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Links between rural electrification and gendered off-farm employment in sub-Saharan Africa

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Abstract

We analyze the relationship between household electricity access and off-farm employment of women and men in rural Africa, using primary survey data from Kenya, Namibia, Tanzania, and Zambia. Estimating regression models, we find that access to electricity is positively associated with women's off-farm employment status, labor hours, and earnings. For men, access to electricity is significantly associated only with off-farm earnings. Further, we differentiate between the sources of electricity accessible to households and find gendered differences between grid electricity and off-grid solar home systems. While solar home systems are not significantly associated with any of the employment outcomes for men, they are positively and significantly associated with women's off-farm employment status and earnings. We explore differences in gendered time use between electrified and non-electrified households, and also analyze the main purposes of electricity use and perceived impacts on people’s lives to help explain the regression estimates. Our results suggest that electricity access and its sources have different implications for women’s and men’s daily routines and off-farm employment. The findings have relevance for policy, given that access to off-farm income is important not only for the wellbeing and resilience of rural households, but also for gender equity and female financial autonomy.

Keywords: gender; grid electricity; off-grid solar; rural Africa; rural jobs

JEL Codes: C21; C24; J21; J22; Q12; Q41

1. Introduction

Economic development in rural Africa is closely tied to diversifying livelihoods beyond subsistence agriculture. With limited employment options in agriculture alone, off-farm employment presents a crucial pathway for economic advancement and poverty reduction in rural communities. Off-farm jobs—such as in small-scale manufacturing, retail, and services—can increase household income and resilience, especially also against the backdrop of climate change (Hill & Porter, 2017; Azzarri & Signorelli, 2020; Mahmud & Riley, 2021; Musungu et al., 2024). However, in many parts of rural Africa, the growth of off-farm employment is hindered by inadequate infrastructure, including limited access to reliable electricity (Khandker et al., 2014; Asghar et al., 2022).

Nearly half of the population in sub-Saharan Africa (SSA) – around 600 million people – still lack access to electricity, while hundreds of millions rely on unreliable power sources (UNCTAD, 2023; European Commission, 2021). In rural areas, where access to reliable electricity is particularly limited, the type and quality of energy available can profoundly influence people's access to off-farm employment. Off-grid solar home systems, increasingly popular among rural households, have emerged as a flexible alternative in settings where grid expansion is challenging. The sales of small solar systems in SSA surged from under half a million in 2011 to 11.3 million in 2015 (Africa Progress Panel, 2016). SSA continues to lead the global market, accounting for about 70 percent of total solar home systems sales worldwide (GOGLA, 2019). Grid connections and solar solutions each have distinct advantages and limitations in supporting rural communities, but their specific socio-economic implications are, so far, not well understood.

In this paper, we examine how grid electricity and solar home systems relate to off-farm employment in different parts of SSA. Since previous research suggests that the impacts of electricity access are often not gender-neutral (Dinkelman, 2011; Grogan & Sadanand, 2013; Barron & Torero, 2014), we explicitly take a gendered perspective. Men and women experience unique barriers and opportunities in off-farm employment due to social norms, as well as differences in individual responsibilities and access to capital and other productive resources. For instance, electricity access may disrupt time allocation for women and men differently, given that women are typically more burdened with home production (including household chores, care work, etc.) than men. In areas where home production takes up much of women's time, introducing electricity can free up time, thus allowing women to participate in market production, including off-farm employment. Furthermore, introducing electricity in a community may spur economic activities and create new opportunities for women in the local context (Grogan & Sadanand, 2013). By examining the relationship between electricity sources, off-farm employment, and gender, we aim to offer new insights for more inclusive economic development.

Using primary data collected in 2023 from 2,663 households in rural regions of Kenya, Namibia, Tanzania, and Zambia, we contribute to the existing literature on the relationship between electricity access and rural employment in three ways. First, we add to the scarce literature on gender-disaggregated effects of electricity access on off-farm employment in rural SSA. Most existing studies on this topic focus on Asian and Latin American countries, with very limited evidence from SSA. Closest to our study is Dinkelman (2011) who analyzes the role of electricity for employment in South Africa. However, Dinkelman (2011) evaluates employment at the community level, whereas we use individual-level data. Second, existing studies mostly consider either grid or off-grid sources of electricity, whereas we include both and also compare the effects of grid electricity and off-grid solar systems. Very few studies consider both sources (Dasso & Fernandez, 2015; Peters & Sievert, 2016), and we are not aware of any that differentiates in terms of employment outcomes. Third, we use harmonized data from four countries, thus adding to the external validity of the findings.

The rest of this paper is organized as follows. Section 2 briefly discusses electricity in the context of SSA and provides a conceptual framework. Section 3 describes the study locations in the four countries, the household- and individual-level survey, and the statistical methods used for data analysis. Section 4 presents and discusses the results, while section 5 concludes.

2. Background and conceptual framework

2.1 Electricity access in sub-Saharan Africa

Electricity coverage in rural SSA is very low at about 30 percent (World Bank, 2024). This also applies to our four study countries. Electricity access rates in rural areas of Kenya, Namibia, Tanzania, and Zambia are 68%, 33%, 23%, and 15%, respectively (World Bank, 2024). The low electricity access rates in rural SSA are driven by supply and demand-side factors. Relevant supply side factors include insufficient financial capacity by providers to keep pace with population growth, sparsely distributed settlements, and low returns on grid electricity investments (Eberhard et al., 2008; Kirubi et al., 2009; Lee et al., 2016; IEA, 2023). Demand-side factors include the high price of household grid connections and electricity bills (Aliyu et al., 2013; Olatomiwa et al., 2015), as well as the lack of suitable housing structures for electrification (Ahlborg & Hammar, 2014).

Although SSA has the lowest electricity coverage in the world, significant progress has been made in recent years. The annual growth in the number of people with electricity access in Africa doubled from 9 million in the 2003-2010 period to 20 million in 2014-2018 (IEA, 2019). This growth has been particularly strong in East African countries like Kenya, Ethiopia, and Tanzania, which together accounted for over half of the people gaining electricity access during the mentioned periods (IEA, 2019). Since 2018, further progress has been made, with solar systems in particular gaining in importance. In 2022, more than half of the total growth in electricity access was attributable to solar home systems (IEA, 2023). In Kenya, Tanzania, and Zambia, solar home systems are often paired with energy-efficient appliances (LED lighting, mobile phone chargers, etc.), contributing significantly to affordable electricity access in rural areas. In Namibia, solar home systems are not yet as popular as in the other three study countries.

2.2 Conceptual framework

Electricity access may affect rural labor demand and supply through different channels (Kanagawa & Nakata, 2008; Dinkelman, 2011; Akpan et al., 2013; Rao, 2013; Salmon & Tanguy, 2016). We graphically illustrate possible supply-side channels in Figure 1. The primary use of electricity for rural households is lighting (Kohlin et al., 2011). Without electricity, people rely on traditional lighting sources, such as candles and kerosene lamps, which provide poor illumination and can cause eye strain and headaches (Jimenez, 2017; Lenz et al., 2017), often prompting people to go to bed early. In contrast, electric lighting offers brighter and more consistent illumination, effectively extending the hours available for household activities. This shift allows households to perform home tasks that require bright light in the evening, freeing up daytime for income-generating activities (Jimenez, 2017; He, 2019), thus increasing labor supply. Given women's greater involvement in home production, we hypothesize a stronger effect of electricity on women's than on men's labor supply. However, additional time may not always be used only for productive work but also for leisure activities such as watching television (Pereira et al., 2011) or spending time on mobile phones. Another channel through which electricity may affect time allocation is the use of electrical appliances, such as washing machines, refrigerators, or electric stoves, which increase the efficiency of home production and, similar to lightning, also free up day time for other activities.[1] Again, time savings may be channeled to productive uses such as employment (Greenwood et al., 2005; Blackden & Wodon, 2006). Because women are primarily responsible for household chores and care work, women's labor supply may also be more impacted than men's labor supply. However, we do not expect this channel through electrical household appliances to play a major role in the study areas, since the adoption of such appliances is still very limited.

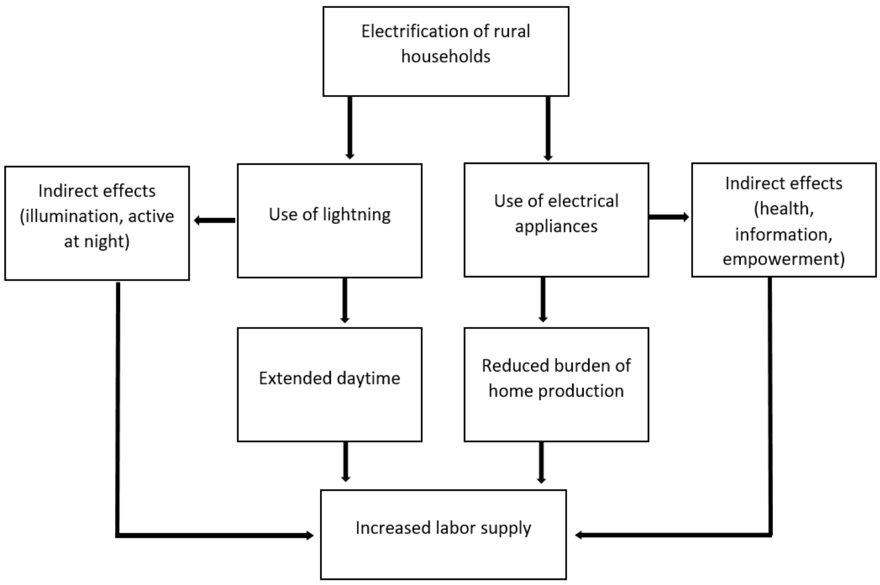

Figure 1: Channels through which rural electrification may affect labor supply

Source: Authors' illustration.

[1] For more details on models of time allocation and home production within the context of household electricity, see He (2019).

There are also indirect channels through which electricity can affect labor supply, such as health, information, and communication. Good health is important for participation in economic activities, and access to electricity reduces the adverse health effects of traditional energy sources, often related to exposure to indoor smoke (Spalding-Fecher & Matibe, 2003; Röllin et al., 2004). Electricity access also enables households to acquire information through television or mobile phones. Information and communication technology (ICT) can improve knowledge of labor market opportunities. This may be particularly relevant for women, who are often more constrained in terms of their physical mobility and access to information. More exposure to information and new opportunities for social exchange may enable and encourage women to seek employment outside their homes (Bullough et al., 2012; Shirazi, 2012; Samad & Zhang, 2019; Rajkhowa & Qaim, 2021).

On the demand side, possible positive labor market effects derive from electrified firms' increased productivity and profit. Such outcomes may generate new jobs and lead to higher wages. Yet, negative consequences are also possible, if electrified firms substitute labor-intensive inputs with electricity-intensive inputs. How electricity may affect the demand for female and male labor may differ, especially if there is job specialization by gender and certain firms are more likely to have access to electricity than others (Salmon & Tanguy, 2016). Explicitly isolating demand-side effects is beyond the scope of our paper.

3. Materials and methods

3.1 Study regions

We use primary survey data collected in Baringo county in Kenya, the Zambezi region in Namibia, the Iringa and Morogoro regions in Tanzania, and the Western province in Zambia. These regions host energy infrastructure and related projects, making them interesting contexts for analyses of electricity access and socio-economic implications. Apart from the Zambezi region, all other regions have a high prevalence of affordable solar home systems. These systems come in various packages and, depending on the provider, can include all or some of the following: small solar panels, batteries, portable chargeable lighting devices, (LED) light bulbs, charging devices for light bulbs and mobile phones, among others.

Although agriculture remains the primary source of livelihoods in our study regions, off-farm employment is also important. Income from off-farm employment accounts for about 30 percent of household total income on average (Mutsami et al., 2024). Self-employment is more prevalent than wage employment due to the scarcity of firms or other formal employers in rural areas. Self-employed people often own small shops or kiosks, selling different types of food and non-food items. Other self-employment activities include transport services, beauty services, earnings from collecting and selling forest products, etc. Wage employment often involves seasonal jobs in the agricultural sector on other farms. Other wage employment activities include jobs in the education, transport, health, public, and hospitality sectors, retail and beauty shops, maids, and security guards (Mutsami et al., 2024).

3.2 Survey data

We conducted an interview-based household survey in all four study countries between May and August 2023. Data were collected from 2,663 households from 182 enumeration areas (EAs). The selection of households followed a two-stage stratified random sampling process. First, we purposively selected EAs to cover a broad range of socio-economic conditions within the study regions. Second, within each of the EAs, villages and households were then selected randomly. The sample includes 703 households from Kenya, 652 from Namibia, 871 from Tanzania, and 437 from Zambia. Pooling the data from the different regions and countries with heterogeneous conditions allows us to gain broader insights into developments across rural SSA. The data for each country are representative for the selected regions but not for the countries as a whole, hence we do not interpret results at the country level.

In each sampled household, the person most knowledgeable about the household conditions, usually the household head, was identified and interviewed using a structured questionnaire. Respondents were asked to answer a series of questions about general household characteristics and the role, employment status, and income of each household member. In addition, the questionnaire included a module on individual-level time allocation over the last 24 hours, which two household adults, one man and one woman, were asked to answer separately, usually the main respondent and his/her spouse. These individual-level time allocation data play an important role in our gendered analysis.

For this study on links between electricity access and off-farm employment, we only use the subset of working-age individuals in the range of 15-64 years for whom time-allocation data are available. Furthermore, for consistency we only include those adults that are either the household head or the spouse of the head, as these roles come with responsibilities that are typically different from the roles of other household members. Thus, our sample includes 3,679 individuals, of which 2,104 are women and 1,575 are men. In a robustness check, we replicate the analysis for all working-age women and men in our sample, which produces similar results (see below).

3.3 Regression analysis

We estimate associations between electricity access and off-farm employment using regression models of the following type:

$$Y_i = \alpha_1 + \alpha_2 E_i + \alpha_3 \boldsymbol{X}_i + \varepsilon_i \quad (1)$$

where Y_i represents off-farm employment of individual i, E_i indicates whether or not i lives in a household with access to electricity, $\boldsymbol{X}_i$ is a vector of covariates, and ε_i is a random error term. The main parameter of interest is α_2, which indicates the association between electricity access and off-farm employment.

We use separate models to estimate associations of different types of electricity. In a first specification, we combine the different types of electricity and define E_i as a binary variable that takes a value of one if the household of individual i is either connected to the grid or uses solar home systems, and zero otherwise. In later specifications, we include two binary variables to estimate the associations of grid electricity and solar home systems separately.

We also use separate model specifications with different outcome variables to analyze various aspects of off-farm employment. In particular, we use three metrics, namely (i) off-farm employment status, (ii) off-farm monthly labor hours, and (iii) off-farm monthly earnings. Off-farm employment status is a binary variable that takes a value of one if the individual generated any income from wage employment and/or non-farm self-employment at the time of the survey, and zero otherwise. Off-fam labor hours and earnings are continuous variables capturing the time spent and income earned in off-farm wage employment and self-employment over a 30-day period. Data for off-farm labor hours were retrieved from the questions on the number of hours worked and calculated per month. Earnings were calculated depending on the specific activities of the individual. For longer-term wage employment, we recorded monthly wage rates. For short-term or seasonal employment, we recorded time periods and earnings over the last 12 months and calculated a monthly average. For self-employment in own businesses, we recorded the net income during the 30 days prior to the survey. For small businesses that are jointly run by different household members, allocation of net income to individuals is difficult. In these cases, we use the questions on incomes of individual household members from the general questionnaire part. Income data expressed in local currencies were converted to international dollars using purchasing power parity (PPP) exchange rates.[2] Due to extreme values at the right tail of the labor hours and earnings distributions, we winsorize these variables at 5 percent.

Many individuals in our sample are not involved in off-farm employment, meaning that Y_i in equation (1) has many zero values in both the binary and continuous specifications. We use the double hurdle (DH) model to deal with this issue (Cragg, 1971). The DH model is popular in analyzing labor supply (Blundell et al., 1987; Matshe & Young, 2004; Salmon & Tanguy, 2016). Alternatives such as ordinary least squares (OLS) ignore the censoring at zero, leading to biased and inconsistent estimates (Maddala, 1983). The Tobit model (Tobin, 1958)

[2] The 2017 PPP rate for each country was collected from the World Bank Open Database in Stata (*wbopendata*) written by Joao Pedro Azevedo. We use the World Bank formula to calculate the international dollars ((Individual earnings 2023/ (Consumer price index (CPI) 2023/CPI 2017))/PPP 2017. The CPI data are taken from the International Monetary Fund (IMF) available at https://data.imf.org/?sk=388DFA60-1D26-4ADE-B505-A05A558D9A42&sId=1479329132316.

considers censoring at zero but treats this issue as a standard corner solution, assuming that the zero observations are due to rational decisions or economic circumstances alone (Newman et al. 2003; Martinez-Espineira, 2006). This assumption of the Tobit model is restrictive and may lead to inconsistent estimates (Croppenstedt et al., 2003). In our analysis, we test for this assumption.

The DH assumes that the decision to participate in off-farm employment is separate from the decision on how much labor to supply or how much to earn from off-farm work. The DH framework conceptualizes off-farm labor supply (or earnings) as a two-stage process. In the first stage, individuals decide whether or not to participate in off-farm employment. If they choose to participate, the second stage determines their participation intensity. The censoring rule in the DH model is given by the following equations:

$$\begin{aligned} y_i &= y_i^*, \quad y_i^* \text{ if} > 0 \text{ and } D_i > 0 \\ y_i &= 0, \quad \text{otherwise} \\ D_i &= \boldsymbol{Z_i}\theta + e_i \\ y_i^* &= \boldsymbol{W_i}\beta + u_i \end{aligned} \qquad (2)$$

where y_i is the actual labor hours (or earnings) of individual i, and y_i^* is the corresponding latent value of individual $i's$ labor hours (earnings). D_i is a latent variable that describes the decision whether or not to participate in off-farm employment, and $\boldsymbol{Z_i}$ and $\boldsymbol{W_i}$ are vectors of explanatory variables, including access to electricity and other relevant socio-economic factors. $\boldsymbol{Z_i}$ and $\boldsymbol{W_i}$ may overlap but do not have to be identical. The DH model first uses a probit to estimate the first-stage censoring rule and then, in the second stage, estimates the truncated regression for off-farm labor hours (earnings), only using the non-censored subsample (del Saz-Salazar & Rausell-Köster, 2008). For our type of situation, the DH model produces more efficient and consistent estimates than OLS or Tobit alternatives (Yu et al., 2011).

3.4 Addressing possible endogeneity

To account for possible endogeneity due to non-random selection into electricity access based on observable characteristics, we use inverse probability weighting (IPW) in our regression analysis. IPW is a propensity score technique that adjusts for confounding and accounts for selection bias using weights (Chesnaye et al., 2022). It creates a pseudo-population without confounding by averaging individual observable heterogeneity across the treatment and control groups and the weighted average reflecting the actual population average (Robins et al., 2000). The IPW first uses a logistic regression model (treatment model) to generate the probability (propensity score) of receiving treatment— electricity access— observed for an individual, after which the predicted probabilities are used as weights in subsequent analysis (outcome model). The weights for the treatment group are calculated as 1/(propensity score), and for the control group as 1/(1- propensity score). In a post-estimation balance test for covariates, the IPW performed better than similar approaches, such as propensity score matching.

The weighted means of the treatment and control groups can be compared because there is no confounding by the measured covariates in the pseudo-population (Shiba & Kawahara, 2021). The treatment model regresses the treatment variable, i.e. electricity access, on observed covariates that could influence treatment participation. The included covariates should, ideally, reflect pre-treatment characteristics and not be an outcome of treatment participation. Since our data do not include questions on when households first had access to electricity and hence cannot clearly identify pre-treatment characteristics, we use variables that are time-invariant or at least unlikely to be influenced by electricity access. These variables include the individual's age and education, the household head's age and education, materials used for the walls and floors of the house, and local population densities (Bensch et al., 2011; Arraiz & Calero, 2015). To check for the robustness of our main results, we also include other (non-electricity related) infrastructure, like access to tarred roads and piped water, into the treatment model for IPW and as control variables in the DH model.

While we try to reduce endogeneity due to observed heterogeneity to the extent possible, we acknowledge that unobserved heterogeneity or reverse causality may be potentially remaining issues. This is why we interpret our estimates as associations and not as causally-identified effects.

3.5 Exploring possible mechanisms

In this study, we estimate associations between electricity access and off-farm employment without analyzing all the possible underlying mechanisms in detail. However, we carry out some exploratory analysis as plausibility checks. In particular, we use descriptive statistics to compare average time use data for various activities of women and men between households with and without electricity access, also differentiating by source of electricity.

We also leverage data on the households' main purposes of electricity use and on their own perceptions of electricity impacts. More specifically, household respondents in electrified households were asked for what purposes they use electricity, including lighting, heating and cooling, cooking, charging electronic devices, operating appliances, and running home entertainment devices. Further, electrified households were asked whether their life changed since they gained access to electricity, capturing whether they felt it made their daily tasks more convenient, allowed them to use modern appliances and technology, made communication and entertainment easier, made their work environment more productive and efficient, and/or improved their homes' safety and security.

4. Results

4.1 Descriptive statistics

Table 1 shows the characteristics of working-age women and men in our sample. About 20 percent of the women and 30 percent of the men generate some income through off-farm activities. For women engaged in off-farm employment, 73 percent are self-employed, and 28 percent are wage-employed. For their male counterparts, 57 percent are self-employed, and 44 percent are wage-employed. On average, women earn less than men in off-farm employment. The average monthly off-farm earnings of women are 192 international dollars, whereas men earn 229 international dollars. Yet, women also work fewer hours off-farm (132 hours) than men (151 hours). Tables A1 and A2 in the Appendix show further details, including descriptive statistics of household-level variables.

Table 1: Descriptive statistics

Variables	Women			Men		
	Mean	SD	N	Mean	SD	N
Age (years)	41.32	11.49	2104	44.50	10.42	1575
Has secondary/higher education (0/1)	0.33	0.47	2104	0.38	0.49	1575
Currently married (0/1)	0.77	0.42	2104	0.91	0.28	1575
Works off-farm (0/1)	0.20	0.40	2104	0.30	0.46	1575
Wage-employment (0/1)	0.28	0.45	413	0.44	0.50	477
Self-employed (0/1)	0.73	0.44	413	0.57	0.50	477
Off-farm monthly labor hours [a]	131.90	79.56	413	151.30	77.18	472
Off-farm monthly earnings [a] (int'l $)	191.64	152.65	397	229.26	157.41	450
Electricity access (0/1)	0.49	0.50	2104	0.51	0.50	1575
Access to grid electricity (0/1)	0.20	0.40	2104	0.21	0.41	1575
Access to solar home system (0/1)	0.29	0.45	2104	0.31	0.46	1575
Kenya (0/1)	0.27	0.45	2104	0.28	0.45	1575
Namibia (0/1)	0.23	0.42	2104	0.21	0.41	1575
Tanzania (0/1)	0.33	0.47	2104	0.35	0.48	1575
Zambia (0/1)	0.17	0.37	2104	0.16	0.37	1575

Notes: Working-age adults (15-64 years) are included. Off-farm labor hours and off-farm earnings are reported for only those with positive hours and earnings. SD, standard deviation; N, number of observations. [a] winsorized at 5 percent at the right tail.

Figure 2 shows the sectors in which different groups of women and men work, differentiating by household access to and sources of electricity. The agricultural sector includes work on other farms and employment in livestock herding or fish farming. The health, education, and public sectors include mostly longer-term public employment in these sectors. The travel, tourism, and recreation sectors include working in hotels, lodges, and conservancies. The food industry and retail sectors include working in shops, bars, and restaurants. The service sector includes a variety of services, such as welders, barbers, housemaids, security guards, and cleaners, among others. The natural resources sector includes collecting and selling firewood, charcoal, and other nature-derived products.

The upper part of Figure 2 shows that the food industry and retail sectors is the most important sector for women working off-farm in wage employment and self-employment. This is true in electrified and non-electrified households. However, in electrified households the share of women in this sector is larger. Almost 60 percent of the women in grid-electrified households are employed in the food industry and retailing, compared to about 40 percent in solar-electrified households (right figure panel). For the agricultural sector, the patterns are different: women in non-electrified households are more engaged in off-farm agricultural employment than women in electrified households. Within electrified households, women in solar-electrified households are more engaged in the agricultural sector than women in grid-electrified households. The lower part of Figure 2 shows that the food industry and retail sector is also the most important off-farm sector for men in electrified households (both grid and solar), but not in non-electrified households where other sectors – especially agriculture, travel and tourism, and services – are playing a larger role.

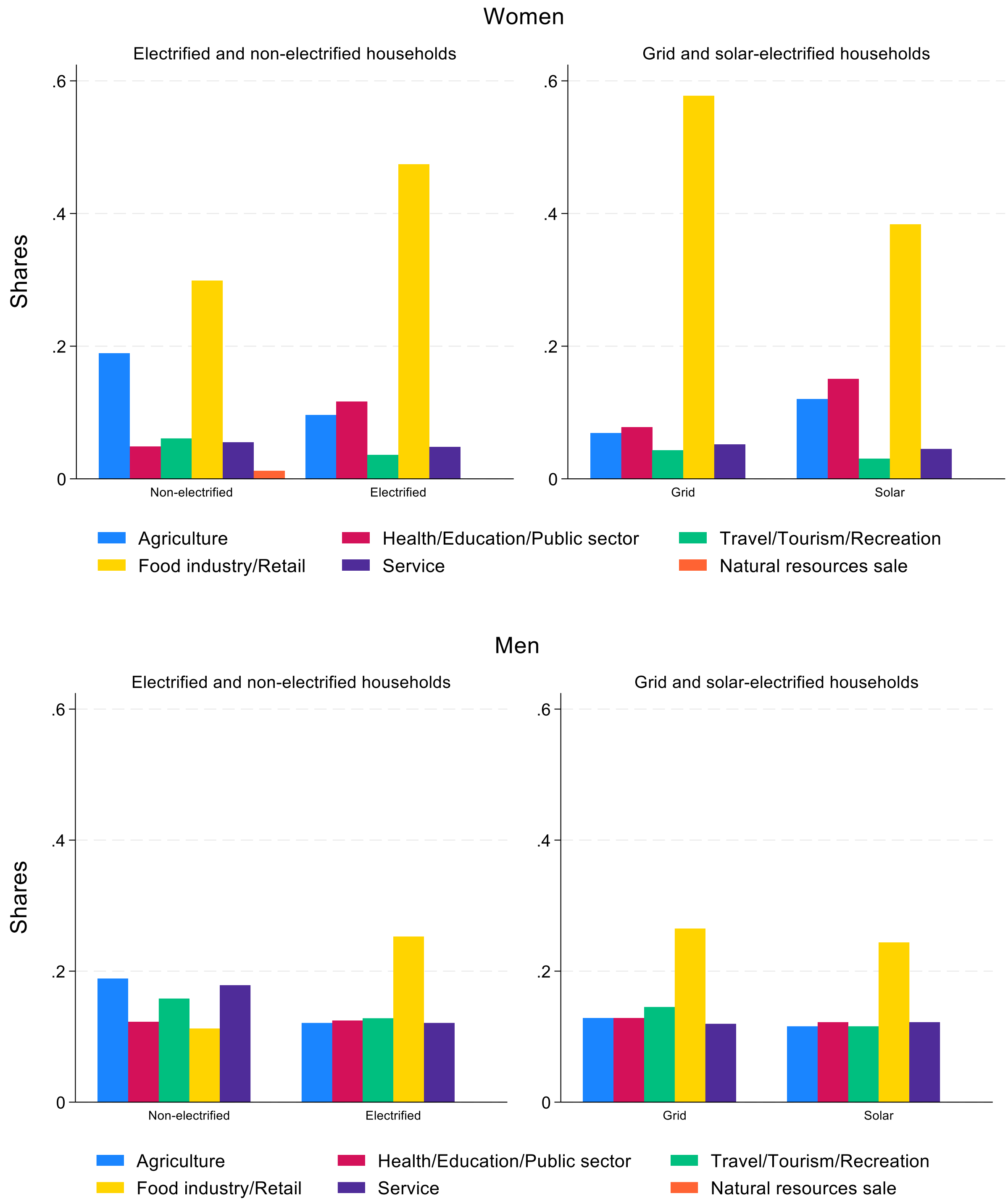

Figure 2: Off-farm employment sectors of women and men

Notes: The shares do not add up to one because individuals may be active in more than one sector. The shares are calculated as the number of women/men who stated to work in each sector divided by the total number of women/men in the sample. The number of women in electrified households is 249, in non-electrified households it is 164, in solar-electrified households it is 133, and in grid-electrified households it is 116. The number of men in electrified households is 281, in non-electrified households it is 196, in solar-electrified households it is 164, and in grid-electrified households it is 117.

4.2 Associations between electricity access and off-farm employment

We now present the regression results, first looking at the implications of electricity access in general (this subsection), and then differentiating further between grid electricity and solar home systems (next subsection). Table 2 shows the regression results based on the models in equation (1). We find a positive and statistically significant association between electricity access and off-farm employment status for women but not for men. The estimates suggest that electricity access is associated with a 6 percentage point higher likelihood of a woman being wage-employed or self-employed in off-farm activities. For men, the association is not statistically different from zero. In both models, for women and men, we cannot reject the null hypothesis that the covariates we included in the treatment model are balanced between those with and without electricity access (see Figure A1 in the Appendix for an overlap graph).

Table 3 shows the results of the DH model for the outcome variable, monthly labor hours. The first and third columns show the first-stage probit regressions, whereas the second and fourth columns show the second-stage truncated models. The truncated model results reveal that access to electricity is positively and significantly associated with women's labor hours, but not with men's labor hours. On average, women in electrified households work 23 hours more per month in off-farm activities than women in non-electrified households. Based on results from likelihood ratio tests (lower part of Table 3) we reject the null hypothesis that the Tobit model is appropriate, meaning that the DH model is preferred.

Table 4 shows the results of the DH model for monthly off-farm earnings. The first-stage probit regression results are similar to those in Table 3. The second-stage truncated model results show that access to electricity is positively and significantly associated with both women's and men's off-farm labor earnings. Both estimates are in a similar magnitude. On average, women and men in electrified households earn 74-77 dollars more per month than their counterparts in non-electrified households. Again, we reject the null hypothesis that the Tobit model is appropriate, implying that the DH model is preferred.

Table 2: Associations between electricity access and off-farm employment status (IPW)

Variables	Women	Men
Electricity access	0.058**	-0.003
	(0.026)	(0.033)
Age group	0.251***	0.294*
	(0.084)	(0.151)
Has secondary or higher education	-0.291*	0.637
	(0.153)	(0.451)
Head's age group [a]	-0.250***	-0.345**
	(0.071)	(0.155)
Head has secondary or higher education	-0.112	-0.904**
	(0.153)	(0.460)
Head is male	0.526***	0.550*
	(0.204)	(0.292)
Currently married	0.105	0.521***
	(0.202)	(0.184)
Floor material is cement/tiles	1.322***	1.294***
	(0.139)	(0.153)
Building has cement	1.234***	1.222***
	(0.199)	(0.207)
Population density at the region level	0.002	0.001
	(0.005)	(0.005)
chi2(10)	15.601	13.030
Prob >chi2 (covariates balance test) [b]	0.112	0.222
N	2104	1575

Notes: The dependent variable is a binary variable that takes a value of 1 if the individual is wage- or self-employed, and 0 otherwise. Marginal effect estimates are shown with standard errors clustered at the enumeration area level in parentheses. [a] Age is subdivided into five groups: 1=15-24 years, 2=25-34 years, 3=35-44, 4=45-54, 5=55-64 years. [b] The null hypothesis for the covariate test is that the covariates are balanced. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 3: Associations between electricity access and off-farm monthly labor hours (DH)

Variables	Women		Men	
	Probit	Truncated	Probit	Truncated
Electricity access		22.898**		7.904
		(10.607)		(9.109)
Age	0.032***	2.459	0.036***	4.442
	(0.006)	(4.257)	(0.008)	(4.393)
Age squared	-0.000***	-0.043	-0.000***	0.002
	(0.000)	(0.050)	(0.000)	(0.042)
Has secondary or higher education	0.117***	33.580**	0.249***	92.391***
	(0.032)	(13.594)	(0.094)	(25.088)
Currently married	-0.014	24.869	-0.122***	12.159
	(0.033)	(18.246)	(0.045)	(14.992)
Head's age	-0.004***	0.808	-0.014***	-4.611**
	(0.001)	(0.922)	(0.005)	(2.039)
Head is male	-0.070**	-18.946	0.112**	-9.195
	(0.034)	(19.096)	(0.050)	(18.991)
Head has secondary or higher education	0.097***	-8.079	-0.099	-85.020***
	(0.029)	(14.210)	(0.089)	(22.948)
Cropland size in hectares	-0.022***	1.938	-0.008	-0.952
	(0.006)	(3.055)	(0.006)	(2.503)
Number of livestock (TLU)	-0.001	0.238	0.001	0.302
	(0.001)	(0.670)	(0.001)	(0.430)
Household size	0.001	-3.630	-0.007	0.519
	(0.005)	(2.599)	(0.007)	(2.308)
Other HH members working (15+)	0.023**	1.861	0.034**	-1.865
	(0.010)	(4.822)	(0.014)	(4.913)
Number of under-5 children	-0.030**	-5.149	0.002	-10.589
	(0.012)	(7.977)	(0.015)	(6.502)
Country dummies	Yes	Yes	Yes	Yes
Log-likelihood	-953.748	-3303.408	-906.975	-2705.528
LR chi2(16)		97.027		159.997
Prob > chi2		0.000		0.000
N	2104	413	1575	472

Notes: The dependent variable is the number of hours worked per month in off-farm employment. The coefficients are average marginal effects. The double hurdle is estimated in two stages using a probit and truncated regression. Standard errors clustered at the enumeration area level are shown in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 4: Associations between electricity access and off-farm monthly earnings (DH)

Variables	Women		Men	
	Probit	Truncated	Probit	Truncated
Electricity access		76.877***		74.039***
		(23.401)		(22.922)
Age	0.032***	14.487	0.032***	22.161**
	(0.006)	(9.076)	(0.008)	(9.573)
Age squared	-0.000***	-0.167	-0.000***	-0.063
	(0.000)	(0.104)	(0.000)	(0.091)
Has secondary or higher education	0.108***	79.297***	0.240***	-158.851***
	(0.032)	(28.662)	(0.091)	(52.220)
Currently married	-0.026	14.355	-0.096**	62.061**
	(0.033)	(34.619)	(0.045)	(29.943)
Head's age	-0.004***	0.276	-0.012***	-13.883**
	(0.001)	(2.095)	(0.004)	(6.116)
Head is male	-0.046	-13.124	0.100**	-20.740
	(0.033)	(36.732)	(0.050)	(50.426)
Head has secondary or higher education	0.094***	36.547	-0.092	236.923***
	(0.030)	(30.360)	(0.086)	(55.614)
Cropland size in hectares	-0.021***	5.100	-0.004	11.745**
	(0.006)	(7.848)	(0.006)	(4.991)
Number of livestock (TLU)	-0.001	2.951***	0.000	2.331***
	(0.001)	(1.119)	(0.001)	(0.838)
Household size	-0.000	2.800	-0.007	2.368
	(0.005)	(5.059)	(0.007)	(4.964)
Other HH members working (15+)	0.018*	0.911	0.027*	-5.919
	(0.010)	(7.470)	(0.014)	(11.129)
Number of under-5 children	-0.029**	-2.642	-0.011	-8.378
	(0.012)	(15.235)	(0.015)	(13.422)
Country dummies	Yes	Yes	Yes	Yes
Log-likelihood	-934.745	-2447.178	-889.578	-2820.308
LR chi2(16)		33.776		82.380
Prob > chi2		0.006		0.000
N	2104	397	1575	450

Notes: The dependent variable is the monthly earnings from off-farm employment. The coefficients are average marginal effects. The double hurdle model is estimated in two stages using a probit and truncated regression. Standard errors clustered at the enumeration area level are shown in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

4.3 Grid electricity versus off-grid solar systems

Tables 5 and 6 show the estimates of the relationship between employment outcomes when we differentiate electricity access between grid electricity and solar home systems. The base group consists of those without any electricity access. The estimates in Table 5 reveal that grid and solar electricity are both positively and significantly associated with women's off-farm employment status. The magnitude of the association is similar for both types of electricity, namely around 8-9 percentage points. In contrast, neither grid electricity nor solar electricity are significantly associated with men's off-farm employment status.

For labor hours, women in households with access to grid electricity work 6 hours per month more in off-farm activities than women in households without electricity (Table 6). Also for men, we observe a positive and significant association between grid electricity access and off-farm labor hours. For solar electricity access, the associations with male and female off-farm labor hours are both statistically insignificant. The results in Table 6 further show that both types of electricity are positively and significantly associated with women's off-farm earnings, while for men, only grid electricity but not solar electricity is significantly associated with off-farm earnings. Overlap graphs for individuals with access to different sources of electricity are shown in Figure A2 in the Appendix.

Table 5: Associations between grid and solar electricity access and off-farm employment status (IPW)

Variables	Women	Men
Grid versus no electricity	0.080**	-0.060
	(0.037)	(0.047)
Solar versus no electricity	0.085**	-0.065
	(0.039)	(0.056)
Controls	Yes	Yes
N	2104	1575

Notes: The dependent variable is a binary variable that takes a value of 1 if the individual is wage- or self-employed, and 0 otherwise. Marginal effects are shown with standard errors clustered at the enumeration area level in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 6: Associations between grid and solar electricity access and off-farm labor hours and earnings (DH)

Variables	Off-farm labor hours		Off- farm earnings	
	Women	Men	Women	Men
Grid	6.004***	5.270*	13.830***	30.434***
	(2.146)	(3.003)	(4.275)	(6.343)
Solar	1.565	-0.045	8.086**	6.308
	(1.751)	(2.545)	(3.559)	(5.008)
Age	4.486***	6.650***	7.972***	12.081***
	(1.058)	(1.527)	(1.868)	(2.555)
Age squared	-0.051***	-0.047***	-0.087***	-0.080***
	(0.012)	(0.017)	(0.022)	(0.027)
Has secondary or higher education	20.541***	69.390***	32.076***	10.634
	(5.169)	(21.148)	(9.082)	(24.569)
Currently married	1.742	-14.518*	-3.005	-6.739
	(5.076)	(8.206)	(8.089)	(11.494)
Head's age	-0.418	-3.459***	-0.743*	-6.050***
	(0.272)	(0.740)	(0.383)	(1.098)
Head is male	-12.215**	15.443*	-10.445	19.920
	(6.021)	(8.724)	(7.994)	(12.781)
Head has secondary or higher education	11.235**	-35.997**	23.036***	29.326
	(4.404)	(15.597)	(8.005)	(27.090)
Cropland size in hectares	-2.624***	-1.428	-3.273*	1.356
	(0.930)	(1.206)	(1.735)	(1.910)
Number of livestock (TLU)	-0.018	0.176	0.315	0.674***
	(0.159)	(0.168)	(0.233)	(0.249)
Household size	-0.563	-0.938	0.204	-1.356
	(0.779)	(1.185)	(1.057)	(1.859)
Other HH members working (15+)	3.330**	4.825*	3.503	5.670
	(1.434)	(2.484)	(2.130)	(3.770)
Number of under-5 children	-4.570**	-2.155	-5.693*	-2.957
	(2.060)	(2.838)	(3.116)	(4.033)
Country dummies	Yes	Yes	Yes	Yes
N	2104	1575	2104	1575

Notes: The dependent variables for the first two columns are monthly labor hours in off-farm employment, and for the last two columns, monthly earnings from off-farm employment. The coefficients are average marginal effects. Only the second-stage truncated regressions from the double hurdle model are shown. Standard errors clustered at the enumeration area level are shown in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

4.4 Possible channels

We now explore some of the channels through which electricity access may influence off-farm employment, starting with a comparison of women's and men's daily time allocation to various activities in households with and without electricity access. These simple comparisons do not control for confounding factors but they can still provide some useful insights. The results in Table 7 show that women and men in electrified households spend significantly less time on household chores, eating and grooming, and resting and sleeping than their counterparts in non-electrified households. On the other hand, individuals in electrified households spend significantly more time on leisure and other activities such as studying, traveling, and religious activities. Women in electrified households also spend significantly more time in farm and off-farm activities than women in non-electrified households, while for men these differences are not statistically significant. These patterns are in line with the conceptual framework discussed above and with the regression results. We also differentiate the analysis by type of electricity source (Tables A3 and A4 in the Appendix).

Table 7: Time allocation to various activities in electrified and non-electrified households

Activities	Women			Men		
	Electricity access	No electricity access	Difference	Electricity access	No electricity access	Difference
Farm	1.953	1.423	0.530***	3.761	3.526	0.234
	(2.723)	(2.530)		(3.849)	(4.026)	
Off-farm	1.183	0.962	0.222*	2.353	2.022	0.331
	(2.790)	(2.312)		(4.030)	(3.582)	
HH chores	5.058	5.656	-0.598***	0.922	1.712	-0.789***
	(2.488)	(2.658)		(1.744)	(2.597)	
HH care work	0.759	0.847	-0.088	0.122	0.109	0.013
	(1.257)	(1.570)		(0.583)	(0.604)	
Leisure	1.492	0.846	0.646***	2.731	1.740	0.992***
	(1.958)	(1.547)		(2.735)	(2.491)	
Eating/ grooming	2.661	2.957	-0.295***	2.754	3.186	-0.432***
	(1.081)	(1.364)		(1.248)	(1.690)	
Resting/ sleeping	9.833	10.518	-0.685***	9.984	10.565	-0.580***
	(2.187)	(2.237)		(2.279)	(2.442)	
Others	0.873	0.521	0.351***	0.956	0.701	0.255***
	(1.602)	(1.261)		(1.716)	(1.575)	
N	906	966		635	643	

Notes: Mean values in hours per day are shown with standard deviations in parentheses. HH, household. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Knowing for what purposes households use electricity can also help to understand the observed links between electricity access and off-farm employment. Table 8 shows that households with access to grid electricity are significantly more likely than households with access to solar home systems to use electricity for lighting, heating and cooling, cooking, charging devices, operating appliances, and home entertainment. The largest differences are observed for operating appliances and charging devices.

We further examine to what extent people subjectively feel that electricity access improves their lives, as shown in Table 9. The most frequently mentioned positive impact of electricity is the higher convenience of daily tasks and technology use.[3] These positive impacts are mentioned more often among households with access to grid electricity than among households with solar systems. Some households also mentioned higher efficiency and productivity at work, again with a higher frequency among those with grid electricity access. These findings are in line with the results from the regression analysis in Table 6, suggesting that grid electricity has larger associations with off-farm employment outcomes than solar home systems, probably due to differences in power supply.

Table 8: Electricity use by type of electricity source

Electricity use	Grid	Solar	Difference
Lighting	0.992	0.960	0.032***
	(0.089)	(0.195)	
Heating and cooling	0.040	0.002	0.038***
	(0.196)	(0.043)	
Cooking	0.053	0.011	0.042***
	(0.224)	(0.105)	
Charging devices	0.790	0.558	0.232***
	(0.407)	(0.497)	
Operating appliances	0.375	0.079	0.296***
	(0.485)	(0.270)	
Home entertainment	0.243	0.077	0.165***
	(0.429)	(0.267)	
N	754	1084	

Notes: Proportions of households stating that they use electricity for a particular purpose are shown with standard deviations in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

[3] We did not specify technologies but let respondents self-define for their particular context. Apart from electric light, mobile phones and TV sets are the most commonly-used technology devices for which electricity is used in the local contexts.

Table 9: Perceived impact of electricity on households

Perceived impacts	Grid	Solar	Difference
Daily tasks more convenient	0.853	0.789	0.064***
	(0.355)	(0.408)	
Technology use	0.650	0.364	0.285***
	(0.477)	(0.481)	
Productive and efficient work	0.296	0.110	0.186***
	(0.457)	(0.313)	
Home safety and security	0.346	0.343	0.003
	(0.476)	(0.475)	
Others	0.019	0.011	0.007
	(0.135)	(0.105)	
N	754	1084	

Notes: Proportions of households agreeing with the statements that electricity access improves their life in terms of the specific categories are shown with standard deviations in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

4.5 Robustness checks

In this subsection, we report the results of two types of robustness checks that we carried out. First, we include other infrastructure accessible to the households, access to piped water, and availability of tarred roads close to the homestead into the IPW treatment model and DH truncated models, as there may be complementarities between electricity and other infrastructure components. Results are shown in Tables A5, A6, and A7 in the Appendix. The estimates in these alternative specifications are similar to our main results. Second, we run the IPW and DH models with the full sample of women and men aged 15-64 years, not only with the household heads and spouses included in the main analysis. These alternative results are shown in Tables A8, A9, and A10 in the Appendix.[4] Some of the coefficients are somewhat smaller in magnitude with this larger sample, but the signs and significance levels remain consistent. Overall, the robustness checks support the same conclusions.

4.6 Discussion

We find that access to electricity is positively associated with women's off-farm employment, off-farm labor hours, and off-farm earnings, whereas for men we only find a significant

[4] In the IPW treatment models with the full adult sample, we did not include marital status and population density because with these variables included the covariate balance test failed.

association with off-farm earnings. These results relate to the existing literature in different ways. The positive association between electricity access and female off-farm employment status is in line with the findings of Dinkelman (2011), Grogan and Sadanand (2013), Barron and Torero (2014), and Dasso and Fernandez (2015). A positive association between electricity access and women's off-farm earnings is also reported in Dasso and Fernandez (2015), but not in Dinkelman (2011), who finds that the wages of women were actually reduced with access to grid electricity. However, aligned with our findings, Dinkelman (2011) also shows that men's earnings tend to increase with access to grid electricity. For labor hours, we find a positive association with electricity access for women, but not for men. However, when differentiating between grid and solar electricity, we find that grid electricity is positively associated also with the labor hours of men. This is in line with Dinkelman (2011), Khandker et al. (2014), and Dasso and Fernandez (2015).

We expect that some of the differences between our findings and those from earlier studies are likely due to differences in the outcome variables considered and how exactly they are measured. While we focus on off-farm employment – defined as being engaged in income-generating activities outside of the own farming business but including work on other farms – other studies define employment either as earnings from all farm and off-farm activities (Dinkelman, 2011; Dasso & Fernandez, 2015) or earnings from non-agricultural activities (Barron & Torero, 2014). Furthermore, while we combine electricity access through the grid and solar home systems, most earlier studies focus only on electricity access through the grid.

Our findings in terms of different sources of electricity show that electricity from solar home systems is positively associated with women's off-farm employment and earnings but has no significant association with men's employment outcomes. We also find that households with access to the grid have relatively higher electricity use and perceive a larger positive impact on their lives. Combining these findings implies that solar home systems may be a lower-grade alternative to grid electricity but can still benefit rural households without grid access and may be useful for women's daily lives and off-farm employment in particular. In other words, our results suggest that solar home systems can contribute to closing the gender gap in terms of off-farm employment in rural Africa.

Our time-use analysis shows that women and men in electrified households spend more time on market production, such as farm and off-farm activities, and less time on household chores, care work, and other activities, such as resting, sleeping, eating, and grooming. While the use of time-saving electrical devices (e.g., electric stoves, washing machines, etc.) is not yet widespread in rural Africa, almost all households with electricity use electric lighting, which prolongs the day and thus increases the time available for off-farm activities. These findings are in line with Lenz et al. (2017). In their study in rural Guatemala, Grogan and Sadanand (2013) find that electricity access does not affect the time use of men, which is different from our results. The dissimilar findings may be due to different socio-economic and cultural contexts, including different gender roles.

5. Conclusion

Our paper contributes to the literature on electricity access and employment in rural SSA. We have studied gendered links between electricity access and rural off-farm employment, finding that electricity access is positively associated with women's off-farm employment, labor hours, and earnings. For men, we only find a significant association between electricity access and off-farm earnings. While access to grid electricity is positively associated with men's off-farm labor hours and earnings, access to solar home systems is not. In contrast, for women, both access to grid and solar electricity is positively associated with off-farm employment and earnings.

Our analysis has three limitations that may inspire follow-up research. First, with our data and approaches we have analyzed associations and not causally-identified effects. Second, due to data limitations, we have only considered access to electricity and not electricity quality or consumption levels. Including more details on electricity quality and use could possibly provide more granular insights into how the livelihoods of rural households change. Third, we have only looked at labor supply, which is a partial perspective, given that electricity access in rural regions may also influence local labor demand. Despite these limitations, we have added to the literature in terms of the regional context, using data from four countries in SSA and thus increasing external validity, and in terms of differentiating between different sources of electricity, namely grid electricity and solar home systems.

Rural SSA still has a lot of room for growth in electricity infrastructure. Access to grid electricity is likely more beneficial, but solar home systems are more affordable and can also be beneficial. Our data suggest that solar home systems can contribute positively to women's off-farm employment and earnings, thus possibly reducing gender disparities. Off-farm employment and income can be important mechanisms for women to strengthen their financial autonomy, often with positive effects on female empowerment and family welfare (Debela et al., 2021). We encourage the provision of affordable solar home systems to rural areas, especially in locations where grid connection is not feasible or unlikely to happen any time soon due to various constraints. Improving access to electricity can boost economic activity, but should not be misunderstood as a magic bullet to increase off-farm employment. Various efforts to support rural employment generation – including a strengthening or various infrastructure elements and rural institutions and services – are needed for effective rural poverty reduction, household resilience, and sustainable development.

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Appendix

Table A1: Description of variables

Variables	Question	Coding
Electricity access	What is the main power source of electricity?	1 if grid electricity or solar home systems are reported
Works off-farm	Was member employed in any job away from the own farm including its own business, in the last 12 months?	1 if yes and 0 if no
Wage employment	What is the type of employment?	1 if employee and 0 if otherwise
Self-employed	What is the type of employment?	1 if self-employed/own business and 0 if otherwise
Off-farm yearly labor hours	What is the number of hours worked?	Number reported
Off-farm monthly earnings (self-employed)	What is the approximate total income from the business operated by member in the last 30 days?	Number reported
Off-farm monthly earnings (wage- employed)	How much are you paid in a day/month, etc.?	Number reported
Age	How old are you?	Number reported
Education	What was the highest class/grade that member completed?	1 if secondary or higher education reported and 0 otherwise
Currently married	What is member's current marital status?	1 if married monogamously or polygamous and 0 otherwise
Cropland size in hectares	What is the size of your cropland?	Number reported
Number of livestock (TLU)	Number of livestock owned 12 months ago	Number reported and converted to tropical livestock units
Household size	Make a complete list of all individuals who normally live and eat their meals in this household (at least 3 months in the last 12 months).	The sum of members listed
Number members working (15+)	Is member employed or involved in any income-generating activities, including farming?	1 if yes and 0 if no
Floor material is cement/tiles=1	What is the major material of the floor?	1 if cement creed, ceramic, or other tiles are reported
Building has cement=1	What is the major construction material of the external wall?	1 if bricks, cement, or concrete are reported
Number of under-5 children	Make a complete list of all individuals who normally live and eat their meals in this household (at least 3 months in the last 12 months).	The sum of members below 5 years of age

Table A2: Household-level characteristics

Variables	Mean	SD	N
Head's age (years)	46.845	12.343	2248
Head is male (%)	0.738	-	2248
Head has secondary or higher education (%)	0.373	-	2248
Cropland size in hectares	1.709	2.232	2248
Number of livestock (TLU)	4.088	11.445	2248
Household size	5.477	2.417	2248
Number of HH members working (15-64 years)	0.366	0.846	2248
Floor material is cement/tiles (%)	0.301	-	2248
Building has cement (%)	0.158	-	2248
Has under-5 children (%)	0.479	-	2248
Number of under-5 children	1.368	0.613	1077
Others			
Population densities (population per square kilometer)	33.40	24.047	5

Notes: SD, standard deviations; N, number of observations. The number of households is smaller than the total number of sampled households, 2663, because we restrict our analysis to working-age household heads and spouse (15-64 years). Population density is at each country's regional level and retrieved from census data.

Table A3: Time allocation in grid- and non-electrified households

Activities	Women			Men		
	Solar electricity access	No electricity access	Difference	Solar electricity access	No electricity access	Difference
Farm	1.617	1.423	0.194	3.243	3.526	-0.283
	(2.642)	(2.530)		(3.690)	(4.026)	
Off-farm	1.588	0.962	0.626***	2.773	2.022	0.751**
	(3.251)	(2.312)		(4.407)	(3.582)	
HH chores	4.736	5.656	-0.920***	0.871	1.712	-0.840***
	(2.491)	(2.658)		(1.655)	(2.597)	
HH care work	0.703	0.847	-0.145*	0.116	0.109	0.008
	(1.271)	(1.570)		(0.484)	(0.604)	
Leisure	1.747	0.846	0.901***	2.831	1.740	1.092***
	(2.200)	(1.547)		(2.661)	(2.491)	
Eating/ grooming	2.801	2.957	-0.155**	2.831	3.186	-0.355***
	(1.240)	(1.364)		(1.458)	(1.690)	
Resting/sleeping	9.801	10.518	-0.717***	9.833	10.565	-0.731***
	(2.274)	(2.237)		(2.426)	(2.442)	
Others	0.803	0.521	0.281***	0.958	0.701	0.256**
	(1.500)	(1.261)		(1.780)	(1.575)	
N	375	966		249	643	

Notes: Mean values in terms of hours per day are shown with standard deviations in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table A4: Time allocation in solar- and non-electrified households

Activities	Women			Men		
	Solar electricity access	No electricity access	Difference	Solar electricity access	No electricity access	Difference
Farm	2.190	1.423	0.767***	4.095	3.526	0.568**
	(2.756)	(2.530)		(3.918)	(4.026)	
Off-farm	0.897	0.962	-0.064	2.082	2.022	0.060
	(2.374)	(2.312)		(3.748)	(3.582)	
HH chores	5.285	5.656	-0.371***	0.955	1.712	-0.757***
	(2.463)	(2.658)		(1.800)	(2.597)	
HH care work	0.799	0.847	-0.048	0.126	0.109	0.017
	(1.247)	(1.570)		(0.640)	(0.604)	
Leisure	1.312	0.846	0.466***	2.667	1.740	0.928***
	(1.747)	(1.547)		(2.784)	(2.491)	
Eating/ grooming	2.562	2.957	-0.394***	2.703	3.186	-0.482***
	(0.942)	(1.364)		(1.089)	(1.690)	
Resting/sleeping	9.856	10.518	-0.662***	10.082	10.565	-0.483***
	(2.126)	(2.237)		(2.177)	(2.442)	
Others	0.922	0.521	0.401***	0.955	0.701	0.253**
	(1.670)	(1.261)		(1.675)	(1.575)	
N	531	966		386	643	

Notes: Mean values in terms of hours per day are shown with standard deviations in parentheses. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table A5: Robustness check for off-farm employment, including additional infrastructure (IPW)

Variables	Women	Men
Electricity access	0.056**	0.006
	(0.027)	(0.034)
Age group	0.244***	0.355**
	(0.085)	(0.161)
Has secondary or higher education	-0.312**	0.648
	(0.154)	(0.456)
Head's age group	-0.247***	-0.412**
	(0.070)	(0.167)
Head has secondary or higher education	-0.073	-0.896*
	(0.153)	(0.458)
Head is male	0.558***	0.726**
	(0.203)	(0.291)
Currently married	0.122	0.564***
	(0.201)	(0.185)
Floor material is cement/tiles	1.303***	1.297***
	(0.139)	(0.154)
Building has cement	1.177***	1.131***
	(0.198)	(0.205)
Population density at the region level	0.004	0.004
	(0.005)	(0.005)
Access to piped water	0.652***	0.700***
	(0.144)	(0.160)
Access to tarred road	-0.435**	-0.340
	(0.205)	(0.231)
chi2(12)	13.255	17.481
Prob > chi2 (covariates balance test)	0.351	0.132
N	2104	1575

Notes: The dependent variable is a binary variable that takes a value of 1 if the individual is wage- or self-employed, and 0 otherwise. The null hypothesis for the covariate test is that the covariates are balanced. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table A6: Robustness check for off-farm monthly labor hours, including additional infrastructure (DH)

Variables	Women		Men	
	Probit	DH	Probit	DH
Electricity access		22.406**		6.377
		(10.336)		(9.066)
Access to piped water		3.133		9.954
		(13.141)		(11.160)
Access to tarred road		15.289		-2.073
		(11.932)		(12.653)
Age	0.032***	2.415	0.036***	4.640
	(0.006)	(4.177)	(0.008)	(4.384)
Age squared	-0.000***	-0.041	-0.000***	0.002
	(0.000)	(0.049)	(0.000)	(0.042)
Has secondary or higher education	0.117***	32.885**	0.249***	93.245***
	(0.032)	(13.848)	(0.094)	(25.257)
Currently married	-0.014	26.044	-0.122***	11.395
	(0.033)	(18.375)	(0.045)	(15.085)
Head's age	-0.004***	0.699	-0.014***	-4.796**
	(0.001)	(0.939)	(0.005)	(1.976)
Head is male	-0.070**	-19.268	0.112**	-6.749
	(0.034)	(19.084)	(0.050)	(18.926)
Head has secondary or higher education	0.097***	-9.624	-0.099	-85.310***
	(0.029)	(14.355)	(0.089)	(23.243)
Cropland size in hectares	-0.022***	1.633	-0.008	-0.943
	(0.006)	(3.122)	(0.006)	(2.474)
Number of livestock (TLU)	-0.001	0.281	0.001	0.331
	(0.001)	(0.659)	(0.001)	(0.427)
Household size	0.001	-3.627	-0.007	0.652
	(0.005)	(2.567)	(0.007)	(2.312)
Other HH members working (15+)	0.023**	2.597	0.034**	-1.624
	(0.010)	(4.781)	(0.014)	(4.830)
Number of < 5 children	-0.030**	-5.467	0.002	-10.360
	(0.012)	(7.942)	(0.015)	(6.393)
Country dummies	Yes	Yes	Yes	Yes
Log-likelihood	-953.748	-2348.814	-906.975	-2705.048
LR chi2(16)		93.486		159.590
Prob > chi2		0.000		0.000
N	2104	413	1575	472

Notes: The dependent variable is the number of hours worked per month in off-farm employment. The coefficients are average marginal effects. The double hurdle is done in two stages using a probit and truncated regression. Standard errors are shown in parentheses and are clustered at the enumeration area level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table A7: Robustness check for off-farm monthly earnings, including additional infrastructure (DH)

Variables	Women		Men	
	Probit	DH	Probit	DH
Electricity access		77.612***		69.688***
		(23.416)		(23.089)
Access to piped water		-8.133		13.747
		(22.753)		(23.886)
Access to tarred road		42.279*		26.348
		(22.399)		(18.316)
Age	0.032***	14.635	0.032***	20.239**
	(0.006)	(9.129)	(0.008)	(9.569)
Age squared	-0.000***	-0.166	-0.000***	-0.061
	(0.000)	(0.104)	(0.000)	(0.090)
Has secondary or higher education	0.108***	77.923***	0.240***	-149.532***
	(0.032)	(28.325)	(0.091)	(55.630)
Currently married	-0.026	18.352	-0.096**	62.278**
	(0.033)	(34.823)	(0.045)	(30.108)
Head's age	-0.004***	-0.087	-0.012***	-12.185*
	(0.001)	(2.108)	(0.004)	(6.334)
Head is male	-0.046	-14.364	0.100**	-25.634
	(0.033)	(37.228)	(0.050)	(53.662)
Head has secondary or higher education	0.094***	33.190	-0.092	225.776***
	(0.030)	(30.354)	(0.086)	(58.545)
Cropland size in hectares	-0.021***	4.368	-0.004	11.224**
	(0.006)	(8.197)	(0.006)	(4.915)
Number of livestock (TLU)	-0.001	2.951**	0.000	2.481***
	(0.001)	(1.168)	(0.001)	(0.830)
Household size	-0.000	2.561	-0.007	2.911
	(0.005)	(5.033)	(0.007)	(4.984)
Other HH members working (15+)	0.018*	2.915	0.027*	-5.394
	(0.010)	(7.518)	(0.014)	(11.052)
Number of <5 children	-0.029**	-3.718	-0.011	-8.467
	(0.012)	(15.304)	(0.015)	(13.568)
Country dummies	Yes	Yes	Yes	Yes
Log-likelihood	-934.745	-2445.607	-889.578	-2819.458
LR chi2(16)		31.758		82.089
Prob > chi2		0.011		0.000
N	2104	397	1575	450

Notes: The dependent variable is the monthly earnings from off-farm employment. The coefficients are average marginal effects. The double hurdle is done in two stages using a probit and truncated regression. Standard errors are shown in parentheses and are clustered at the enumeration area level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table A8: Robustness check for off-farm employment of all women and men (IPW)

Variables	Women	Men
Electricity access	0.035**	0.022
	(0.017)	(0.019)
Age group	0.027	0.044*
	(0.028)	(0.026)
Has secondary or higher education	-0.033	0.190
	(0.126)	(0.124)
Head's age group	-0.100**	-0.126***
	(0.042)	(0.043)
Head has secondary or higher education	-0.317**	-0.527***
	(0.131)	(0.164)
Head is male	0.511***	0.388***
	(0.120)	(0.147)
Floor material is cement/tiles	1.348***	1.160***
	(0.145)	(0.150)
Building has cement	1.234***	1.165***
	(0.248)	(0.224)
chi2(8)	11.982	12.714
Prob>chi2 (covariates balance test)	0.152	0.122
N	3695	3367

Notes: The dependent variable is a binary variable that takes a value of 1 if the individual is wage or self-employed, and 0 otherwise. Standard errors are in parenthesis and are clustered at the enumeration area level. The null hypothesis for the covariate test is that the covariates are balanced. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table A9: Robustness check for off-farm monthly labor hours for all women and men (DH)

Variables	Women		Men	
	Probit	DH	Probit	DH
Electricity access		16.522**		-1.184
		(7.365)		(6.675)
Age	0.034***	1.561	0.037***	-0.227
	(0.003)	(2.348)	(0.003)	(2.276)
Age squared	-0.000***	-0.020	-0.000***	0.002
	(0.000)	(0.029)	(0.000)	(0.028)
Has secondary or higher education	0.063***	19.741**	0.027	-13.707
	(0.017)	(9.369)	(0.018)	(9.979)
Currently married	-0.001	-9.914	0.025	9.339
	(0.016)	(9.505)	(0.021)	(10.817)
Head's age	-0.001***	-0.275	-0.001*	0.121
	(0.000)	(0.344)	(0.001)	(0.397)
Head is male	-0.058***	21.012**	-0.005	-0.774
	(0.017)	(9.797)	(0.019)	(9.041)
Head has secondary or higher education	0.069***	-2.397	0.060***	16.596
	(0.017)	(9.025)	(0.021)	(12.176)
Cropland size in hectares	-0.014***	2.953	-0.007*	-0.569
	(0.004)	(2.180)	(0.004)	(1.841)
Number of livestock (TLU)	0.000	0.021	-0.000	0.085
	(0.001)	(0.268)	(0.000)	(0.395)
Household size	-0.005	-2.093	-0.016***	0.411
	(0.003)	(1.867)	(0.004)	(1.560)
Other HH members working (15+)	0.010*	2.257	0.022***	-1.004
	(0.005)	(3.464)	(0.006)	(3.022)
Number of <5 children	-0.001	-1.576	0.014	-6.177
	(0.008)	(5.446)	(0.010)	(4.431)
Country dummies	Yes	Yes	Yes	Yes
Log-likelihood	-1260.171	-2787.731	-1335.038	-3315.879
LR chi2(16)		195.300		326.274
Prob > chi2		0.000		0.000
N	3695	504	336	599

Notes: The dependent variable is the number of hours worked per month in off-farm employment. The coefficients are average marginal effects. The double hurdle is done in two stages using a probit and truncated regression. Standard errors are shown in parentheses and are clustered at the enumeration area level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table A10: Robustness check for off-farm monthly earnings for all women and men (DH)

Variables	Women		Men	
	Probit	DH	Probit	DH
Electricity access		36.113***		25.527**
		(12.529)		(10.494)
Age	0.034***	12.030***	0.036***	3.064
	(0.003)	(3.377)	(0.003)	(3.048)
Age squared	-0.000***	-0.135***	-0.000***	-0.029
	(0.000)	(0.043)	(0.000)	(0.038)
Has secondary or higher education	0.062***	39.417***	0.020	16.129
	(0.016)	(11.344)	(0.019)	(15.812)
Currently married	-0.004	9.379	0.027	29.496**
	(0.016)	(15.494)	(0.020)	(12.344)
Head's age	-0.001***	-0.226	-0.001	0.041
	(0.000)	(0.544)	(0.001)	(0.543)
Head is male	-0.047***	-1.420	0.001	-29.180**
	(0.017)	(16.226)	(0.017)	(13.382)
Head has secondary or higher education	0.061***	24.491*	0.063***	21.240
	(0.017)	(13.399)	(0.021)	(17.424)
Cropland size in hectares	-0.015***	2.960	-0.006	3.290
	(0.004)	(4.368)	(0.004)	(2.322)
Number of livestock (TLU)	0.000	0.824	-0.000	1.052**
	(0.001)	(0.580)	(0.000)	(0.442)
Household size	-0.005	0.864	-0.015***	1.455
	(0.003)	(2.443)	(0.004)	(2.054)
Other HH members working (15+)	0.007	-3.180	0.017***	-2.347
	(0.005)	(4.793)	(0.006)	(4.469)
Number of < 5 children	-0.004	-1.743	0.005	-6.199
	(0.007)	(7.369)	(0.009)	(6.255)
Country dummies	Yes	Yes	Yes	Yes
Log-likelihood	-1227.703	-2781.677	-1303.160	-3303.531
LR chi2(16)		112.975		241.012
Prob > chi2		0.000		0.000
N	3695	483	3367	572

Notes: The dependent variable is the monthly earnings from off-farm employment. The coefficients are average marginal effects. The double hurdle is done in two stages using a probit and truncated regression. Standard errors are shown in parentheses and are clustered at the enumeration area level. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

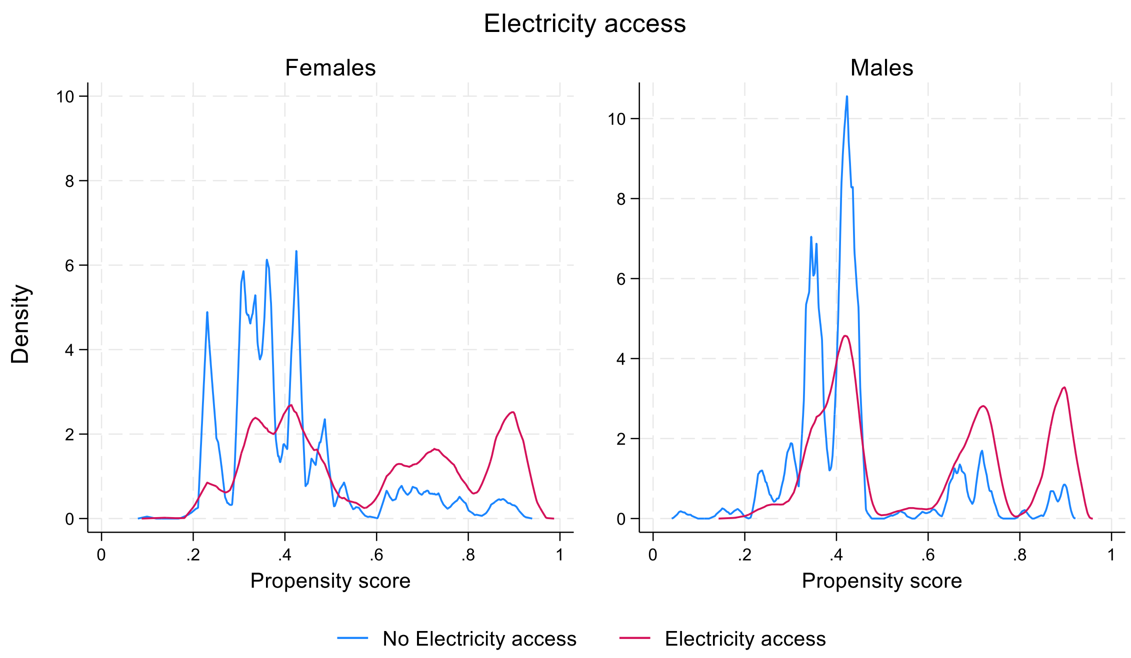

Figure A1: Overlap graph for electricity access

Notes: The covariates included are age, education, head's age and education, marital status, quality of floor, quality of wall, and population density.

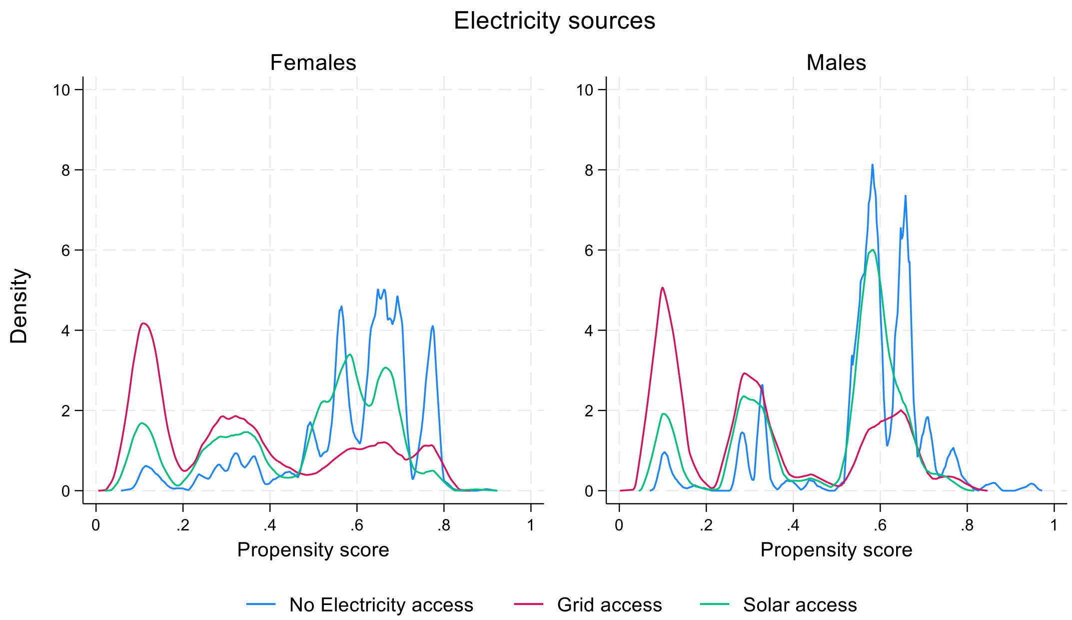

Figure A2: Overlap graph for electricity sources

Notes: The covariates included are age, education, head's age and education, marital status, quality of floor, quality of wall, and population density.