Productive Use of Energy – PRODUSE

Micro-Enterprise Electricity Usage in Two Export-Oriented Fishing Communities at Lake Victoria, Uganda

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Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
P.O. Box 5180
65726 Eschborn, Germany
info@produse.org

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Sina Mabwa

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Productive Use of Energy – PRODUSE

Micro-Enterprise Electricity Usage in Two Export-Oriented Fishing Communities at Lake Victoria, Uganda

By Sven Neelsen and Jörg Peters[47]

Abstract

This paper aims to shed light on the nexus of electricity, firm performance and economic development in a dynamic rural area in Southern Uganda. Using quantitative firm-level data on 200 micro-enterprises complemented by qualitative case studies we find that newly-provided access to the grid increases the importance of electricity-using appliances and alters the sectoral distribution of economic activities. By contrast, we find no evidence for an expansionary effect of electrification on firm profits or worker remuneration. In fact, many entrepreneurs consider the direct gain from connecting to the grid to be small. Qualitative information, however, suggests that a positive indirect impact of electrification on firm performance is induced by the overall expansive effect electrification has on local demand. The demand increase can be partly assigned to people moving into the electrified community from surrounding non-electrified areas. We conclude that if productive energy promotion policies are put in place, they should address drawing up thorough business plans to enable local entrepreneurs to take informed connection and investment decisions.

1. Introduction

Decades of political turmoil and violent conflict have left Uganda as one of the poorest countries in the world. Since the early 1990s however, it is slowly, but steadily moving towards more peace and prosperity. An ambitious Structural Adjustment Programme sought to re-activate land, labour and capital for productive purposes and prudent fiscal and monetary policies have warranted moderate but constant economic growth and brought down inflation. Not least, the regulatory framework was liberalised to encourage private economic activity, foreign trade and investment.

This chapter aims to shed light on the nexus of electricity and mirco-enterprise performance in a dynamic rural area in Central Uganda. The non-primary sectors of two fishing communities, one with access to the electricity grid and one without, serve as the object of analysis. Both communities are fish landing sites at the shores of Lake Victoria with direct outlet channels to international markets. In summer 2008, we surveyed 200 micro-enterprises in these two regions using structured questionnaires. The information we obtained allows us to investigate the use of energy and its connection to firm structure and business performance. We complemented this initial more quantitative approach with three qualitative case studies of enterprises representing stylised firm types in the summer of 2009.

The remainder of this chapter is organised as follows: *Section 2* introduces our empirical strategy for measuring the effects of grid access on firm performance and discusses comparability issues that complicate the intended cross-sectional comparison of the two surveyed regions. *Section 3* describes the economic environment in the surveyed regions including the availability of infrastructure, micro-finance and Business Development Services (BDS). *Section 4* provides descriptive results on indicators for energy usage, firm structure and performance. We exemplify the role of electricity in three rural Ugandan enterprises by case studies presented in *Section 5* before *Section 6* concludes.

2. Empirical Strategy and Data

2.1. Sampling and Survey Design

In early 2008, two communities assumed to satisfy the comparability requirements set out in the overall PRODUSE methodology (*Chapter 2*) were identified in Central Uganda's Buikwe district. Both Kiyindi and Ssenyi are economically active fishing communities on the shores of Lake Victoria. Kiyindi, with some 4,000 inhabitants, was connected to the grid in 2002. In the following, it is therefore referred to as the *access region*.

47) The authors are grateful for valuable comments and suggestions by Benjamin Attigah, Lucius Mayer-Tasch and Kilian Reiche. They particularly thank Maya Hirsch for conducting the qualitative interviews.

Ssenyi currently has a population of approximately 3,000 and to date is not covered by the grid. Hence, we subsequently refer to it as the *non-access region*. The reliability of the electricity grid in the access region during the time of the survey was low. Due to load shedding schedules the grid is shut down every two days during evening hours. In addition, unannounced outages and voltage fluctuations decrease the quality of the electricity service. This lack of reliability has to be borne in mind when interpreting the results presented below.

For the initial structured interview survey carried out in August 2008, all enterprises operating in a permanent structure solely used for business purposes were included in the sampling population. This definition excluded home enterprises. No specific industries were over-sampled or omitted from the survey. Effectively, only micro-enterprises were surveyed, because no firms with more than 5 (permanent) employees existed in the surveyed regions at the time the study was carried out. To warrant representativeness, we applied stratified sampling with firm location as stratification criterion.

In the course of the initial survey a total of 228 firms were interviewed by six electrical engineering students of Makerere University, Kampala. The surveying was conducted under the supervision of one of the PRODUSE team members, who is also one of the authors of this chapter. After the discarding of incomplete questionnaires, 200 valid interviews remained, of which 99 came from the non-access and 101 from the access region. The structured interviews were complemented by qualitative interviews with key informants conducted by the field supervisor. Key informants included senior staff of the Ministry of Energy and Mineral Development as well as of the private utility UMEME, of the Association of Microfinance Institutions of Uganda (AMFIU), of the BDS providers Enterprise Uganda and the Business Uganda Development Scheme (BUDS). In addition, interviews were conducted with the Mukono district authorities and administration, local leaders and development practitioners with expertise in energy, microfinance and various other fields. Valuable information was also provided in informal conversations with the inhabitants and entrepreneurs of the survey-areas.

2.2. Treatment, Comparability Issues and Indicators

The study originally intended to follow a methodological approach that uses cross-sectional comparisons between areas with and without grid access to identify causal effects of electrification on, for example, firm performance (*Chapter 2, methodology*).

Under the restriction that the choice of locations for data collection was limited to sites of existing GIZ activities in the Ugandan energy sector, local researchers identified two fishing communities on Lake Victoria – one electrified and one non-electrified – that fulfilled the minimum methodological requirements of this empirical approach. Both communities are so-called *gazetted* landing sites. Because certain sanitary requirements are met in these sites, the fish landed here is permitted for export to the European and other international markets, creating large additional income opportunities for the local population.

During field work, however, it became evident that the income from fish trade in the non-access region was about one-fourth higher than in the access region. Therefore, and despite the prudent prior investigation through local researchers, the comparability of the access and the non-access regions turned out not to be fully satisfying from a methodological point of view. Because the two areas do not only differ in terms of access to electricity but also in terms of trade income, we cannot precisely distinguish the effects of one factor from that of the other.

The possible bias resulting from this issue likely differs between the different firm performance indicators in our analysis. It is easy to see that the desired ultimate impact indicator, firm profits, can be expected to be severely distorted. With the fishery sector forming the main source of income in both regions, the higher volume of fish trade and thus purchasing power in the non-access area most likely leads to higher firm revenues and, ultimately, higher profits across the entire local economy. In such a scenario, it is hardly possible to disentangle the effects of electricity access and higher fishing revenues. While we nevertheless provide descriptive statistics on firm profits and employment, it is therefore difficult to derive robust insights on firm performance and direct income generation from our results.

There are, however, intermediate effects of electrification that can be expected to be not substantially distorted by the different income levels in the two regions: in particular, it is frequently expected that the structure of the local economy changes in the wake of electrification. We focus on three outcomes to proxy potential structural change: the patterns of capital usage, the sectoral distribution of economic activity and the variety of goods sold. Upon access to the grid we expect an increased importance of electricity using machinery and equipment and an increased relevance of the service sector. These indicators are examined by comparing, firstly, the regions, secondly, connected and non-connected firms and, thirdly, users and non-users of decentralised electricity.

Given the comparability problems making the quantitative impact assessment difficult, we complement the quantitative analysis by a supplementary qualitative inspection of stylised firm types. These case studies provide examples for typical patterns of electricity usage that range from a carpentry firm that considers a grid connection not profitable to a comparatively large fish production site that critically depends on electricity use.

3. Economic Conditions in the Surveyed Area

The survey regions, situated on the shoreline of Lake Victoria, have greatly benefited from political reform and economic expansion in Uganda in recent years. Lake Victoria today is the single most important source of freshwater fish in the world. The value chain connects the survey region to global markets. The fish is caught on a small scale by local fishermen, immediately reloaded to trucks coming from Ugandan urban centres and cooled by crushed ice. Processing the fish next to the fishing sites is only possible with electricity (except for dried, of course, which is more targeted for the local market, however). If the capacity of the arriving trucks is not sufficient to pick up the catch of the day, the remaining fish rots before it can be transported away. Albeit only a small share of the income created in the Ugandan fishery sector trickles down to the starting point of the value chains, this share is large enough to provide accredited landing sites like the ones sampled in our study with rather exceptional financial means for rural Ugandan standards. For the surveyed communities, it is estimated that more than half of the working population is active in and around the fishery sector.

3.1. Roads and Energy Infrastructure

The two communities are located some 70 km from Kampala and are accessible by a 35-40 km dirt road branching off the well-maintained, but often congested Kampala-Jinja highway. For its larger part, the dirt road is in a bad condition and after heavy rainfalls it becomes almost unusable for regular vehicles.

Uganda exhibits an electrification rate among households of around 6 % with 42 % of households in Kampala and only 2-3 % of rural households being connected to the grid (NRECA 2011). The access area, connected to the grid in 2002 thus forms a rare exception to a countryside that is otherwise mostly cut off from grid electricity. Instead, where financial funds are available like in our non-access area, rural households and enterprises employ generator sets, photovoltaic systems or car or dry cell batteries to power electricity-using equipment.

Despite low overall access to the grid in Uganda, a growing demand for electricity often outdoes a stagnant supply-side. Load shedding is therefore frequent and as urban areas receive preferential supply, rural areas in the access region are most severely affected by the scarcity in electricity supply (see *Section 2.1*). During the time of surveying, scheduled outages took place in the evening hours of every second day. In addition, connected firms in the access region reported that unannounced blackouts occurred three times per week on average.

At the time of the survey in 2008, the cost of connecting to the grid without the installation of additional poles amounted to 300,000 UShs. For a one-pole service, the total fee increased to 420,000 UShs, which was roughly in line with the then reported connection cost in the survey region of an average of 404,595 UShs. One third of the connected firms were illicitly connected via other enterprises. The kWh-tariffs vary by level of consumption and time of use. For the low-voltage service an initial 15 kWh were sold at a reduced 62 UShs per kWh, each additional kWh cost 420 UShs. 280-470 UShs per kWh were charged for the three-phase low-voltage service.

3.2. Access to Finance and Business Development Services

The improvement of macro-economic conditions in Uganda has coincided with the development of one of the most diverse microfinance sectors in Africa. Micro-credit is provided through local savings associations, by NGOs and specialised microfinance institutions. Moreover, most commercial banks now run microfinance schemes (AMFIU 2007). The non-access-area has one formal microfinance institution that grants loans up to 10 million UShs. Credit and savings cooperatives exist in both communities and major microfinance and commercial banks run branches in a larger town located within 40 km of the landing sites. While many institutions require assets as collateral, the build-up of a successful credit history with escalating loan sizes can be sufficient. In principle, this makes credit available to all entrepreneurs regardless of their initial capital.

Micro-loan take-up rates among the surveyed firms are comparatively low: Only 20 % of enterprises had obtained formal credit with the average credit size amounting to 2.2 million UShs. Interest rates ranged from 20-30 %, depending on the institution and loan size and reportedly constituted an obstacle to increased borrowing for many firms. Of the 159 firms that had never applied for formal credit, 55 % cited excessive interest as one reason for non-application. Furthermore, widespread mistrust in microfinance institutions hindered the diversification of financing through formal sources. Cases of fraud had occurred in both survey-regions, with impostors having reportedly vanished after collecting deposits for loans that never materialised.

With regards to BDS, technical and managerial training were offered by BUDS and Enterprise Uganda, next to the activities of numerous NGOs. Yet, most programmes were tailored to the requirements and capacities of urban small and medium enterprises. The trainings were usually held in urban areas and are not free of charge. The uptake of BDS in rural areas was further complicated by the lack of organisation of a heterogeneous micro-enterprise sector for which comprehensive business associations barely existed. The virtual absence of appropriate BDS was reflected by the marginal use of such services in the survey area. Less than 5 % of interviewed entrepreneurs had ever received a form of entrepreneurial training. For the few firms that did, it was mostly provided by private suppliers, for instance by an internal car manufacturer for an engine repair shop and a cosmetics firm for a hairdresser and retailer of beauty products.

3.3. The Typical Enterprise in the Survey Area

Table 53 presents characteristics of the average non-primary sector firm in the survey area, i.e. over both survey regions. The non-primary sector was service-intensive with more than half of the firms engaging mainly in the resale of goods they elsewhere purchased. Another 12 and 11 % were in hospitality services or hairdressing, respectively. Wood and metal manufacturing ranked fourth with 9 % of all interviewed enterprises. Reflecting this industry structure, the average capital endowment was about 1 million UShs (617 US $) – just slightly above the average monthly profit. The strong focus on services was also mirrored in a customer base that almost exclusively consisted of local private buyers. Unlike the areas' export oriented fishery sector, direct external demand as a crucial driver of economic growth played a minor if any role in the survey areas' secondary and tertiary sectors.

Finally, with both surveyed regions reported to have been on a fast growth track due to their accredited landing site status, well over 50 % of the interviewed enterprises had been founded a maximum three years prior to our survey.

4. Quantitative Evidence: Energy and Enterprise Outcomes

4.1. Energy Usage

Traditional or electric energy is used by more than 80 % of enterprises in both the access and non-access regions (see *Table 55*). Not surprisingly, the share of electricity users at 50 % is higher in the grid-access region, where 38 % of enterprises are connected to the grid. Non-connected users of electricity and also many enterprises with a grid connection use decentralised electricity sources like generators, car batteries and photovoltaic

Table 53: Average Firm Characteristics in the Survey Area

Inputs & Profits		Line of Business	%
No. of workers	0.81	Commerce	51
Resale value of capital (UShs)	1,046,862	Hospitality	12
Monthly profit (UShs)	957,721	Hairdressing	11
Selling majority of goods to ...	**%**	Manufacturing	9
		Food	5
Private individuals	95	Private health services	4
Traders & retailers	5	Repair services	4
Exporters	1	Other	7
Majority of goods consumed in ...	**%**	Enterprise age	
		=< 1 year	24
Parish	83	1 year < age =< 3 years	33
Outside parish, in Uganda	17	3 years < age =< 5 years	16
Outside Uganda, in Africa	1	> 5 years	27.5

systems. In fact, every fourth connected enterprise backs up its grid connection with generators or car batteries. The popularity of backup electricity sources is unsurprising given the low reliability of the grid as discussed in *Section 3.1*.

Table 54 presents different reasons for not connecting to the grid reported by non-connected entrepreneurs in the access region. 40 % of the non-connected entrepreneurs say that they do not require electricity for their businesses to function. More than three quarters answer that the cost of electricity is too high to break even on the investment in the connection and the running costs. Surprisingly, only around 5 % name the unreliability of the electricity grid as a principal reason to abstain from connecting.

Table 54: Reasons for Not Connecting

What is/are the reason(s) you did not connect to the grid?	% of Observations
connection requested, not yet established	3.17
electricity not needed for operation	39.68
grid-electricity too unreliable	4.76
cannot afford connection fee	52.38
cannot afford consumption payments	25.40

The share of firms in the non-access region that uses decentralised electricity is an astonishingly 22 %. This high rate can be assumed to reflect the advantageous income opportunities in the surveyed area.

Traditional energy, mostly paraffin and candles for lighting and charcoal and wood for cooking purposes, plays an important role in both regions. A major difference between access and non-access regions is the use of paraffin. While 60 % of enterprises in the non-access area use it, the share is 25 % in the access region, indicating substantial substitution of traditional with electric lighting sources upon grid access. The comparison of connected and non-connected firms within the access-areas shows that 60 % of connected enterprises also use traditional energy sources. Here, paraffin and candles are the most important components, which indicates that traditional energy is used for backup or complementary lighting also among the connected.

Table 55: Share of Firms Using the Respective Energy Source (in %)

Energy Source	Access	Non-Access	Connected	Non-Connected	Decentr. Electricity	No Decentr. Electricity
	n=101	n=99	n=38	n=63	n=39	n=161
Non-human energy	82.2	84.9	100.0	71.4	100.0	79.5
Electricity*	44.6	22.2	100.0	11.1	100.0	17.4
Traditional**	47.5	66.7	60.5	39.7	51.3	58.4
Electricty & traditional	25.7	15.2	60.5	4.8	51.3	13.0
Electricity only	18.8	7.1	39.5	6.4	48.7	4.3
Traditional only	21.8	51.5	-	34.9	-	45.3
Grid	37.6	-	100.0	-	25.6	17.4
Grid only	6.9	-	18.4	-	-	4.4
Decentralised electricity	16.8	22.2	26.3	11.1	100.0	-
Generator	9.9	11.1	18.4	4.8	53.9	-
Car batteries	7.9	13.1	7.9	7.9	53.9	-
PV-system	0.0	2.0	0.0	0.0	5.1	-
Dry-cell batteries	40.6	41.4	29.0	47.6	41.0	41.0
Paraffin	24.8	59.6	36.8	17.5	38.5	42.9
Candles	29.7	14.1	47.4	19.1	23.1	21.7
Charcoal	12.9	30.3	7.9	15.9	25.6	20.5
Wood	3.0	14.1	5.3	1.6	5.1	9.3

*Electricity use = grid, petrol (generator), car-batteries, PV-system (excluding dry-cell batteries)

** Traditional energy is defined as paraffin and candles for lighting and charcoal and wood for cooking.

The average monthly energy bill in the non-access area amounts to around 48,500 UShs and as such is 38 % higher than in the access area (see *Table 56*). The differences in spending on decentralised electricity (generators, car and rechargeable batteries and photovoltaic systems) demonstrate that it is mainly used as backup in the access area, whereas it forms the sole electricity source in the non-access area. Furthermore, entrepreneurs in the non-access area have no choice but to use traditional fuels such as kerosene for lighting, which is an additional cost driver.

It is striking that grid and decentralised electricity users spend double the amount on traditional energy – mostly for lighting – than non-connected and non-decentralised electricity using firms. This may indicate that access to electricity, be it through grid access or the financial ability to operate a generator or car or other rechargeable batteries, leads to the establishment of firms with high lighting requirements. In times of blackouts or interrupted access to decentralised electricity, these firms therefore may have to spend heavily on traditional energy to substitute for the lack of electric lighting.

Improved lighting commonly is the most visible effect of rural electrification. For its productive use, practitioners hope for the lighting improvement to enhance productivity and output, since better lighting may enable both longer business hours and increased accuracy of work. The lighting sources in use and the lumen hour consumption that we discuss in the following therefore may form an important driver of potential electrification effects on the production process.

As shown in *Table 57*, only slightly more than every second firm in the access-area and about two-thirds in the non-access-area use artificial lighting at all. Nevertheless, in both survey regions lighting is by far the most important application of both traditional and electric energy.

Table 56: Energy Expenditures in UShs

Energy Source	Access	Non-Access	Connected	Non-Connected	Decentr. Electricity	No Decentr. Electricity
All	35,180	48,490	59,992	20,214	127,712	20,950
Electricity*	23,207	21,309	44,931	10,104	97,310	4,090
Grid	11,455	-	30,447	-	12,782	4,090
Diesel/petrol	11,290	19,304	14,088	9,603	78,244	-
Car-batteries	461,000	2,005	396,000	500,000	6,284	-
Dry-cells	2,525	2,345	1,561	3,106	3,166	2,259
Traditional	9,447	24,835	13,498	7,003	27,235	14,600
Paraffin	2,704	12,083	5,084	1,269	16,650	5,093
Candles	1,429	829	2,586	731	1,874	952
Charcoal	4,610	9,396	5,092	4,319	6,835	7,014
Wood	702,000	2,525	735,000	682,000	1,874	1,539

*Electricity use = grid, petrol (generator), car-batteries, PV-system (excluding dry-cell batteries)

Table 57: Lighting Sources

Lighting Source	Access %	Non-Access %	Connected %	Non-Connected %
Uses lighting at all	55.5	65.7	97.4	30.2
Electric lighting	40.6	12.1	97.4	6.4
Only electric lighting	16.8	8.1	39.5	3.2
Traditional lighting	38.6	57.6	57.9	27.0
Only traditional lighting	14.9	53.5	23.8	0.0
Traditional and electric lighting	23.8	4.0	57.9	3.2

Access to the grid in fact seems to enable a substitution of traditional with electric lighting sources. In the access region, 41% of firms use electric lighting and 39% traditional lighting whereas in the non-access region the share of electric lighting users is 12% and that of traditional lighting users 58%. A comparison of electric lighting use between connected firms in the access-region and decentralised electricity users in the non-access region furthermore indicates that the use of electric lighting is driven by cost-considerations. Among connected firms in the access region, electric lighting use at 97% is almost universal whereas only about half of the 22% of firms that use decentralised electricity in the non-access area use the electricity for lighting. For those entrepreneurs in the non-access area who do not use their decentralised electricity sources for lighting, the expected additional revenue of improved lighting seems to be too small to justify its costs.

While the figures in *Table 57*. indicate that electric lighting indeed substitutes for traditional lighting in many connected firms, substitution is far from complete. Instead, 58% of the connected use both traditional and electric lighting, most likely reflecting a high necessity for backup lighting sources in the face of frequent grid load-shedding and blackouts.

With respect to the type of electric lighting device used, compact fluorescent lamps and fluorescent tubes are more popular than the classic and less efficient incandescent bulbs. This finding is presumably the result of a government programme that exchanged compact fluorescent lamps for used incandescent bulbs at no additional cost.

On the level of traditional lighting, paraffin-powered hurricane lanterns are the most important lighting device in the non-access-area while in the access area, candles take up the largest share.

4.2. Capital

The average total resale value of a firm's capital stock does not differ between the access and non-access regions as it amounts to just above 1 million UShs (588 US $) in both regions. The results in *Table 58* however also indicate that access to the grid leads to a shift in the composition of the capital stock towards more electricity using machinery and equipment:

- The total value of non-energy-using capital is twice as large in the non-access-area as it is in the access area.
- The traditional energy-using capital stock is about 20 % larger in the access area.
- The electricity-using capital stock is 40 % larger in the access area.

Table 58: Capital Endowment

	Total Resale Value (in Ush)		Share of Total Capital	
Capital Item	Access	Non-Access	Access	Non-Access
TOTAL Capital stock	1,029,145	1,064,937	100000	100
Non-energy	266,946	494,045	49.27884	61.01457
Furniture & containers	145,560	186,363	28.38087	39.81462
Bicycles and carts	6,38	55,808	1.449839	3.10805
Tools	115,000	195,308	19.44814	16.78088
Other	0	56,565	0	1.311022
Traditional energy	189,792	159,164	8.243956	7.676992
Motor vehicles	133,663	48,484	2.702026	1.128544
Generators	51,579	65,656	3.034878	2.289752
Refrigeration	2,970	38,888	.8438344	1.740632
Cooking	1,074	4,202	.9453967	1.61458
Other	504	1,932	.7178211	.9034834
Electric energy	572,405	411,727	42.4772	31.30844
Telecommunications	335,316	162,585	27.37341	25.84019
Refrigeration	90,495	5,050	7.489697	.4676393
Processing	81,762	15,070	2.052955	.4663388
Hairdressing	12,326	8,383	1.589813	.2168649
Other	52,504	220,636	3.971325	4.317405

Next to the overall increase in the electricity-using capital stock in the access region, the electricity-using capital stock here is also more diverse. Electric refrigerators and freezers, electric goods processing machinery (for example sawing machines, sewing machines, mills) and electric hairdressing equipment take up substantially larger shares of the capital stock here than in the non-access area. However, the overall relevance of processing machinery and hairdressing equipment in the capital stock is limited as telecommunications devices (mostly cell phones and sound systems) form the bulk of electricity using capital and more than a quarter of the overall capital stock.

Nevertheless, the data suggests that next to a degree of substitution of traditional and non-energy using capital with energy using capital, access to the electricity grid also enables an increasing number of people to engage in business operations requiring refrigeration and the processing of goods that would otherwise be reserved to those who can afford to operate decentralised electricity sources. Also, taking into account the

higher overall incomes in the non-access region which can be expected to coincide with a higher capital stock ceteris paribus, the finding of similar overall value of capital stock across areas indicates that electricity access induces substantial investments, particularly in electricity-using appliances.

4.3. Employment and Operation Hours

A common hypothesis on the effect of electrification on businesses is that the improvement of lighting services enables the extension of business activities into night-time and thereby increases daily operation hours. The results we present in the prior section indicate that grid access increases the use of electric lighting both as a substitute of and complement to traditional lighting sources. This shift in lighting sources certainly coincides with improved lighting quality (lumen) during a given working hour. However, as is shown, our results do not suggest that grid access increases working hours. In fact, businesses in the non-access region operate slightly longer per day as they open 14 minutes earlier and close 22 minutes later than the average enterprise in the access region.

With respect to the comparison of connected and non-connected enterprises within the access region, the connected enterprises operate longer per day, as on average they open almost one hour earlier and close almost 1.5 hours later than non-connected firms. Yet, other factors than the availability of electric lighting appear to guide the entrepreneurial decision when and how long to operate. One such factor is time wise fluctuations in demand. Both communities are trading hubs that attract customers with substantial purchasing power from the surrounding, less developed fishing communities. These solvent external customers are mainly served during daytime and by firms located next to the shoreline where the market and industrial area of the grid-connected community is situated. Since the external customers leave at around 6 pm to reach their home villages while it is still light, the majority of the shoreline businesses close early. Their lighting requirements are therefore limited. Further, because the external demand is mainly in retailed goods, no particular electric equipment is required to serve it. In summary, there is limited incentive for the profitable businesses on the shoreline to open longer hours and use electric lighting. By contrast, the enterprises that depend on electric lighting in the access region are primarily located in the more residential parts of the community where the local population creates demand well into night-time. Electric lighting, hospitality (refrigeration) and entertainment (music, movie theatres) here play an important role. Consequently, the incentive to continue business operations after dark and to connect to the grid is much higher in the residential part of the grid-connected community. This is also why virtually all firms offering such services in the residential area are connected.

As for the users of decentralised electric energy sources, only half use electric lighting but on average they continue to operate until well after dark (8:25 pm; sunset is between 6:30 and 7pm). Combined with their higher overall levels of employment, decentralised electricity users show the highest level of labour input among all groups analysed in this study.

Table 59: Hours of Operation and Monthly Labour Input %)

	Opening Time	Closing Time	Daily Hours of Operation	Monthly Hours of Labour Input
Access	08:08	19:12	11:04	565h 26min
Non-access	07:54	19:34	11:40	585h 12 min
Connected	07:36	20:04	12:28	720h 20min
Non-connected	08:27	18:40	10:13	472h 00 min
Decentral electricity	07:46	20:25	12:38	775h 25 min
Non-Decentralised electricity	08:04	19:07	11:03	526h 44min

As depicted in *Table 60*, there is no difference in permanent employment per firm between the access and non-access regions. Between one third and one half of the employed workers are family members. In both areas, every second enterprise has employees and the mean is 0.8 employees per firm. Connected firms hire half a worker more on average than non-connected firms, as do decentralised electricity users compared to non-users.

Table 60: Employment and Remuneration

	No. of Employees*	% Family Members	Compensation per Hour (in UShs)	Total Compensation per Month (in UShs)
Access	0.81	48.3	298.4	78,787
Non-access	0.81	31.3	269.5	80,258
Connected	1.12	49.6	355.0	82,379
Non-connected	0.64	47.2	250.3	75,728
Decentralised electricity	1.29	27.3	287.7	99,241
No decentralised electricity	0.71	44.1	282.9	72,851

* Workers beyond the firm owner are counted.

The evidence for job creation through access to modern electricity is therefore weak. The higher employment figures in connected firms and among those using decentralised electricity may in part be the product of electric energy with the extension of working hours into night-time the most likely reason. It is also likely, however, that a large share of the employment difference stems from other factors.

For the following discussion of labour remuneration it has to be taken into account that in African economies labour is often not paid in the form of a fixed periodical salary but by units produced or sold or hours actually worked. Therefore, the figures on total hourly compensation comprise the monetary pay plus the money value of remuneration in kind per working hour. It is some 10 % higher in the access area than in the non-access area but the difference is small in absolute terms (28 UShs, or 2 US $ Cents). This small difference is maintained when calculating the total monthly remuneration, taking together wages per hour and working hours per month. Connected firms exhibit substantially higher wages per hour but only a slight difference in total remuneration per month. The higher wages among connected firms offer a tentative indication that labour is used more productively in connected firms. This, in turn, could lead to a reduction of total working hours in the short term. However, using cross-sectional data it is hardly possible to answer this question. It is also difficult so say to what extent the higher wages depend on the connection status.

Yet, looking at the users of decentralised electricity does not support this relationship: the users do not pay higher wages than the non-users. The monthly remuneration is only higher because of the longer working hours in firms that use decentralised electricity.

4.4. Market Access

Table 61 and *Table 62* provide details on the customer base of firms with different access to electricity. We here examine whether better access or use of electricity improves firm competitiveness also beyond local markets.

Regardless of whether a firm is located in the access or non-access region, whether it is connected to the grid or not or uses decentralised electricity sources, the vast majority of sales are to private individuals residing in the same parish as the firms or in its immediate surroundings. Therefore, while, the access and non-access region's primary sector fishing industry sells to the national and international market, these outlet channels remain blocked for the secondary and tertiary sector micro-enterprises that we interviewed in our survey. Next to the aforementioned lack of reliability of the electricity grid, other determinants of competitiveness like relative location, traffic infrastructure and human capital likely hinder or appear to hinder an enhanced integration of the surveyed local economies with non-local markets.

Table 61: To Whom of the Following Does the Enterprise Sell the Majority of its Goods and Services to? (in %)

	Access	Non-Access	Connected	Non-Connected	Decentralised Electricity	No Decentralised Electricity
Private individuals	95	94	95	94	92	94
Traders & retailers	5	6	5	5	8	5
Exporters	1	0	0	2	0	1

Table 62: In Which of the Following Places Are the Majority of this Enterprise's Goods and Services consumed? (in %)

	Access	Non-Access	Connected	Non-Connected	Decentralised Electricity	No Decentralised Electricity
In parish	86	79	84	87	92	80
Outside parish, in Uganda	13	21	16	11	8	19
Outside Uganda, in Africa	1	0	0	2	0	1

4.5. Firm Profits

The survey questionnaire permits us to acquire data on monthly profits by two approaches. In the first direct approach the interviewers asked entrepreneurs to assign the profits they had earned from their businesses in the month preceding the interview to one of four profit categories. For the second approach we calculated profits as the difference between the reported monthly revenue and the reported monthly expenditures.

Examination of the data offers some indication that the second indirect approach provides a higher degree of accuracy. Most importantly, the self-reported profit data acquired by the first direct questioning method appears overly low when compared with the micro and macro-level information on profits and income from key interviews and other sources. The same picture of large profit underreporting by the direct questioning method evolves when the profit data are compared to reported business expenditures and capital stock. After all, we cannot rule out that because of mistrust in the interviewers or a lack of bookkeeping, direct profit questioning leads to substantial underreporting and possibly reporting bias. We therefore limit the presentation of firm profits in *Table 63* to the data raised by the second, indirect method.

The calculated average monthly profits are lower in the access than in the non-access regions, lower among connected than among non-connected businesses and also lower among firms that use decentralised electricity sources than among firms who not use them. In total, our data therefore suggest that electrification does not necessarily lead to higher profits on the level of the individual firm.

This finding however has to be interpreted against the background information provided in *sections 2.2* and *4.2*: firstly, overall income levels in the non-access region are higher than in the access region because of a more dynamic fishery sector. Secondly, within the access area many of the non-connected firms are located in the marketplace area of the community that attracts many solvent customers from surrounding communities. Many of the connected enterprises are instead located in the more residential areas of the community where demand is mostly local. Therefore, to derive more robust findings on electrification impacts on firm profits, our cross-sectional approach needs to be complemented with over-time data to enable, for instance, a difference-in-difference study of potential effects.

Table 63: Calculated Profits in an Average Month

	Access	Non-Access	Connected	Non-Connected	Decentralised Electricity	No Decentralised Electricity
UShs	703,816	1,216,755	318,883	935,998	783,653	999,886
US $	414.01	715.74	187.58	550.59	460.97	588.17

4.6. Industry Structure and Product Variety

The high earnings from the fishery sector have allowed both the access and non-access regions to develop comparatively large and diversified economies. Residents use the money earned from the fish trade to demand a variety of production inputs and final goods. Their demand is increasingly met by local producers and traders.

Table 64: Industry Structure (in %)

	Manu-facturing	Food Production	Hair-Dresser	Batt.-Charge	Priv. Clinic	Laun-dry	Repair Service	Hospita-lity	Com-merce	Other Services	Total
Access	9.9	4.0	12.9	3.0	4.0	2.0	4.0	8.9	50.5	1.0	100
Non-access	7.1	5.1	8.1	2.0	4.0	3.0	4.0	15.2	50.5	1.0	100
Connected	5.3	0.0	21.1	7.9	7.9	0.0	2.6	7.9	47.4	0.0	100
Non-connected	12.7	6.4	7.9	0.0	1.6	3.2	4.8	9.5	52.4	1.6	100
Decentralised electricity	5.1	5.1	23.1	7.7	5.1	2.6	7.7	7.7	33.3	2.7	100
No decentra-lised electricity	9.3	4.4	7.5	1.2	3.7	2.5	3.1	13.0	54.7	0.6	100

Comparing industry structure in the access and non-access region, we find little evidence for a clear effect of electrification (see *Table 64*). While the manufacturing of wood, metal and textile products accounts for a slightly larger share of business activities in the access region than in the non-access region, services continue to dominate the economic structure in both areas with some 90 % of firms engaging in the tertiary sector. No trends towards either a higher degree of industrialisation or an overall more service-focused sectoral distribution through electrification is visible.

The service sector in both areas is dominated by the retail and wholesale business. Within the service sector there are, however, two exceptions to the general lack of differences in economic structure between the access and non-access regions. Firstly, the hospitality sector takes up a higher share in the non-access region. This is most likely the result of a higher turnout of people that reside outside the community in the non-access area that we elaborated above. Secondly, hairdressing businesses form a larger share of enterprises in the access region than in the non-access region. This can in fact be attributed to grid access: most hairdressing business activities like the operation of electric clippers, dryers and smoothers which require electric energy and electric lighting is needed to enable accurate work after nightfall. In addition, hairdressing shops frequently obtain electronic entertainment media to attract customers and some sell electric appliances and self-burned compact discs. Access to grid electricity appears to permit people unwilling or unable to meet the high cost of decentralised electricity sources such as generators to enter the hairdressing business and to diversify their business into other electricity-using activities. While this trend can also be confirmed by qualitative information from field work and anecdotal evidence (see *Section 5*), its overall economic impact remains unclear. With the data at hand we can only state that more hairdresser businesses are the result of electrification. However, crowding out effects on the income of already existing hair dressers are likely. In fact, our data indicate that hairdressing businesses are on average more profitable in the non-access region than in the access region. Also, connected hairdressers do not exhibit higher profits than the non-connected ones.

The comparison of connected and non-connected firms within the access-region and the comparison of users and non-users of decentralised electricity underscore the finding that the availability of electric energy alone does not trigger an increase in manufacturing activities. In fact, our data suggests that manufacturing firms are less inclined to connect to the grid or use decentralised electricity than service firms. The high investment costs of electric machinery paired with sharp competition on the market for manufactured goods (e.g. imports from Asia) here appear to be the main culprits. Instead, service firms are more likely to get connected and employ decentralised electricity, especially for activities such as hairdressing, where much added value can be gained with comparatively small investments such as in light bulbs, electric clippers and sound systems.

Table 65: Products Sold (in %)

	Food (Processed or Raw)	Durable Consumer Goods	Health Care Products	Materials & Investment Goods	Services (Beauty, Medical, ...)	Other	Total
Access	45.5	11.9	6.9	9.9	23.8	2.0	100
Non-access	49.5	10.1	8.1	7.1	18.2	7.1	100
Connected	42.1	7.9	7.9	7.9	34.2	0.0	100
Non-connected	47.6	14.3	6.4	11.1	17.5	3.2	100
Decentralised electricity	23.1	10.3	2.6	18.0	41.0	5.1	100
No decentralised electricity	53.4	11.2	8.7	6.2	16.2	4.4	100

Table 65 shows what products are mainly sold in the surveyed firms. Again, no substantial difference between the access and non-access regions can be found. In both areas, foodstuffs are by far the most important single product group. Personal services rank second, with a 5.6 percentage point larger share in the access region that in the non-access region. This difference can most probably be attributed to grid access since it makes electricity using industries such as hairdressing more accessible in comparison to a scenario where electricity has to be obtained from costly generators. Underscoring the above findings from the comparison of the access and non-access regions, the comparison of connected and non-connected firms in the access region and the comparison of users and non-users of decentralised electricity show that connected firms are more likely to sell services while the sale of durables (consumer goods and materials) is more common among non-connected firms.

5. Qualitative Evidence: Stylised Case Studies

In summer 2009, we complemented the initial quantitative approach with a series of in-depth qualitative and open-ended interviews with three local business owners in the access area. With the insights gained from this exercise we intend to visualise typical patterns of production and electricity requirements. Every one of the three cases stands for a different set of challenges and opportunities with regards to the productive impact of electricity. The first case study describes a carpenter that might have some potential to use electricity productively, yet abstains from getting connected, as the expected additional profits would not cover connection and operation costs. The second case study presents a large-scale fish production site that depends on electricity for its daily operations. This firm type does certainly not occur in large numbers in a rural African setting, yet its contribution to the local economy can be substantial. The last case refers to a hairdresser extending his range of offered services using electric appliances.

5.1. Electricity Not Required: Carpentry and Upholstery

The carpenter visited for this qualitative interview does both carpentry work and upholstering. Although his villages is covered by the electricity grid, his business is not connected, as he produces mainly using manual tools. For carving work that requires electric machinery he regularly takes his materials to the next electrified town that is located about 10 km from his business. While the carpenter believes that he could increase production and sales by using electric tools he does not see an urgent need to connect. On the one hand, local labour supply is highly flexible and cheap. An apprentice earns 2 US $ per day and is only paid when his services are required. On the other hand, while electricity consumption payments would not pose an obstacle to connect, the investment required to establish the initial connection (connection fee plus house wiring) and to equip his workshop with the necessary machinery is high compared to what the carpenter's business generates in revenue and profits. The carpenter estimates that the initial investments would be well over 1,000 US $. In comparison, his monthly revenue amounts to some 300 US $, a large part of which he spends on materi-

als, intermediate goods and transportation. The carpenter does not want to obtain a microcredit to connect and purchase electric equipment as he is unsure whether the interest payments and the pressure of regular payback would be justified by any potential increase in income from such an investment.

With regards to electricity requirements, the carpenter's business is similar to a large number of enterprises in the local economy. Connecting to the grid would improve the production opportunities of these businesses. However, the required volume of investment is assumed to be out of proportion with its perceived short and mid-term benefits. Hence, these enterprises cannot be expected to connect in the near future. Consequently, no direct electrification impacts on productive use will occur here.

However, the carpenter and many other non-connected entrepreneurs in the access area report a positive development of demand in response to the extension of the grid to the community. This notion is supported by information acquired through interviews with local leaders that state that the establishment of the grid has led to growth of both the community's population and economic activity.

5.2. Electricity is Crucial: Aquaculture

Recently founded by immigrated entrepreneurs from Europe, an aquaculture firm in the access region engages in the fishing, processing and marketing of silver fish. The product is sold both in the access-region and to neighbouring countries, mainly the Congo. An aquaculture plant for tilapia breeding that also includes facilities for cooling, processing, packaging of products as well as housing for employees was under construction in summer 2009. The firm aims to commercialise Tilapia both on the national and the international market. Negotiations with customers in Belgium and the United Kingdom were reported to be under way at the time of the interview. Unlike most local competitors, it has the possibility to expand in the national and other African markets due to higher standards in terms of hygiene and packaging.

The total investment to set up the enterprise was about 100,000 US $. With 34 employees at present, the firm plans to employ about 300 people once in full operation. Because skilled personnel are scarce in the local community, the firm brings in its own workers from other parts of the country.

Electricity is crucial for the enterprise's current and future functioning. The firm uses electric pumps for the daily exchange of water in the aquaculture ponds and electric machinery to vacuum package its product. At its full future capacity the facilities are estimated to require 50 kW at an output of fifteen tons of fish per day. The firm has connected to the grid. Because it is located about half a kilometre from the main grid, connection costs amounted to some 15,000 US $. With electricity as an indispensable production factor, the enterprise counters the frequent load-shedding and unannounced power outages with different backup systems such as generators and batteries. It also keeps fresh water reserves for its ponds in case electricity and, thus, the electric water exchange pumps become unavailable for extended periods of time.

The aquaculture firm represents the large-scale often not locally financed business activities that crucially depend on electricity. The reliability and affordability of electricity are key determinants of their competitiveness on external markets. To the degree that the income generated through national and international trade flow back to the local community – for instance through wages being paid to employees who then spend them on locally offered consumption goods – local economic activity is stimulated that increases overall local welfare. Where investment opportunities exist, as in the case of the fishing communities along Lake Victoria, a further improvement of grid reliability can be expected to entice the setup of more firms like the aquaculture enterprise.

5.3. Electricity Improves Offered Services: Barber, Phone and Computer Shop

The interviewed entrepreneur runs a business that combines a barber shop and a retail and repair business for electronic appliances like TV sets, DVD players, mobile phones, computers and radios. He has spent his entire life in the access region. Since the grid was extended to the village about 5 years before the interview,

he has observed rapid growth both in terms of the village population and local economic activity. He states, for instance, that many fishermen from surrounding islands have moved their permanent homes and families to the area and believes that the availability of electricity to provide electric lighting and to power entertainment media are the main drivers of this development. In his opinion, the new residents' additional demand has triggered increases in both the volume and variety of goods sold in the village. With a growing client base that is willing to pay a small surcharge on products rather than travel to urban areas to purchase them, merchants like him are able to offer higher quantities and a larger variety of products locally.

The entrepreneur started his business as a barber one year before the grid arrived. He then used a generator to provide adequate lighting and power the electric shavers and the TV set and sound system he had set up to attract customers. He connected to the grid as soon as it reached the village, then paying a connection fee of 350,000 UShs (186 US $). His monthly electricity bill typically amounts to 20,000 UShs (12 US $). The shop reports to have profited greatly from the expansion of the village that has taken place after the establishment of the electricity grid. Demand for the electric appliances and electronic repair services, which the enterprise started to offer shortly before electrification, has steadily increased. With the growth in demand and turnover he has obtained additional storage facilities and can now serve up to 5 barber shop customers at a time. His sound system has also affected surrounding businesses: petty traders in foods are now selling their products next to his store as they seek to benefit from the attraction of people by the store's music.

The firm does not own a generator anymore. When power is cut off scissors are used instead of electric shavers to continue the hairdressing business. As load-shedding in the entrepreneur's view is becoming ever more frequent he plans to again purchase a generator in the near future.

The business represents the broad class of enterprises that use electricity to provide goods and services they offer but that also are able to function on non-electric machinery or also provide other goods and services that do not require permanent access to electricity. Just like the carpentry business described above, the main potential for positive electrification impacts here are indirectly brought about by an electrification-induced population and thus customer base growth. Business with similar responses to electrification were found in interviews with restaurant and bar owners that use electric equipment for lighting, refrigeration and entertainment but perceive the expansion of their business mainly to be rooted in an overall increase in demand.

6. Conclusion

This paper has examined the use of energy and the performance of micro-enterprises in two fishing communities along the Ugandan shore of Lake Victoria. In spite of careful preparation of the study and due to both project-related reasons and budgetary restrictions the analysis of the data was complicated by comparability issues between the region with access to grid electricity and the one without. The intended examination of impacts of electricity usage on firm performance was not possible in a way that would be entirely satisfactory from a methodologically rigorous point of view. Therefore, we applied a hands-on approach combining quantitative and qualitative methods. We examined intermediate indicators less likely to be distorted by the comparability problems. Furthermore, we conducted a supplementary qualitative case study on stylised firm types in order to visualise both electrification impact potentials and problems that may prevent such impacts from unfolding.

In the region that is connected to the electricity grid we find a 38 % connection rate among the surveyed microenterprises. The share of enterprises that use decentralised electricity sources like generators is about 20 % in both the access and non-access regions showing that even when only an unreliable electricity grid is accessible firms tend to back-up against outages. Almost irrespective of the usage of electric energy, traditional energy sources for lighting in particular continue to play a crucial role in the surveyed firms' energy portfolio. These high overall shares of electricity users in both regions further suggest a high demand for electric energy for African rural standards.

Both quantitative and qualitative information indicate that electrification effects on firm performance measured by profits or employee's income are small. In fact in our sample profits are smaller in the access area and for connected firms and users of decentralised electricity. For reasons that may stretch from a lack of a skilled workforce to access to finance and geographical remoteness, external markets remain inaccessible even after the grid is extended to her village. Particularly among small manufacturing firms, the effects of electricity on the production process appear to be weak. With regards to the structure of firms and that of the local economy as a whole, however, we observe moderate electrification effects. In particular, we find some evidence for a shift in firm investments towards electricity-using capital. Furthermore, the observed patterns of sales suggest that services and goods that are locally produced and provided slightly gain in importance in response to electrification. It has to be stated, however, that more robust analysis using a larger sample of communities is needed to confirm such structural impacts.

The qualitative case studies underscore the findings from the more quantitative approach. The first case, a one-man carpenter, who has no real productive interest in electricity, represents a type of enterprise very common in the rural African economy. The second case, a large fish processing plant that requires electricity for its production process, may form an exception but it reflects the large potential for electrification to enhance welfare if an attractive business opportunity exists as is the case for Lake Victoria fishery. As the third example, the selected barber shop also offering electronic repair and entertainment services, shows the potential of electrification to increase the variety of goods and services and to open up business opportunities hitherto reserved to those who could afford decentralised electricity sources.

When measured at the level of the individual firm, the overall direct gain from connecting to the grid appears to be small. Opportunities opened up through electrification appear more specific. For instance, fish processing enterprises gain from electric cooling. Moreover, by being more affordable than decentralised electricity sources, grid electricity leads to the establishment of additional hairdressing businesses. A further positive impact of grid access on firm performance is induced by the overall expansive effect the establishment of the grid has on local demand, partly due to people moving from outside areas to the community. This view was confirmed in various interviews with village leaders and members of the district administration. Grid access apparently forms an important pull-factor that stimulates additional economic activity through the demand channel rather than through the supply side.

Yet, the influx of people into the grid-access area naturally coincides with (skilled) population losses in surrounding, non-electrified areas for which welfare losses are likely. While such effects must be considered in examining the net welfare effects of electrification, their analysis is beyond the scope of our paper.

With respect to complementary services in electrification projects that target the productive use of energy, our findings suggest that the productive take-up of electricity should not be encouraged by all means. The reason is that it is not clear from the outset that a grid connection or switching to electric machinery is beneficial for the enterprise. Rather, the capacity to take reasonable decisions has to be strengthened at the level of the individual firm. Promotion activities could, for example, assist entrepreneurs in the drawing up of a firm-specific business plan that includes a thorough assessment of possible gains from connecting. The plan should then serve entrepreneurs as a basis for the decision whether to get connected and to invest in electric appliances – or to rather abstain from a not worthwhile investment.

Methodologically, future surveys should try to draw observations from a larger number of settlements to limit structural bias such as the one faced in this study. Some structural differences may be hard to detect without a profound and in most cases prohibitively expensive pre-survey. Yet, the Uganda experience highlights the necessity for extensive and prudent field investigations to enable the identification of areas that are suitable for cross-sectional impact measurement.

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