Electricity access empowers women through expansion of economic, physical, and mental spaces in Zambia

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Abstract

Expanding electricity access (Sustainable Development Goal (SDG) 7) and empowering women (SDG 5) are closely linked. Most studies quantifying the benefits of the former for women focus on their economic empowerment; however, if and how such access results in women's empowerment is best understood by examining the cultural context, norms, and gender roles in which that access occurs. For instance, time saved from the use of electric appliances may be used for productive engagements, but if gender roles restrict women from leaving the home or engaging in paid work, such benefits are not realized. Here, we delve deeper into the multi-faceted and context-specific concept of women's empowerment via 28 semi-structured interviews with Zambian women. We include households with and without electricity to understand women's subjective meaning of empowerment and how access to electricity may (dis) empower them. We analyze their responses using Deshmukh-Ranadive's (2005) *Spaces* approach to empowerment which categorizes an individual's spaces into physical, economic, political, socio-cultural, and mental space. We find that electricity access empowers women by expanding their economic and physical, along with mental, space. This occurs via paid opportunities outside the home using electrical appliances and women reporting greater economic independence, camaraderie, self-reliance, and agency as a result. Additionally, by asking women to define what empowerment means to them, we not only bolster the claim that electricity access empowers women both economically and socially, but also ensure future programs account for empowerment explicitly in their plans.

1. Introduction

Access to energy, electricity in particular, and women's empowerment are closely linked. Women are noted to benefit from access to electricity in several ways, such as improved health and indoor air quality from using better cookstoves [1], increased productivity and employment opportunities [2, 3, 4, 5, 6] and a reduction in fertility rates [4, 7]. At the community level, increased electricity access allows for streetlights and public spaces that create new opportunities for economic and social independence for women [1]. These benefits alone however may not result in women's empowerment as sociocultural norms, power relations within households, and hierarchical structures can prevent women from realizing them [8, 9]. For example, electricity access can create employment opportunities for women, but if women are not able to control financial resources, improve their bargaining power within the household, or improve their participation in key decisions, then those opportunities do not necessarily result in empowerment. Furthermore, if access to electricity leads to women allocating greater time to household work, then access may decrease the time for self-care, resulting in disempowerment.

Studies that focus specifically on whether and how electricity access impacts women's empowerment have used different approaches and specific indicators to measure several aspects of empowerment. For example, Matinga et al. [8] uses McCauley et al.'s [10] three tenets of energy justice, including distributive justice (costs/benefits), procedural justice (process) and recognition justice (ownership) to show that while both men and women in Nepal benefit from the use of electric appliances such as mobile phones, cookers, and televisions, there are several constraints to empowerment. These constraints were decisions about the placement of lights in the house which were not decided by the household members, but rather by the electrician. Such placement might not necessarily benefit women, particularly if it is not in the area of the house where they spend the majority of their time. Similarly, the use of mobile phones helped women stay connected with their family and friends, but men complained that mobile phones enabled women to have extra-marital affairs. Rosenberg et al. [9] in their mixed-methods study in India found that when a household gains access to electricity, even to appliances that would benefit women, intra-household power dynamics result in men continuing to control household affairs, including electricity use by women. Winther et al. [11] showed how men's influence over decisions as well as gender ideologies, norms and social positions resulted in gendered access. They suggested women's empowerment can only be achieved via their increased participation in energy programs at the operational, management, and ownership level.

A number of studies also focus specifically on women's economic empowerment as a result of electrification, in particular women being able to afford their own expenses [12], having more independence in how they run their businesses [13], and increased employment opportunities and income [2, 3, 14, 15].

The goal of this study is to better understand the concept of women's empowerment beyond just the economic aspect and more within the socio-cultural context and gender norms of Zambia, along with its relationship to electricity access. We do this by conducting 28 semi-structured

interviews in communities that either do not have access to electricity or were recently electrified. Using the Spaces Approach [16], described below, we examine what empowerment means to women in these communities and how electricity contributes to or erodes empowerment. Below we provide the country context, the theoretical framework used, and relate the empirical work in empowerment to the Spaces approach. In Section 2, we describe our methods and how we analyze our data. In section 3, we present the results followed by a discussion in section 4.

1.1. Zambia

Only 46.7 percent of the population in Zambia has access to electricity: 14.5 percent of the rural population and 85.7 percent of the urban population [17]. Zambia also experiences high gender inequality, ranking 131st out of 191 countries in Gender Inequality Index (GII) [18]. In recent years, the country has deployed several large-scale grid extensions and many mini and off-grid power technologies. The country's Rural Electrification Agency (REA) has set a goal of increasing electrification in rural areas to 51 percent by the year 2030 and has argued that such access contributes to better living standards [19]. Yet the extent to which these projects and REA's plan will benefit men and women differently (or at all) has not been examined. If access to electricity can indeed empower women, then large-scale electrification efforts should help Zambia progress toward both universal electricity access and gender equality. To understand why and how (dis) empowerment can take place, we examine here women's narratives of empowerment, and how their life and bargaining position within the household may change because of electricity access.

1.2. Measuring Empowerment: The Spaces approach

The concept of empowerment is multidimensional, and context-specific, and needs to elaborate what agency means within a cultural context. This could include reevaluating theories and concepts of social identities including that of men. Seminal works by Davis [20], Joseph [21], Hooks[22] Acker [23], and Ahmed [24] emphasize the need to have an intersectional lens to have a contextual understanding of women's struggles, which can be portrayed as a monolith. This is particularly important when understanding gender relations in the global South in a development context. The Eurocentric approach taken by scholars and practitioners may not be helpful to understand or explain the struggles of women in the global South [25]. Indeed, several empirical studies have noted the negative impacts of women's economic empowerment programs and interventions on their agency. The International Center for Research on Women (ICRW) noted that the unintended consequences of economic empowerment can result in poor health outcomes, increased time poverty, and an increase in gender-based violence among others [26]. In a qualitative study by Moonzwe Davis et al [27] in India, the authors note that health outcomes for women in Mumbai, India were based on women's reproductive status and argued that a single measure of empowerment might not be universally applicable and even less useful compared to measures that are defined contextually. Salia et al [28] studied the economic benefits of microfinancing for women in Ghana and noted that it was associated with conflict

among spouses, among other negative outcomes. These unintended consequences differ across countries as well. For example, Mason [29] in a cross-country study on measuring women's empowerment and domestic violence noted that women's employment was associated with an increase in domestic violence in India and Pakistan, but not in Thailand and the Philippines.

In this study, we use definitions by both Kabeer [30,31] and Narayan-Parker [32]. Kabeer [30,31] describes empowerment as the ability to make strategic life choices through a change, which involves a *process* (means through which the change takes place) and *agency* (the woman being an actor in the process), that moves a woman from a state of disempowerment to empowerment. Narayan-Parker [32] adds that empowerment also entails the expansion of a woman's freedom of choice and actions that help shape her life, leading to greater control over decisions and resources. Specifically, we use the Spaces Approach [16] to measure (dis) empowerment. In this approach, every individual has an allotment of *space*, which influences their capacity to act and their behavior both within the household and outside of it. Space could be physical, economic, socio-cultural, political, or mental. Of these, physical, economic, sociocultural, and mental spaces are relevant to the analysis of impacts at the household and community level. Political space refers to the political situation in the household as well as women's access to, control of, and participation in public offices locally, regionally, and nationally. Political space, while clearly important, falls outside the scope of this study.

According to Deshmukh-Ranadive [16], physical spaces refer to a woman's ownership and control of, and access to, her natal and marital houses, the spaces within them, personal mobility, as well as control over her body and its consumptive, productive, and reproductive functions. This space also includes space and land outside the house such as school or places of work. Within the context of this study, physical space refers to where electric appliances might be placed in the house, whether or not the woman in the household has the freedom to use those appliances, and the freedom a woman has to visit places outside her house.

Economic space in this approach is determined by the ownership of properties, assets, and income. It allows women to have more control over goods and services. Electricity access that creates employment opportunities for women represents an expansion of her economic space. If such employment involves working outside of her house, it indicates an expansion of her physical space as well. An increase in income for women resulting from access to electricity [2, 3, 14, 33, 34, 35] may provide an expansion in economic space. Burney et al [12], in their quantitative study of a distributed photovoltaic irrigation project in Benin, found that the project positively impacted women's empowerment by creating economic independence and thus expanded their economic space. The expansion of both economic and physical space has been possible in cases where women have been part of the electricity project itself. For example, Standal & Winther [15] found that traditional perspectives of female ability and decision-making were challenged when women engineers were included in the supply of electricity in Afghanistan. Similarly, de Groot et al [13] note that providing energy services in the informal food sector (where more women were employed) gave women control over how they ran their

enterprises, thus affecting their control and agency. Nevertheless, linkages between female entrepreneurship and empowerment in the context of electricity access in Zambia are not extensively researched.

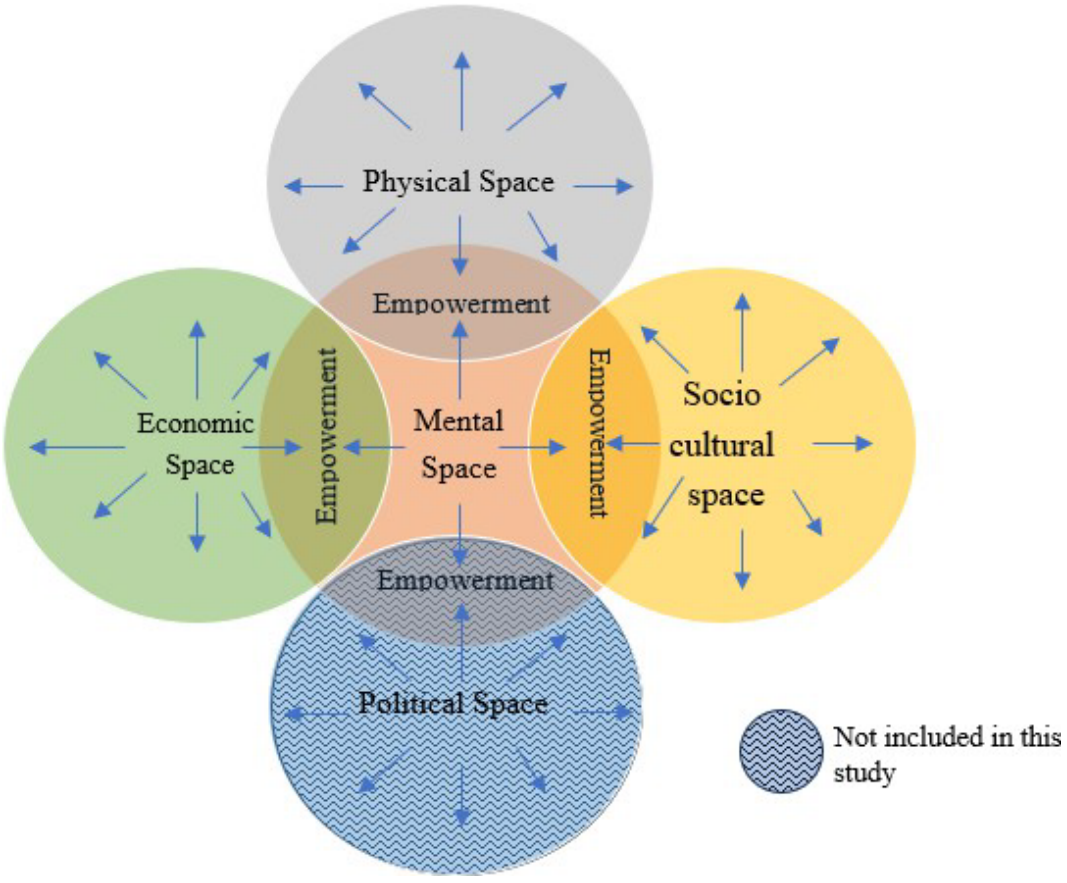
Deshmukh-Ranadive [16] refers to socio-cultural space as a person's position within kin-based hierarchies, which differ from culture to culture. A lack of power in this space can also determine how one benefits from electricity access. For example, Johnson et al. [24] analyzed a solar mini-grid in Zambia and found that electrification benefits were distributed between men and women based on socio-cultural practices and norms both in the household and in the community. Within the households and businesses, the electric appliances, when available and affordable, were used by the male members of the community. Business ownership and economic activities were dominated by male members as they are seen as the primary breadwinners. Thus, the appliances, habits, routines, and norms that contribute to energy culture differ along gender lines and economic status. The expansion of this space through electricity access and how one's position within the household affects expansion have not yet been studied.

Finally, mental space is described by Deshmukh-Ranadive [16] as the feeling of freedom that allows a person to think and act, allowing them to move away from restrictions and lead to a change in perceptions and a feeling of strength. Expansion in mental space can take place in one of two ways. The first is through collective power, where women mobilize their efforts, leading to greater confidence. While there is a lack of studies connecting women's collective action and empowerment to electricity access, all of the studies on empowerment mentioned earlier indicate an expansion in the mental space. The second expansion is through information. Information either through media or social groups helps women improve their self-esteem or change their attitude. Studies of empowerment outcomes from watching television [36, 37] is a good example. Jensen and Oster [36] note that the introduction of cable television can alter gender attitudes, finding significant increases in reported autonomy, decreases in the reported acceptability of beating, and decreases in reported son preference. Sievert [38] found that exposure to information through television led to lower acceptance of intimate partner violence in Sub-Saharan Africa. This literature suggests that women seeing other women in an elevated status on television leads to increased self-worth. Seidu et al [39] find that watching television enhances women's household decision-making in SSA. Expansion in mental space is a necessary condition for empowerment, and expansion in mental space and at least one other space indicates empowerment; see Figure 1 below. Disempowerment occurs when existing mental space shrinks due to various factors that reduce an individual's agency. While empowerment cannot take place without the expansion of mental space and at least one other space, disempowerment requires only the contraction of mental space.

1.3. Community-level expansion of spaces

The studies cited above provide examples of different spaces; however, community-level expansion of spaces has not been studied widely. Understanding community-level benefits from electrification is particularly important to understand the expansion of physical space. If women

158 view their visit to community spaces and buildings as a way to socialize or explore economic
159 opportunities, it can enhance their self-confidence and boost comradery. Their positive
160 experience and the freedom to access public spaces contributes to a feeling of empowerment. For
161 example, Wamukonya and Davis [40] noted that in Namibia, 87 percent of households that were
162 electrified felt safer at night. Similarly, Chaplin et al. [41] reported that access to electricity and
163 the streetlights it provides leads to increased perceptions of safety in communities including non-
164 connected households in Tanzania. However, Aklin et al [42] in their assessment of the
165 socioeconomic effects of solar microgrids in India found no effect on women's perceived need
166 for better lighting to improve safety. The reason for differences in these studies could be context-
167 specific and warrants further analysis. Within the context of electricity access, Osunmuviya and
168 Ahlborg [43] define empowerment as being able to make energy-related decisions and having
169 equal access and control over the resources necessary to access and use electricity. While several
170 impacts or outcomes of electricity access can be considered as indicators of empowerment, few
171 studies measure empowerment directly either quantitatively or qualitatively.



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173 **Figure 1***:* Authors' illustration of the *Spaces* Approach. As each space expands, the shared area
174 between mental space and other spaces indicates empowerment. (*Figure to be published in*
175 *color)*

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2. Methods

2.1. Study site, data collection, and COVID-related challenges

This study intended to include a larger sample of interviewees, i.e., over ~100 women, and travel to several remote areas in Zambia where new off-grid projects were in construction or being planned. However, vaccine availability was short in Zambia and the number of COVID-related deaths was high in country, particularly during the pandemic's second and third waves [44]. Consequently, the study was redesigned to allow data collection to be completed with the help of a non-governmental organization (NGO) named LiChi Community Solutions, (https://lightupzambia.org/) which has a successful record of providing off-grid solutions to rural villages in Zambia. We established a partnership with LiChi prior to this project. We also designed our data collection methods to involve minimal risks to field staff. The study was reviewed and determined to be exempt by our Institutional Review Board (ID: STUDY00006126).

For this study, we interviewed women from four provinces in Zambia and from households that did not have access to electricity or had been electrified in the past three years. The interview locations were Mwanambiye, Mufulo, Katuya, Mulobezi (Western Province), Lupiya village, Kabwe, Mufumwambe(Central Province), Lusaka (Lusaka Province), and Chingola, Chililabombwe, Miseshi (Copperbelt Province). Due to travel restrictions from COVID-19, some of the sites were chosen based on advice from local authorities. We also hired enumerators who were volunteers at LiChi to conduct interviews in English as well as in the local language. Here we report exclusively on the English interviews for analysis as recordings in the local language were done in remote areas with ambient disruptions and ultimately proved too difficult to transcribe and analyze.

We conducted 28 semi-structured interviews (14 of each rural and urban households) that included both quantitative and qualitative questions to analyze the five spaces introduced above. These consisted of warm-up questions (Section1), questions about the role of electricity in their lives (Section 2), questions on their thoughts about empowerment (Section 3), questions about their decision-making abilities in their household (Section 4) and a few demographic questions. (See Supplemental information for the interview guide). Of the 28 households, 14 households were connected to the grid, 4 households had off-grid electricity and 10 had no access to electricity. The quantitative data helped us to understand the use of electricity both in the household and at community buildings and places. The qualitative questions targeted social norms and human behavior, particularly women's perceptions of empowerment and their beliefs regarding the extent to which they feel empowered through electricity access and the expansion of their space. Three research questions (RQs) flowed directly from our literature review and the overarching objectives of this study:

RQ1. What are the impacts of electricity access to women in Zambia?

RQ2. What does empowerment mean to women in Zambia?

RQ3. Does electricity access and its impacts empower women?

2.2. Data Analysis

The qualitative responses obtained were analyzed in MAXQDA software using constant comparison analysis developed by Glaser and Strauss [45], which has been used to analyze qualitative data obtained through interviews and focus groups. There are three stages in this method. In Stage 1 (open coding), transcribed interviews were broken down into smaller segments, with a code attached to each segment. In this study, each of the topics or segments within the interview aligned with different types of everyday activities used in (*redacted for blind review*): 1: Cooking (Code Cooking), 2: Energy (Code Energy), 3: Care Work (Code Care), 4: Paid Work (Code Paid Work), 5: Entertainment Time (Code Radio/TV), 6: Decision-making (Code Decision). In Stage 2 (axial coding), we grouped the codes into categories. These categories included the impacts or benefits that respondents say resulted from electricity access. For example, if respondents say that they saved time from use of electrical appliances, it was coded as "time savings". In Stage 3 (Selective Coding), we categorized the codes from Stage 1 into one or more types of space. For example, we categorized decision-making under mental space, physical space, or economic space depending on the type of response. That is, if a woman can decide the amount she spends on self-care, then it is categorized under economic space since deciding to spend on self-care indicates a certain control over income. If that decision boosts her self-esteem, it is also categorized under mental space. The codes in each stage are compiled in Table S1 of Supplemental information section. We answer our RQs using the themes that emerged from this coding below. Finally, we conducted a mapping exercise in which we, via coding, mapped each area of activity to the impacts (and benefits) that our respondents indicated resulted from gaining access to electricity. We then applied the contextual meaning of these impacts to map them onto the spaces they expanded.

3. Results

3.1.RQ1: Impacts of electricity

Women in households with electricity spoke about the impacts they experienced, while women in households without electricity discussed perceived impacts or the impacts they observed in other households. About two-thirds of our sample were households with either grid electricity or off-grid systems with most of these households indicating a need to buy appliances such as electric stoves, space heaters, refrigerators, and irons. Urban women respondents indicated that their life was centered around electricity, which was in contrast with rural women respondents who had less reliable connections or lacked connectivity. Most of the women indicated that having access to electricity was beneficial, with one respondent focusing on the quality of the connection specifically. Nearly all women noted that they were responsible for cooking and caring for children and other members of the households, and therefore reflected on how electricity access would aid their roles.

Interviewees identified and highlighted six key positive impacts. The first was the time and effort saved from the use of appliances in cooking, which allowed women to avoid using charcoal, the use of which typically required more time. A 33-year-old woman who worked selling baby clothes identified *"…[electricity] will actually help me with this…because if I have a stove it's better than waking up trying to put up charcoal… that is the whole process and mind you I have children as well so [charcoal] is our last choice…".* Another woman, 27 years old, who was unmarried and unemployed spoke of how power outages sometimes impeded this benefit, *"…yes…it's convenient to just switch on the stove and put my food on and cook for the family, it's been very convenient for me (unintelligible). I think it's something that we take for granted, and the power goes off then, that's [the] only challenge, yeah yes, [cooking] has [changed] significantly…*". The respondents noted that electricity access helped them in not just saving time using appliances but allowed them to cook different types of foods. Yet the use of charcoal was still preferred due to the specific type of foods prepared, as explained by a 36-year-old married woman of 2 children working at a financial institution. *"…Of course, charcoal, yes, that is a decision you have to make depending on what you're cooking…"* , further adding *"…the more you use the stove, the more it (electricity) will be consumed by certain food stuffs like beans that take too long to cook…like…dry fish that take too long, these other things [I] would rather use charcoal, it will be cheaper…"* Our interview questions related to cooking and energy-related were asked separately, but respondents' answers often conflated these categories, since their energy needs were primarily, and in most instances solely, for cooking.

The second benefit included the business opportunities that became possible when households gained access. These opportunities allowed women to purchase larger appliances such as ovens and sewing machines, increasing their earning potential through home businesses. A 31-year-old woman, unemployed, but married with four children identified, *"…I can say it has helped me because where I am it's a stationary [sewing machine] and running a stationary you have to use electricity. Without electricity then we are doing nothing."* Another woman, a 27-year-old social worker, remarked how the lack of electricity increased her cost of food storage, *"…I don't have electricity, I don't have a fridge...I always have to ask people to keep for me and then I pay them something. But if I had electricity I would have my own fridge and it would help me, even things like maybe making fritters or scones, or [I'd] be able to make them faster…".* Business opportunities were discussed by respondents, both those employed and those not, indicating the need for additional income for the household or themselves. A 32-year-old early childhood teacher and a mother of two children noted that she owns a popcorn machine but cannot use it as she does not have an electric connection. A 37-year-old single woman and an English teacher highlighted the productivity gains from the use of electricity in her workplace. *"Where I work there is no electricity, when I have electricity…I can have enough time to do work, I can prepare lesson plans… [right now], I have to do lesson preparation during the day, I don't do much of IT work due to lack of electricity."* She also spoke of additional business opportunities that would bring in supplemental income: *"Like I said, I wasn't living here some 6 months ago. I have a popcorn machine, make popcorn and sell to kids at the school…now at this point 6 months ago I*

stopped because I didn't have electricity that came here which I can use to connect the popcorn machine…". She generalized this for women, saying, *"..if [women] have electric connection they have broader kind of businesses which they can do… Some women will go with selling fish, some kind of meat, relish, which can be refrigerated…".*

Women also spoke of children being able to study longer due to electric lighting. Not only did light prolong women's days, but they were also able to reallocate their time to more productive or enjoyable activities during the day and then study at night. The way children study changed with electricity. A 31-year-old, unemployed married woman with four children discussed the importance of electric lighting and television to her children's education: *"…my children are able to even watch from the TV what others are doing. When…we didn't have electricity they were not able to study, but currently right now as we have electricity in our house they are able to study anytime…".* A 26-year-old registered nurse and a single mother of 1 child who cohabitated with the child's nanny said that having lights helped her change her baby's diapers at night: *"…yeah, it does help in the care of the child…especially maybe in the night you don't have to start looking for a candle, you just turn on the lights and change the diaper…".* Another employed mother of 2 in her early thirties spoke of how she uses the internet to help her children with schoolwork, stressing the convenience that comes with electricity: *"… for example if it is a homework, my child may come with work that I don't fully understand, I need to get my laptop, go and google and access the information there, you need electricity"*

A fourth benefit, women remarked on the increase in their perceived safety due to lights in the community, especially in the streets. Women felt that their mobility increased during evenings. A 24-year-old self-employed and unmarried salon owner identified the positive impact of lighting the street. *"…[if] there's security lights …you can't be attacked by people at night…",* referring to the accessibility created by security lights. A 26-year-old registered nurse believed that the presence of lights in government buildings deterred theft, stating, *"…offices where they have electricity, theft is reduced…."* The 32-year-old early childhood teacher explained that the lack of lights in roads impacted her child-care decisions (including budgeting extra for care at home) since it was too dark outside to go to the hospital: *"…for example, if someone is sick in the middle of the night, we normally just make the first aid work for us because you can't take the patient to the hospital, it's dark and we can't go and we can't do certain things because it is dark."*

The fifth benefit that women shared was how electricity access in government offices, schools, health clinics and other public buildings made everyday services such as photocopying, printing, and scanning more accessible. A 27-year-old unmarried woman said, *"…Because in the world of today when you would want a document, if it is in softcopy, they just connect their printers, their computers, they print out and give it to you…".* Electricity access at schools was especially helpful for kids learning computer science, as explained by the 37-year-old English teacher and the inconvenience caused by the lack of electricity in the schools, particularly during exams: *"…In my zone, only 1 school has electricity, there are 9 schools that don't have electricity…it is*

difficult to teach some subjects like ICT (Information and Communication Technology)…so our pupils have to go to school that has ICT , where they do their practicals".

Finally, respondents identified the importance of electricity for public health. A 64-year-old woman said*, "living in a house with electricity, it's better than living with a candle. Because for example in the hospital if there is no electricity a lot of patients die, especially those who have who are on oxygen because there is no electricity."* The value of having electricity at health clinics and hospitals was reinforced by the 26-year-old single mother who worked as a registered nurse: *"…it does help, can be easily seen, because mostly people fall sick in the night… "* and adding, *"…you are able to store medicines, there are medicines which are not going keep at room temperature, you are supposed to freeze them, so electricity is important…"*. An employed, and married mother of 2 children in her early thirties noted that health services were faster, noting, *"It is faster to be attended… [because of computers and being checked-in]"*

3.2. RQ2. Meaning of Empowerment

Respondents were asked to define empowerment in their own words and determine whether having electricity helped them achieve empowerment as per their subjective definition. They were asked to reflect on their beliefs about women's empowerment and where needed, were provided the term for women's empowerment in their local language (*Ukukampusha banamayo* in Bemba). The definitions ranged from women having additional financial resources to having capabilities to be self-reliant. Analyzing these interviews specifically for terms commonly seen in empowerment literature, such as independence, agency, and freedom, we identified four themes that emerged from women's definition of empowerment. These included economic independence, camaraderie, self-reliance, and agency. The most common theme, economic independence, stemmed from women being able to engage in paid work as a pathway to becoming independent. For instance, the 24-year-old salon owner identified empowerment as, *"…simply [meaning] women getting involved into money generating activities, so they also become independent…"*. A 32-year-old diploma (in teaching) holder defined empowerment as, *"…women should totally involve themselves in activities which will help them to get money".*

The second theme, camaraderie, emerged as respondents explained that being part of organized groups such as cooperatives or informal groups with other women made them feel good and provided strength from sisterhood. A 27-year-old tertiary degree-holder described that being part of a woman's group helped them to rely on each other's strength, to be more involved*, "…You realize that nowadays people are put in groups that I would say cooperatives or other groups. Women would find themselves in groups where they're involved…".* A 26-year-old single teacher spoke of how she loves her job and the personal connections that make it enjoyable for her: *"..it helps to remember things and also to have connection with a lot of people, knowing them, and how they think, and how they do things".* Another 27-year-old single woman working at the bank talked of the sense of belonging and good times she experiences watching television while visiting her relatives, all of whom have electric connections and appliances.

The third theme, self-reliance, emerged from women discussing opportunities to do something on their own, particularly without their spouse. A married, employed woman stated that "*it's that women are able to do things on their own and be able to help themselves without really relying on someone or relying on their husband…".* A 27-year-old social worker stated that being empowered is being able *"…to help someone do something on their own…you know, independent, able to take care of their needs. So if I am in power, then at least I know that I can do some things for myself without having to ask relatives or neighbors…".* The 32-year-old early childhood teacher described empowerment as *"giving women the assistance they need to do things on their own, assist them in a way which you can help do things on their own".*

Finally, respondents discussed how agency was empowering. Separate from self-reliance, our respondents explained that agency emerged from having an additional strength or ability to bring about a change. For instance, a 36-year-old woman who was employed at a financial institution and married with two children, argued, *"I would say it's putting a woman in a position where she can, I think, sustain herself, she can stand, like, giving her uh capability, able to live this life, like, smoothly you know? Empowering…can be in terms of a business…can be financial empowerment and whatnot,…just putting a woman at that level of advantage …".* She described empowerment as the agency that comes with that additional strength to make an impact, from having decision-making capabilities and economic resources to have an impactful change for oneself *and* others. A 27-year old single woman who lived with her parents, siblings, and cousins and was employed at a bank supporting client services, reflected on agency via rights to resources and properties, stating that *"…women's empowerment means giving women opportunities…because when you look at history, you find that the men used to hunt and the women would just stay home preparing the food and looking after the kids but then at this stage now where it is modernized, the woman is now able to go to school, and finish, and work and also gets to enjoy the privilege of owning property, starting a business, just thriving as a woman and making money.* Another 34-year-old married woman with 4 children who was running her business as a fruits and vegetable seller said that she associates the word *help* with empowerment adding that it helps women move to a favorable state—*"..making them move from where they are".* This description, in particular can be related to the movement from the state of disempowerment to empowerment noted by Kabeer [20,21].

In comparing the respondents' definitions of empowerment, it is evident that women view economic resources as an enabler of agency. With additional income, or being employed, along with the capability to make their decisions regarding household expenditures, women expressed that they (would) feel empowered. Each of these themes as described by our respondents are indicative of the *change* that Kabeer [20,21] refers to as components of empowerment.

3.3.RQ3: Electricity access and Women's Empowerment

To answer our final research question, we mapped the four themes above onto different spaces to understand how electricity access contributed to women's empowerment. Our respondents were able to identify three main areas (spaces) of their lives that benefited directly from electricity

access and how those related to empowerment. The first was the expansion of their economic space. Owning and using electric appliances helped women generate income through businesses inside and outside the home. Our respondents considered small-scale business opportunities such as sewing, hair dressing, selling meat and chickens, all of which required electrical appliances. A 36-year old woman identified that "*we have tailors, we have hairdressers, because of this electricity we have people that are into production, like small-scale farmers…".* Another woman (unstated age) in a family of 6 said, *"if there's electricity in the area, women will be able to get their fridges, store their products. If, for example they are into [the] business of selling sausages, chickens, they'll be able to keep their chickens there and able to sell to their customers...".* An employed woman in her early thirties, and a mother of 2 children emphasized that running a business goes hand in hand with electricity access, stating, *"You cannot separate business from electricity".*

Secondly, having access to electricity saves time and allows women to reallocate time for other activities outside the home, be it for paid work, or for gathering or receiving healthcare at government buildings, churches and health clinics. As this creates an opportunity to explore the spaces outside their home, such as a clinic or place of worship, it is also an example of expansion in their physical space. A single mother of two children (age undeclared) identified the importance of electricity and being able to use health clinics with an electricity connection, *"…It has changed my experience because, for example, if someone is sick, is not breathing well, they should be able to use the oxygen and those use electricity."* Another spoke of going to the church and the power of electricity to literally amplify her voice, *"…In my place of worship there's electricity and I enjoy it because I love singing. When singing we use the microphones that are connected to the PA system, of course to the socket, so it has changed my life very much, like I said even when I'm standing in front of people the voice becomes so audible because I am using a microphone."* Singing, in this instance, may also be considered an expansion of a woman's mental space, which electricity facilitated by allowing the respondent to pursue an activity they enjoy. Being able to decide for themselves signaled a feeling of strength in our respondents. The expansion of mental space seemed to occur in two ways. First, electricity enabled women to make direct decisions on important matters such as diet and food expenditure. A 24-year old woman: "*Having electricity would definitely change the way we make decisions: decisions like diet and food expenses…"* Second, electricity helped women pursue activities that made them feel better about themselves, such as going to the market or church. This space expanded not only because of the time saved, but because of improvements in safety and increased business opportunities in community spaces such as the market. A 32-year-old diploma holder in teaching and food seller said*, "[with] electricity in the house you will find that even the activities concerning cooking it would be shortened and most of the time it would be spent to other activities like going to sell in the market*". The cascading effect of having the freedom to pursue activities that one enjoys that can be facilitated by electricity was summarized aptly by an employed and married mother of 2 children in her early thirties: *"..if you like dance like me, you*

need the radio to be on., it needs electricity. If you love movies, you need TV to be on…..Those are some forms of entertainment that depend on electricity."

For almost all of these respondents, their roles of cooking, gathering firewood/charcoal (energy-related), and care work were intertwined. During the conversations, they noted how having an electric stove would reduce their time in cooking and other energy-related activities and make their care work easier. Thus, reallocating their time from one activity to another is enabled through time-saving electric and electronic appliances. Lighting seems to have made a huge difference since they could start household work early, not wait until dawn and aid in business as noted by the 37-year-old English teacher*,"…Some women can be running shops, they can be selling, if we have electricity, this mean they can go up to 20:00 hours, someone is in the stand, but when is no electricity, it is not easy for them to sell in dark"*

Our interviews also provided important insights into how decisions regarding household expenditure were impacted by (the lack of) electricity. A 27-year-old single woman working at a bank explained that her food related decisions were dependent on the available appliances: *"…If I am buying vegetables, or if I am buying meat, I have to make sure I can refrigerate it. And if it is vegetable, I have to keep it fresh so I need to budget to see for how long to buy…".* This was also echoed by a 37-year-old single woman working as an English teacher and who also had off-grid electricity at her house. She talked about how her decisions regarding food were dependent on electricity access. She prioritized dried foods since fresh foods and meat need to be saved in a refrigerator, which she did not own. She explained, *"…you eat fresh foods only the day you buy, that's when you visit the market…limited in buying sausages, chickens, meat …we don't each such food. But when we have access to electricity, I will get myself a deep freezer, I can be buying chickens, sausages, fresh foods, fresh fish..".* Some respondents noted that electricity did not change their household decisions regarding expenses either because they weren't dependent on it for their activities or because they already owned an appliance. The 32-year-old early childhood teacher noted that she had not built her self-care around electricity since she doesn't have electricity and that it will not affect her self-care expenses but it would positively impact her should she be able to purchase an iron and hair dryer. Another example is the single mother of 1 infant child working as a nurse who did not expect much changes in her expenses since she already owns a fridge.

An employed mother of 2 children in her early thirties, who stated that she has never been without electricity, spoke of the multiple ways in which electricity is useful in her household. From appliances such as an electric geyser to heat water to how she uses the internet to help her children with schoolwork, stressing the convenience that comes with electricity: *"…I can quickly iron clothes for my kids, play some video games as a form of entertainment….or just switch on the TV and kids [are] able to watch while I am doing something".* In contrast to this was the experience of a 34-year-old married woman who sold fruits and vegetables. She mentioned that she used to have lights at her parents' home but in her married home, she spends a lot of time fetching firewood for cooking. She urged an electric stove would reduce that time.

While cognizant of our small sample, we situate this relationship between electricity access and empowerment in the context of Kabeer's [20,21] definition, where electricity access is the enabler of the *change* (a new job, time savings, pursuing an activity they enjoy, etc.) through which women feel empowered.

3.4. Mapping exercise

Figure 2 represents the results of the mapping exercise. We mapped the categories of activities to the impacts and/or benefits that the women described as directly resulting from the use of appliances in those activities as well as indirectly from saving or reallocating time. Having electricity access led to multiple impacts and benefits in some categories. For example, women were able to engage in paid work with the use of electricity, the revenue from which helped them buy other appliances. Thus, *Paid Work* maps to *Business Opportunities* and *Buying appliances.* Note that having access to electricity saved time in cooking and energy-related activities via use of appliances such as electric stoves and refrigerators. While the ownership of these appliances can indicate an expansion of economic space, the sense of freedom to use the saved time in another activity of their choice could also be viewed as an expansion of mental space. Recalling that the expansion in mental space is a condition for empowerment to take place, our respondents indicated that electricity access results in less drudgery and saves time resulting in their having the choice to use their time as needed. It thus expands their mental space along with economic space (through opportunities to engage in paid work or own appliances), or physical space (creating time for them to explore the spaces outside of their home), resulting in feelings of empowerment. An important conclusion is that the feeling of empowerment results in multiple ways (time savings and a reduction in drudgery), and in a non-linear fashion (time savings leading to time reallocation in an activity of their choice which then gives them the feeling of having power and strength).

4. Discussion

Women's empowerment is integral to achieving gender equality (SDG 5). In this study, we examined the relationship between women's empowerment and electricity access within the cultural context of Zambia. The unique aspect of this study is that we connect the impacts of electricity access to women's empowerment, while allowing our participants to define what empowerment means to them. We then used the Spaces approach to examine how electricity expands (or decreases) spaces. The interviewees in our study reported expansion in three spaces: economic, physical, and mental. Economic space was expanded via the pursuit of paid work opportunities inside and outside the home, made available by saved time in cooking. The additional income also allowed women to make decisions on household expenditures. Expansion in physical space occurred primarily via paid work and travel to government buildings, clinics, and church where the presence of electricity made a remarkable and positive change in their experience.

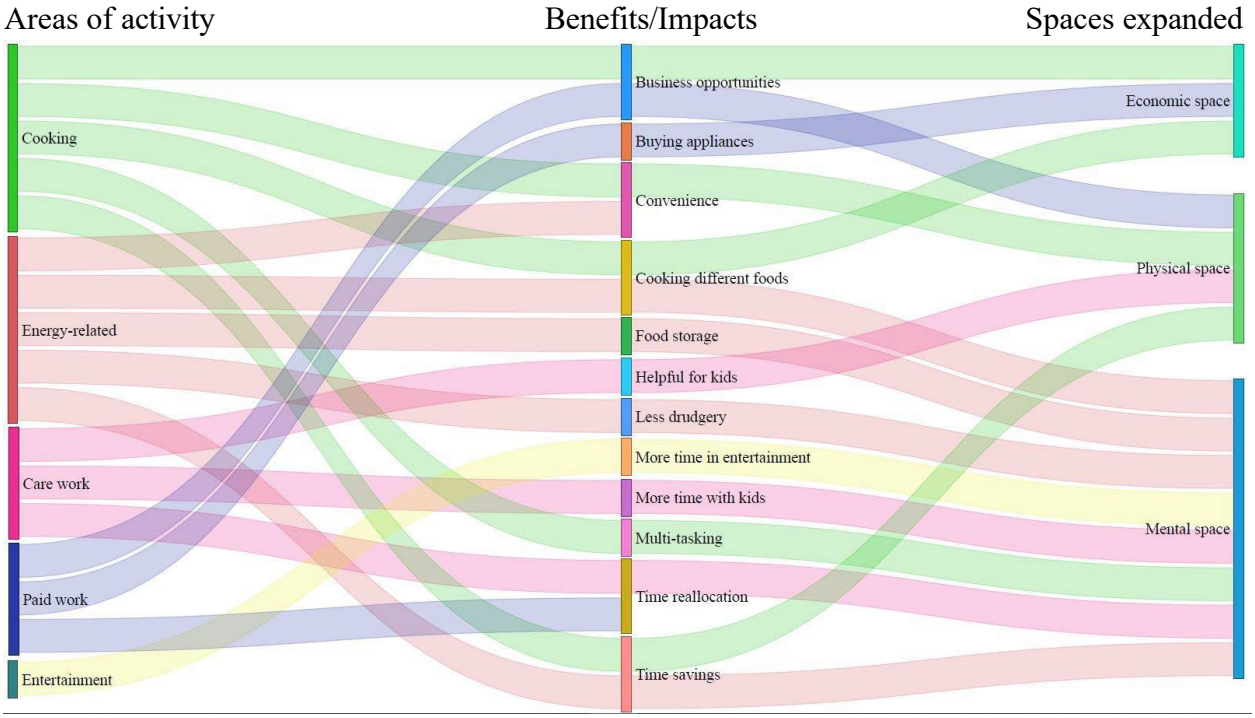

Figure 2: Mapping areas of activity (Column 1) to the spaces they expand (Column 3) via impacts of electricity (Column 2). (*Figure to be published in color).*

In each of these instances, women also reported increased economic independence, camaraderie, self-reliance, and agency, each representing an expansion of mental space. Thus, our results suggest that empowerment is a direct result of electricity access via the use of electrical appliances that save time, reduce drudgery and create opportunities for paid work inside and outside the home.

To understand these results within the context of Zambia, it is essential to highlight the gender norms that are part of its social structure. There are deep-rooted beliefs about girls belonging in the kitchen and these types of discriminatory practices have been identified as challenges to achieving gender equality [46]. The government of Zambia has responded by prioritizing women's empowerment via the Gender Equity and Equality Act No. 22 of 2015 and creating several programs such as microcredit schemes and girls' education programs. Electricity is crucial to both programs. However, the government also acknowledges that rural women might lose out on the benefits from information and communication technologies (ICT) due to a lack of necessary infrastructure [46]. In the households interviewed here, the off-grid technologies used most included (a small number of) solar photovoltaic panels, or inverters (Figure 3), many of which do not have enough capacity to provide the suite of benefits discussed by government officials. Reliability of these electric connections, which many women in our interviews stressed was crucial, play a direct role in the activities women engage in and the benefits from which they derive.

Figure 3 (Left to right): Rooftop solar panels, solar inverter, solar prepaid system, solar lights. *Photo credit: Enumerators*

Evaluating the impacts from electricity access to women using the Spaces approach highlights several opportunities for promoting women's empowerment. The first opportunity is to engage in paid work. Economic empowerment through opportunities outside of the home increase a woman's agency, mobility, and access to resources, and can help her gain economic independence. In other words, an expansion in multiple spaces. Having more disposable income would also allow households to get an electric connection if they don't have one since the high cost of connection has been noted as a barrier to having a grid connection in Zambia [47]. As Cohn and Blumberg [48] discuss, when women are engaged in key production activities, specifically activities that are valued and held important, they cannot be easily replaced. This results in strategic indispensability. Second, women's (non-economic) empowerment can be promoted indirectly by reducing drudgery and saving their time and effort in daily activities. The ability to decide for themselves as well as having access to important services outside of home boosts morale.

Our study identifies two components that are essential to achieving universal electricity access. First, contextual understanding of how access benefits women and promotes gender equality through their empowerment, and second, identifying the greatest area for scaling up electrification. Measuring empowerment focusing only on quantitative outcomes may or may not identify if a women's agency is improved. For example, if empowerment were to be measured as increased income for a woman, while ignoring her (lack of) decision-making capabilities within the household, it would be difficult to understand whether or not the income resulted in moving her from a disempowered to empowered state. Understanding and subsequently measuring empowerment that is context-specific will help evaluate if and how women are able to make strategic life choices. Within the context of electrification, our results suggest that having electricity access within and outside the household should result in women being and feeling empowered. Thus, electrification programs need to be tailored to ensure that women benefit not

just from having access within the household but also from viable opportunities to work outside the home that have been identified as having empowering potential by women and making public places accessible to women. This requires the development of complementary infrastructure such as roads or public sanitation, which might help households view the benefits as a bundle rather than focusing on electricity alone. Building roads can improve access to markets without which alternate income-generating activities may not be possible. Finally, and most importantly, programs must acknowledge the power of information. Sociocultural norms are at the heart of empowerment and evidence from the literature [36, 37, 49] shows that information through television and radio [50] can bring about dramatic changes in women's mental space. Thus, targeted efforts to disseminate information about issues such as women's rights and domestic violence should be added to development projects that currently focus solely on improving electricity access.

Finally, our study has limitations. First, our sample size was drastically reduced due to pandemic conditions. Studies that have shown notable outcomes in education, fertility, and empowerment typically have a large number of households (e.g., at least 5000 households) [41, 51] or have been analyzed several years following access [2, 48]; Second, partner relations are crucial to understanding women's agency within the household and beyond and thus play a key role in achieving empowerment. In our study, we focused on how women related their agency to having access to electricity and therefore did not examine how their agency is defined by their intrahousehold relationships. As such, questions were framed specifically to delve into interlinkages between empowerment and energy. The questions about women's ability to make household decisions regarding expenditure was an opportunity to explore their relationship with their partner, however, since our focus was limited to electricity access (or lack thereof), we did not follow up to make them feel uncomfortable. Should this study be expanded to use objective metrics to measure empowerment, this would be an important aspect to capture. Despite these limitations, however, the women's narratives collected here provide a rich cultural context in which to better understand how empowerment and electricity access are related in Zambia. Indeed, it remains one of the few studies to establish a direct connection between subjective definitions of women's empowerment and electricity access. The larger implication of these results is that since empowerment is subjective women benefit in other ways besides economic empowerment.

Supplemental information

Interview Guide

Introduction to interview

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Muli Shani (Hello in Bemba, a local language). My name is _____(Name of the volunteer). I am a volunteer with LiChi Community Solutions Ltd. Our founder is Likonge Makai Mulenga, who is an electrical engineer. We help bring electricity to communities like yours. I am here today to understand if and how access to electricity impacts women's lives. This interview is part of the research conducted by Ms. Sudha Kannan at Michigan State University in USA and Ms. Likonge Makai Mulenga at University of Tshwane. Are you willing to participate in this study?

Thank you for your willingness to participate in this study and share your story.

We will be conversing for about 30-45 minutes. We will be focusing on categories of everyday activities. If you are uncomfortable answering any question, please let me know. Also, if you would like to ask me any questions, please let me know. All information you provide today will be confidential and protected.

As I have to take notes of your experiences, it would be better to record our conversation. If you are not comfortable with it during our interview, I can turn it off. The taped audio will not be shared with anyone outside the research team. May I please have your permission to do so?

Semi-Structured Interview Questions

Section 1: Warm-Up Questions

Question ID	Question	Notes for the volunteer
1	Could you tell me how long have you lived in this town/village?	
2	Could you tell me a little bit about your family?	If our respondent doesn't give much details, ask the follow up questions
Follow up	2.1. Are you married? 2.2 Do you have children? 2.3 Are you employed? If yes, can you tell me more about your work?	

Question ID	Question	Notes for the volunteer

3	Do you have electricity in your home?	If respondent says Yes, please use Interview Guide A

		If respondent says No, please use Interview Guide B

Interview Guide A: For households with electric connection

Question ID	Question	Notes for the volunteer
4	What type of connection do you have?	If respondent says Grid or Off-Grid, have them describe the type of connection. For example, solar home systems, solar lights alone, etc.
5	Is the connection reliable?	If the respondent says that it is not reliable, go to the follow up question
Follow up	If it is not reliable, can you tell me more about why it isn't?	

Section 2: Role of Electricity in lives of women

Next, I would like to ask you questions about how electricity affects daily your daily activities. The first category is *Cooking*. Cooking refers to preparing, cooking food, boiling water and related activities.

Question ID	Question	Notes for the volunteer
5	Has the electric connection in your home benefited you in cooking?	If respondent says yes or no, have them describe it further
6	Has the time you spend in cooking changed because of an electric connection?	

Our next category relates to *Energy*. Please consider activities such as preparing fuel, collecting fuels, using space heaters, stove and using generators.

Question ID	Question	Notes for the volunteer
7	Has the electric connection in your home benefited you in the activities that I described?	If respondent says yes or no, have them describe it further
8	Has the time you spend in these activities	

	changed because of an electric connection?	

Next category is *Care Work*. Care work refers to the time spent caring for, attending to, or playing with/for younger children including helping children with school work.

Question ID	Question	Notes for the volunteer
9	Has the electric connection in your home benefited you in care work?	If respondent says yes or no, have them describe it further
10	Has the time you spend in these activities changed because of an electric connection?	

Next category is *Paid Work*. Paid work refers to working outside the home for pay or being involved in business at home

Question ID	Question	Notes for the volunteer
11	Has the electric connection in your home benefited you in paid work?	If respondent says yes or no, have them describe it further
12	Has the time you spend in paid work changed because of an electric connection?	

Next category is *Entertainment Time*. Please consider any time you spend watching television, listening to radio, or other activities for fun.

Question ID	Question	Notes for the volunteer
13	Do you get to enjoy watching television and/or listen to radio?	If the respondent says yes, ask question 14 If respondent says no, go to question 16
14	If yes, what type of shows do you watch on television or listen to on the radio?	
15	Has the time you spend watching television and listening to radio changed compared to other activities changed because of an electric connection?	
16	Can you share why you do not spend time in watching TV or listening to radio?	

Section 3: Empowerment

Next, I would like to get your thoughts on Ukukampusha banamayo (Empowerment in local language).

Question ID	Question	Notes for the volunteer
17	What does Ukukampusha banamayo mean to you?	
18	Do you think that electricity access contributes to Ukukampusha banamayo?	If the respondent doesn't answer much, please go to question 18.1
18.1	Do you think that electricity access contributes to Ukukampusha banamayo in each of the following activities? a. Cooking b. Energy-related activities c. Care work d. Paid work e. Entertainment time	
19	Does electricity disempower you? How so	

Section 4: Decision-Making in the household

I would now like to ask you a few questions about decisions you make in your household

Question ID	Question	Notes for the volunteer
20	Could you talk about how decisions about each of the following are made in your household? a. Diet & Food expenses b. Children's education & education expenses c. Health & health-related expenses d. Your self-care and related expenses e. Whether or not you take up a paid employment	Please have the respondent talk about each of the categories.
20.a	Has having electricity changed the way you make these decision?	

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	I am going to name a number of places, could you tell me if each of them has electricity and if that changes your experience there. a. Health Clinic b. Places where your relative live	

	c. Places of worship d. School e. Government offices f. Other community places	

Finally, can you please a couple of questions about yourself?

Question ID	Question	Notes for the volunteer
21	Could you please state your age in years?	
22	What is the highest level of education you've received?	(Don't list the options but suggest) - Primary - Secondary - High School - Some college - University

Thank you for your time, this interview has concluded.

Interview Guide B: Households with no electricity

Question ID	Question	Notes for the volunteer
4	Have you tried to get an electric connection?	If respondent says no, go to the follow up question
Follow up	Why haven't you tried to get a connection?	

Section 2: Role of Electricity in lives of women

Next, I would like to ask you questions about how you think electricity affects daily your daily. The first category is *Cooking*. Cooking refers to preparing, cooking food, boiling water and related activities.

Question ID	Question	Notes for the volunteer
5	Do you think that having an electric connection will affect your time spent in cooking?	If respondent says yes or no, have them describe it further
6	What cooking appliances would you like to purchase if you get a connection?	

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Our next category relates to *Energy*. Please consider activities such as preparing fuel, collecting fuels, using space heaters, stove and using generators.

Question ID	Question	Notes for the volunteer
7	Do you think that having an electric connection will affect your time spent in these activities?	If respondent says yes or no, have them describe it further
8	What appliances related to these activities would you like to purchase if you get a connection?	

Next category is *Care Work*. Care work refers to the time spent caring for, attending to, or playing with/for younger children including helping children with school work.

Question ID	Question	Notes for the volunteer
9	Do you think that having an electric connection will affect your time spent in these activities?	If respondent says yes or no, have them describe it further

Next category is *Paid Work*. Paid work refers to working outside the home for pay or being involved in business at home

Question ID	Question	Notes for the volunteer
10	Do you think that having an electric connection will help you in getting a paid work or starting your own business?	If respondent says yes or no, have them describe it further

Next category is *Entertainment Time*. Please consider any time you spend watching television, listening to radio, or other activities for fun.

Question ID	Question	Notes for the volunteer
11	Do you like to watch television or listen to the radio either in neighbor's home or elsewhere?	
12	Would you buy a TV or radio if you had an	

	electric connection?	

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723 Section 3: Empowerment

Next, I would like to get your thoughts on Ukukampusha banamayo (Empowerment in local language).

Question ID	Question	Notes for the volunteer
13	What does Ukukampusha banamayo mean to you?	
14	Do you think that electricity access contributes to Ukukampusha banamayo?	If the respondent doesn't answer much, please go to question 14.1
14.1	Do you think that electricity access contributes to Ukukampusha banamayo in each of the following activities? a. Cooking b. Energy-related activities c. Care work d. Paid work e. Entertainment time	

Section 4: Decision-Making in the household

I would now like to ask you a few questions about decisions you make in your household

Question ID	Question	Notes for the volunteer
15	Could you talk about how decisions about each of the following are made in your household? a. Diet & Food expenses b. Children's education & education expenses c. Health & health-related expenses d. Your self-care and related expenses e. Whether or not you take up a paid employment	Please have the respondent talk about each of the categories.
15.a	Do you think having electricity would change the way you make these decisions?	

	I am going to name a number of places, could you tell me if each of them has electricity and if that changes your experience there. a. Health Clinic b. Places where your relatives live	

	c. Places of worship d. School e. Government offices f. Other community places	

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Question ID	Question	Notes for the volunteer
16	Could you please state your age in years?	
17	What is the highest level of education you've received?	(Don't list the options but suggest) - Primary - Secondary - High School - Some college - University

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733 Thank you for your time, this interview has concluded.

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Table 1

Stage 1: Open codes	**Stage 2: Axial Codes**	**Stage 3: Selective Codes**
Cooking	Business opportunities	Economic space
Energy	Buying appliances	Physical space
Care	Convenience	Mental space
Paid Work	Food storage	Socio-cultural space
Radio/TV	More time with kids	Political space
Decision	Cooking different foods	
	Less drudgery	
	Helpful for kids	
	Time reallocation	
	Multi-tasking	
	More time in entertainment activities	

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Conflict of Interest

Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.