay through a sales agent rather than directly through mobile money. Some used to pay through mobile money but now no longer do. The reasons for this were not

clear but at the baseline it was reported that mobile coverage was not good in Region 1 although this was not mentioned at the end line.

Access to mobile money has increased compared to that recorded at the baseline, in all regions (Region 3 was not recorded at the baseline). Most notably there is now parity between men and women's access to mobile money in Region 1 and in Region 2 women's access has only increased by a few percentage points (26.7% to 31.3%). The following table shows the differences.

Mpesa account ownership	Region 1	Region 2	Region 3	Region 4
Women (baseline)	82.4 %	26.7 %	n.a	57.4 %
Women (endline)	97.8 %	31.3 %	89.4 %	79.2 %
Men (baseline)	92 %	54.1 %	n.a	70.8 %
Men (endline)	97.1 %	84.4 %	94.4 %	88.9 %

Access to bank accounts is considerably lower than access to mobile money with men having notably higher access to bank accounts. Highest access is in the wealthier region, Region 1. Women in Regions 2 and 4 have particularly low access to bank accounts at 4.2% and 3.8% respectively.

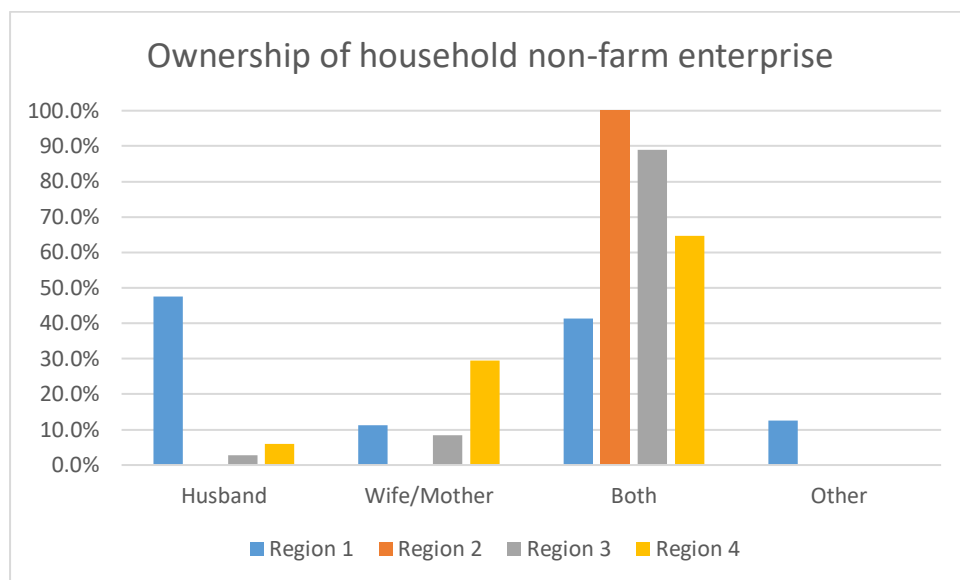


Bank account ownership has increased significantly in Region 1 and for men in Region 2 compared to the baseline. However, bank account access for women in Region 2 is lower and access for women and men is lower in Region 4 compared to the baseline. As noted earlier the socio-economic status of those interviewed in Region 4 is lower now than at the baseline and it is likely that a different group of people were surveyed.

Access to bank accounts	Region 1	Region 2	Region 3	Region 4
Women (baseline)	25.5 %	6.7 %	n.a.	21.3 %
Women (endline)	41.3 %	4.2 %	24.7 %	3.8 %
Men (baseline)	34.8 %	14.8 %	n.a.	25.8 %
Men (endline)	45.8 %	34.4 %	27.8 %	22.2 %

Ownership of household non-farm enterprise

For households with a non-farm enterprise the ownership was primarily joint with both husband and wife except in Region 1 where more enterprises were owned by the husband. In Region 2 there were only three enterprises. More women than men owned enterprises in Region 4, mostly selling local brew and clothes.

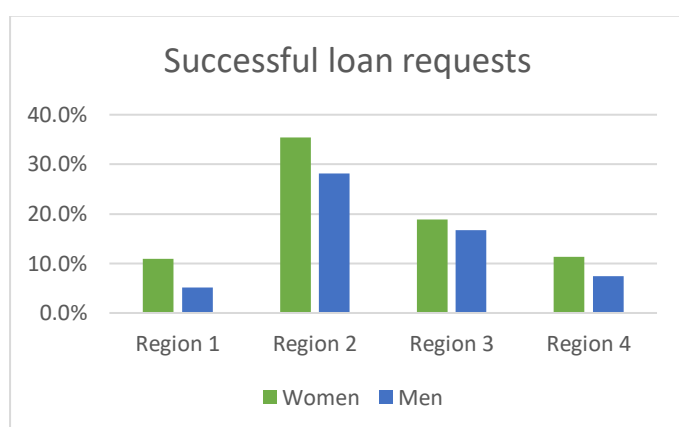


Solar account registration and payment

The SHS and microgrid accounts were owned almost exclusively by men, even if men and women in the same household were equally responsible for paying bills and deciding when to top up. Reasons given were because he was the head of the household and he was responsible, but also in a few cases he was the only one with a mobile phone or she had no income- *"I am the father of the house and provider"*. Three women had registered their own accounts, two of whom are household heads.

Loans

A small number of loan requests have been made with women applying proportionally for more loans.



Financial decision-making dynamics

Decision making was explored by looking at who in the household decides on purchasing key expenditure items and this was explored further in the Focus Group Discussions and interviews regarding energy decisions.

In all regions for all items the end line quantitative survey showed that most decisions are made jointly (with the exception of education in Region 1). Responses were different depending on whether the respondent was a woman or a man with each stating that they made the decision much more frequently than any other household member. Responses were quite different between Region 1 and the other regions, which could be because far fewer women were interviewed in the region. The baseline quantitative survey also found that spending on most items was typically taken by both, except for in energy expenditure when the head of the household was more like to make the decision. This was not the case at the end line.



In contrast with the quantitative survey findings, half of the interviewees (15, men and women) said that the decision was made by the husband, but none disagreed with the decision. In addition, three women said that they discussed it but the final decision was the husband's and nine said they made the decision jointly as a family or it was mutually agreed. Two women household heads made the decision and in just one case the women conferred with her husband who didn't have the money, but she went ahead anyway. This shows that the 'decisions made jointly' appear to be nuanced with many seeming to mean that it was discussed or that the woman agreed rather than a clear joint decision, as shown in some of the quotes in the table below. In most cases the discussion was initiated by the husband.

Energy types have different gendered decision-making dynamics: acquiring energy – charcoal and firewood – from the SSIs and FDGs tell us that they are usually undertaken by women and paid for with cash. However, acquiring solar, making payments and maintaining the system in this context were considered to be a man's responsibility– whilst the survey found that energy related decision making was made jointly (average from survey at 55% however this did not break down energy types), men overwhelmingly put forward the idea of getting solar and whilst often involved their families in the decision-making process, it was ultimately their final decision.

Clearly, then, the decision-making process is rarely a man or woman's sole responsibility, nor does the 'joint-decision making' metric capture the power dynamics at play within the household when making purchasing decisions about solar.

How decisions were made on solar connection	
Women	Men
<p><i>"He explained it to me then I agreed' he went to buy it though he didn't share with me but after he bought and bring home I accepted it"</i></p> <p><i>FGD 8 "to me when my husband was looking to be connected with [SHS] honestly I didn't accept the idea I didn't like it, but being connected and saw the uses of it I was attracted and I join hand with my husband as one"</i></p> <p><i>"After he back and told me we are get connected with [SHS] I accepted it because he explained to me and know the benefit of it so we didn't have any disagreement... No I agree with him because what he did was good I was living in dark so I was very happy"</i></p> <p><i>"To me we discussed together so I can say he shared with me before get connected because we all work, we go farm what we get use together"</i></p> <p><i>"The idea was from the husband and said we should take the solar to help us with light and we agreed that it will help us because we were sleeping in the dark and used our torch and charging the phone we were taking them to the neighbors but now the solar helps us in everything charging, light and other things watching tv."</i></p>	<p><i>"The decision is mine but I confer with my wife"</i></p> <p><i>"It is our custom which we have established upon ourselves that we must sit together and decide for every matter in our family"</i></p> <p><i>Discussed with all family "At home I am the chairman of the family and my secretary is my wife and kids are members that are the way we do things in our family we involve each other in every family thing"</i></p> <p><i>"We shared it with my wife because it is our routine in our family"</i></p> <p><i>"No there was no any problem because we discussed together and agreed each other so called them"</i></p>

<p><i>"the idea [to get a solar home system] was from my husband maybe because he saw his friends thus he like the and decide to contact [SHS company] power and took it."</i></p> <p><i>"We shared though I told him economic situation is not good but he said don't worry we will get money to pay, so I told him it is ok"</i></p> <p><i>"My husband was the one who had the idea to install [...]because he is the head of the family"</i></p> <p><i>"The whole family participated but my husband made the final decision"</i></p> <p><i>"we discuss together because we are family thus we did so"</i></p> <p><i>"the reason we make decision together is that...is just a form of agreement because if you make decision on your own you cannot pay this money alone or husband might refuse to pay the loan thus we discussed together, we agreed and make decision together and not just for this matter many other issues we discuss together because you can't pay loan by your own".</i></p> <p><i>"he can't make alone there will be conflict, if someone didn't like we cannot able to buy it and if someone buy without agreement there will be no care of that appliance in the house so to us we agreed till now we discuss things together"</i></p> <p><i>"we make decision together because we are one flesh, we were united at church so I cannot decide alone I must share with my husband"</i></p>	<p><i>"I share with her but the final decisions are from me because I am the father of the family"</i></p> <p><i>"Yes, my wife was worried that there were times we would not pay for it but later we agreed and we were connected with solar"</i></p>
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Making solar mobile payments in the solar home system region were largely done by men or by children, even when they were absent from the household, or money was transferred to the woman's phone to make the payment. In the microgrid region, it was also mixed with the responsibility mainly falling on the man but the actual payment being done by anyone in the household.

More men mention buying appliances than women, particularly sub-woofers to improve TV quality, radios, decoders (to watch additional programmes) and extra bulbs.

Respondent: TV, decoder, Sub-woofer, phone charging and 5 lighting bulbs, among these devices I bought decoder and sub-Hoffer where the decoder is for viewing news and other programs but also sub- Hoffer for promoting the sound of TV as well as listening to music

Interviewer: Who made the decisions to buy them?

Respondent: Myself

Interviewer: Why you and not your wife?

Respondent: Mmh!!! In my family I am responsible for buying equipment

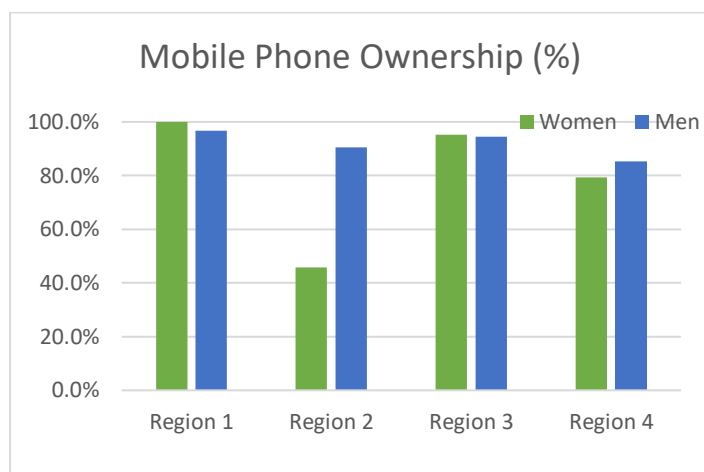
The decision to purchase appliances is a mixture between men's or a joint decision. In one case the woman buys the appliance she wants and her husband those he wants and there are no disagreements. One man said he conferred with his wife but *"I involve her so I can hear what ideas she has it does not matter whether she agrees or disagrees I will still buy because I have already decided"*.

One respondent mentioned that appliances can be used as assets to sell when you need to pay for something – eg. tuition fees, then buy it back when you have the money - *"It is for home use for example TV for watching the news, bulbs for light, iron for ironing etc. Also equipment may be an asset for example if you do not have tuition fees for a student you can sell it and later you can look for money and buy it again and return it home"*.

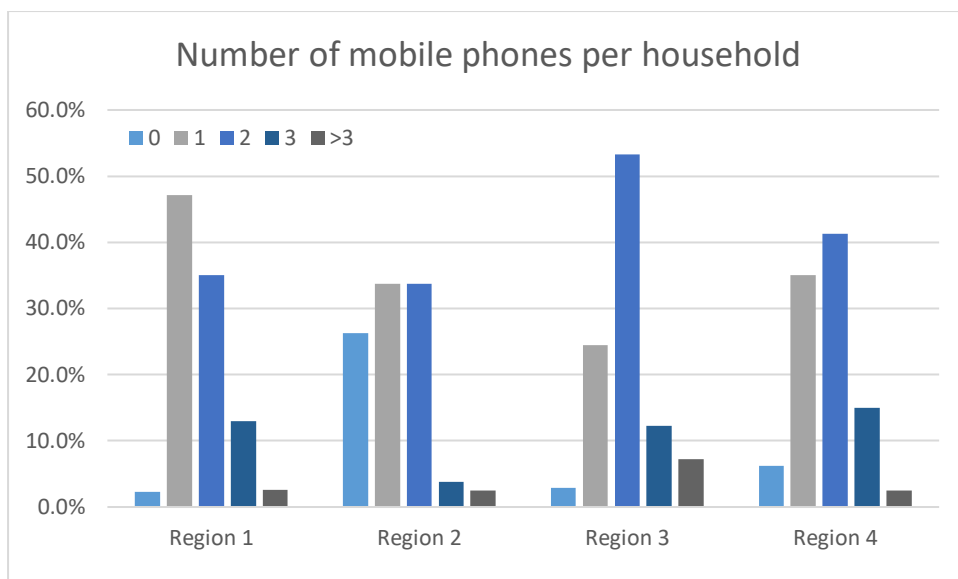
Access to information and communication appliances

Mobile phone ownership and use

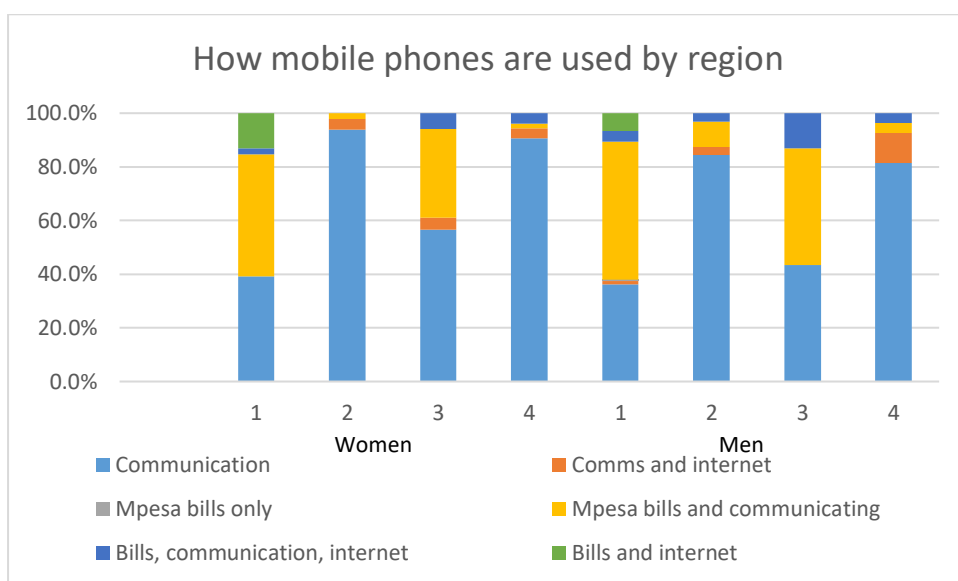
Mobile phone *access* is very high (100% for men in all regions, 100% for women in Region 1 and more than 90% in Regions 3 and 4, and 83% for women in Region 2) but mobile phone *ownership* is notably higher for men, particularly in the poorer region, Region 2, where only 46% of women own a mobile phone. There is no comparison with the baseline as at that time only mobile phone access was measured, and was high, but during the focus group discussions there seemed to be a difference between ownership and access. Therefore, the questions were broken down further at the end-line to differentiate between phone access and phone ownership to further investigate the gender differences in phone ownership in some regions.



Most (between 50% and 73%) households in regions 1,2 and 4 had two or more mobile phones. In line with the ownership figures Region 2 had the highest number of households with no phone in the house, followed by Region 4.



Respondents were asked how they use their mobile phone. Region 1 respondents use their mobiles for payment and internet more than the other regions. In Regions 2 and 4 phones are used most for communication only. Despite high mobile money access in Region 4 there is little use of the phones for payment. Men (in right 4 columns) generally use their phones for more than communication than women.



Access to television and radio

Men and women with TV expressed how they liked to relax watching TV and for many they liked to keep up to date and learn new information. Women enjoyed the TV for plays as well as news and recognised the benefits for the children too. More women mentioned the plays than news compared to men who focussed on news and sport. Women also appreciated the educational benefits of the TV and radio for them and their children on learning about their country and the wider world.

"Second what make me happy is my children can study at appropriate time and watching television to know about the country."

“Also when listening to the radio I get different information which is useful and also listen to the good music that I like.”

Electrification process

Where did people find out about the SHS company or the microgrid?

A third of respondents mentioned they had heard about, or learned more about, the microgrid at a local village meeting which seems to include men more than women. In fact, more than half of the microgrid customers heard about it from house-to-house calls from the company agents or at the village meeting called by the Village Chairman following the visits. One woman had heard about the microgrid plans from a women’s group and then attended the village meeting and one from a woman friend.

SSI Man: “I got the information right here in the village through brochures and also people from [...] company came here in the village and spoke with the village chairman...The chairman called for a public meeting where [...]representatives spoke about the benefits of [...]electricity...people were convinced and we were connected to [...]electricity for the cost of 40,000”

SSI woman “I got from the women group , and also the village Government summoned a meeting and explained about the purpose of introducing such a system to our village . I am the one who gave the idea because I am one of the official member on the village Government so I got it from there and came to share (SSI27)

“I saw a billboard that [...] electricity was coming here to Murusagamba and there was a group of four people promoting [...] they registered our names “(SSI3)

“There were people who were passing through our houses advertising about their service and registering those who were interested were connected after a while”

SHS customers were more likely to learn about the company and SHS through friends and word-or-mouth as well as formal marketing. One customer had learned of it from the radio, another seen posters, one had read brochures and some had got the information ‘on the street’. A number of the women customers first heard of the company and SHS from their husbands rather than learning of it themselves.

“I saw the ones who are advertising [...] and gave us information that they give posters and we got some and decided to go to the respective place in order to get solar information (FSHS)”

“My husband heard it from the street and came to discuss it with me about buying the solar power system”

“I got from radio and I consult my fellow neighbours who bought [...] already, I ask them about payment and where can I get and they direct me. I consulted [name of sales agent] there he is, I ask him payment amount and where can I get then he connect me with [the sales agent] [...]who advise and make communication with [...]then [...]came to install.”

There is scope for marketing targeted at women, potentially through women’s groups, at places women visit such as food markets, or through house to house visits, as demonstrated

in the microgrid region. House-to-house visits have the advantage of informing women who are based at home. Although membership of women's groups varies considerably; in Region 1 only 11% of women were part of a women's group and this rose to 29.4% in Region 3, so there is scope for companies reaching a wider audience.

Training

Few (five) of the women interviewed had received training on their SHS or electricity connection and instead, their husband had received the training. That said, not all the microgrid male customers had received training either. More women had received training from the microgrid agents than the SHS company (four women compared to one). In all cases the training was simple and restricted to switching appliances on and off, charging mobile phones, some safety elements and payment.

Interviewer: So you haven't get any training on how to use it maybe if your called in a seminar or agent comes here and train you

Respondent: No the man is the one who knows

Interviewer: have you received any training?

Respondent: I cannot answer that question. My husband know all of that. He was told how to take care of the solar system

There is a clear gap in training women on their solar connection. Although the training provided is rudimentary, providing training directly for women would ensure they can make the most of their solar system and may result in more efficient use of the system and less frustration with the system, for example limited TV viewing due to limited charge.

Sales agents

No one interviewed had come across a women sale's agent, although the remote customer service team were reportedly had more of a gender mix for the SHS company. Almost all respondents were happy with their agents and believed them to be easily available and cooperative. There was no concern from respondents that the agents were men, yet there was some unease from one respondent about lone male agents visiting households when only women and children are present.

Perceptions of safety and well-being

Prestige

There seems to be a sense of pride with those that have an SHS or microgrid connection. Four women mentioned that they are in better social standing because when the national grid has power cuts neighbours can use their solar home system to charge phones, and "[we are] perceived that we have very good life and well organized with what we do".

"There is difference between me and my neighbours for example during rainy season most of the people use other types of solar so if there is no sunshine their solar do not work properly they give dim light but mine is still strong."

"[SHS company] solar it is good am proud of it am different from my neighbours even when it rain season or even if there is a lot of clouds but I get power as often so I love [SHS company]"

Male, SHS: *“With modern devices you get respect. Now friends come to watch news bulletins. Now reduce movement as watch TV at home. Like the wider perspectives of TV. Rest at bicycle hire or home, mostly watching TV”*

“Have appliances they can’t have. Have more time when neighbours have to sleep if they have no light”

“Feel better as have light for working and studying when they lack light and can’t charge their phones or watch TV. They sleep earlier”

Microgrid customers frequently mentioned that other microgrid customers were similar to them but that *“...what differentiate us is use, everyone has their own equipment depending on their living standard...others use electric iron, refrigerators, TV, Radio and welding equipment but some do not have any equipment the electricity is for light only”*

Perception of safety

Light made people feel safer because light is seen to deter potential thieves and makes people think someone is at home. Men and women mentioned that they felt safer going outside during the night. In addition, men felt better that their wives were safer at home.

“I get security for my family and livestock and I can go outside during the night without any fear and live happily.”

“Benefit that I get from the solar is having light even if a thief comes will think twice because I keep the light on.”

“I like backyard light due to security as it reduces thieves, you can chase a thief and be seen through the light easy, that is what makes me happy.”

At the baseline health and safety issues relating to cook stoves and kerosene was investigated and found that reported historic instances of burns related to kerosene usage (i.e. the fossil fuel source that is typically displaced by access to solar lighting) were very low in all regions. This is likely to reflect only moderate reported kerosene usage across all regions. In contrast, around 15% of people reported respiratory issues related to energy use. However, it is not known if this is attributable to their lighting source or their cooking source, quite likely a mixture of the two.

Perceptions of well-being

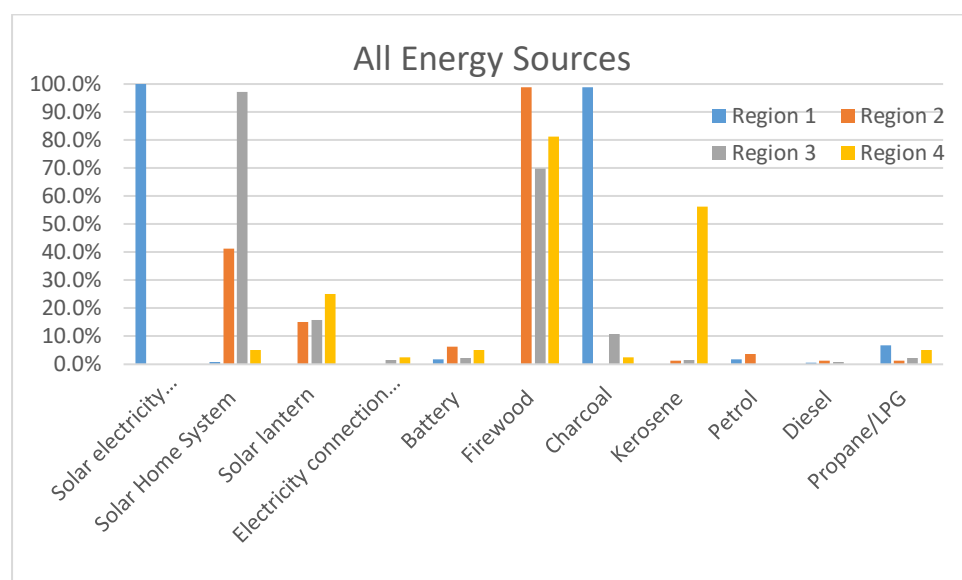
At the baseline, overall, both women and men were generally satisfied with their lives, despite a recognition that many of their needs were not met. There was little statistically significant difference between their responses on this. Interestingly, despite the ‘double burden’ for women, many women and men believed that happiness is linked to the lack of formal responsibility to be the main breadwinner and so women are living happier lives because they are ‘being provided for by their husbands’.

This echoes the gap between *perceptions* of gendered roles and reality: when discussed in more detail, most people recognised that; a) many women contribute significantly to the household income and; b) women can be severely limited in their lives and frustrated, even when they are partly or entirely financially sustained. This latter point was most vocally

stressed by those women who had previously said they had limited decision-making power at home, despite contributing financially. Overall, most participants agreed happiness was attached to financial freedom, absence of needing to work for money, as well as peace and good human relationships.

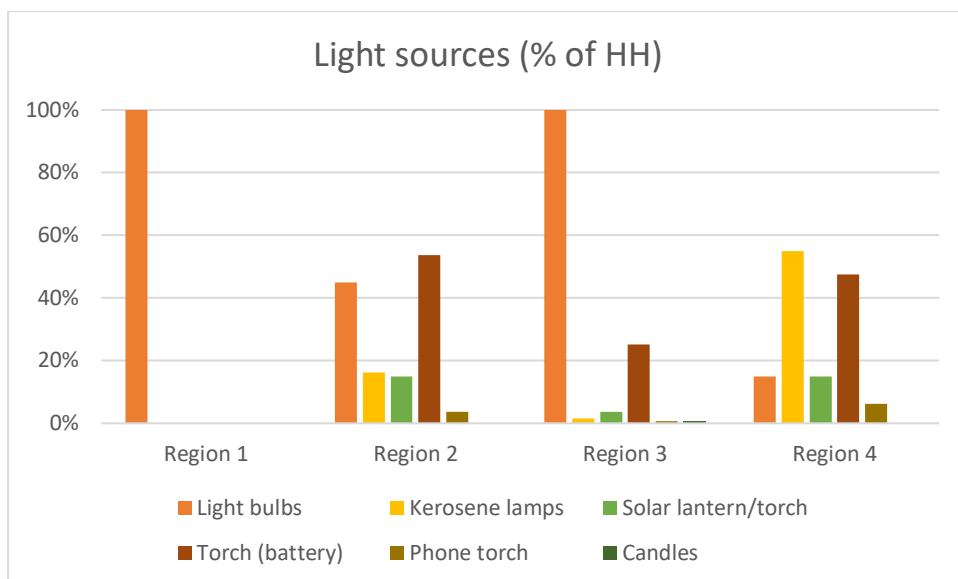
Energy usage

Firewood is the most common energy source in Regions 2, 3 and 4, particularly in Region 2 where only one respondent does not use firewood. In contrast few respondents in Region 1 use firewood with almost 99% using some charcoal. As expected in Region 1 all households were connected to the microgrid and in Region 3 almost all households had a solar home system (SHS). 41% of respondents in Region 2 had an SHS compared to zero at the baseline, and just 4 (5%) respondents in Region 4 had an SHS. At the baseline 57% of Region 1's households already had an SHS. However, in the end-line only three households still use their SHS, mainly for lighting. There were a few grid connected households in Regions 3 and 4. Solar lanterns are used in all regions without the solar microgrid.



Lighting

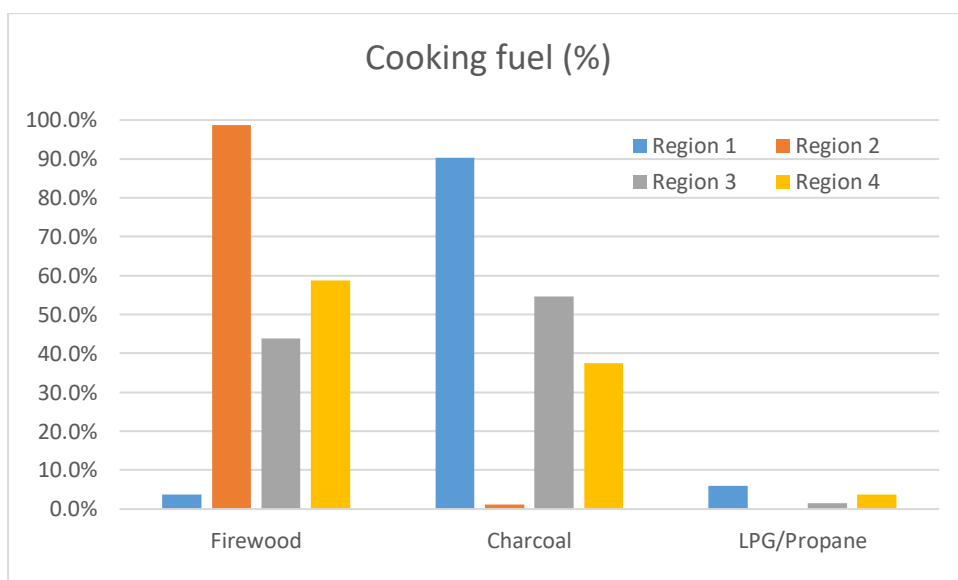
All households in the two treatment regions have lighting powered by SHS, solar mini-grid or grid electricity. With the fewest SHS Region 4 relies more on kerosene lamps and torches along with some solar lanterns. Region 2, with over 40% SHS ownership also some reliance on kerosene, solar lanterns and torches. In Region 1 no respondents said they used kerosene or a solar lantern. This is in contrast to literature findings, Harsdorff and Bamanyaki (2009) which found that there were not significant changes on expenditure on fuel because of fuel stacking, i.e. people do not get rid of their kerosene lamps when they obtain an SHS, they use it alongside to maximise the quantity and quality of energy services. They were not asked about torches or candles yet at least one interview respondent mentioned using torches because of frequent power cuts.



Benefits of solar lighting were cited as no longer needing to buy candles, lanterns, torch batteries, kerosene and stopping using regular solar which was not working well due to a faulty battery, for example: *“I have stopped using regular solar which was not working at times because its battery was faulty but now I use [the microgrid] electricity”* and *“Before I purchased other type of solar which used to have technical problems like battery, bursting of bulb so I decided to get connected to [...] so I can get help”*.

Cooking

The figure below shows the high dependency on firewood in Region 2 and the high use of charcoal in Region 1, the wealthiest region. The questionnaire in Regions 2, 3 and 4 did not include charcoal as a potential energy source so it did not feature prominently. However, when asked about cooking fuels the answers change a little and shows more charcoal use in Regions 3 and 4.



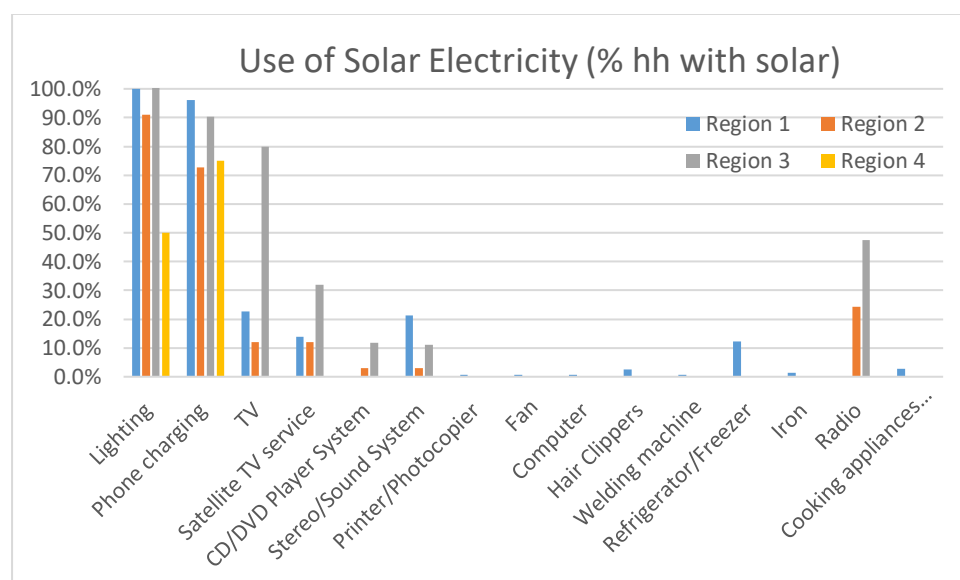
Although a few households use gas cookers the majority use fuelwood and charcoal for cooking. The reasons for cooking fuel choice depend on the financial situation of the family and availability of firewood for collection. There was a preference for charcoal if they could

afford it due to lack of smoke and taste in water and food, however not all households could afford charcoal and so collect firewood for ‘free’. Where firewood was bought it was not necessarily any cheaper than charcoal and in at least one case more expensive. If both were available, then the choice of fuel was often made on the basis of time available for cooking with firewood being quicker than charcoal.

Use of SHS/solar mini-grid and appliances

SHS / Solar mini grid are used for lighting by all customers and for mobile charging by a large percentage of those with solar. SHS owners in Region 3 are more likely to own a TV and/or a satellite TV and a radio than other solar customers as this was offered within their package with the supply company. At the baseline TV ownership was also higher in Region 3. Those in Region 1 were not asked about radios or CD/DVD player systems directly so the ownership is likely to be higher than reported². At the baseline more than 25% of the Region 1 participants had a radio.

In Region 1, where there is greater power capacity and greater wealth, there are significantly more, and more varied, appliances: 43 fridges, two printers/photocopiers, two welding machines, two computers, nine hair clippers, two fans, five irons plus blenders and one popcorn machine. Note that at the baseline Region 1 already had a significant number of these appliances probably because a large number of households had an SHS. The number of fridges has increased significantly with the microgrid from 3.9% to 12.1%, probably because the power capability of the microgrid is better than the SHS. The figures on blenders (food appliances) was not recorded at the baseline but it is likely that this has also increase for the same reason. However, in some cases the figures have reduced, for example at the baseline 35.8% of households had a TV and this has reduced to 22.6% whilst those households with a computer has also reduced from the baseline (from 2.4% to 0.6%). This may just be explained by the fact that some interviewees were different.

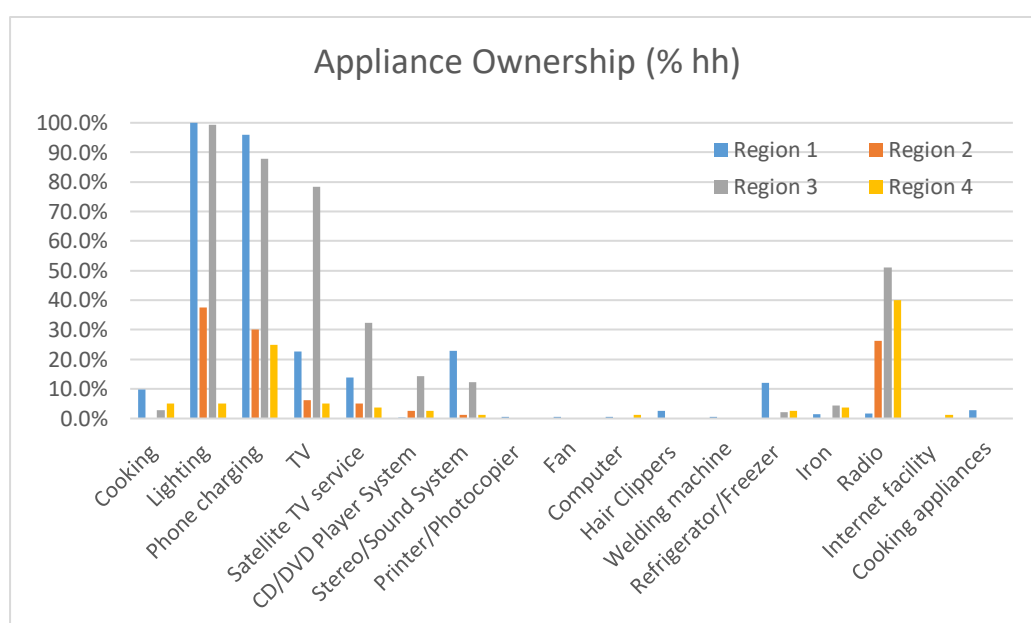


Overall appliance ownership across the regions is similar to the appliances used by solar customers but also includes for gas cooking stoves and appliances run on grid electricity and battery. The largest difference is that in Region 4 where 40% of the respondents own a battery-

² Those that reported it mentioned them as ‘other’

operated radio. Despite high phone ownership, ownership of a mobile phone charger is low in Regions 2 and 4 implying these households must pay to charge their phones elsewhere.

	1	2	3	4
Cooking (gas stove)	9.9%		2.9%	5.0%
Light bulbs	100.0%	37.5%	99.3%	5.0%
Mobile phone	97.2%	63.8%	95.0%	81.3%
Phone charging	96.0%	30.0%	87.8%	25.0%
TV	22.6%	6.3%	78.4%	5.0%
Satellite TV service	13.8%	5.0%	32.4%	3.8%
CD/DVD Player System	0.3%	2.5%	14.4%	2.5%
Stereo/Sound System	22.9%	1.3%	12.2%	1.3%
Printer/Photocopier	0.6%			
Fan	0.6%			
Computer	0.6%			1.3%
Hair Clippers	2.5%			
Welding machine	0.6%			
Refrigerator/Freezer	12.1%		2.2%	2.5%
Iron	1.4%		4.3%	3.8%
Radio	1.7%	26.3%	51.1%	40.0%
Internet facility				1.3%
Cooking appliances (blenders, popcorn)	2.8%			



Use of other energy sources

Use of the other energy sources varies little across the regions:

- Firewood is used for cooking in all regions with just two households using it for lighting in Region 2.
- Charcoal is used for cooking only.
- Kerosene is used for lighting and two households use for cooking (one each in region 2 and 4)
- Petrol is used for motorbikes
- Solar lanterns are used for lighting
- Diesel is used by one household for cooking, but same household says it uses gas but does not own a gas stove.
- Propane is used for cooking
- Batteries are used for lighting, radios and mobile phone charging

Annex 2: Literature review

Background

To identify the knowledge gaps in the field of electrification and gender and formulate appropriate research questions, we start with a review of the current literature, focusing on studies which tackle gender differentiated impacts related to solar home systems and solar microgrids. This section also builds upon an extensive literature review carried out in 2013 by our academic partner for this study, IDS: 'The evidence of benefits to poor people of increased renewable energy capacity'. One of the key findings of the IDS review was that electricity brings particular benefits for women, such as providing flexibility in how their time is used and improving their ability to earn an income.

Small-scale, decentralised electrification, in the form of solar home systems and microgrids, plays an important role in off-grid areas. Electricity access has the potential to affect women and men differently because of socio-economic structural inequalities and differentiated roles in society, particularly women's responsibility for the domestic sphere and the 'double burden' of being responsible for unpaid domestic care work *and* contributing to household income that is part of many women's experience globally. Factors affecting women and men's ability to benefit from electricity are also complex and include intra-household dynamics as well as the wider context of social norms, institutions and markets (Clancy et al, 2011). While post-evaluation of electricity access projects and programmes provides evidence of diverse types of impact, there is a lack of gender-differentiated studies, particularly those which account for contextual dynamics. Ignoring gender in the process of electrification risks reinforcing structural inequalities and the benefits not reaching all.

In this review we recognise that comparison of impacts associated with different tiers of electricity provision will be purely anecdotal. For most of the review, we have focused on studies which differentiate between findings on impact for women and men of access to off-grid electricity systems. Where relevant, we may reference studies focusing on grid electrification, acknowledging that the energy services these offer, and the impact they have, may be greater. We have excluded studies on pico solar lighting. In some instances, we have referenced studies which treat the household as a unit partly due to the lack of gender-disaggregated information but also to get a sense how strongly a certain impact is associated with off-grid electricity in general. We draw on studies that have employed a range of methodologies and levels of statistical rigour. Though the geographical focus of our research is East Africa, and specifically Tanzania, we have drawn upon findings from around the world; at the same time being aware that geographical and socio-cultural contexts cause broad differences in impact.

Gendered impacts: key concepts

Historically, development studies have often regarded the household as a homogenous unit. According to Moser (1993) there are three reasons why it is important to break this down further, especially when considering gender. Firstly, the members within it may have very different experiences depending on their gender, age, role, etc. Secondly, the balance of power over decision-making and access to resources between adults in a household can be very unequal. Finally, the boundaries regarding gendered division of labour are often blurred. While it is generally true that unpaid domestic and care duties fall to women, they are also often responsible for providing a supplementary (or even primary) income and fulfilling a community role. Some studies suggest that, for women, electricity access has the potential to allow greater

flexibility in time-allocation and improve health outcomes. However, due to structural inequalities, there may also be barriers preventing women from accessing the full opportunities offered by off-grid electrification.

Gender theorists have also long focused on the differentiation of needs for women and men. Molyneux (1985) differentiates between practical needs – those which arise as a result of existing gender roles and, when met, maintain these roles – and strategic needs – those which, when met, challenge and transform existing gender roles. For example, we might say that a solar home system can address women’s practical needs by providing good quality, bright light by which to complete daily tasks more easily. However, it may also fulfil strategic needs if it enables women and girls to study more, increasing access to education and knowledge, and thus, opportunity. Meeting practical needs can improve quality of life for women, but inequality cannot be tackled without addressing strategic needs as well.³ We hope to explore the extent to which electrification, in addition to making life cleaner and easier, can change the lives of women, for example by increasing empowerment or reducing gender inequality.

Gender theorists such as Kabeer (1999) have stressed the importance of factors such as cultural norms, access to resources and household decision-making dynamics in the process of women’s empowerment. Kabeer (1999) defines empowerment as ‘the expansion of people’s ability to make strategic life choices in a context where this ability was previously denied to them’ and considers empowerment to be made up of ‘resources, agency and achievements’. According to her conceptualisation, resources relate to material resources (like money and tools), but also human resources (like time), and social resources (like family and community networks). Agency is most often considered to relate to decision-making power but can also refer to aspects like negotiation and resistance. Achievements are the evidence of these factors. To explore progress towards women’s empowerment in this study, we plan to focus on decision-making and access to resources within our impact categories.

Kabeer (1999) also points to the need to ‘disentangle differentials which reflect differences in preferences from those which embody a denial of choice’. For this reason, we are keen to explore women’s and men’s aspirations and levels of satisfaction with aspects of energy services, and life more broadly. The quantitative part of our study will focus on direct and indirect impacts of access to electricity, whilst the qualitative part will deepen insight by exploring the influence of intra-household dynamics on women’s and men’s experiences.

Gender in the Tanzanian context

In Tanzania, gender inequality is widespread. Women have lower access to educational, economic and healthcare opportunities, as well as fewer property and inheritance rights. This is reflected by the Gender Inequality Index (GII), which ranks Tanzania 125th out of 155 countries, based on women’s access to healthcare, education and political voice (HDR, 2015).

Labour force participation for women is at 92%, though it is still low compared to men, whose participation is at 95.7% (Wilson & Sharmin, 2016). Many women entrepreneurs in Tanzania often carry the ‘double burden’ of both work and family responsibilities, have problems

³ Clancy et al. (2003) have argued that practical needs should be broken down into practical and productive needs, because of the particular significance of energy as an input into productive activities. Addressing strategic needs is part of a pathway towards empowerment. Most electricity interventions often stop at addressing practical needs, and less on strategic needs.

accessing credit that will enable them to build up their businesses (Ellis et al, 2007). The cultural and gender expectations that underpin these challenges have been slow to change despite the increasing opportunities for women outside the household. In terms of healthcare access, gender inequity is also prevalent. Survey data recorded in 2010 shows that over 38% of women state that their husbands make decisions about their healthcare (UNICEF, 2010a).

In the 1990-2000s the Tanzanian government ratified several international conventions, including the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW). Yet, according to customary law, women's access to land and property is often determined by their relationship and status relative to men, either as sisters, daughters or wives (Pitamber & Hamza, 2009). In case of separation or divorce, a woman may lose basis for access to land, in many cases resulting in impoverishment (ibid).

The government of Tanzania has undertaken legal and polity reforms to address gender inequality and increase women's and girls' empowerment, and the engagement of Tanzanian women in politics has also been increasing over the years (Strachan, 2015). In fact, women's representation has grown at a faster rate than any other SADC member country (Gender Links, 2015 cited in Strachan, 2015). It is worth keeping in mind these broader political developments in relation to women's empowerment in Tanzania, and how these could potentially interact with, and influence, intra-household dynamics related to electricity access.

Framework for the literature review

Based on the key impact areas that emerged from the IDS literature review (Pueyo et al, 2013), we have divided the literature findings into the following categories of impact arising from access to household-level solar electrification. In the first two categories, we have further divided the findings into those relating to solar microgrids and to solar home systems since the impacts varied considerably. Within these impact categories, we will also look at how cultural or social norms, intra-household dynamics and decision-making influences outcomes.

1. Changes in time use and task allocation
2. Changes in household finances
 - a. Savings in fuel expenditure
 - b. Changes in income and economic empowerment
3. Information and communication appliances
4. Changes in perceived safety and well being

Literature review findings

1. Changes in time use and task allocation

Anecdotal evidence suggests that access to electricity can affect the length and structure of the working day. While lighting can extend the number of useful hours in a day, electricity can power equipment which can improve the efficiency of time-intensive domestic tasks, freeing up time that can be used on other things (ICRW, 2010). Below we discuss the extent to which this is borne out in quantitative and qualitative evidence from studies on SHS and solar microgrids (and of other technologies including electricity grid), and how women and men's experiences differ.

a. Solar home systems (SHS)

Solar home systems can provide women greater flexibility in the spread of tasks throughout the day, but findings vary widely

Most of the studies available looked at small to medium-sized solar systems (up to about 35Wp). Given the relatively small capacity of the systems, most time impacts relate to the effects of improved lighting. Results from studies in East Africa, for example, broadly show that evening lighting allowed tasks to be spread out over the whole day, increasing comfort and efficiency. What the results don't show is any clear shift in the type of activity performed (for example a shift away from chores, towards, for example, recreation or rest). In Rwanda, Grimm et al. (2014) found that increased quality and quantity of light in the evenings (from an entry-level 1Wp system) meant, for women and men, that activities like cooking or studying could be spread throughout the day and evening. However, they found no impact on total number of hours spent on studying or chores, or any displacement of activities for men or women.

This is supported, to a certain extent, by the findings of Harsdorff and Bamanyaki in Uganda (2009). They found that both women and men carrying out domestic and productive work found it more convenient and effective with access to a 35Wp SHS. They noted that women in houses with a SHS carried out more hours of domestic work *in the evening* than houses without (2.2 hours, compared to 1.9 hours). They also found that overall, women in households with SHS worked more than women in control households and had less recreation time. Interestingly, those with a solar home system, on average, spent nearly one hour more per day reading than those without a solar home system and that this was the same for both women and men.

A large study employing sophisticated community matching techniques, carried out by d.light and IDinsight in Uganda, found no impact (for men or women) on the time spent on household chores, studying or income-generating activities as a result of having a small SHS, despite participants reporting on average nearly three hours of extra light per day.

Samad et al (2013) hypothesise that the increased workload associated with electricity access could be a consequence of limited power of women within the household to control how they spend their time. In their study in Bangladesh, electricity did not appear to affect the pattern of time use as the same tasks were carried out at roughly the same time of day, with or without access to a SHS.

In contrast, Standal and Winther (2016) found, through interviews carried out with both women and men in Afghanistan, that those with access to SHS would spend more time with friends and neighbours than before they had the solar electricity which provided extra time in the evenings and nights. Women also reported that this gave them the chance to network with other women.

b. Solar microgrids

Depending on the capacity, microgrids⁴ (compared to SHS) are likely to offer the opportunity to use a wider range of appliances, and more powerful ones that could be used for productive activities. In comparison to the relatively small number of gender-differentiated studies on small SHSs, several exist for microgrids, and there appear to be a greater degree of observable impacts on women's time use and task allocation.

⁴ A localised energy grid that operates independently, in this case using solar as the prime resource

Lumampao et al. (2004) looking at a community-based micro-hydro system in the Philippines, notes that significant time was saved when a rice mill was set up. Rice pounding was usually performed by women and children, taking about an hour a day. The time the mill saved them was spent doing other chores and farm-work. Women's overall workload didn't appear to change, there was simply more time to fit it in, as a result of better lighting in the evening and less time spent hand-pounding the rice. This was especially useful for women with children to care for and women themselves said they felt satisfied that they were able to get more done.

A mixed-method study by Matly (2003) in Sri Lanka on the effects of rural electrification including grid, micro hydro and SHS, found that that households gained back two hours a day as a result of having electricity to relieve the burden of manual labour, and that women had gained slightly more than men. Nearly 100% cited 'women's work relief' as one of the top impacts of this time-saving. However, it is interesting to note adult males tended to use this as free time for entertainment and socialising, but women mostly used it for housework and childcare. Matly points out the critical role that socio-cultural context plays in keeping women's days structured in this way: *'A typical good wife for both [women and men surveyed] is a hard worker who cares for children. Hard work is one of the most common features of the female stereotype, and reality mainly fits with the stereotype. Work overload, task segmentation, limited itineraries from home to field and back are not propitious to socialization and empowerment'*. This appears to present challenges for electrification's ability to have a structural impact on women's lives, without other supporting interventions, in this context.

However, choice and decision-making are important aspects of empowerment – being better equipped to carry out tasks relating to childcare and the home can be a source of satisfaction and stress relief as noted in the Lumampao (2004) study. Matly also observes that, with electricity, often for the first time, women gain control over a section of their daily routine as time is extended (into the night) and that leisure starts to play a small, but important, role. This leisure time is most often used for watching television, which can be a 'tool of progress and status' within a community.

The greatest time-saving impacts are seen when electricity can power agricultural processing equipment, electric cooking appliances – and when the burden of collecting water is relieved

So, what does this imply in terms of women's practical, productive and strategic needs? The findings seem to vary considerably across contexts. It is important to consider that, from the point of view of time-use, electricity is only one small part of the picture. The tasks eased by electricity may not be the most time-consuming ones – activities such as child-care or gathering fuel and water are likely to represent a significant burden. For example, examining the national Ghana Living Standards survey, Costa et al. (2009) found that access to electricity is correlated with improvements in working hours for men only, whereas access to water is correlated with a reduction in women's total working hours (but not men's). This implies that access to water may have a much more immediate and significant impact on women's lives than electricity (although it is worth bearing in mind that electricity, at a community level, is often needed in the treatment and distribution of water).

Studies which show the most significant impacts of access to electricity on time-use (e.g. ADB, 2010 on the impact of grid electricity in Bhutan) often reveal that time-saving for women is primarily from reduction in time spent gathering fuel for cooking. In these cases, it could be that sufficient electricity available for electric cookers (enabled grid electrification rather than solar

home systems or solar microgrids) or that electricity access is somehow associated with improved access to other forms of cooking fuels or stoves. Either way, it indicates that improved cooking solutions could have a very significant impact on women's time use.

Significant impacts of electrification on women and girls take time to emerge, sometimes an entire generation, and other inputs and policy interventions are needed

Analysing historical studies on the impacts of grid electrification, it becomes clear that the most significant effects take time, sometimes even a whole generation, to materialise. O'Dell et al. (2014) cite a study by Lewis (2014) examining electrification in the United States from 1930-1960, which finds that household electrification had no immediate effect on women's employment. It did, however, increase school attendance of adolescent girls. This turned out to have an important effect on employment opportunities for the next generation.

As O'Dell et al. point out, this indicates that key indirect benefits for women from electricity access can be delayed, and that electricity access needs to be part of a broader strategy to enable women to spend their time on activities (education or earning an income, for example) which will improve direct and indirect economic outcomes. It is also likely that appliance ownership will increase over time, as will electricity consumption (up to the capacity of the system) so the benefits for women may also increase over time (Khandker et al, 2009).

The above findings from East Africa and South Asia, on the impact of SHS and for microgrids on women's time, are largely inconclusive. We need to treat the evidence with some caution as these studies take place in different countries and contexts. As Matly (2003) points out, the arrival of electricity does not appear to bring about major changes in the structure of women's lives, or their status in society. Instead there appears to be a small increase in choice of how free time is used. This choice may be part of a slow, but crucial, pathway towards greater empowerment. Time-use is clearly a challenging area to explore.

To obtain useful information on how to maximise the benefits of solar home systems for women, it is important to acknowledge if and how task distribution changes over time for women and men, but also why, and how, extra time is used, who decides, and what aspirations and preferences exist. We also need to be conscious that the time-horizon of our study may be too short to observe significant changes.

2. Changes in household finances

a. Savings in fuel expenditure

There is some evidence of cost-savings on fuel spend, but evidence inconclusive and little gender-differentiated information is available.

Access to off-grid electricity sometimes means that households can save money on purchasing expensive fuels, such as kerosene for lighting. Some studies find significant savings from small systems once the system has been paid off (Grimm et al. 2014, Rwanda; IDinsight and d.light, 2015). In contrast, Harsdorff and Bamanyaki (2009) did not find any significant changes on expenditure on fuel because of fuel stacking, i.e. people do not get rid of their kerosene lamps when they obtain a SHS, they use it alongside to maximise the quantity and quality of energy services. Most of the evidence on savings by households is often not gender differentiated, as

the household is presented as a unit. In addition, if savings occur, there is little evidence on how money is spent, who decides, and who benefits.

b. Changes in income and economic empowerment

Anecdotal evidence suggests electricity can create opportunities to earn additional income at a household level through having good quality lighting in the evening, or by using electricity as an input to the provision for goods or services. In this study, we are not looking at external enterprises, and our focus is the household. There is a certain amount of overlap with the previous section, given that available time is a pre-requisite for income-generating activities.

Household-level electrification can provide income generating opportunities, but the amount of power, nature of local economies, access to markets and business inputs are critical

Concerning the effect of access to electricity on income generating opportunities, and economic empowerment for women, results are mixed. Several survey-based studies in East Africa find no significant impact (and little in the way of gender differentiation) as a result of access to small and medium sized solar home systems for women and men. d.light and IDinsight (2015, Uganda) find no significant impact on asset accumulation or socio-economic status for women or men within a community. One reason for this could be that some systems are not large enough to support appliances that could be used for productive activities. Furthermore, it depends on the nature of economic activity in the region. Harsdorff and Bamanyaki (2009, Uganda) find little impact on productive activities with access to a 35Wp SHS, noting that only a small number of households carry out productive activities in the evening anyway, and access to electricity has no impact on this, except for a small number of phone-charging and hair dressing businesses which have sprung up.

In contrast, looking at grid electrification in Zanzibar, Winther (2006) found some evidence of increased income-generating activity: women with access to the grid could make and sell flavoured ice and may work later into the evening on handicrafts. While this does not take women far out of their traditional role, it may be an important step towards economic empowerment. In Nicaragua, women of the El Canal community rented land to produce vegetables, which they sold on to local markets and supermarkets. After electrification, these women could use electric pumps to irrigate and maintain their crops increasing their income (Enatrel et al, 2014).

In South Asia, across a range of technologies, there are mixed results but, again, little gender disaggregation of findings. Banerjee (2011) looking at the impact of a micro-hydro grid in Nepal finds on average an 11% increase in non-agricultural income with electricity consumption mostly used for lighting. They do point out that 'as electricity consumption is currently low and mostly used for lighting, it may take a while for the microgrid to have a major impact on income'. Urmee and Harries (2011, Bangladesh) found that an unquantified number of people reported the ability to start businesses, such as TV halls and phone charging, especially after dark. It is clear from these research studies that economic activities are micro in nature in line with size of the systems.

What does this mean for our understanding of gender differentiated impacts? Overall, there is limited evidence of SHS having significant impact on household members' ability to earn an income *on its own*. This variation is echoed in the IDS literature review of 143 papers on the

effects of electrification on the poor (Pueyo et al, 2013). This thorough literature review found only 24 per cent of studies dealing with impact of electricity access on income showed a positive impact.

Context is critical in determining the extent to which women are able to benefit from electricity access, particularly when it comes to economic impact. Context include social norms, institutions, markets, policy as well as the specific dynamics within a household (Clancy et al. 2011). Matly (2003) looking at a range of sustainable energy systems in India and Sri Lanka, provides a practical example of this. She found that, while extra hours of light are, in some cases, used for new, paid, home activities like processing clove nuts, wrapping cigarettes and weaving, cultural stereotypes around the types of activities suitable for women and lack of employment opportunities in the region had a significant impact on lack of options for women. There also needs to be a market for the goods produced. Availability or lack of time played a minor role compared to sociological constraints and market limitations: women do not necessarily have access to markets or capital that would enable them to enter into new economic activities.

With this in mind, there is potential scope for partnerships between electricity providers and public-sector organisations or community organisations to improve economic development or provide inputs. Notably, a study on grid electrification by Cecelski (2005) in Tunisia states that government provision of equipment for productive activities – such as sewing, weaving and knitting had increased opportunities for women in a village, and many women said they preferred not having to migrate to the city for work.

The structure of local economies is also important in our expectation of how different energy technologies can affect women and men. It is important to note that the majority of women with low-incomes in developing countries are employed in agriculture (Mehra and Rojas 2008, in Gill et al 2010). There is some indication (e.g. Winther 2016) that if the primary kind of employment is agricultural and electricity is not used for this purpose (e.g. there is not enough power, or additional inputs or resources are required) then an electricity connection can have little impact on income levels.

Standal and Winther (2016), comparing findings from interviews in India and Afghanistan (solar home system and microgrid electrification), found that in Afghanistan, access to electricity had doubled the income of many households because there was more time in the evening for carpet weaving, mostly performed by women and children. This additional income had been used to enable increased nutritional intake and, in some cases, to buy educational resources for children.

In contrast, electricity access had little impact on households in India, where most income is from agriculture and electricity was not used for this purpose (Standal and Winther, 2016, Afghanistan and India findings echoed by Kumar and Rauniyar in Bhutan 2011, grid, not gender disaggregated). Similarly, Lumampao (2004) in the Philippines noted that a small number of women had used the availability of light in the evening to start food vending businesses, but that linking the micro-hydro system to a rice mill had the biggest economic impact on women.

If the level of electricity service is important in determining the benefits for women, what then do we observe from studies of grid-connected communities? There are some marked results.

For example, Khandker et al. (2012) found in a study in India⁵, that household access to grid electricity increases employment hours by more than 17 per cent for women, but only 1.5 per cent for men.

Grogan and Sadanand's (2013) study in Nicaragua found that household electrification causes women from rural areas to be 23 per cent more likely to work outside home with no such effect for men, although these impacts were concentrated among women aged under 35.

In order for income generation to influence empowerment, women must have the power to negotiate how it is used....

We can see mixed results on the impact of electricity on women's ability to earn an income. An important point to add, from a gender perspective, is that earning additional income alone does not necessarily equate to economic empowerment for women if we take Kabeer's (1999) consideration that empowerment comprises access to resources and decision-making. From the point of view of building up economic assets, Winther (2008) makes the point that, in Zanzibar, the money earned by women is often seen as a family resource in a way that men's might not be. Whereas men tend to invest in longer term asset-accumulating initiatives, money earned by women is often used to support their family in everyday life. This is notable, as it can mean education or nutrition can be increased, particularly for children. However, from an economic empowerment point of view, it can mean that women still suffer from a lack of long-term financial security and access to capital. In a survey in rural Bhutan, it was found that while electricity access significantly increased women's participation in decisions related to health and education, this was not the case for finance (ADB, 2010).

...and choice around workload is essential to avoid adding additional pressure on top of the 'double time burden'

The opportunity to undertake economic activities can be beneficial, but it can put pressure on the already heavy workload of women, especially when they do not have full decision-making power over how additional time, or money, is used. Mukherjee 1999 (cited by Matly 2003) makes the point that while the ability to earn an income can bring about improvements in women's conditions overall: 'such work may, in conjunction with electricity, lower the quality of rural life by increasing the length of the working day and decreasing the time for social interaction, rest and recreation, childcare, and cooking without improving the material conditions of life'. As seen previously, choice is critical, and it is important for women to be able to choose to rest or socialise, rather than earn an income, if this is their preference.

3. Information and communication appliances

Off grid electricity can enable the up-take of information and communication appliances such as TV, radio and mobile-phone which can, in turn, provide entertainment, information and educational content. There is interest in the potential for this to affect resources, networks and outlook of women. IEG (2008) confirm that lighting and television account for 80 per cent of rural electricity consumption. The evaluation of World Bank Projects by the IEG covered about 12 countries including Ghana, Lao PDR, Peru, Philippines and Sri Lanka. In India and Sri Lanka,

⁵ Empirical analysis was by using 2005 India Human Development Survey (IHDS) rural household-level data, consisting of more than 24,000 households, available after the data cleaning. The IHDS had a nationally representative sample of 41,554 urban and rural households.

Matly (2003) finds that television is just as much a tool for information and education as entertainment, with access to the television distributed equally between women and men. Women in particular can benefit from information about life beyond their local area and educational resources, echoed by a small study carried out by Khan and Azad (2014) in Bangladesh on solar home systems.

Communication appliances, especially television, can have important effects on women's empowerment, especially if they have a say in when and how they are used

Several studies have analysed in detail the effect of access to (grid-electricity powered) television on women's attitudes and behaviours. Jensen and Oster (2008) in India, found that access to cable TV reduced the likelihood of women's acceptance of domestic violence and preference for sons. Women also reported increased autonomy in terms of movement and decision-making within the household. These effects were observed within a year of access to television. The authors suggest that 'television exposes rural households to (mostly) urban lifestyles, values and behaviours that are radically different than their own and households begin to adopt or emulate some of these' but also that television may increase access to information on family planning or change the value of men or women's leisure time.

In another case, women interviewed in Afghanistan said that TV gave them an opportunity to learn about women's rights (Standal and Winther, 2016). This implies that the empowering role of television has as much to do with the content of the programming as the ownership of, and ability to power, the device itself.

In a study in Zanzibar, Winther (2006) found that (in 2001) while only 10% of households interviewed owned a TV, 74% of men and 54% women watched at least 3 times a week. It was often a communal activity, and one which brought women and men together in the same space, whereas previously the women had gathered together indoors and the men outdoors. Overall, increased socialising could give women the opportunity to increase their social capital and networks, one element in Kabeer's (1999) definition of empowerment. At the same time, if TV is not owned by households, women's ability to watch elsewhere may be restricted by mobility especially in the evenings, even more so in conservative societies such as Zanzibar and Bangladesh (IEG, 2008).

Unlike for television, a number of SHS studies confirm that mobile phones and radio were typically being used before electricity arrived. Harsdorff and Bamanyaki in Uganda (2009) found that 94% of women and men surveyed listened to the radio, and 85% had a mobile phone, and that access to a SHS made no difference to the likelihood of owning and using these appliances. In contrast, only 9% of those studied had a TV, and those were all in houses with a 35 Wp solar home system. This was echoed by ADB (2010) in Bhutan and Bensch et al. (2012) in Senegal. In contrast though, the IEG 2008 report points out that electricity, particularly from the grid, allows users to listen to radio for longer (as they are powered by batteries otherwise) and found that in the Philippines those connected to grid used it for 105 hours a month compared to just 13 hours for non-electrified households.

In Nicaragua, the experience in the country's Electrification Project, PELNICA showed a high impact in the ability for households to charge mobile phones: from 4% of the population at the time of the baseline study, to 42% in the year 2014 and additionally, most of the households having a television and radio to be better informed (ENATREL et al, 2014).

There is also an important question as to who owns the appliance and decides which programme is watched and when. Standal and Winther (2016) found that while access to TVs and smartphones connected both women and men to the outside world, these appliances were most often owned and controlled by men, who also sometimes decided which programmes were and weren't suitable. Similarly, in Zanzibar, Winther (2008) found that electrical appliances were never given to a bride as a wedding present. The 'rules of inheritance in Zanzibar are that only men can own houses'. Electricity is part of the house and because men install the electricity and pay the monthly bill, it follows that they decide how and when it is used. (Winther, 2008).

To summarise, radio and mobile phones are important communication tools, but in reported research they existed in houses long before an off-grid electricity system was available. Electrification makes the biggest difference to access to television and lighting. For example, Barnes and Sen (2004) in India find that more than 40 per cent of surveyed homes connected to the grid have invested in a television in comparison to only 10 per cent purchasing a grinder. However, access to television may change social interactions, often increasing it and bringing women and men together in the same space. There may also be an influence on women's attitudes and behaviours. However, in many cultures it is men who own and control access to the television. More information is needed about ownership and purchasing within households.

4. Changes in perceived safety and well being

There is little quantitative evidence available on how access to solar home systems and microgrid connections affects health and safety, even less that is gender-differentiated. However, there is anecdotal evidence that it can lead to improvements in *perceived* health and safety (Wheldon et al, 2015). This limited evidence is often linked to reduced kerosene use leading to improved indoor air quality, and lower risk of burns and fires. It can also be a result of an increased feeling of security because of electric light. Perceived well-being may not be a primary concern for outcomes from a gender equality point of view, but we should not underestimate the importance of these factors to women's everyday lives.

There is some evidence that electricity access lowers incidences of burns and fire by displacing kerosene, also anecdotal evidence that improved lighting leads to increased sense of security, particularly for women – but studies are few

Of households with access to very small solar home systems in Rwanda, 45% said that indoor air quality had improved with access to the system, whereas no-one in controls said that indoor air quality had improved over the same period (Grimm et al. 2014). A Uganda study showed reductions in incidences of fires and burns amongst those with a small solar home system of 93% and 83% respectively, although there was no impact on self-reported health status (IDinsight & d.light, 2015). Other effects reported include reduced exposure to kerosene soot (Lumampao, 2004, micro-hydro, Philippines) and reduced eyestrain from poor-quality lighting (Cecelski, 2005, grid, Tunisia). Elsewhere, some studies find no significant difference in impact

between those with access to the solar home system and those without (Harsdorff and Bamanyaki, 2009).

There is some gender-differentiated information on self-reported incidences of respiratory illness. For instance, Banerjee et al (2011) in Nepal found that access to electricity from a micro-hydro system lowered loss of time through respiratory or gastric illnesses for women by 3 hours per month, compared to those without access to a system. In addition, Banerjee et al claim that women, in comparison to men, stay longer in a house exposed to kerosene lights and cooking stoves. Samad et al. (2013) found similar effects from access to solar home systems in Bangladesh: respiratory disease was reduced by 1.2% for women, and less for men. However, this could be attributable to the adoption of clean cooking technologies, rather than electrification, and it is unclear whether clean cooking was introduced specifically at the same time as SHS, or whether some people chose to get clean cooking. The findings on self-reported health and well-being impacts seem to be inconclusive.

Availability of lighting after dark is also often linked to women's safety and freedom of movement. For example, Standal and Winther (2016) observed that women in their research area of Bamiyan in Afghanistan were relatively free to move around. Many in the study attributed this to the availability of hand-held solar lanterns to help them tend to animals and carry out chores at night (supported by Khan and Azad, 2014, Bangladesh). Similarly, Nelson and Kuriakose (2017 refer to Panjanwani, 2005) also explain that women and their families benefit from dependable light, including street-lighting as it improves safety and wellbeing (e.g., reducing gender-based violence through improved street lighting; cutting indoor and outdoor air pollution through reduced use of kerosene; improving provision of clean water through boiling). In contrast, Bensch et al. (2012) in Senegal observed there was more reported crime against households with a SHS, as they tended to be wealthier.

Conclusion

Overall, it seems access to solar home systems and solar microgrids can bring important benefits to the lives of both women and men. However, there is significant variation in findings across studies and contexts, as well as a lack of gender-disaggregated findings, in particular studies which explore reasons behind differing experiences between women and men.

While there is limited evidence that access to solar home systems changes the nature of, or time spent on, domestic activities, there is some evidence to suggest that the clean, reliable lighting they provide gives greater flexibility, allowing tasks to be spread throughout the day and into the evening. Some studies find that women's workload increases with access to a solar home system, or that domestic and unpaid care work expands to fill the available time. This could be linked to socio-cultural expectations which keep women in traditional roles despite the introduction of electricity. However, others find that that leisure time and socialising in the evening increases.

The greatest time-related impacts, for women in particular, can be seen when the electricity system is powerful enough to enable to use of agricultural processing equipment (which reduces manual labour) and electric cooking appliances which eliminate the time spent on fuel collection. There is also an indication that access to water can play a particularly significant role in easing women's time burden.

Some patience is required. Historical studies show that the most significant results of electrification take time to emerge, sometimes an entire generation. It has also been shown that electricity access needs to be part of a broader strategy to enable women to spend their time on activities (education, earning an income for example) which will have direct and indirect impacts on socio-economic outcomes.

Findings on the impact of access to solar home systems on fuel expenditure is mixed. Some studies show that significant savings can be made once the system is paid off. Other studies stress that fuel-stacking means that households still spend on kerosene despite having access to clean, modern electricity. There is limited disaggregated data to indicate if and how this affects men and women differently.

While there is some evidence that solar home systems can support small businesses, such as phone charging and hairdressing, there is limited evidence of widespread, direct impact on asset accumulation of women or men's socio-economic status. Some other studies, particularly those looking at higher capacity electricity connections, find evidence of improved business opportunities, particularly for women, and increased opportunity to work outside the home. The impact potential seems to be dependent on the nature of economic activity in the region. Household-level electricity connections seem to have the greatest impact where non-agricultural economic activity is widespread. But aspects like access to markets and other business inputs and productive assets are also critical. Where economies are primarily agricultural, having sufficient power for water pumping, agricultural processing and cold storage is critical.

Earning an income does not necessarily contribute towards women's economic empowerment, unless women have the power to negotiate how their income is used. Studies show that, in many contexts, women's income is seen as a family asset, which can have very positive outcomes, for example for children, but makes it hard for women to build up longer term financial security and assets.

Equally, without the power to decide how their time is used, the opportunity to undertake additional economic activity and work longer hours into the night, runs the risk of adding pressure to the already heavy workload of women. Choice (including the choice to rest) is a critical element of empowerment.

Off grid electricity can enable the up-take of information and communication appliances such as TV, radio and mobile-phone which can, in turn, provide entertainment, information and educational content. A range of studies point to the role that television can play in influencing the attitudes and behaviour of both women and men, for example on subjects like family planning and women's rights. Mobile phones and radios were typically used before the household electricity connection arrived, but this can enable them to be charged more conveniently and used more frequently than before. From an empowerment point of view, it is important to establish who owns the appliance and decides how and when it is used.

There is little quantitative evidence available on how access to solar home systems and microgrid connections affects health and safety, even less that is gender-differentiated. This limited evidence is often linked to reduced kerosene use leading to improved indoor air quality, and lower risk of burns and fires. It can also be a result of an increased feeling of security because of electric light, particularly for women. Perceived well-being may not be a primary

concern for outcomes from a gender equality point of view, but we should not underestimate the importance of these factors to women's everyday lives.

Decentralised electricity may not lead directly to empowerment, but crucially, the literature suggests that the small amount of choice solar presents to women in how they carry out their daily tasks, how often, or where or when they socialise, can further contribute towards greater empowerment over time. Intra-household dynamics have proven to play a key role in mediating the benefits of decentralised electricity for women and men, as women are more likely to profit if they have adequate decision-making power and control over how they allocate their resources: particularly time and finances. This is influenced by the socio-cultural context and gender norms. Electricity can be considered as a contributing factor, within a broader web of practical, cultural, political, environmental and economic dynamics at the household, that leads to women's empowerment.