PNAS
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Supplementary Information for

Power Quality and Modern Energy for All

Veronica Jacome, Noah Klugman, Catherine Wolfram, Belinda Grunfeld, Duncan Callaway, and Isha Ray

Veronica Jacome
E-mail: v.jacome@berkeley.edu

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Supporting Information Text

Having a range of interview types and interviewees ensured that we captured a wide set of experiences and perceptions related to electricity access on the island. Thus, interviewees were purposively selected for broad representation. We identified participants from a variety of locations - regionally and within local communities - interviewing some households far from local roads, closer or farther to local transformers, those in apartment buildings, shared spaces, or single family homes. We identified wealthier residents and poorer residents by the types of homes (e.g. materials and structural stability) and types of neighborhoods (infrastructure build-up, density, closeness to markets, and businesses). Once inside the home, we took note of immovable furniture and other more expensive assets, and asked basic socio-economic related questions, to assess socioeconomic status. This range of interview selection and documentation of experiences led to saturation on key themes and informed our survey instrument.

We conducted surveys in sites A and B. The two sites were chosen because they have similar socioeconomic and geographical characteristics, and are located on different parts of the Unguja grid. Grid independence was important as it allowed for a robust set of results: a failure at one feeder level could not dominate the results. Furthermore, both sites can be considered peri-urban, neither part of the main urban hub on the island, nor strictly isolated (each site has a designated bus line, and is roughly equidistant to the nearest urban hub). Table S1 shows household and participant characteristics for each site. The participating households were classified into top, middle, and bottom thirds to represent socioeconomic levels. Each site contained roughly the same number of top-, middle-, and bottom-tier households. We placed households in these tiers by following the methods in Jacome and Ray (2018), incorporating education levels, job type and status, and household assets and building materials (1). For a more thorough discussion please see page 267 in (1). We note that because all our participants were connected to the main electric grid, even our low-tier group is not the poorest of the Zanzibari community; thus our groups are not representative of the lowest socioeconomic status on the island.

The survey instrument served as our source of information on the electricity and voltage problems, including the most severe ones, experienced by households. The full range of possible problems that respondents chose from was: not enough hours of electricity; low voltage problems; unpredictable interruptions; unexpectedly high bills; too expensive; do not trust the utility; power is not sufficient for the appliances I use; maintenance or service problems; unpredictable bills; no problems; other.

In Table S2 we compare all household and participant characteristics (for both sites A and B combined) to all of Zanzibar. All of Zanzibar statistics (under Zanzibar Total in the last column of Table S2) come from the 2014-2015 Household Budget Survey (HBS) (2). Our participants were found to be representative of Zanzibari residents, if not faring slightly better on most socioeconomic metrics, such as education, asset ownership, and employment. (Unemployment was higher in our sample because we incorporated working at home in this figure, while HBS separated it.) This representation is to be expected since HBS did not subset by those connected to the grid. Furthermore, because of this sampling difference, electricity appliance ownership data in HBS was much lower than ours. For example, 76 percent of households in our sample owned a TV, while HBS found just 53.3 percent. Therefore, we did not include Zanzibar Total information for electrical appliances. Nevertheless, our sample's appliance ownership figures are comparable to figures found in (1). Other statistics were not easily comparable, including age dependency ratio, and total employed and unemployed. HBS calculated the age dependency ratio as the number of people under 15 and over 64 divided by those between 15 and 64, while we calculated it as those under 18 and over 70 divided by those between 18 and 70. For employment, HBS included those that worked from home (roughly 22% of the population), while we did not specify. We believe lack of specificity is reflected in our higher unemployment rate. Lastly, HBS shows household ownership of many goods decreasing, sometimes drastically, from the 2009/2010 survey to the 2014/2015 survey. For example, in 2009/2010 53.9 percent of households owned a bicycle, while in 2014/2015 only 33.9 percent did. The 2014-2015 HBS report concludes that ownership of goods found in their survey is not always a reliable indicator of socioeconomic status, leading the authors of this paper to question the value of comparing some of these ownership figures.

For our power systems analysis, we assigned a per unit (PU) voltage to participating survey households based on the PU mean and first quartile (Q1) voltage measured at the closest sensor. PU mean was rounded up if the voltage captured at a sensor fell within the +/- 10% range - deemed acceptable by ZECO - for 90% of the time (or if the Q1 voltage was within the +/- 10% range). Otherwise, we rounded to the nearest .5 Volt. This choice in PU aggregation takes into account the range of voltage fluctuation at each sensor and the allowable voltage range set by ZECO.

Table S1. Household and Participant Characteristics For Site A and B

Subject Participants by Site	Site A	Site B
# of Households	76	75
# of Participants (>18 yrs)	222	183
Size of Household, avg.	5.6	5.5
# of Top-Tier Households	21	26
# of Middle-Tier Households	26	26
# of Bottom-Tier Households	29	23
Employment Type (%)		
Employed	54.5	55.2
Unemployed	32.88	24.04
Student	6.3	3.28
Head of Household		
Highest Education Level		
Primary I or II	30.6	30.2
Secondary I or II	51.4	41.3
University	2.8	3.2
No Formal Education (%)	15.3	24.2
Households Assets (%):		
Fridge	30.3	24.2
Freezer	26.3	26.7
TV	79	74.7
Sofa Couch	19.7	12
Motorcycle	13.2	13.3
Car	13.2	10.7
Bicycle	76.3	57.3
Iron (electrical and non-electric)	30.3	36

Table S2. Household and Participant Characteristics compared with all of Zanzibar

Subject	Participating Households by Socioeconomic Status				
	Top	Middle	Bottom	Sample Total	Zanzibar Total
By Residents	(n=208)	(n=236)	(n=272)	(n=716)	
Age of Residents, yrs , (%)					
<18	40	41.5	48.5	43.4	54.1 (< 20 yrs)
18-29	26	20.8	22.4	22.6	15.5 (20-29 yrs)
30- 49	25	19.1	23.0	22.6	19.8
50-69	9.1	8.1	9.9	9.1	9.5
$\geq$ 70	1	1.8	2.6	2.0	1.8
Age Dependency Ratio	63	71	95	77	86
By Participants (ages 18 and older)	(n=127)	(n=138)	(n=140)	(n=405)	
Sex					
Female	53	66	65	184	
Male	74	72	75	221	
Male to Female Ratio	1.4	1.1	1.2	1.2	.9 (all population)
Employment Type (%)					
Employed for wages	31.5	5.1	5.7	13.6	
Self-employed	43.3	55.8	40.7	46.7	
Total Employed (%)	75	61	46	60.7	53.9
Unemployed (%)	16	31	38	28	7.7
Retired	1.6	3	4	2.2	
Seeking	1.6	1.5	.7	1.2	
Disabled	0	0	.7	.3	
Student	31.3	8.0	3.6	14.3	13.9
Other	3.2	.7	3 .2	2.2	
Head of Household					
Highest Education Level					
Primary I or II	12.8	26.5	48.9	30.4	27.5
Secondary I or II	62.9	55.1	19.1	46.7	42.5
University	7.7	2	0	3	2.2
Masters	2.6	0	0	.7	NA
No Formal Education (%)	7.7	16.3	31.9	19.3	23.3
By Household	(N=47)	(N=52)	(N=52)	(N=151)	
Size of Household, avg., sd	5.5, 1.0	5.2, 1.1	5.5, 1.1	5.4	5.6
Number of Children, avg., sd	1.7, 1.3	1.9, 1.3	2.5, 1.5		
Households Assets (%):					
Fridge	28	29	19	25	
Freezer	40	25	15	17	
TV	79	79	71	76	
Computer	17	2.0	0.0	6.3	
Blender	32	44	17	33	
Motorcycle	17	17.3	5.8	13.3	7.1
Car	13.5	9.6	11.5	11.5	2.1
Bicycle	66	73.1	61.5	66.9	33.9
Iron (electrical and non-electric)	57	40	21	33	30.8

References

1. V Jacome, I Ray, The prepaid electric meter: Rights, relationships and reification in unguja, tanzania. *World Dev.* **105**, 262–272 (2018).
2. Govt. of Zanzibar, Zanzibar household budget survey 2014 2015. *Off. Chief Gov. Stat. Zanzibar* (2015).