Materialien

Gunther Bensch
Merle Kreibaum
Tukae Mbegalo
Jörg Peters
Natascha Wagner

The Status of Energy Access in Three Regions of Tanzania

Baseline report for an urban grid upgrading and rural extension project

Heft 111

Impressum

Vorstand des RWI

Verwaltungsrat

Forschungsbeirat

Ehrenmitglieder des RWI

RWI Materialien Heft 111

Herausgeber: RWI Leibniz-Institut für Wirtschaftsforschung

Hohenzollernstraße 1–3, 45128 Essen, Tel. 0201 – 8149-0

Schriftleitung: Prof. Dr. Christoph M. Schmidt

Konzeption und Gestaltung: Claudia Lohkamp

ISSN 1612-3573

ISBN 978-3-86788-781-6

Materialien

Gunther Bensch, Merle Kreibaum,
Tukae Mbegalo, Jörg Peters, Natascha Wagner

The Status of Energy Access in Three Regions of Tanzania

Baseline report for an urban grid upgrading and rural extension project

Heft 111

rwi

Datenbeschreibung Bildungsprämie: Programmteilnehmer und Anspruchsberechtigte

Die Deutsche Bibliothek verzeichnet diese Publikation in der deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über: http://dnb.ddb.de abrufbar.

The evaluation consortium acknowledges the outstanding support of Stephen Kirama and his team at the Economics Department of the University of Dar es Salaam in conducting the original research on which this publication is based. Furthermore, we would like to thank Stephan Klasen and Maximiliane Sievert for their support and guidance. The views presented in this publication are those of the authors and do not necessarily represent those of the consortium member organisations.

Kooperationspartner

ERASMUS UNIVERSITEIT ROTTERDAM

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

Mitglied der Leibniz-Gemeinschaft

Das RWI wird vom Bund und vom Land Nordrhein-Westfalen gefördert.

ISSN 1612-3573?
ISBN 978-3-86788-781-6

Content

Verzeichnis der Tabellen und Schaubilder

Acknowledgements

The evaluation consortium acknowledges the outstanding support of Stephen Kirama and his team at the Economics Department of the University of Dar es Salaam in conducting the original research on which this publication is based. Furthermore, we would like to thank Stephan Klasen and Maximiliane Sievert for their support and guidance. The views presented in this publication are those of the authors and do not necessarily represent those of the consortium member organisations.

Executive summary

More than 1.1 billion people in developing countries lack access to electricity with a large share living in rural Africa. It is hypothesized that economic and human development are difficult without electricity access. Tanzania is one of the poorest countries in the world and the country's huge geographical extent and low population density makes infrastructure development such as electrification a particularly difficult exercise. The electrification rate is extremely low at around 46 percent in urban and 4 percent in rural areas. The access to reliable modern energy has become one of 17 Sustainable Development Goals (UN 2014) and the international community has embarked on a historical mission through the United Nations initiative Sustainable Energy for All (SE4All) that strives to provide electricity to everybody by 2030. Investment requirements to achieve this goal are enormous and large gaps exist so far. Additional investment initiatives are required.

This report presents results from a baseline survey for an upcoming electrification project that intends to rehabilitate and extend three isolated grids in Western Tanzania, namely those installed in the towns of Biharamulo, Ngara and Mpanda. Given the baseline nature of this report, most attention will be paid to energy access and usage in the absence of the project, and less attention to the project itself. The survey was conducted between December 2014 and February 2015 as part of an impact evaluation to examine the project effects in Tanzania on different socio-economic impact dimensions. A second survey is planned to be conducted about two years after connection of the new generator sets. The focus of this study is on two types of treatments: the *service upgrade* of already connected households and enterprises *in towns* suffering from frequent outages and load shedding, and the *new connection* of hitherto non-connected households and enterprises in the *surrounding villages*. In the sampled rural areas, a control group of communities was surveyed that is foreseen not to be connected by the time of the follow-up survey. For the urban sample, no control group approach can be pursued, simply because comparable towns facing the same situation of deteriorating isolated grids in a similar socio-economic environment that could serve as a control group do not exist. This approach is complemented by a willingness-to-pay analysis to capture the effect of the service upgrade.

In total, we interviewed around 1,000 households in rural areas, 300 households in urban areas, and 500 urban enterprises. The impact indicators we look at are related to current appliance usage and the potential improvements in lighting usage for recreational, productive, or educational purposes that might result from electrification. The purpose of this report is to present the collected data and to portray the socio-economic living conditions in the surveyed areas as well as to examine the comparability of the selected treatment and control groups foreseen for the ex-post impact evaluation. If these groups turn out to be non-comparable before the intervention, the impact estimate in the follow-up may be biased.

In general, the quality of the collected data appears to be good. Non-response rates are low at clearly below 5 percent for all questions. Patterns across the income distribution are consistent, for example poorer rural households are more inclined to use traditional energy sources. Moreover, we could underpin the assumption of sufficiently similar treatment and control villages. While a few statistically significant differences could be observed, the size of these differences (i.e. the economic significance) is small and will not threat our identification assumptions.

Although we are not yet in the impact analysis phase of the study, some interesting findings can be taken away for policy makers. Electricity usage in the programme's target regions is already widespread. Around a fourth of the surveyed rural households already use generators and solar panels, which people in most cases have obtained themselves. This obviously reduces the access-to-modern-energy effect of the intervention. It has to be noted, though, that this phenomenon of self-electrified households is perceivable in most areas in Africa that are considered for grid extension programmes and not due to the specific targeting design of the intervention, which is predominantly inhabited by subsistence farmer. Relatedly, many households have replaced wick and kerosene lamps for lighting. Fuel-run lamps make up only about half of the lighting consumed in the programme's target regions, the remainder being provided by battery-run, electric or solar lamps. As one consequence, current energy expenditures are moderate at 8 percent of overall expenditures.

Another interesting finding is that the quality of electricity service in towns seems to be better than expected. Households do not report extremely high numbers of outages (for African comparisons) and are also overall pretty satisfied according to their subjective statements. On average, they are willing to pay a surcharge of 17 percent for reliable electricity. Enterprises, in contrast, are less satisfied and claim that outages do hamper their business. This might indicate that reliability is more an issue for productive users than domestic ones, which is also in line with intuition and findings in the literature.

Providing the electricity grid to rural areas is always associated with high expectations in terms of economic development impacts. Although it is too early to come to a conclusion, our qualitative baseline survey in the villages to be connected by the project indicates that impact expectations should not be too high for this particular target region. Resident enterprises only serve local markets. Only very few exceptions exist where the local production serves demand that is coming from outside the area. Therefore, if electrification leads to increases in production this will mostly only attract local purchasing power that, in consequence, is distracted from other local purchases. What might happen after electrification is that new enterprises are created which produce goods or services substituting for current imports from urban areas or even goods dedicated to be exported to other regions of the country. This effect will probably be small such that the net effect on the local economy would be negligible. This is in line with the general observation that energy is a necessary but not sufficient condition for rural development.

1. Introduction

More than 1.1 billion people in developing countries lack access to electricity with a large share living in Africa. In rural areas, connectivity is particularly low at only 15 percent (SE4All 2015). It is often hypothesized that lacking access to electricity hampers human development in many regards. The lack of access to modern lighting in households limits their possibilities to pursue productive activities after nightfall, but also educational and recreational activities. Likewise, enterprise development and the provision of public services like health care and schooling becomes more difficult. In addition, even in grid covered areas service quality is often bad with frequent outages adversely affecting in particular production processes in firms who have to interrupt their work or resort to expensive generators (APP 2015). Tanzania is one of the poorest countries in the world and the country's huge geographical extent and low population density makes infrastructure development a difficult exercise. The electrification rate is extremely low at around 46 percent in urban and 4 percent in rural areas. While electrification rates have increased between 2000 and 2010, they have stagnated since then (SE4All 2015). The access to reliable modern energy has become one of 17 Sustainable Development Goals (UN 2014) and the international community has embarked on a historical mission through the United Nations initiative Sustainable Energy for All (SE4All) that strives to provide modern and reliable energy to everybody by 2030. Yet, investment requirements to achieve this goal are enormous and large gaps exist so far. Additional investment programs are required.

In this report, we present results from a baseline survey for an intervention co-financed with donor support. 133,000 people in Western Tanzania are supposed to benefit from the rehabilitation and extension of three isolated grids that are run by diesel generators. The survey was conducted between December 2014 and February 2015 in the project area covering the three towns of Biharamulo, Ngara and Mpanda and their surroundings. It is part of an impact evaluation encompassing two survey waves in order to examine the intervention's effect on different socio-economic impact dimensions. For this purpose, a second survey will be conducted two to three years after the baseline survey. In line with the target group of the project, the focus of this study is on two types of treatments: the *new connection* of hitherto non-connected households and enterprises in the *surrounding villages* and the *service upgrade* of already connected households and enterprises *in towns* suffering from frequent outages and load shedding. In the sampled rural areas, a control group of communities was surveyed that is foreseen not to be connected by the time of the follow-up survey. Here, the evaluation methodologically follows a difference-in-differences approach. It is one purpose of this baseline report to examine the comparability of the rural treatment and control groups. For the urban sample, no control group approach can be pursued, simply because comparable towns facing the same situation of deteriorating isolated grids in a similar socio-economic environment that could serve as a control group do not exist. Here, the baseline survey presented in this report provides the basis for a simple before-after comparison to be conducted after the follow-up survey. This approach is complemented by a willingness-to-pay analysis to capture the effect of the service upgrade.

In total, we interviewed around 1,000 households in rural areas using a structured questionnaire and conducted semi-structured interviews among rural enterprises. In town, we interviewed 300 households and 508 enterprises, both using structured questionnaires. The indicators we look at are related to the potential improvements in lighting usage for recreational, productive, or educational purposes. Moreover, we examine the baseline situation for appliance usage. A potential replacement of non-electric appliances by electric ones and new uptake of so-far non-existent appliances can have effects on people's life and on production processes in enterprises.

The study is designed in a way that findings of this evaluation after the follow-up can contribute to the growing body of evidence on socio-economic impacts of electrification and the effect of non-reliable grid access on people's well-being and in particular on productive processes in enterprises. The literature on impacts of electrification is so far dominated by evidence from non-African countries (Grogan and Sadanand 2012, Khandker et al. 2013, Khandker et al. 2012, Lipscomb et al. 2013, Rud 2012, and Van de Walle et al. 2013). Few exceptions exist from

Africa (see for example Bernard 2012, Bensch et al. 2013, Lenz et al. 2016 and Peters and Sievert 2016). We present more indicator-specific literature as part of our motivation of the underlying theory of change in Section 3. Evidence on the effects of unreliable grids on enterprise performance is scarce and coming from India (Allcott et al. 2014) and China (Fisher-Vanden et al. 2015) only, although Ramachandran et al. (2009) emphasize that more than half of African enterprises name unreliable electricity access as the major barrier to their development.

The purpose of this report is to present the collected data and to portray the socio-economic living conditions in the surveyed areas with a particular focus on energy access and usage. Given the baseline nature of this report, most attention will be paid to the status quo in the absence of the intervention, and less attention to the intervention itself. Furthermore, the report assesses the quality of the data and examines the comparability of the selected treatment and control groups foreseen for the difference-in-differences comparison in the rural target group of the project. The report is organized as follows: Section 2 and 3 introduce the country background, the Tanzanian energy sector and the project under evaluation as well as the methodological approach and the sampling. Section 4 presents the survey results in rural areas and shows the relevant socio-economic characteristics and energy consumption patterns, while Section 5 does the same for the urban part of the target population. Section 6 concludes on general data quality and Section 7 provides a short conclusion in general.

2. The study area and project context

2.1. Regional context

The project targets three district areas (see Figure 1). Two of them, Biharamulo and Ngara district, are located in north-western Tanzania at the border to Rwanda (Kagera region) and the third, Mpanda district[1], is situated in the West of the country at the Congolese border (Katavi region[2]). Both regions are located at a distance of roughly 1,400 kilometres from Dar es Salaam. Road access is difficult and the social services are scarce in most of its rural areas. Kagera region with a population of 2.5 million and Katavi region with 560,000 inhabitants both experience an annual population growth of 3.2 percent (National Bureau of Statistics Census 2012). The district and town area population can be taken from Table 1, although the population that can actually be considered as urban is probably only half the figures mentioned under town area population. Mpanda is clearly the largest of the three towns.

The agricultural sector is the most important sector of employment in both project regions. It is estimated that 80 percent of the population in the Kagera region is engaged in agriculture. Agriculture is a growing sector with a national annual growth rate of 6 percent. The major cash crops growing in the region are tobacco, cotton coffee and tea. Banana is the major consumption crop and key for food security. On a small scale, cotton is grown in Biharamulo district. Similarly, agriculture is one of the core activities of the local Katavi economy in the South. In addition, both regions are endowed with good beekeeping forests.

[1] *A considerable share of villages to be electrified actually belongs to Mlele district rather than to Mpanda district. In addition, Mpanda town is officially not part of Mpanda district. As the generator will be located in Mpanda town, in the following we refer to this third intervention area as Mpanda project area.*

[2] *Formerly, Mpanda district belonged to the Rukwa region. After the administrative reorganisation of the region, the new region Katavi was created with Mpanda as the capital town.*

Mining is another important source of revenues in the three districts. The Kagera belt has considerable potentials for mining by both small-scale and large-scale miners. Mining activities are mainly practiced in Biharamulo district, where the Tulawaka Gold Mine is under operation, and at Ngara District where the implementation of the larger Kabanga Nicel Project, however, is delayed. Mineral types include gold, nickel and cobalt. Small-scale mining is carried out at Karagwe and Kyerwa. Similarly, the Katavi region is endowed with mineral deposits of different kinds including gold, green tourmaline, gemstone, and copper. Most of the mining activities are conducted by small scale miners. There is only one large mine, a gold mine owned by Kapufi Gold Mining Ltd. at Singililwa. Due to poor technology and lack of capital for local miners, the amount of minerals extracted is very small compared to the existing stock in the ground.

Table 1
Population figures

	Biharamulo	Ngara	Mpanda
District population	323,500	320,100	564,600
Population in town area	24,600	21,000	81,500
Total number of grid connections	1,600	1,600	2,300

Note: The district population for Mpanda refers to Mpanda district, Mpanda town and Mlele district. The town area population is represented by the population of wards classified as mixed or urban.
Source: National Bureau of Statistics Census 2012; TANESCO

The manufacturing sector is at its infancy stage in the regions. In Katavi region the manufacturing sector is ranked third after agriculture and tourism. The activities consist of manufacturing simple consumer goods like food, beverages, textiles, tobacco, wood products, rubber products, iron, steel, and fabricated metal products, which are mostly for the local market.

2. The study area and project context

Figure 1
The target areas of the project

Source: Nations Online Project
www.nationsonline.org/oneworld/map/tanzania-political-map.htm

Agricultural commodities dominate the exports from the regions. Trade with the neighbouring countries Burundi, Rwanda, the Democratic Republic of Congo, and Zambia differs across the region given their uneven connectedness. Trade opportunities with neighbouring countries are limited for Mpanda, because the boarder to the Democratic Republic of Congo is Lake Tanganyika and the border to Zambia is located at 328 kilometres from Mpanda District Capital. In turn, major roads connect Biharumulo town to Bukoba, Mwanza, Burundi, and Rwanda. The town is a market hub important for trade and services and a crossroad for transport. Trade with neighbouring countries, particularly Burundi is important for some imported consumer goods such as the locally brewed 'Rubisi' beer and fabric cloth locally called 'Kitenge'. Moreover, many trucks on their way to Bukoba, Burundi and Rwanda pass through the town and make overnight stops, which triggered the development of a considerable number of bars and lodges. The picture looks similar for Ngara district. In particular, Kabanga town, which is located near the Burundi boarder, benefits from trade with the neighbouring country. Consequently, many businesses are found in Biharamulo and Ngara in retailing, provision of lodging, food and beverages.

2.2. The status of energy provision and brief project description

The country's large size and low population density in combination with its low-income setting make infrastructure development a difficult exercise for Tanzania. The national grid only covers the Eastern and Central parts of the country leaving out most of the other regions particularly in the West, where district capitals and other important centres are served by diesel generators. Electrification rates are low even for African standards: in the Kagera region of Biharamulo and Ngara, 1 to 2 percent of the rural population have access to the electricity grid and in the Katavi region (Mpanda) this share merely amounts to 4 percent. According to official statistics, solar energy is not widely used in the regions and only about 5 percent of the population in Kagera region use solar energy (PMORALG 2013). On the national level, around 40 percent of the population in urban and 2 percent in rural areas have access to electricity. Hydropower accounts for approximately half of Tanzania's total power generation; the remainder is generated by thermal plants run on fossil fuels, mostly domestic natural gas, diesel and coal. Overall, power supply does not meet the increasing demand with significant blackouts and power rationing as obvious consequences.

Energy is among the six priority areas identified in the *Big Results Now* initiative launched early 2013 with rural electrification as one major focus. The aim of this initiative is to accelerate the achievement of middle income status by 2025 and the transition out of aid dependency. The inclusion among the priority areas marked a significant shift in policy priorities towards energy provision as compared to the year 2011 when the state-run utility company TANESCO (Tanzania Electric Supply Company) applied for co-funding for the electrification project, for which this report has been prepared; and it had institutional consequences. Energy supply, transmission and distribution was no longer the sole concern of TANESCO and the Ministry for Energy and Minerals (MEM), but became linked to the President's Delivery Bureau charged with managing the *Big Results Now* initiative.

The upcoming electrification project, for which this report has been prepared, receives donor co-funding in the form of a grant, with the other half of project costs borne by the Tanzanian government. The project aims at upgrading and operating local electricity networks in the three districts Biharamulo, Ngara, and Mpanda. At the time of setting up the project, all sites were considered to be located too far away for connection in the near future to the existing national grid, which is mainly limited to the eastern parts of the country.[3] As a consequence, so far only the district capital towns Biharamulo, Ngara, and Mpanda are connected to decentralized electricity networks powered by stand-alone diesel generators, which also serve few peri-urban zones. The three sets of diesel generators are between 25 and 35 years old and hence far beyond their economic lifespan. The generators not only use twice as much fuel as modern generators, but production is also at only about 35 percent of their capacity leading to frequent outages and heavy load shedding. The risk is high that the generators deteriorate in the very near future in a way that would effectively disconnect the users from the electricity services. The project therefore intends to step in and replace the dilapidated generators by six modern, considerably more efficient generators of 1.25 MW each. This will improve the reliability of the electricity provision and allow the extension of the existing grid to further rural areas in the town peripheries. The network is to be

[3] *Biharamulo has been connected to the national grid in a very short time frame after the baseline in mid-2015. Given the rather hasty grid extension process, it is, however, not clear whether the quality of the connection will actually lead to an improvement of electricity supply in the town and its outskirts.*

extended by a total of 171 km of 33 kV line, and 44 km of low voltage line as well as a total of 44 sub-stations.

Within a pre-specified distance to the electricity line of 100 metres, the project will bear the expenses of connecting the households to the grid. Beyond actual consumption cost, households only have to pay the value added tax of 18 percent on the usual connection charges, which amount to 27,000 and 48,814 TSh (12.60 and 22.70 €) for rural and urban households, respectively, as long as they live up to 30 m from the electricity grid.[4] Urban households living further away may pay up to 106,000 TSh (50 €). Another prerequisite for being connected to electricity is that the house has to be iron roofed as thatched roofs are more prone to fires. Households have already been informed about this requirement and some of them report to have purchased an iron roof in order to be eligible for electricity. This issue will be further discussed in the identification section below. Additional rural grid extension in the project area is financed by the Rural Electrification Agency (REA), which covers low and medium voltage lines, sub-stations and household connections in selected villages. These REA activities have also been included in the present evaluation, since they will rely on the generators and grid extension financed by the assessed electrification project and since the electricity service to households is supposed to make no difference between electrification by REA or by TANESCO. The respective villages will be referred to as 'REA sites' as compared to the 'TANESCO sites' financed exclusively by the project under scrutiny. Methodologically, the present evaluation is not affected by this change in scope, which only has to be accounted for when attributing the impacts to the different funding partners.

[4] *At the time of the survey the exchange rate between Euro and Tanzanian Shillings was 1 € for approx. 2,150 TSh. The data collected in this study revealed that even for the poorest households from the lowest quintile of the income distribution, these connection charges merely amount to half the expenditures of a single month, for the highest quintile less than 5 percent. For some households, this may still be too much to connect instantly, but for most households conditions are very favourable.*

In addition to the electricity provision component, the *implementation phase* includes training and technical assistance components. Partner representatives at TANESCO will be trained on certain management tools related to the project. Moreover, parts of the target group (micro and small enterprises, MSE) will be trained to strengthen their capacities related to the use of electricity.

The *operation and maintenance* phase (O&M phase) will then follow after the implementation phase. During the first ten years a dedicated fund established by the project pays for upcoming maintenance costs. This affects mainly the so-called *level two* maintenance activities, i.e. those that cannot be conducted by TANESCO staff, but that have to be done by contractors or the manufacturer of the generators. *Level one* maintenance activities are expected to be performed by TANESCO itself. It is important to note that the kind of generator to be employed is already in use in other parts of the country and managed and maintained by TANESCO.

3. Evaluation Approach

3.1. Evaluation Objective

The purpose of this baseline is to portray the socio-economic before situation in the urban and rural target region of the electrification project to provide a basis for a rigorous impact evaluation two to three years after the connection. This baseline does not address the capacity building and technical assistance activities at TANESCO, which will be handled as part of a separate institutional analysis of the project. The research questions pursued by this evaluation follow the Theory of Change of the intervention outlined in Figure 2.

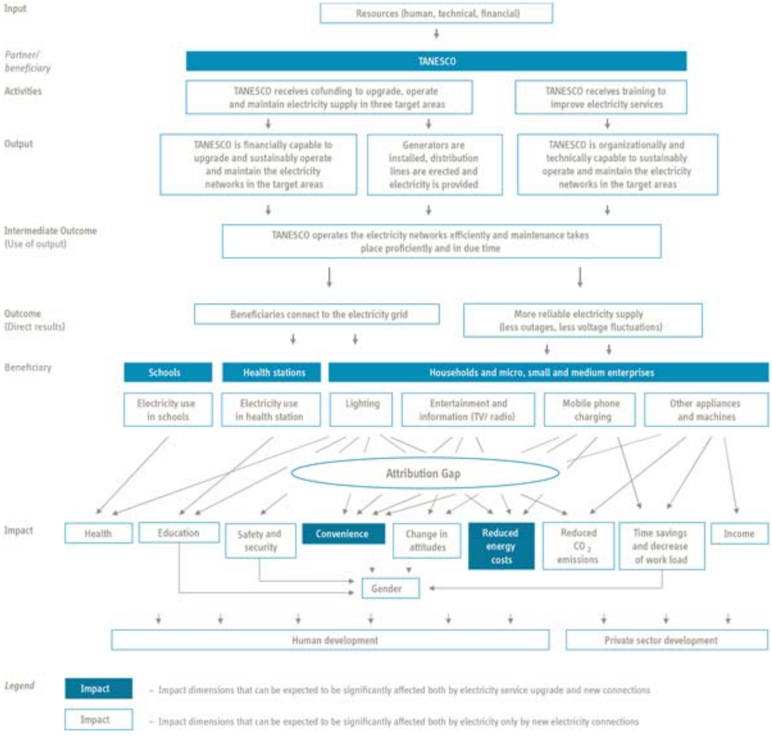
In our analysis and hence also in our methodological approach we explicitly distinguish between rural beneficiaries that will be newly connected to the extended grid and the beneficiaries in towns that are already connected to the grid before the intervention and benefit because of an increase in service quality. We use structured and semi-structured questionnaires for the four different beneficiary groups rural enterprises, rural households, enterprises in towns, and households in towns (see also Section 3.3 on Data collection) that allow for answering the following research questions.

Outcome level:

- (i) What is the connection rate of households, enterprises and social infrastructure institutions in the newly connected project area?
- (ii) How do connection rates evolve in the town centres with rehabilitated connections?
- (iii) How does the frequency and duration of outages change?
- (iv) For which purposes, by whom and how much electricity is used?
- (v) Which socio-economic groups (incl. income groups) benefit from availability of electricity?

Figure 2

Results chain of the electrification project



Note: *This results chain abstracts from the minor component of MSE business development trainings, which is also geared towards increasing the uptake and use of electricity among beneficiaries for income-generating purposes.*

Source: *own representation*

Impact level:

(i) How have expenditures for energy changed?

(ii) To what extent has safety/protection changed?

(iii) To what extent has comfort/convenience changed? What monetary value do households attribute to this increased convenience?

(iv) To what extent do activities during evening hours change – both inside and outside the household? Have study hours/reading time of children changed? Do women and children enjoy more or less rest for physical recuperation?

(v) How have, in response to the possibly increased media exposure, attitudes and behaviours, such as fertility-related decisions and children's school enrolment changed?

(vi) Has the availability of electricity triggered new economic activities or displaced old ones?

(vii) Have new enterprises been created?

(viii) Has school attendance changed as a result of electricity use?

(ix) How are impacts distributed across different income groups?

(x) What (if any) positive and/or negative unintended effects have occurred?

On the **household level in newly connected villages**, literature suggests that the major impact is on 'softer' levels such as increased convenience and comfort induced by using electric lighting and appliances such as radio, TV, or a mobile phone charger as well as on the level of expenditures (see for example Acker and Kammen 1996, Bensch, Peters and Sievert 2013, Peters and Sievert 2016 or Lenz et al. 2016, Wamukonya and Davis 2001). There is also some evidence for effects on income, and educational indicators (Khandker et al. 2012, Khandker et al. 2013) as well as employment (Dinkelman 2011) and general poverty as measured by the HDI (Lipscomb et al. 2013).

Furthermore, we examine impacts on activities after nightfall, which might be affected due to increased usage of lighting and television. The time children dedicate to studying at home is an indicator, for instance. In addition, we study the impact on behaviour and attitudes resulting from increased media exposure, such as on women's status, reproductive behaviour decisions, and children's school enrolment. Some studies suggest that the information and exposure provided by radio and in particular television can influence a wide range of attitudes and behaviour (see Olken 2006, La Ferrara et al. 2012, Chong and La Ferrara 2009, Peters and Vance 2011, Peters et al. 2014*a*, Jensen and Oster 2008). As the results chain shows health effects from reduced household air pollution are also possible. However, even if this impact exists, it will be rather small given that household air pollution is largely induced by cooking fuels. Cooking habits, in turn, are usually not affected by an electrification intervention in rural Africa. We therefore abstain from looking into this dimension in the context of this evaluation.

For **improved household connections in town**, the increased convenience and comfort might be induced through an increase in the usage intensity of electricity, more reliable service provision, and/or a reduction of back-up electricity generation. The latter may additionally trigger energy cost reductions. In order to elicit convenience and comfort aspects, we use direct questions on satisfaction and perceived convenience. These questions are similar to those used in the happiness and subjective poverty literature and in the marketing literature. In addition, a willingness-to-pay analysis (WTP) is conducted in the present baseline phase, i.e. households are asked how much they would be willing to pay for a reliable to get a well-defined package of electricity services. Moreover, a willingness-to-accept (WTA) module is applied asking for the price at which connected households would accept to give up the current unreliable electricity connection. In general, WTP and WTA are suspected to yield non-reliable results. Especially those approaches are prone to biases that rely on stated preference, i.e. if respondents are asked to state a value for a hypothetical situation or good and do not face a real decision with monetary implications. Respondents may, for example, answer or behave strategically, ignore income constraints, or may not be habituated to hypothetical exercises (Hausman, 2012; Carson and Hanemann, 2005). We took these concerns into account when designing the corresponding parts of the questionnaire by referring to field-tested tools for the formulation of our WTP and WTA questions (Whittington 2002; Kremer et al. 2011; Devicienti et al. 2004; Abdullah and Jeanty 2011; FAO 2000). Moreover, in our case, the hypothetical situation to be valued – a reliable electricity supply or a complete failure of the electricity supply – is more tangible than in many other cases in which respondents do not have a clear relationship to the good to be valued (e.g, environmental goods).

On the **micro-enterprise level**, various effects are possible. In newly connected villages, manufacturing firms like carpenters or welders might use electricity to run new machinery, shops and service firms like hair cutters can use smaller appliances like fridges, radios or electric haircutting machines to improve services or attract customers. Electric lighting can improve processes in all type of companies and might lead to an increase in operation hours. For remote areas, research has shown that only in few cases electricity access in fact is a major bottleneck for firm performance. Most entrepreneurs are rather limited by the lack of access to markets. Only in exceptional cases, enterprises have the opportunity to sell their products on markets beyond their own community. Demand for their products is by and large coming from the community itself and thus already saturated. Accordingly, even if new products can be offered, they mostly attract local demand that has to be retracted from other locally offered goods such that the net effect on local businesses is often negligible. As a consequence, customers may benefit from a few new locally available products and services, but productive use potentials are very limited (see for example Peters et al. 2011, Peters and Sievert 2016 or Peters et al. 2015).

For enterprises in the town centres, impacts can be expected to be more widely notable. Here, enterprises are already connected and the electrification treatment will rather be an improvement of service quality and reliability. Very little evidence exists on this treatment. Using data from India, Allcott et al. (2014) find that productivity losses because of frequent outages are subtle only, because enterprises adapt activities and, most notably, because enterprises use generators as backup. Small enterprises face much higher losses and hence here impacts of service improvements can be expected to be more pronounced. In designing this study, we also had to consider that entrepreneurs are far more difficult to survey, since they are generally less patient due to their running businesses – even more so in urban areas. Consequently, we sought to keep the questionnaire short and to concentrate our data collection on generator usage, adaptation and coping strategies to outages as well as productivity indicators (expenditure structure, size and type of workforce, operating hours, number of customers, sales, revenues). We furthermore decided to apply the WTP and WTA approaches to enterprises only at follow-up (also bearing in mind that they do not require both baseline and follow-up data).

Only very few studies exist that exploit variation in electricity exposure between regions or villages. Most studies compare households with and without electricity.

For Africa, the only exception is Peters et al. (2014*b*)[5], although the number of surveyed villages is still rather small at 50. Outside of Africa, regional effects are examined in Brazil (Lipscomb et al. 2013), South Africa (Dinkelman 2011), and India (Rud 2012, van de Walle et al. 2013). Being able to include a total of around 100 villages will enable us assess **village level effects** such as connection rates, non-payment rates, firm creation, or effects on migration that are so far uninvestigated.

The indicators that we use to answer the various research questions are presented in Section 4 and 5. For each beneficiary group we differentiate between general indicators (e.g. occupation, household size, asset ownership, or enterprise creation) and indicators that are more closely related to energy access, such as reliability of electricity, energy and appliance usage, energy expenditures and media exposure. According to the Theory of Change and existing literature outlined above, there are different channels through which these indicators may be affected. The energy-related indicators will be affected more directly, whereas the general indicators are likely to be impacted in a rather indirect and mostly subtle manner. While this baseline report assesses whether there are structural differences in the indicators between the compared groups, the objective of the impact evaluation will be to convincingly disentangle these structural differences from the actual impact of the intervention. Our approach to this methodological challenge is outlined in the following subsection.

3.2. Identification Strategy

A key element of a rigorous evaluation design is a convincing strategy to empirically identify which observed changes are genuine impacts of the intervention. Beyond the electrification intervention, there are many factors outside of the project‘s control that also cause changes in impact indicators – such as general market trends, economic shocks, weather conditions, and other government or donor programmes. The challenge of an impact evaluation is to follow an approach that

[5] *See also Lenz et al. (2016).*

will allow to filter out the changes caused by these other external factors and isolate the changes that can be attributed solely to the project‘s activities.

Impacts among the four beneficiary groups are assessed using different identification strategies. **For rural households**, a difference-in-differences (DiD) approach is applied. Here, the treated households will be compared before and after the intervention. This first difference is adjusted by subtracting the same before-and-after difference in a control group. This control group is supposed to mimic the counterfactual development that would materialize in the treatment group in the absence of the intervention. DiD does not require the two groups to be at the same *level* for a certain indicator under evaluation, but only requires that *changes* in this indicator would be the same in the absence of the treatment. Income may, for example, differ between the two groups at baseline, but it is supposed to follow the same trend over time if none of the two groups was treated. Whether this so-called *parallel trend assumption* holds cannot be ultimately tested, but the more similar the two groups are at the baseline stage the more likely the assumption holds.

Both ‘TANESCO sites’ and ‘REA sites’ are treatment communities. For the selection of the control group, we restricted ourselves to villages in the project regions due to the remoteness of the area. Recruiting control villages from outside the project region would have implied completely different agricultural and climatic and thus socio-economic conditions. See Section 3.3 for more details on the sampling.

If the parallel trend assumption holds, the virtue of the DiD approach is that time-invariant household characteristics are controlled for. This helps to remove the major source of bias in the evaluation of electrification interventions caused by the fact that households have to pay a typically sizable connection fee and, hence, not all households will decide to obtain a connection. It is quite likely that this decision is driven by certain household characteristics. For the observable part of these characteristics (e.g. income) a bias in our impact assessment can be avoided by controlling for these characteristics using multivariate regression techniques or propensity score matching. The DiD approach mostly pays off if it comes to unobservable characteristics that drive the decision to connect. For example, more 'modern' household heads who might be more aware of the advantages of an electricity connection, and, hence, are also more inclined to get connected. In a simple comparison of connected and non-connected households at one point in time, we may attribute the difference in evaluation outcomes to electricity usage although it is due to the unobservable characteristic. DiD controls for these unobserved confounding factors as long as they are time invariant, which can be assumed for the usual suspects like being modern or more motivated and engaged.

The same DiD identification strategy will be applied for outcome and impact indicators that are elicited on village level including the number of firms in the respective community. While this will also help to evaluate effects of electrification on the **rural enterprises** in terms of firm creation, the major identification strategy for this beneficiary group is a small *n* qualitative case study approach. In principle, it also follows a DiD technique by assessing the firm's behaviour in treatment and control villages before and after the treatment. Different from the structured quantitative analysis among rural households and communities, it does so in a qualitative and semi-structured flexible manner. This comparison is obviously less robust and more prone to different sources of bias, but it nonetheless offers insights into how access to electricity affects the micro-enterprises' scope of work. The main research efforts will be made at the follow-up stage. Nevertheless, already during the present baseline we conducted interviews with rural enterprises in order to portray their current situation and expectations related to electricity access.

For both **urban households and urban enterprises** we apply a simple before-after comparison. Recruiting a control group and thus applying a DiD approach turned out to be impossible already during the inception phase in mid-2014. The underlying assumption for such a before-after comparison is that the outcomes under evaluation would not change between the baseline and the follow-up if the electrification did not happen. This assumption might be violated if secular changes (improvements of general economic conditions, technological change, seasonality etc.) affect the households' behaviour with respect to the outcome over time. A growing economy, for example, might affect the household's income. One would then falsely ascribe an increase in an income-dependent outcome variable (e.g.

expenditures) to electrification although this increase would have taken place anyhow due to economic growth. In order to control for such secular changes, we will include secondary data on the regional economic development into the analysis.[6] Furthermore, we will try to identify confounding factors by conducting semi-structured interviews with key informants on the general development in the towns and the business sectors.

For **urban households** that are already grid connected, effects on classical socio-economic indicators will be rather subtle. While we will make an attempt to grasp effects on back-up electricity sources (generators, or car batteries, dry-cell batteries), the strongest effect will be on convenience and adaptation costs. In order to approximate the change in these difficult-to-measure dimensions, we will apply contingent valuation (willingness-to-pay) before the rehabilitation of the grid. This approach does not require a control group. The willingness to pay (WTP) of a household for a good (or a service) reflects the "true" value that the person assigns to this good, i.e. the maximum price that the person would be willing to spend to purchase the good. In the case of electricity the true value includes not only economic benefits in the narrower sense (e.g. kerosene savings or income generation potentials), but also convenience factors or subjective security issues. Likewise, the household faces costs related to electricity usage, again not only costs in a narrower sense (e.g. monthly fees) but also non-monetary costs such as behavioural problems related to excessive TV exposure of children. By quantifying her WTP, the interviewee implicitly sums up all perceivable benefits and contrasts them with the sum of costs. The most straightforward approach to obtain the WTP is the *dichotomous choice method*, for which the respondent is asked if s/he is willing to pay a certain price. For the *double bounded dichotomous choice method*, which we are following in this study, respondents are confronted with up to four follow-up questions asking whether they are willing to pay a certain higher or lower amount depending on the first answer.

[6] *A similar approach has been applied by Peters et al. (2015).*

Table 2 summarizes the methodological decisions taken in the design of this evaluation.

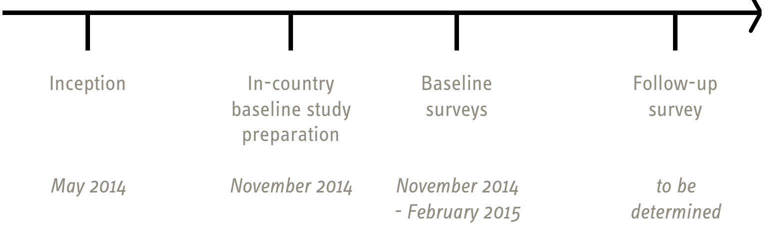
Table 2
Methodological approaches followed for the different beneficiary groups

Beneficiary group	Identification strategy	Main survey tool	Willingness-to-pay analysis
Rural communities	difference-in-differences	structured questionnaire	-
Rural households			-
Rural enterprises	qualitative difference-in-differences assessment	semi-structured questionnaire	-
Urban households	before-after comparison	structured questionnaire	x
Urban enterprises			-

3.3. Data collection and sample composition

Surveys were conducted in rural areas at community, household and enterprise level and among urban households and enterprises. This section describes the sampling, the survey tools and the implementation of the baseline survey that took place between November 2014 and February 2015. The approach was planned during an Inception phase in mid-2014 and was fine-tuned during an in-country baseline study preparation shortly before the survey started (Figure 3).

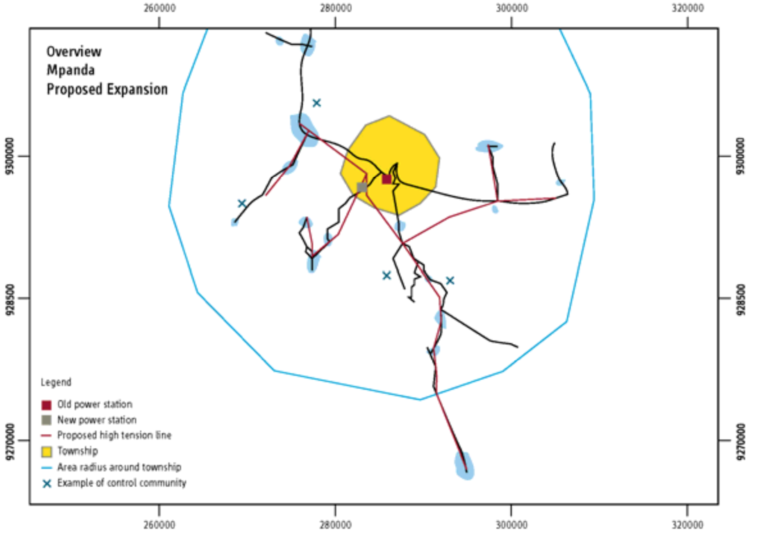
Figure 3
Evaluation study timeline



The sampling for the rural survey was stratified along three dimensions: Districts, sub-villages, and households. Within the three districts Ngara, Biharamulo, and Mpanda the communities targeted by the electrification intervention were identified, i.e. TANESCO and REA sites. It turned out that the planned electricity grids mostly cover only parts of villages that span several kilometres with scattered households and different sub-villages. Community data has therefore been collected on the level of sub-villages. Villages are usually split up into about four sub-villages, which have an own administrative structure. Households have then only been sampled within these sub-villages.

Figure 4

Planned electricity network around Mpanda town



Note: Scale is 1 : 300,000. The blue line is the 20km radius around the power station.
Source: TANESCO

To illustrate this, Figure 4 shows the area around Mpanda town, represented by the large red square in the pink circle. The extensions of the grid (red lines) mostly follows the main roads (black lines). As can be seen for example in the cases of

Kabungu in the North, transformers (green/ black circles) can be placed in multiple sub-villages within the same village, such as in Kabungu centre and the one hosting the secondary school. The sub-villages further away from the main road, in contrast, can usually not benefit from the electrification in the first place. Sub-villages are therefore the appropriate level for sampling households and for conducting interviews at the community level.

It turned out that there were 54 TANESCO and REA sites as treatment sub-villages (ten in Biharamulo, 24 in Ngara, and 20 in Mpanda). This fitted well in the planning that the sample was supposed to include approximately the same amount of control sites and in total 1000 households. The rural household data was thus collected from 54 treatment and 46 control communities with ten interviews per community.

The selection of the 46 control sub-villages was based on observable characteristics such as the presence of an economic centre or a primary school, the number of inhabitants and the economic structure. In addition, they should not be planned for electrification within the coming two years. Control sub-villages were mostly chosen within the radius around the urban centres that corresponds to the extension of the planned electricity grid. Alternatively, they could be located slightly further down the main roads outside this radius. In Mpanda, 20 control communities were sampled, 16 in Ngara, ten in Biharamulo. For the exemplary case of Mpanda, the location of treatment and control survey sites is shown in Figure A1.

All 100 selected sub-village leaders and a random sample of ten households per sub-village have been interviewed. The sampling within sub-villages was facilitated by the fact that lines were usually already demarcated by engineers hired by REA or TANESCO. Based on the sketches of the planned electricity grids, households were randomly chosen in a corridor of around 100 metres along these planned lines. As described in Section 2.2, connections to the grid will be subsidised up to a distance of 100 m to the electricity line. In control villages, it was estimated on the ground where a line would be placed if this village was to be connected. This would usually be along the main road so that the local road infrastructure served as a means of orientation. Furthermore, households were selected in approximately equal intervals (e.g., every tenth house), depending on the size of the sub-village.

Table 3
Sample composition

Beneficiary group	TANESCO	REA	Control	Total
Rural communities	29	25	46	100
Rural households	290	250	460	1000
	Biharamulo	**Ngara**	**Mpanda**	**Total**
Urban households	100	100	100	300
Urban enterprises	132	132	244	508‡

Note: ‡ among the 508 interviewed businesses, 31 are small mining enterprises that do not have their offices in town and thus do not belong to the core sample of this evaluation made up by the remaining 477 enterprises.

Beyond sub-village leaders and households, rural entrepreneurs have been sampled purposively in a way that each craft encountered was interviewed at least once in order to get a fair impression about their energy use and productive electricity use potentials. Rural entrepreneurs turned out to be few and mostly small shop keepers.

For the urban household survey, 100 households were interviewed in each of the three towns Ngara, Biharamulo, and Mpanda. Urban neighbourhoods (or wards) were chosen based on a probability proportional to size approach. In each ward one TANESCO customer was identified based on available customer registers. Analogously to the rural household survey, then approximately every tenth house was selected, conditional on being a TANESCO customer as well. Urban MSE were sampled within urban wards in a way that equal numbers of the three enterprise types trade, services, and manufacturing were interviewed. In addition, mining enterprises have been sampled and more enterprises have been sampled from Mpanda, since this town is bigger and exhibits more economic activities. In consequence, 508 firms in total were interviewed, 244 in Mpanda, 132 in Ngara, and 132 in Biharamulo.

3. Evaluation Approach

The field work for the community and household interviews was carried out in November and December 2014 and in January 2015 for the urban MSEs.

With the community questionnaire we gathered information on social and economic activities in the surveyed sub-villages (all questionnaires can be found in the appendix). Face to face interviews were carried out with elected sub-village leaders. If feasible, important indicators (e.g. the number of enterprises in the sub-village) obtained in interviews with the leaders were cross-checked in additional interviews with key informant persons residing in the village such as government officials. The collected information includes aspects such as the distance to the closest main road, the quality of the existing roads, availability of social and financial infrastructure as well as energy sources, telecommunication signal quality, and information on in- and out-migration during the last three years. This data helps tracing the local development in the community, identifying differences between the three survey regions and testing the comparability between treatment and control sites.

For the household surveys, the household heads or their spouses were interviewed. Both the rural and urban household questionnaires include socio-economic background information such as household composition, occupations, income and expenditures, assets owned, and schooling. In addition, a range of questions on energy and electricity sources but also the source of lighting and an activity profile were included. Another very probable area of change following an (improved) access to electricity is the ownership of appliances. In addition to these objective measures, questions on people's satisfaction with the quality of electricity supply have been added. The rural household survey furthermore comprises a section on agricultural activities and production; the urban questionnaire features questions on reliability and costs of the TANESCO connection. As the main treatment for households in towns will be an increase in service quality, i.e., the provision of reliable electricity access, a contingent valuation/ Willingness-to-Pay (WTP) question is also added. Several instruments have been incorporated in the questionnaire design to avoid that interviewees cannot be found for the follow-up interview. Name and mobile phone number of the interviewee and of a person outside the household who is well acquainted with the family have been elicited.

Enterprise owners in town were asked about the type and activities of their firm and about their electricity usage with a particular focus on cost and reliability of the electricity supply. In addition, access to finance and markets as well as possible business development services were of interest. Subjective measures for the enterprise's economic situation and the quality of the electricity supply were included.

Overall, most interviewees (approximately 95 percent) consented to participate in the survey. Particularly in the villages, where the population is keen to be connected to the grid, enumerators were warmly welcomed. In towns, it took more effort to soothe people's suspicion and to convince them to consent to the interview, in most cases because TANESCO in some areas does not enjoy a very favourable reputation. In general, enumerators had the impression that people did disclose trustworthy information and sub-village leaders and inhabitants were also willing to participate without reservations. Interviews usually took between 40 and 60 minutes. The main challenge during the rural survey was the remoteness of some villages and the lack of mobile phone network coverage. This implied difficulties both in terms of localizing the villages and getting in touch with local contact persons. Finally, the beginning of the rainy season made transport and logistics in the survey difficult on some survey days.

4. Baseline results for rural intervention areas

4.1. Community profile

In this section, we present basic community-level data that portrays the livelihood conditions of the surveyed households in the three subsamples TANNESCO sites, REA sites and control sites. At the same time, it scrutinizes the key assumption of our identification approach, the comparability of treatment and control group. The data refers to the sub-villages as the lowest administrative unit. For some key indicators, we will also disaggregate the data by the three surveyed districts in order to elucidate potential differences between them.

Table 4 shows basic demographic statistics of the sampled communities. In combination with the data presented in Table 5 on basic physical infrastructure, the important finding is that the control group does not differ considerably from the two treatment groups. The only infrastructure indicator that exhibits a visible difference for control sites is the distance to the main road. Virtually all other infrastructure features are quite similar or only slightly and thus not statistically[7] different for the control group. In addition, differences do not always show into the same direction. While REA villages show more economic activities in terms of kiosks and mills, TANESCO villages have the highest share of secondary schools and control villages the highest share of health centers, for example. As Table 4 shows, control groups are somewhat smaller in terms of population size.

[7] *In the following, statistical tests are applied to all variables to assess differences between the compared groups. These are either t-tests comparing two mean values (e.g. average number of flour mills) and chi-squared tests comparing two shares or categorical variables (e.g. share of primary schools or fertility of land).*

Table 4
Demographic statistics on the sampled communities

	TANESCO	REA	Control	Total
Number of communities	29	25	46	100
Average population per sampled community	1235 (1535)	1314 (1460)	1099 (972)	1192 (1273)
Average number of households	252 (217)	278 (244)	209 (164)	239 (202)

Note: Standard deviations in brackets.

Source: Tanzania energy baseline community survey 2014

Looking closer into the available infrastructure inTable 5, we see that almost all sub-villages have some sort of school and religious building as well as kiosks and flour mills. Secondary schools are far more common in Ngara (55 percent as compared to 25 percent for the other two districts, not shown in the table). Around half the communities have direct access to a health facility in their sub-village; financial services are slightly more common, at least in the two north-western districts Ngara and Biharamulo. However, the most available financial services are informal, ranging from saving groups to mobile banking agents. Most communities are not far away from the main road, with distances averaging 3 to 6 km (the total average being 4.3 km) and the largest distance being 20 km for two communities in Ngara. Communities in Mpanda are closest to main roads. Most communities are also accessible during the rainy season.

Table 5
Basic physical infrastructure available to the communities

		TANESCO	REA	Control
Primary schools, in %		97	100	93
Secondary Schools, in %		48	24	37
Any schools, in %		97	100	98
Dispensaries, in %		55	48	46
Health centers, in %		3	8	11
Religious buildings, in %		79	96	87
Access to financial services, in %	formal banking	14	8	0
	informal banking	55	76	65
Kiosks or stores, in %		97	100	100
Average number of kiosks or stores		12	30	13
Flour mills, in %		86	84	85
Average number of flour mills		3	4	2
Distance from main road, in km		3.6 (4.1)	2.8 (5.1)	5.5 (5.9)
Accessibility to main road during rainy season, in %	good	38	60	20
	average	45	16	59
	possible with difficulties	17	20	17
	possible in case of emergency	0	4	4

Note: *Standard deviations in brackets. Formal banking refers to commercial banks and micro-finance institutions, informal are saving groups, money lenders, or mobile banking agents.*
Source: *Tanzania energy baseline community survey 2014*

Access to information and telecommunication is another key locational factor. Reception is slightly worse in control sites, which is in line with the distance to main roads. But overall, all three groups have similar access rates with the difference being rather in the reliability of the signal. Also, none of the differences is statistically significant (Table 6). Only mobile phone network quality seems to be better in REA sites, but quite comparable in TANESCO and control sites. In addition, many sub-village leaders were unaware of internet availability leading to high non-response rates for questions on internet availability.

Table 6
Availability of mobile phone networks and broadcasting services, in percent

			TANESCO	REA	Control
Radio signal	Availability	yes	100	100	100
	Quality	good	96	76	61
		medium	4	24	33
		bad	0	0	7
Mobile phone network	Availability	yes	97	100	96
	Quality	good	48	60	37
		medium	28	32	33
		bad	21	8	26
Television signal	Availability	yes	76	88	67
	Quality	good	41	40	37
		medium	34	40	22
		bad	0	4	4

Source: Tanzania energy baseline community survey 2014

Table 7 shows the availability of different traditionally used energy sources in the surveyed sites. Dry-cell batteries used for radios and light emitting diode (LED) lamps are available in virtually all sites. Kerosene, which is used for wick lamps, and cooking fuels (firewood and charcoal) are also widely available. Candles seem to be on the retreat, even though their penetration is still relatively high as compared to other Sub-Saharan African countries. Diesel and petrol, used in generators, is also available in most sites. Given the higher requirement to the distribution network of Liquefied Petroleum Gas (LPG), it is virtually not available in the surveyed communities.

4. Baseline results for rural intervention areas

Table 7

Source of energy available in communities, in percent

	TANESCO	REA	Control
Dry-cell batteries	90	96	96
Firewood	93	84	93
Charcoal	83	72	89
Petrol	79	92	72
Kerosene	72	100	76
Candles	48	72	65
Diesel	45	52	54
Gas	3	0	4

Source: Tanzania energy baseline community survey 2014

With the major part of the population being occupied in farming, Table 8 depicts the quality assessment of farming land fertility (individual perception of the interviewees), which gives a sense of the conditions of land as the main input factor for the local economy, though it has to considered that village chiefs may not always be best informed about this indicator. There is no clear picture across the three subsamples of this study. Differences can rather be observed between the regions (not shown in the table): in Mpanda, as many as half the communities rate the farming land as less fertile, whereas this share amounts to only 17 percent in the two north-western districts.

Table 8

Fertility of farming land, in percent

	TANESCO	REA	Control
very fertile	31	8	13
fertile	45	68	48
less fertile	24	24	39

Source: Tanzania energy baseline community survey 2014

As a last dimension of the local livelihood, we look at migration patterns represented by figures in Table 9. For the last three years, the movement of people within the country is similar across the three groups. International migration, however, is virtually inexistent. Also, when looking into year-specific data, no particular trends can be observed (not shown in the table).

Table 9
In- and out-Migration during last three years

	Share of communities with migration, in %			Average number of migrants across all communities		
	TANESCO	REA	Control	TANESCO	REA	Control
Left to seek work (within country)	97	78	77	15	38	21
Left to study in town	86	88	66	14	13	15
Left to another continent	3	0	2	0	0	0
People moved into the community	79	72	80	22	68	27

Source: Tanzania energy baseline community survey 2014

To conclude, the careful selection of control sites seems to be successful with three groups that are comparable to a sufficient extent. The differences we have found will be accounted for in the analysis.

4.2. General household characteristics

In this section we present selected descriptive statistics on the socio-economic structure of the households in the project area to illustrate the living conditions in the project area, but also to document the quality of the collected data and our methodological approach. A summarizing assessment of the quality of the collected data follows in Section 6.

For the purpose of our survey and analysis, we adopt a common working definition of a household as a group of individuals who live in the same house. These individuals pool their resources together to meet their basic food needs under the authority of a single person, called the 'head of the household'. In our sample, we have 1,000 rural households with a total of 5,668 members. The average household size is around 5.7 (Table 10). The average share of children under six is at 22 percent, which is in line with the overall age structure of the country according to which the share of children aged 0-14 years is 45 percent (CIA World Factbook 2014 estimates). Household size and the share of children below 7 are very similar for treatment and control communities indicating that the two groups of communities are comparable along that demographic dimension. Two variables exhibit statistically significant differences, the sex and age of the household head. In both cases, the statistical significance is contrasted by a very small difference, which does not give reasons for further concerns in terms of comparability of the treatment and control group. Nonetheless, we will include the socio-economic variables as control variables in order to account for such differences.

Table 10
Household's structure variables

	Control	Treatment
Household size	5.7	5.6
Share children 0-6 years, in %	22	21
Female household heads, in %	9	12**
Age of the household head	40.5	42*

*Notes: Asterisks represent statistical significance of the difference between control and treatment communities. * indicates that the difference is statistically significant at the 10, ** at the 5, *** at the 1 percent level.*

Source: Tanzania energy baseline rural household survey 2014

As highlighted already in the section on village characteristics, agriculture is the main income source for the majority of the households (Table 11). Nearly 90 percent of all household heads are employed in the agricultural sector. There is a small difference between the two groups with household heads in treatment communities being less likely to be farmers. Again, the difference is not large, but it indicates the necessity to control for the sector of activity of the household head in the final analysis. None of the differences in Table 10 is statistically significant.

Table 11
Sector of activity of the household head, in percent

	Control	Treatment
Farming	89	84
Public Sector	3	5
Other market work	7	8
Retirees	0	2

Source: Tanzania energy baseline rural household survey 2014

Considering the eight main expenditure categories listed inTable 12, the highest share of total expenditures is spent on food (44 percent). The second highest non-energy expenses are on transportation at 10 percent, followed by clothing, telecommunication and health. Generally, there are no large differences in the spending structure of treatment and control communities.

At the bottom of the table we present the average expenditures of the households. The expenditures presented here represent total annual expenditures of 3,06 million TSh (1,423 €, control) and 2,86 million TSh (1,330 €, treatment), respectively. Households in treatment areas have lower expenditures than those in control areas, but this difference is not statistically significant. At an average household size of 5.7 this results in yearly expenditures per capita of 536,804 TSh (250 €) or 501,776 TSh (233 €), respectively which is well below the per capita GDP of Tanzania of 1,41 million TSh (654 €) for the year 2013 (World Bank 2013).

Table 12

Share of total expenditure spent for various expenditure aggregates, in percent

	Control	Treatment
Expenditure aggregate		
food	44	42
rent (for house and fields)	4	2**
health (excluding health insurance)	4	5
transportation	10	10
clothing	6	7
schooling	4	6***
remittances	3	3
telecommunication	6	6
Total yearly expenditure (TSh)	3,059,781	2,860,123

*Notes: Expenditures do not cover auto-consumption. Neither do they include energy and electricity, which are presented in the next chapter. Outliers in terms of expenditures and in terms of age have been excluded from the average total yearly expenditures. Asterisks represent statistical significance of the difference between control and treatment communities. * indicates that the difference is statistically significant at the 10, ** at the 5, *** at the 1 percent level.*

Source: Tanzania energy baseline rural household survey 2014

Turning to subjective indicators of well-being, Table 13 shows that the majority of households consider their budget to be `tight' or `insufficient' to make ends meet. The treatment group is slightly more optimistic to the extent that more households regard themselves as being `tight' on money but fewer as having `insufficient' funds, which is also reflected in a weakly significant difference between the compared groups.

Table 13

Households' perception of income sufficiency, in percent

	Control	Treatment
Perception of household's income		*
sufficient	14	13
tight	33	40
insufficient	53	47

*Note: * indicates that the difference between control and treatment communities across all three categories of this variable is statistically significant at the 10 percent level as tested by a Chi-squared test.*

Source: Tanzania energy baseline rural household survey 2014

As most households report to be farmers we next assess their landownership and type of agricultural activity further. Almost all households, namely 98 percent, report to cultivate land with no differences across treatment and control groups. However, landownership varies slightly across the two groups; 83 percent in the control and 87 percent in the treatment group also own the land they work on (Table 14). This is consistent with the result that treatment households spend slightly less on rent. An average of 68 percent of households keeps livestock of some kind with no statistically significant differences between treatment and control groups.

Table 14

Households owning land and keeping livestock, in percent

	Control	Treatment
Land owners (with and without title)	83	87*
Keep livestock	67	69
HH cultivates land	98	98

*Notes: Asterisks represent statistical significance of the difference between control and treatment communities. * indicates that the difference is statistically significant at the 10, ** at the 5, *** at the 1 percent level.*

Source: Tanzania energy baseline rural household survey 2014

With electric assets being discussed in the next section on energy and electricity, Table 15 lists main non-electric household assets. Most households have at least one bicycle (66 percent in control and 59 percent in treatment villages). Some households possess motorcycles, cars are very rare. Only 21 and 29 percent use a savings account, respectively, either with a bank or a savings association. The differences are statistically significant and it is usually the control group that is slightly worse off than households in the treatment communities. Again, all differences are rather small in absolute numbers and do not point at a structural big difference between the two groups.

Table 15
Household asset ownership

	Control	Treatment
Bicycle, in %	66	59**
Motorcycle, in %	16	20*
Car, in %	2	3*
Savings account, in %	21	29***
Number of rooms	3.2	3.4**

*Notes: Asterisks represent statistical significance of the difference between control and treatment communities. * indicates that the difference is statistically significant at the 10, ** at the 5, *** at the 1 percent level.*

Source: Tanzania energy baseline rural household survey 2014

Next we turn to the educational profile of the households. The majority of household heads has either attended or completed primary education (76 percent, Table 16). Comparison between control and treatment communities shows that slightly fewer household heads have attended primary education only in the treatment group, while slightly more heads have completed primary or higher schooling. The differences are not statistically significant. Across treatment and control groups only roughly 11 percent of the sampled household heads have no education at all.

Examining primary school enrolment rates for children between 6 and 11 years, we see that the situation has not changed much from one generation to the next: In 88 percent of the households, at least some children go to school (Table 16). While the overall share is close to equal between treatment and control communities, the share of households sending all as opposed to only some children to school is higher in treatment areas. This is also consistent with the slightly higher expenditures for education among treatment households. While the detailed educational profile shows some subtle differences between treatment and control, overall the two groups are very similar in terms of educational attainment and school enrolment.

Table 16

School enrolment and educational attainment, in percent

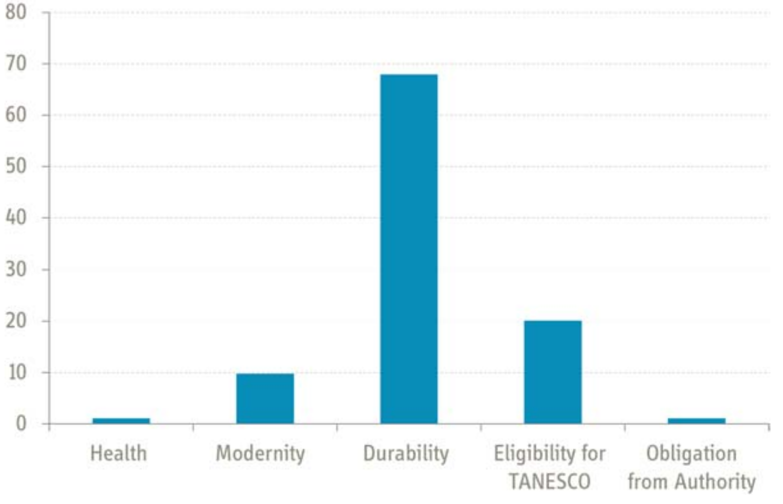
	Control	Treatment
Educational attainment of household head		
no formal education	12	10
uncompleted primary education	15	11
completed primary education	61	65
secondary education and more	12	14
Children 6-11 (School enrolment)		
all children in HH	52	60
some children in HH	36	29

Source: *Tanzania energy baseline rural household survey 2014*

Having an iron roof is a mandatory eligibility criterion to obtain a connection to the national electricity grid according to TANESCO rules. Households have to replace their thatched roof if they want to get connected. Overall, around 80 percent of households have an iron roof, with 72 percent in control and 87 percent in treatment communities. People prefer iron roofs regardless of the TANSECO standard due to a higher durability. Moreover, in-house humidity decreases considerably compared to thatched roofs. Nonetheless, since the eligibility criterion was already communicated to the population in the treatment communities at an early stage, we would expect that a certain number of households has already made the investment in anticipation of the grid extension. This would then constitute a treatment effect and could compromise our identification assumption to some degree. Our questionnaire therefore probed deeper into this matter. For starters, 22 and 27 percent have made the investment in the last two years in the treatment and control group, respectively. The difference between treatment and control group is not statistically significant. Thus, apparently, people have not yet increased their investments into improving their roofs because of the electrification. In addition, for these households that have made the investment in the last two years, durability is still the most important motivation, expressed by 68 percent of households, while around 20 percent state the TANESCO standard as the main motivation (see Figure 5).

Figure 5

Stated reason for getting an iron roof, in percent



Notes: The figure only presents responses for those households who have obtained their iron roof in the last two years (23 percent of all households that have an iron roof).

Source: Tanzania energy baseline rural household survey 2014

Electrification might have effects on the propensity to migrate, as staying in the village becomes more attractive while it may as well increase the capacity to migrate. In around 15 percent of the households at least one person has left the village. Most of them stayed in the same district (47 percent in control and 40 percent in treatment communities); another 21 and 28 percent, respectively, stayed in the same region, while a similar share left the region (24 as compared to 19 percent) and notably fewer moved to the capital Dar es Salaam. Out of the country migration hardly exists (Table 17). The main reasons for migration are work (54 percent in control and 60 percent in treatment communities), followed by schooling and studying (30 as compared to 26 percent). With regard to migration, treatment and control communities are overall very comparable.

Table 17
Destination of emigrants and reason for emigration, in percent

Destination	Control	Treatment	Reason	Control	Treatment
Same district	47	40	Seasonal work	4	5
Same region	21	28	Daily wage	32	41
Dar es Salaam	8	12	Regular work	18	14
Other region	24	19	Studies	30	26
Abroad	0	1	Other	16	14

Note: Migration for wedding reasons has been excluded from the table and from the analysis.
Source: Tanzania energy baseline rural household survey 2014

4.3. Energy usage among rural households

4.3.1 Energy sources

In spite of an officially very low electrification rate in the surveyed regions, already around 25 percent of the households have some type of electricity source (22 percent in control and 27 percent in treatment communities). Seven of the surveyed sub-villages already have a small village grid run by a generator (two TANESCO and four REA sites and one control site). Yet, only a small number of households and businesses is connected to these generators and they only run during evening hours when households need lighting and wish to watch TV.

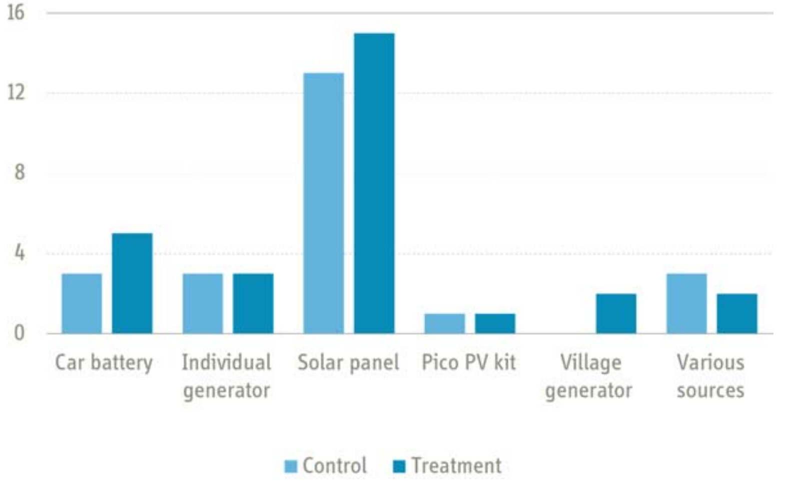
Solar panels are the most common off-grid electricity source; a few others use an individual generator or a car battery. This pattern is very similar in our two groups, except for village generators that do not exist in any of the control communities (Figure 6). Pre-electrification rates, thus, do not pose a threat to our identification assumption, but their magnitude is certainly interesting from an accountability perspective: the number of households newly served with electricity thanks to the intervention is clearly lower than the number of household connections. For the households that already use electricity the impact of the electrification intervention will be smaller and limited to a service upgrade and – for generator owners – a decrease in costs.[8] Both will of course lead to an increase in usage intensity

[8] *Generator users can be expected to connect to the grid, because costs of electricity consumption are considerably lower.*

that can be expected to impact the households' living conditions, but in a less pronounced way than for people who hitherto do not use electricity.

Figure 6

Electricity sources available to households, in percent



Notes: The figure only includes those 24 percent of households that have an electricity source.
Source: Tanzania energy baseline rural household survey 2014

Most households have already been using their electricity source for some years. The average usage time of the specific source ranges between three years for solar panels and nearly six years for individual generators. Car batteries and village generators have on average been in use for three years. While the average cost for solar panels was 335,000 TSh, annual maintenance cost is rather low at around 1,460 TSh. It is not surprising that ownership of solar panels increases with income: In the poorest quintile, only around six percent own one, while in the richest quintile 26 percent do so. There are no significant differences in the usage and distribution of SHS between treatment and control communities.

Table 18
Usage of traditional energy sources, by expenditure quintiles in percent

Energy Source	Average		Expenditure Quintile	
	Control	Treatment	Lowest	Highest
		HH with access to electricity		
Kerosene	49	61***	50	55
Dry-cell batteries	89	87	77	88
		HH without access to electricity		
Kerosene	31	33	33	32
Dry-cell batteries	82	69**	58	77

Notes: *Asterisks represent statistical significance of the difference between control and treatment communities. * indicates that the difference is statistically significant at the 10, ** at the 5, *** at the 1 percent level.*

Source: Tanzania energy baseline rural household survey 2014

Looking at the traditional energy sources that household employ, dry-cell battery driven LED-torches are dominating (Table 18). 88 percent of the households that do not have access to electricity report batteries as one key energy source, without notable differences between control and treatment groups. Similarly, differences between households with and without electricity are not very strong. This underpins that the electricity mostly generated by individual solar panels does not completely replace traditional sources of energy. For example, a considerable 75 percent of the households having access to electricity reports making complementary use of batteries as energy source.

4.3.2. Appliance usage

An assessment of appliance usage will eventually contribute to answering the research question, for which purposes, by whom and how much electricity is used. It thereby also provides a better understanding of why certain impacts on ultimate indicators such as health and convenience can be observed. The number of households using appliances for non-productive rather than for productive purposes is considerably higher (Table 19). Mobile phones are very common overall; households without own electricity sources charge them in shops or at their neighbours' house. Sound systems and TVs are logically more common in households with electricity where battery-run radios are furthermore substituted by bivalent ones that can be used with batteries and grid electricity. Treatment households possess more appliances. While the differences are statistically significant for battery driven radios, TV and charcoal iron, the magnitude of the differences is not notable. Improved access to information is frequently considered as one of the potential impacts of electrification. In our sample, radio is by far the most important source of information, stated by 79 percent of households, followed by neighbours and friends (14 percent, see also Table 19).

Table 19
Appliance usage and main sources of information, in percent

Appliance	Control	Treatment	Source of information	Control	Treatment ***
Mobile phone	81	79	Radio	78	80
Radio (battery only)	55	59*	TV	1	3
Radio (bivalent)	17	18	Newspaper	0	0
TV	10	14**	Neighbour/ friends	14	14
Sound system	1	2	Mobile phone	5	3
Charcoal iron	29	39***			

*Notes: Asterisks represent statistical significance of the difference between control and treatment communities. * indicates that the difference is statistically significant at the 10, ** at the 5, *** at the 1 percent level.*

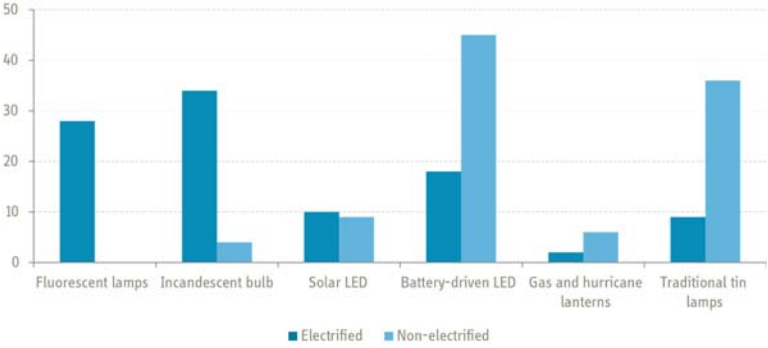
Source: Tanzania energy baseline rural household survey 2014

Only 32 households (3 percent overall and in each of the groups, respectively) use any of their appliances for some productive purpose. Most of these (23 households) use their mechanic sewing machine to produce goods as a business. Other appliances used for business include, for example fuel-run grain mills (three households) and mobile phones (two households).

Table 20 presents the daily hours of light as well as lumen hours (which is a measure of the quantity of light consumed to account for lamp types of different brightness) that households consume differentiated by their main source of lighting.

Figure 7

Primary lighting devices of households with and without electricity, in percent



Note: Fluorescent lamps include neon tubes and energy savers.

Source: Tanzania energy baseline rural household survey 2014

Table 20

Daily lighting and lumen hours by main source of lighting

		Hours of light		Lumen hours	
	N	Control	Treatment	Control	Treatment
Fluorescent lamps (neon tubes and energy savers)	71	34	33	20.880	21.020
Incandescent bulbs	114	23	21	15.550	15.870
Solar LED	92	17	14	1.340	1.000
Battery-driven LED	182	16	15	1.550	1.500
Gas and hurricane lanterns	51	9	10	11.480	7.570*
Traditional tin lamps	290	12	11	530	900

Notes: Solar LED includes a few rechargeable lamps. Asterisks represent statistical significance of the difference between control and treatment communities. * indicates that the difference is statistically significant at the 10, ** at the 5, *** at the 1 percent level.

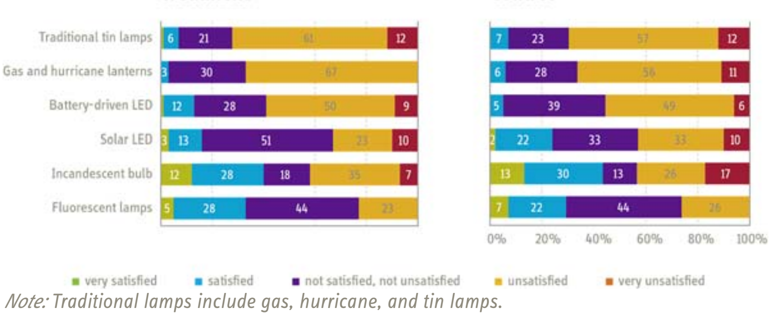
Source: Tanzania energy baseline rural household survey 2014

The majority of households (56 percent) reports to be either `unsatisfied' or `very unsatisfied' with the quality of lighting in their households. Looking at these values by the primary lighting device, one notes that households that use neon, energy savers or light bulbs tend to be more satisfied. Unsurprisingly, households that have to rely on traditional sources and LED lamps frequently express their dissatisfaction. These patterns are broadly similar in control and treatment communities.

The main activities after nightfall comprise listening to the radio, praying or sitting together and chatting. While many children aged six to eleven study for school at home before sunset (i.e., before 6 pm), the majority of them (57 percent) have to do at least parts of their homework after nightfall, 47 percent even study exclusively at night. This share is higher for households with access to electricity, where 78 percent of children study partly and 57 percent completely after nightfall. However, the average overall studying time is 1.7 hours and does not vary significantly between households with and without electricity. This indicates that kids shift their study time from day-time to night-time if improved lighting becomes available but do not increase their total study time. Also, there is no substantial difference in total study hours between treatment and control communities. Kids in treatment communities study more after nightfall (but less before), which may at least partly be due to more households using electricity (Table 21).

Figure 8

Satisfaction with lighting quality of different lighting devices



Note: Traditional lamps include gas, hurricane, and tin lamps.

Source: Tanzania energy baseline rural household survey 2014

Table 21
Studying after nightfall

	Average		HH with electricity	HH without electricity source
	Control	Treatment		
Study time, in hours	1.8	1.7	1.9	1.7
Study time after nightfall, in hours	0.7	1.0**	1.2***	0.7
Share of study time at night, in %	42	59***	67***	45

Source: Tanzania energy baseline rural household survey 2014

4.3.3. Energy expenditures

One of our research questions as well addresses energy expenditures. Table 22 shows the shares of energy and electricity expenditures in the total annual household expenditure. Energy expenditures account for four to eight percent of the total annual household expenditures in our sample, or 230,900 TSh on average (107 €).

For households without electricity, the cost for energy is more or less evenly split among kerosene for lighting, batteries, and firewood/ charcoal, each of these making up between two and three percent of annual expenditures. In households with access to electricity, the shares for the different energy sources are generally smaller and firewood/charcoal make up a higher part of annual cost (at four percent on average) than batteries or kerosene (at one percent each).

Kerosene and batteries become less important with higher overall income (each decreasing from three to one percent, although the absolute spending can of course remain similar), while the share spent on firewood or charcoal increases from two to four percent from the poorest to the richest expenditure quintile.

Table 22
Energy expenditures by wealth level (measured by expenditures), in percent

	Share of ... in total expenditures	Total		Expenditure Quintile	
		Control	Treatment	Lowest	Highest
HH with access to electricity	electricity	4	4	4	4
	energy	6	5	7	4
HH without access to electricity	electricity	0	0	0	0
	energy	7	7	8	7

Note: Installation costs are not included in the energy expenditures.
Source: Tanzania energy baseline rural household survey 2014

4.3.4. Environmental effects

The intervention might lead to environmental improvements by replacing harmful or inefficient traditional fuel types. For starters, it is important to emphasize that electricity in rural Africa is never used for cooking. Firewood usage, thus, will be unaffected by the programme. As shown in the previous sub-sections, though, households in the target areas use kerosene and dry-cell batteries to run wick lamps, LED-lamps, and radios. Kerosene as a fossil fuel emits globally harmful carbon dioxide as well as locally harmful pollutants such as carbon monoxide. Although the electricity transmitted via the grid will not be generated renewably, its generation will be much more efficient and hence less carbon intensive than burning kerosene in a wick lamp. Therefore, carbon dioxide emissions will be reduced for those energy services already used by the population. However, this reduction will be negligible. Grimm et al. (2013) calculated that the monthly carbon dioxide emission reductions per household by replacing wick lamps and candle usage through a solar lantern are equivalent to the emissions of driving 5 km in a regular car. Given that households will likely increase their energy demand after electrification, per capita carbon dioxide emissions will likely increase as well. This will be assessed as part of the follow-up.

Households in rural Africa are increasingly using dry-cell battery driven LED-lamps. While this is clearly an improvement in lighting quality compared to candles and kerosene lamps, it induces waste problems, since dry-cell batteries are not disposed of appropriately. In two thirds of cases they are thrown to unmanaged garbage, and otherwise disposed of in the nature or latrines. Dry-cell batteries are also used in radios. Electricity will most likely replace this potentially harmful energy source. [9]

4.4. Rural micro-enterprises and their expected gains from electrification

We portray the baseline situation of rural micro-enterprises and their current off-grid electricity use. We complement this presentation by an ex-ante assessment of the expected impacts of electrification on rural micro-enterprises based on a number of semi-structured interviews with local entrepreneurs, community leaders and field observations.

4.4.1. Market conditions in the villages

The three regions are rather remote and economically not very developed, which is particularly noticeable in the villages. The rural enterprises are micro-enterprises; no larger enterprise or industries exist. In the village centers several micro-enterprises can be found, most of which are kiosks that sell soft drinks and food, or charge phones, flourmills, tailors and hairdressers. Except for carpenters and builders, not many villagers are craftsmen. Table 23 provides an overview on the existing micro-enterprises. It can be seen that kiosks are most common. They are present in all except one village with the average number of kiosks reaching almost 16. Around 36 percent of the villages also have a store. Goods and products that are not locally produced by the villagers are sold in the kiosks or stores (e.g. hygiene products, torch batteries, salt, and cooking oil) or imported from the town. Tailors and hairdressers constitute further important groups of micro-entrepreneurs; several of them are found in almost every village.

[9] *See Bensch et al. (2015) for a discussion of Africa's transition from kerosene to LED and the potential environmental consequences.*

Diesel driven flourmills are important for the agricultural communities and at least one is found in 85 percent of the villages. Furthermore, carpenter and builders exist almost in every village; the average number of carpenters and builders is at 4 and 9, respectively. Builders and carpenters are needed to construct and maintain the simple houses and to provide basic furniture. In 42 percent of the villages the kiosks are the largest enterprises followed by builders and carpenters. Less frequently found micro-enterprises are bars, restaurants and sawmills existing in two fifth of the villages. Car-repair workshops and welding enterprises are even less common. To date there are only very few microenterprises offering entertainment (music recording, TV theater). This will probably change once electricity is available.

Table 23
Main micro-enterprises in the study villages

	Share of villages, in %	Average number per village		Created in last two years, in %
Kiosks	99	15.7	(21.0)	59
Stores	36	1.1	(2.6)	8
Bars	41	1.4	(2.8)	8
Restaurants	36	1.9	(4.2)	15
Carpenters	81	3.7	(6.1)	12
Builders	91	8.9	(13.2)	16
Tailors	93	7.0	(10.4)	26
Hairdressers	76	2.1	(2.6)	39
Beauty salons	13	0.3	(1.1)	2
Flourmills	85	2.8	(2.4)	22
Sawmills	37	2.1	(5.0)	10
Auto workshops	16	0.3	(1.0)	6
Welding workshops	16	0.3	(0.7)	3

Note: For average numbers we present the standard deviations in brackets.
Source: Tanzania energy baseline community survey 2014

Table 23 also lists another feature of economic activity in the rural communities, the percentage of villages in which any of the respective micro-enterprises was newly created within the last two years. This information is also important from an evaluative perspective, since it will be used as a yardstick at the time of the follow-up survey in order to assess the firm creation dynamics before and after electrification. As already mentioned above, no larger firm settled in one of the villages. All economic activities are carried out by micro-entrepreneurs. Hairdressing shops rank second in the creation of new businesses; they newly opened in 39 percent of the villages. New tailor shops opened in more than a quarter of the villages and new flourmills in more than one fifth of the villages. The average number of newly created enterprises is below one for all enterprise types except kiosks, of which on average 3.4 opened within the last two years.

With regards to village market and trading conditions, almost 60 percent of the villages have their own market and in half of these villages the market is a weekly event (Table 24). If there is no market in a village, the next market is located at an average distance of around seven kilometers. In addition, 94 percent of the village leaders report that traders are coming to their village, in most cases at least at a weekly basis.

Table 24

Market and trading conditions in the villages

Market in village, in %	56	
If no market in village, distance to nearest market	6.75	(6.32)
Traders coming to the village, in %	94	

Note: For average numbers we present the standard deviations in brackets.

Source: Tanzania energy baseline community survey 2014

Altogether, this overview shows that the villages under study do not exclusively rely on agriculture, but have some small businesses established that cater to the needs of the local population. All of these enterprises are small and mostly have the same local customers who buy products on the basis of small loans, which they pay back later. As can also be taken from some representative responses by businessmen and -women (see Box 1), most entrepreneurs lack access to markets beyond the village frontiers, which is a sine qua non for the development of rural micro-enterprises. Neither is there much traffic of people coming from outside the villages. Exceptional cases are villages close to national borders where micro-entrepreneurs sell exported cigarettes, local and imported beers to customers of the village and visitors from the neighbouring country.

Box 1
Selected responses from semi-structured micro-enterprise interviews about rural demand for their products and services

A shop salesman in Musenyi village highlighted the following:
"There are no customers here, just see. We have been here together for the whole interview, have you noticed any interruption in our interview because of customers?"

Another kiosk vendor explained:
"There is no customer here, so it is difficult to invest much in this business. Probably with electricity outsiders may come to invest here and money circulation will be higher. In turn, my business will be running smoothly."

4.4.2. Current use of off-grid electricity by the rural microenterprises

Although the villages are not connected to the grid so far, some enterprises already use off-grid electricity sources. Many kiosks, bars, and restaurants use solar panels. Hairdressers tend to rely on car batteries and solar panels. Flourmills mostly run on fuel. Some sawmills have generators but they more regularly rely on manual labor instead.

The interviewed micro-entrepreneurs repeatedly pointed out that to date they could not afford electricity. The main reason are the high costs of off-grid electricity sources. Micro-entrepreneurs do not have the means to invest in generators and micro-grids to operate their business, as their current and prospective revenues are too limited.

Box 2

Selected responses from semi-structured interviews about the costs of electricity faced by rural micro-entrepreneurs

A businessman running a restaurant in Ntungamo village about the costs of generator use for his business:
"I use Tshs. 75,000 for oil to refuel the generator. I need 3 litres for music to operate from 16:00 to 22:00. Imagine each litre is Tshs. 2,500, a total 7,500 each day. This is too much, but I have to incur these costs because without electricity, we cannot sell any products in this restaurant. Even if not many customers are coming, by playing music and lighting you get some of them anyhow."

A ward leader from the well-developed village Kasulo, which has a generator, explained:
"Since 1997 the source of energy in the village is an own generator and nearly three quarters of the households use this source of energy for about 5 hours per day. [...] Per month it costs Tshs. 7,000 to charge mobile phones and the households or shops pay Tshs. 50,000 for a fridge, 20,000 for a TV and they nearly need Tshs. 90,000 to 200,000 for light. Due to these high costs for energy and lack of access to electricity [from the national grid], small enterprises such as carpenters, saloons, and hotels are not performed well in the area."

A Ntungamo's salesman about the costs of relying on car batteries for electricity:
"When charging twice per week, it cost Tshs. 6,000. This is very expensive."

A businesswoman who runs a large store in Mwibambo, a village bordering Burundi, elucidated:
"Electricity is very important here. But generators are very expensive and we are suffering greatly due to lack of electricity. As a consequence of globalization, business communications through cell phones and laptops (internet) are very important, but these services are very limited here. It is very expensive to charge a mobile phone. We pay Tshs. 300-500 twice per week. We do not have a choice. I have a lot of customers here coming from Burundi, but electricity is a problem."

Respondents agreed that generators have very high running costs for fuel and maintenance. For example, increasing operation hours by using lighting from a generator is too expensive as the high energy costs are not compensated by additional revenues. In Box 2 we provide selected, representative responses given by micro-entrepreneurs when asked about the use and costs of electricity.

4.4.3. Possible impacts of electricity on the rural microenterprises

The interviews made it very clear that the micro-entrepreneurs have high expectations for income and business growth once their communities are connected to the TANESCO grid. Our interviewees argue that electricity access can impact their businesses through four possible pathways.

First, enterprises that currently use expensive off-grid electricity sources might save money (see the previous sub-section). Second, electric lighting will allow the micro-entrepreneurs to extend their operation and opening hours. Opening hours after sunset would be further encouraged through improved security in the villages, which was repeatedly mentioned as another important result of electric lighting (see Box 3). However, most enterprises currently already operate from 8:00 to 20:00.

Third, if stable electricity supply is in place, for some it may be a good investment to buy electrically operated machines and devices, which will either enhance the productivity or product quality of existing enterprises or allow offering new services and products. Especially kiosk owners see business opportunities in having a fridge or freezer to cool soft drinks and other food items. The cooling devices would allow them to buy larger stocks of perishable food such as fish and meat and keep it for longer time without wasting. The ordering costs for larger quantities would be lower and the food more timely available. This is expected to ultimately lead to a price cut of products and an increase in sales volumes and profits for shopkeepers. In terms of new services and products, especially bar and restaurant owners hope that with electricity the broadcast of football matches on TV will increase their returns and there are no doubts about potential customers that are willing to pay for this. Whether the entrepreneurs will also have the means to invest in new machinery is unclear. At least, they did not highlight cash or credit constraints during the interviews. Even in the presence of electricity and absence of cash and credit constraints, the rural micro-entrepreneurs are still constrained by the limited local demand. It is likely that certain firm types will benefit and attract parts of the local demand offering products and services for which electricity is needed, which will in turn distract demand from other mostly locally produced or sold goods.

It will thus be important in how far the fourth pathway mentioned during the interviews materializes, which is a shift of economic activities or inflow of capital from outside the villages to the villages. This may either happen through the emergence of businesses that ensure availability of products and services, which are now bought outside the community (e.g. welding) or by attracting new customers from outside the villages. In addition, some interviewees uttered their hope that electrification will attract investors from outside and that it will induce the establishment of institutions like secondary schools, police offices and financial service providers in the villages bringing people with stable monthly incomes as potential customers to the countryside. In this context, some interviewees, however, also made clear that other basic infrastructure such as accessible roads, a conducive legal framework and a supportive public administration needs to be in place to realize economic returns from electricity supply (see the third quote in Box 3).

To summarize, the lack of potential customers is the major bottleneck for realizing net income benefits that are expected due to electricity and it is questionable in how far electricity will help to overcome this bottleneck. In any case, it is beyond the scope of the electrification project to specifically tackle this bottleneck.

Box 3

Selected responses from semi-structured interviews about expected impacts and the additional conditions necessary to realize the economic returns from electricity supply

A shop owner from Nyarutembo village who offers soft drinks, phone charging, and drinking water, expressed:
"Electricity will allow having an additional employee. If the business goes smooth with electricity, I can also increase capital. I need a fridge to cool drinks for my customers; in addition the fridge is an attraction to customers."

Moreover, a business man in Kasulo village said
"... lighting will improve security and increase business confidence."

A businesswoman at Msenyi village elaborated:
"People need infrastructure here like roads, dispensaries, and electrification. But if electricity is the first to come, then this will be highly appreciated because with it many services will be available. As a result, we as business owners will have many opportunities and increased sales."

5. Baseline results for urban intervention areas

5.1. General household characteristics

Most households in the town areas of Mpanda, Ngara, and Biharamulo are grid-connected. As outlined in the methodological section, identifying control towns was not possible. We therefore rely on a simple before-after comparison and only survey households from the three treatment towns. In this section we present selected descriptive statistics on the socio-economic structure for a total of 300 interviewed households and the 1,649 household members.

On average, households in towns consist of 5.5 members, 13 percent of which are children below the age of six (Table 25). Comparing these figures with the rural households we observe that on average households are of similar size but the share of children is smaller indicating slight differences in the age structure.

Table 25
Household structure

Household size	5.5
Share children 0-6 years, in %	13

Source: *Tanzania energy baseline urban household survey 2014*

Nearly one quarter of interviewed households reports to be headed by a woman as compared to 11 percent for rural households. In the female-headed households, there are usually no spouses present and the women live with their children, sometimes their parents. Possibly, the men have migrated but this question has not been asked in the urban household questionnaires. Although we use the term "urban" the three towns could as well be described as rural centers and have not much in common with what one might relate to the term "urban" in a developing countries context. In line with this, farming is still the most important source of income for 49 percent of the households while 24 percent of household heads run a business or are dependently employed in the private sector. 19 percent of them are civil servants (Table 26).

The level of education is also higher than in the countryside, the vast majority of household heads (43 percent) has at least completed primary education, 43 percent of them even have secondary education and more.

Table 26

Characteristics of the household head, in percent

Head of household is female	24
Sector of activity of primary occupation	
Farming	49
public sector	19
other market work	24
Educational attainment	
no formal schooling	5
uncompleted primary education	9
completed primary education	43
secondary education and more	43

Source: Tanzania energy baseline urban household survey 2014

Cultivation of farming land is even more pronounced. 86 percent of the households still own and cultivate land, and 54 percent of them keep livestock of some kind (Table 27). The high share of households being engaged in some kind of farming even in the cities indicates the strong dependence of the three regions on agriculture. It also suggests that the regions are not only geographically remote but also distant from markets and reliance on self-production of food is important for covering the needs of the households.

Table 27

Farming activities of households, in percent

Land owners	86
Keep livestock	54
Household cultivates land	85

Source: Tanzania energy baseline urban household survey 2014

This observation is further supported when turning to the different expenditure categories. The distribution of income across different expenditure categories is rather similar to the one in rural areas: Food makes up the largest share of total non-energy expenditures (37 percent) and most other items receive around five percent of total spending. Notably, and in line with the higher level of education observed among these urban households, spending on schooling is an important source of cost with a share of 13 percent (Table 28). Health care spending ranks last among the different expenditure categories. The share of remittances sent, in turn, is only slightly higher than in the rural areas.

The average total expenditure per household is notably higher than in the villages at around 6.96 million TSh. This represents per capita expenditure of 588 € which comes close to the national per capita GDP of Tanzania of 654 € for the year 2013 (World Bank 2013).

Table 28
Household expenditure

Share of expenditure categories in total expenditure (except for energy and electricity), in %	
food (including restaurants)	37
rent (house and fields)	1
health (excluding health insurance)	3
transportation	7
clothing	4
schooling	13
remittances	4
telecommunication	5
Total yearly expenditure, in TSh	6,959,555

Source: Tanzania energy baseline urban household survey 2014

Looking at the perceptions of well-being, most households feel their income to be tight or even insufficient to make ends meet (82 percent in total,Table 29). This is interesting as concomitantly 41 percent report their living conditions to have improved over the course of the last three years.

Table 29

Perception on household's income and living conditions, in percent

Perception of household's income	
sufficient	18
tight	36
insufficient	46

Family's situation relative to 3 years ago	
much better	1
slightly better	40
same	26
slightly worse	29
much worse	2

Source: Tanzania energy baseline urban household survey 2014

5.2. Energy usage among households in towns

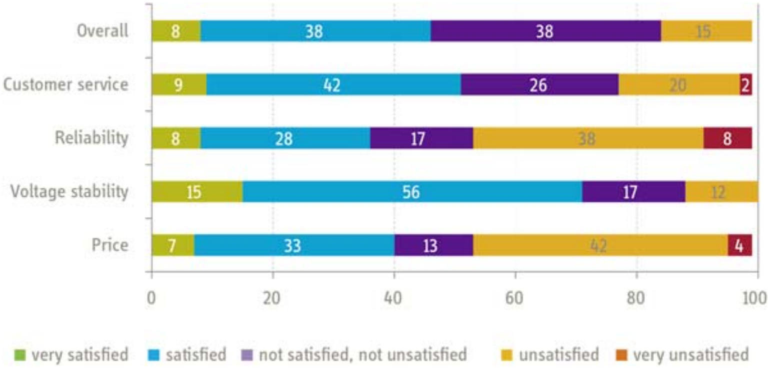
5.2.1. Quality of electricity service

TANESCO household clients in town have been connected to the grid for around six years on average. There is hardly any other source of electricity used by the urban households: 17 households own a solar panel and three households use private generators. These electricity sources are mainly kept as backup sources in the case of blackout. When asked about advantages and disadvantages of being connected to the grid, most households mention a reduction in costs compared to traditional energy sources, generators, and charging a car battery or a mobile phone in a shop. Furthermore, the availability of light and the ease of housework are stressed as improvements due to electricity.

In spite of the deterioration of the generators the grids in the three towns are comparatively reliable. 88 percent of households report to have experienced at least one blackout over the last month; the average number of power cuts per month across all households is seven, hence around two per week. This information will help to answer the research question on how the frequency and duration of outages changed due to the intervention. Due to the lack of other electricity sources, most households (62 percent) have to rely on traditional energy sources in case of blackouts such as candles, kerosene, and battery torches. The relative reliability of the grid is also confirmed by the stated satisfaction of respondents. Less than half of the interviewed households say that they are unsatisfied with the reliability of the grid and 36 percent of customers even report to be very satisfied or satisfied (Figure 9). For voltage stability, another indicator of the quality of the technical service, satisfaction is even higher.

Figure 9

Satisfaction with different aspects of TANESCO's service, in percent



Source: *Tanzania energy baseline urban household survey 2014*

5.2.2. Energy sources and appliance usage

As for the rural sample, it can be seen that electricity crowds out traditional energy sources, although not entirely. Kerosene is still in used by 45 percent of households at least once within 30 days, even more so in wealthier households. Dry-cell batteries are mostly used by the middle expenditure quintiles but less so by the poorest and richest income groups (Table 30).

Table 30

Use of energy sources at least once in 30 days, by expenditure quintiles in percent

Energy Source	Average	Expenditure Quintile	
		Lowest	Highest
Kerosene	45	38	54
Dry-cell batteries	54	29	39

Source: *Tanzania energy baseline urban household survey 2014*

The number of electric appliances owned by households is considerably higher in towns than in the countryside – obviously due to the availability of the electricity grid. Nearly all households own at least one mobile phone, while landline connections are rather uncommon. Both charcoal and electric irons and even fridges are used by many households. Also, the share of electric stoves is high for African comparison at 5 percent. Entertainment devices such as TVs and radios are widespread. More than half the sample has a satellite receiver; PCs and sound systems can also be found in roughly every tenth household (Table 31).

Table 31
Appliance usage, in percent

Appliance	Share	Appliance	Share
Mobile phone	90	Charcoal iron	44
Landline phone	5	Electric iron	51
PC	14	Electric fridge	23
TV	79	Electric stove	5
Satellite receivers	54	Fan	13
Radio (bivalent)	40	Stabiliser	12
Radio (battery only)	13	Mechanic sewing machine	14
Radio (line)	37	Electric sewing machine	3

Source: Tanzania energy baseline urban household survey 2014

Only 5 percent of the sample (16 households) employ some of their appliances for home businesses or home production. In most of these cases, households use their mechanic or electric sewing machines to make goods for the market (four mechanic and two electric ones). But also refrigerators (three) and stabilisers (two), an iron, a sound system and a computer serve non-private uses.

Appliance availability seems to trigger changes in terms of sources of information people rely on: a shift is notable relative to the rural sample away from the radio and turning to neighbours or friends to the own TV (Table 32).

Table 32

Main source of information, in percent

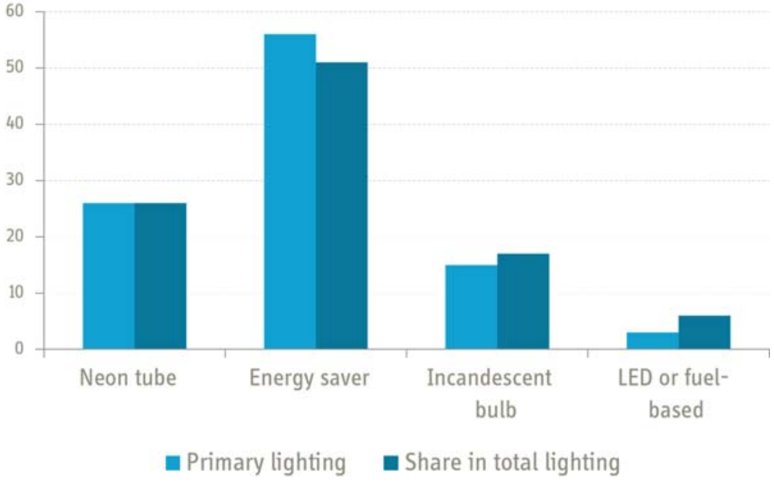
Source of information	Share
Radio	56
TV	39
Newspaper	0
Neighbour/ friends	3
Mobile phone	2

Source: Tanzania energy baseline urban household survey 2014

Energy savers are the preferred lighting source for the majority of households, i.e. the lighting device with the highest usage hours. As can be taken from (Figure 10), these figures are almost identical with the lighting devices' share in total lighting. Households do not use many different lighting device types, they mostly abandoned traditional lighting devices and use quite substantial amounts of artificial lighting which sum up to 50 hours per day, equivalent to 38,000 lumen hours, which is a measure of lighting service provided by the lamps.

Figure 10

Lighting device usage, in percent



Source: Tanzania energy baseline urban household survey 2014

Households who usually have neon tubes or energy savers are most satisfied by the quality of their lighting and those using simple light bulbs are still in almost 80 percent of cases satisfied with the provided light (Figure 10).

Figure 11
Satisfaction with lighting quality of different lighting devices

Source: Tanzania energy baseline urban household survey 2014

5.2.3. Energy expenditures

Table 33 shows the shares of energy and electricity expenditures in total household expenditure. Expenditures on both energy and electricity represent a clearly higher burden for the poorest households and, in particular, electricity expenditures tend to make up a smaller share of expenditures the wealthier the household is.

Table 33
Energy expenditures by wealth level, in percent

		Expenditure Quintile				
	Total	Lowest	2nd	3rd	4th	Highest
Share of electricity in total expenditures	5	10	6	5	4	2
Share of non-electric energy in total expenditures	7	9	7	5	5	6

Source: Tanzania energy baseline urban household survey 2014

5.2.4. Environmental effects

One motivation behind the electrification project in Tanzania was to replace the old generators by more energy-efficient ones. Specifically, the new generators are expected to consume half the amount of fuel compared to the existing generators to produce a given amount of electricity. This will considerably reduce the carbon intensity of the electricity consumed by urban TANESCO customers in the three towns. The fuel savings will need verification at plant level once the generators are in place.

5.2.5. Willingness-to-Pay (WTP) and Willingness-to-Accept (WTA)

To assess the willingness-to-pay of the urban households that are already connected to the TANESCO grid, we posed the following question:

> "Currently your electricity source is unreliable; you experience frequent blackouts and low voltage. Imagine you could have an electricity connection that enables you to always use electricity 24 hours a day without interruptions. Would you be willing to pay additional 2,000 TSh each month to get this better service?
> Please consider your real budget, that means your revenues and all other expenses you have to pay each month. Please note that your answer does not have any effect on any real prices.
> So would you be willing to pay the 2,000 TSh each month to get this better service?"

The demand for stable electricity was apparent in the responses since 26 percent of the households indicated their willingness to pay an additional 2,000 TSh (equivalent to 0.95 €) each month to get this better service. Moreover, 44 percent of the respondents are willing to pay even more than 2,000 TSh each month for stable electricity supply. Less than one fifth of the respondents are not willing to pay more for a stable electricity connection than they are already paying. On average urban households are willing to pay as much as 3,930 TSh (1.80 €) more every month in order to have better services (Table 34).

Table 34

Willingness-to-pay for stable electricity supply, in percent

Willingness-to-pay for stable electricity supply	Share
Not willing to pay more for stable electricity	18
<2,000 TSh more per month	12
2,000 TSh more per month	26
>2,000 TSh more per month	44
	Average
Willingness-to-pay (in TSh)	3,928

Source: Tanzania energy baseline urban household survey 2014

These results clearly show that the urban households are eager and willing to pay for stable electricity supply. Thus, the results so far suggest that the TANESCO extension efforts match the demand for stable electricity supply. To assess the credibility of the responses to the willingness-to-pay question, we also asked a question about the willingness-to-accept the loss of electricity supply in exchange for a financial compensation. As starting point, we asked if the household would be willing to forego its electricity connection for a compensation of 8,000 TSh on a monthly basis. Only 3 households, equal to 1 percent of all households, indicated that they would be willing to take the monthly compensation of 8,000 TSh and give up electricity (Table 35). The clear majority of households, namely 65 percent, clearly indicates that they are not willing to give up electricity at any price. Among the remainder willing to give up electricity, most household expect exorbitant compensations in exchange for giving up electricity. On average, households would ask for as much as 373,000 TSh if they had to forego electricity. Despite the very hypothetical character of this question, this result confirms the findings from the willingness-to-pay analysis showing that the households put a high value on electricity and are not willing to lose the connection to the grid.

Table 35

Willingness-to-Accept regarding loss of electricity supply in exchange for financial compensation, in percent

Willingness-to-accept for stable electricity supply	Share
Not willing to give up electricity at any price	65
<8,000 TSh more per month	4
8,000 TSh more per month	1
>8,000 TSh more per month	30
	Average
Willingness-to-accept (in TSh)	373,000

Source: Tanzania energy baseline urban household survey 2014

5.3. General enterprise characteristics

In this section we present descriptive statistics for a total of 508 Micro and Small Enterprises (MSEs) from the three surveyed towns, Ngaga, Biharamulo and Mpanda. The MSEs have been categorized into *Trade*, *Services*, *Manufacturing* and *Mining*. *Trade* is defined as MSEs which sale goods or merchandise that do not involve their transformation, *Services* are MSEs which focus on serving the customer rather than transforming or just selling physical goods, *Manufacturing* is the production (or maintenance) of merchandise for use or sale using mainly labour and machines or tools and the last category are activities related to *Mining* such as stone grinding, mineral extraction, and gold mining. It can be expected that this classification does not only provide a differentiation of the core activities of the enterprises but also strongly determines their energy needs: trade usually only requires electric lighting and maybe a refrigerator, services typically rely on some sort of devices and manufacturing often requires machines with high energy demand.

Table 36
Basic structure of the enterprise, in percent

		Trade	Services	Manufacturing	Mining
Number of enterprises		158	163	156	31
Year of foundation	before 2000	8	7	10	23
	2000 - 2011	38	45	48	48
	2012 - 2014	54	48	42	29
proprietary	proprietary	95	93	92	77
	partnership, among members from same household	4	2	3	6
	other	1	5	5	17
Member of business association	no	75	75	81	81
	local	24	23	18	16
	national	1	1	0	3

Source: *Tanzania energy baseline urban enterprise survey 2014*

While there are cases of enterprises that are either active in two of these categories or whose activity is a borderline case between two of the categories, we attributed a single category to each enterprise based on an assessment of the business by the enumerators and the entrepreneurs themselves. After some reclassifications, there are in total 158 enterprises in trade, 163 in services, 156 in manufacturing and 31 enterprises in the mining sector in the sample (Table 36). Main enterprise found among trade are mixed consumer goods shop, small kiosks, clothes shops and shops selling hardware and drinks but also includes more specialized shops like CD and cosmetics shops. Service providers found in the sample are mostly guest houses, barbers, photocopying, pharmacies, beauty salons, and restaurants. Finally, manufacturing is less diversified and is concentrated to mills, tailoring, carpentry and welding/ garages.

Many of these enterprises were established in the last decade. The table also presents ownership structure and business association membership as two indicators of *how* established these enterprises are. There is no substantial difference between sectors in term of business association membership. Similarly, ownership structure of the sampled enterprises is very similar in all sectors. Enterprises operate locally with high percentages of proprietary ownership and without any membership in business associations.

Information on enterprise owners is given inTable 37. There are clearly more male than female enterprise's owners in all sectors. Female entrepreneurs are more active in trade and services sectors than in manufacturing and mining sectors. Most of them are experienced in their business with 67 to 81 percent of entrepreneurs already being active in the respective business for at least three years. While most of the entrepreneurs have completed primary level of education, those involved in services tend to be most educated, those in mining least.

Table 37

Enterprise owner and labour force information

MSE Category		Trade	Services	Manufacturing	Mining
Gender, in %	male	71	70	86	97
	female	29	30	14	3
Age		39	42	43	43
Education, in %	no education	3	1	0	16
	primary attended	11	7	15	13
	primary completed	46	30	48	55
	high school	28	36	18	6
	higher school	2	1	5	0
	vocational training	2	4	7	0
	diploma (pre university)	5	11	4	0
	university	3	9	1	10
Business experience, in %	less than three years	33	27	19	19
	three or more years	67	73	81	81
Owner has another business, in %		20	29	17	23
Enterprises without employees, in %		49	18	29	23
Average number of employees (at present)		1	2	3	19
Working hours by employees category	family members	64	69	49	51
	male employees, permanent	67	62	55	68
	male employees, temporary	44	61	57	58
	female employees, permanent	66	60	‡	‡

Note: ‡ = too few observations

Source: Tanzania energy baseline urban enterprise survey 2014

The average workforce in the MSEs is relatively small. Half of the shops are run by the owners without any employees, though it has to be noted that this sector involves frequent out and in employees during a calendar year. Only in mining, a considerable number of employees can be found (bottom of Table 37). Manufacturing firms also tend to employ more people, while both enterprise types rarely employ women. No gender difference in working hours can be observed for the other two categories trade and services.

A final set of key enterprise characteristics is financial access and financial management skills. As can be taken from Table 38, a minority of enterprises has access to financial services and products. Enterprises in trade have the highest loan access rates, followed by services, manufacturing and mining. Financial institutions in many cases offer financial management skills services during lending. Accordingly, it is more likely that enterprises in trade and services sectors utilize financial management skills acquired from the financial institutions. Nevertheless, many of the enterprises lack such skills.

Table 38
Enterprise accessibility to financial institution and financial management, in percent

MSE Category		Trade	Services	Manufacturing	Mining
Loan access		34	25	18	10
Type of bank account owned	none	33	34	43	61
	bank or savings and loan account specific for enterprise	36	37	35	26
Accounting tools	none	37	31	53	74
	book of prime entry	63	66	46	19
	professional accountant or computerized accounts	1	4	0	6

Source: *Tanzania energy baseline urban enterprise survey 2014*

5.4. Energy usage among enterprises in town

Virtually all sampled enterprises are TANESCO clients (Table 39).[10] Main reasons given for not being connected are the inability to afford the initial connection charges and utilization bills, while many non-connected enterprises also stressed that they recently requested a TANESCO connection. Around 20 percent of enterprises are not directly connected but share a connection with neighbours.

[10] *We dropped the mining enterprises from the further analysis, since they are not located in town and thus outside the coverage of the electricity grid. They have been sampled in the first place to give a comprehensive picture of the local micro-enterprises.*

Table 39
Electricity grid connection, in percent

		Trade	Services	Manufacturing
Connection to electricity grid		95	94	87
Reasons not connected	connection requested	14	50	24
	electricity is not needed	0	0	10
	cannot afford	71	38	29
	daylight and public street lighting enough	0	13	29
	disconnected	0	0	5
	other reasons	14	0	5
Average duration of electricity connection, in month		57	52	67
		(59)	(59)	(62)
Type of electricity connection	direct	80	79	87
	via other	20	21	13

Note: Numbers in brackets are the standard deviations.

TANESCO grid connection fees currently amount to 320,000 TSh for urban connections within 30 metres of the electricity grid (as compared to 177,000 TSh. for rural connections). Table 40 shows that enterprises actually spent higher amounts for their electricity installations, in particular those enterprises from manufacturing. Electricity consumption is highest among manufacturing and lowest for trade. Most enterprises already dispose of prepaid meters for electricity payment and actually use electricity regularly as indicated by the large share of enterprises that recharged their prepaid meter within the month previous to the interview. There are slight differences in the actual price paid for electricity between the enterprise sectors that are due to the increasing block tariff structure applied by TANESCO according to which per kWh prices increase if certain consumption thresholds are exceeded (e.g. 75 kWh being the lowest threshold).

Table 40

Electricity installation cost and payments mode

		Trade	Services	Manufacturing
Initial cost of connection, in Tshs.		408,744 (458,602)	474,495 (532,138)	651,242 (581,383)
Loan for connection		10.08	11.11	7.02
Payment mode for running electricity costs	traditional meter (post-paid)	12	12	16
	prepaid meter (pre-paid)	87	88	83
	fixed payment (flatrate)	1	0	0
	by number of equipment	0	0	1
Monthly electricity consumption, in kWh		108 (175)	125 (177)	262 (442)
Monthly expenditure on electricity, in Tsh.		31,010 (38,490)	38,490 (50,670)	74,970 (106,790)
Price paid per Kwh on prepaid system, in Tsh.		415 (466)	406 (272)	436 (278)
Pre-paid electricity recharging within last month, in %		85	90	85

Note: *Numbers in brackets are the standard deviations; Initial installation cost includes connection fee and installations in this enterprise such as wiring, switches and sockets.*
Source: *Tanzania energy baseline urban enterprise survey 2014*

Against the background that the electrification project intends to replace the unreliable large generators located in Biharamulo, Ngara and Mpanda, Table 41 assesses the service reliability in the three towns and how enterprises across the three sectors cope with the potential problems, respectively. There are in fact regular electricity blackouts in all three towns, but the problem seems most severe in Mpanda, where also the highest number of enterprises with back-up electricity sources can be found. Blackouts may last a few seconds or minutes; one or two times per week, however, longer blackouts occur that take between 2 and 8 hours. This is also the reason why enterprises report substantially more blackouts than households: first, they are more affected by short blackouts than households (because the work process is interrupted) and, second, they are more affected by blackouts during daytime, since households' electricity usage mostly happens at night-time. Back-up electricity sources are mainly individual generators. Car batteries or rechargeable batteries as a cheaper but also less powerful and less convenient back-up source are less often used by enterprises. Solar power is rare in the town areas.

5. Baseline results for urban intervention areas

It is frequently argued that unreliable electricity grids and blackouts lead to a reduction of business productivity in enterprises. While this will only be testable at follow-up based on rough capital and labour productivity indicators, we asked for the enterprises' coping strategies in case of blackouts. Responses differ across the three sectors: For trade enterprises blackouts apparently do not pose major problems. 64 percent of trade enterprises simply continue normal operations and another 22 percent simply switch to activities that do not require electricity. Only 3 percent stop operations until electricity supply is resumed. For service and in particular manufacturing enterprises electricity is more essential for their production process. Among trade companies 19 percent have to stop their operations, for manufacturing companies this number is even higher at 41 percent. Nonetheless, in both sectors the majority of companies seems to be able to deal with blackouts in a rather smooth way. 70 percent of service companies and 54 percent of manufacturing companies either continue do not interrupt their operations or engage in non-electric operation.

Beyond blackouts, voltage fluctuations (brownouts) are another problem of unreliable electricity supply. Only around 20 percent of enterprises have an electricity stabilizer. As a consequence, one third of enterprises have already experienced appliance damages, most often TV sets but also fridges, light bulbs and motors among others.

Table 41
Electricity interruptions and coping strategies

		Trade	Services	Manufacturing
Number of electricity blackouts in normal week		8.4 (9.4)	6.5 (6.6)	8.6 (8.5)
Duration of longest blackouts in last month, in hours		20.3 (24.4)	20.4 (28.8)	27.6 (57.9)
Availability of back-up facility, in %		15.3	14.7	21.5
Availability of alternative electricity sources, in %	individual generator	8	29	8
	solar power	4	1	0
	car batteries or other rechargeable batteries	6	1	1
Enterprises for whom these sources are secondary, in %		92	96	71
Coping strategy in case of electricity breakout, in %	continue normal operations	64	48	25
	engage in non-electric business operation	22	22	29
	shift hours of operation	6	1	3
	stop business until resumed	3	19	41
	other	5	10	2
Ownership of electricity stabilizer among TANESCO clients, in %		17	23	18
Experienced appliance damages due to blackout, in %		37	34	44

Note: numbers in brackets are the standard deviations
Source: Tanzania energy baseline urban enterprise survey 2014

Still, electricity is available most of the time and used – beyond enterprise-specific appliances – mostly for the appliances mentioned in Table 42. Electric lighting is most common and actually intensively used. On average, enterprises consume 6 to 9 hours of electric lighting per day (not shown in table). Traditional lighting sources, especially torches, are used by less than 15 percent of enterprises. Hurricane lanterns and tin lamps are virtually non-existent. Among further appliances requiring non-human energy, mobile phones have the largest share. Entertainment devices are most common among service enterprises, machines among manufacturers. Internet connectivity is still low and accessibility is reported to be poor. It is so far barely used for business activities.

Table 42
Ownership of appliances, in percent

	Trade	Services	Manufacturing
electric lighting	95	94	82
solar or rechargeable lamp	18	6	4
traditional lighting	13	14	5
mobile phone	96	88	80
telephone (fixed line)	3	6	1
radio or sound system	49	48	21
CCTV	1	2	1
TV (colour)	39	52	6
fan	15	32	3
air condition	1	1	1
internet, direct connection	2	4	2
internet, via others	2	2	3
machines (welding, milling, drilling, cutting)	0	0	7

Source: *Tanzania energy baseline urban enterprise survey 2014*

Mobile phones play an increasing role as source of information in enterprises. Table 43 shows that mobile phone charging is not constrained by a lack of electricity and that the majority of enterprises already use their phone for mobile banking and getting information on input prices. The use of mobile banking in all sectors is widely spread with on average more than 50 percent of enterprises in all sectors using mobile banking. Similarly, the use of mobile phones to get information on input prices is quite huge, ranging from 67 to 87 percent.

Table 43
Mobile phone charging and services, in percent

		Trade	Services	Manufacturing
Charging of mobile phone at the enterprise	yes	84	79	68
	no, at home	15	18	28
	no, at other place	1	1	4
Mobile phone use for mobile banking		58	55	52
Mobile phone used to get information on input prices		81	67	69

Source: *Tanzania energy baseline urban enterprise survey 2014*

6. General data quality assessment

Community data

The community survey revealed that the community leaders are well-informed about their communities. The decision to collect data at sub-village and not only at village level further improved the reliability of the gathered community data. Most of the sub-village leaders were able to provide complete information about community demographics, infrastructure, and activities. We obtained complete information on community population, the number of households living there, the main economic activities (e.g. number of kiosk, restaurants, flour mills, carpenters) as well as the availability of infrastructure such as primary and school schools, health centres, dispensaries, access to roads, sources of energy and the presence of administrative and religious buildings. The sub-village readers also provided information on media coverage and communications. Information on the availability and quality of mobile and radio signals is readily available. However, in some communities, village leaders were not aware of television signals. In Mpanda district the information on television is incomplete for 6 communities, in Ngara and Biharamulo for 24 communities. At least for some of them, we can infer from television ownership in the village that a signal is in fact available.

Household and enterprise data

The envisaged 1,000 rural and 300 urban household interviews as well as the over 500 urban household interviews were administered successfully. Logistics worked out properly and no interviewee refused participation in the survey. Missing responses were minimized to a large extent by carefully selecting and pre-testing the questions that were included in the survey. Verifications of the collected data were routinely conducted in the field. In particular at survey start, consistency checks were performed in order to ensure that all questions were well administered by the interviewers. All questionnaires were translated to Swahili in order to guarantee a consistent use of language. The statistics we present are drawn from the full sample, are representatively sampled and in fact seem to well represent the region and population under study. Moreover, the enumerators confirmed that respondents understood the questions well. The coherence of the data and the balancing between treatment and control households have also been checked, e.g. by comparing expenditures in different income quintiles.

7. Conclusion

This report presented the results of a baseline survey as the basis for the impact evaluation of an electrification intervention of the Government of Tanzania receives that receives half of project costs as donor co-funding in the form of a grant. The aim of the intervention is to improve the service quality of three isolated grids in Western Tanzania that are currently run by old generators and only connect the township areas. These old generators will be replaced by new state-of-the-art ones. This will ensure the sustainability of the urban connections, which otherwise would most probably deteriorate in the coming years. In addition, the increased capacity of the generators will enable TANESCO to connect so far non-electrified villages surrounding the towns.

This report described the country context and the implementation of the electrification intervention. Furthermore, it outlined the evaluation strategy to assess the impacts of the project. The baseline data collected in urban and rural areas between November 2014 and February 2015 will serve as a yardstick for a future endline survey. While we conducted a small sample size case study among rural enterprises, the focus of the large sample size surveys was on rural communities and households as well as urban households and enterprises. We will then be able to use the two data waves to carry out robust difference-in-differences or before-after estimations to identify the impacts of the intervention. The effect of the intervention on rural enterprises will be assessed using qualitative case-study approaches at the time of the follow-up surveys. Given delays in the project implementation the right timing of these follow-up surveys will need to be discussed.

One major objective of the report was to verify the quality of the collected data. In general, the quality appears to be good, since the data are internally coherent. Non-response rates are low at clearly below 5 percent for all questions. In addition, we found consistent data patterns across the income distribution, i.e. for example poorer rural households are more inclined to use traditional energy sources. With regards to our identification strategy for the impact assessment in rural areas we could underpin the assumption of sufficiently similar treatment and control villages. While a few statistically significant differences could be observed, the size of these differences (i.e. the economic significance) is small and will not threat our identification assumptions.

Although we are not yet in the impact analysis phase of the study, some interesting findings could be reported. Considerable shares of the surveyed rural households already use electricity, mostly from generators and solar panels. On the one hand, this is beneficial for the project success, since these households can be expected to have a higher capacity to connect and appliances and in-house installations are already existent so that consumption increases more rapidly. On the other hand, it reduces the access-to-modern-energy effect of the intervention. It has to be noted, though, that this phenomenon of self-electrified households is perceivable in most areas in Africa that are considered for grid extension programmes and not due to the specific targeting design of the intervention. Another interesting finding is that the quality of electricity service in towns seems to be better than expected. Households do not report an extraordinarily high number of outages (for African comparisons) and are also overall pretty satisfied according to their subjective statements.

References

Abdullah, S. and Jeanty, P.W. 2011. Willingness to pay for renewable energy: Evidence from a contingent valuation survey in Kenya. *Renewable and Sustainable Energy Reviews* 15: 2974-2983.

Acker, R.H. and Kammen, D.M. 1996. The Quiet (Energy) Revolution: Analysing the Dissemination of Photovoltaic Power Systems in Kenya. *Energy Policy* 24 (1): 81-111.

Allcott, H. Collard-Wexler, A. and O'Connell, S.D. 2014. *How Do Electricity Shortages Affect Productivity? Evidence from India.* National Bureau of Economic Research Working Paper 19977.

APP, Africa Progress Panel. 2015. *Africa Progress Report 2015*. Available at http://www.africaprogresspanel.org/wp-content/uploads/2015/06/APP_REPORT_2015_FINAL_low1.pdf

Bensch, G., Peters, J. and Sievert, M. 2013. Fear of the Dark? – How Access to Electric Lighting Affects Security Attitudes and Nighttime Activities in Rural Senegal. *Journal of Rural and Community Development* 8 (1): 1-19.

Bensch, G., Peters, J. and Sievert, M. 2015. The Lighting Transition in Africa – From Kerosene to LED and the Emerging Dry-Cell Battery Problem. *Ruhr Economic Papers* 579.

Bernard, T. 2012. Impact Analysis of Rural Electrification Projects in Sub-Saharan Africa. *World Bank Research Observer*, 27(1): 33-51.

Carson, R. T., and Hanemann, W. M. 2005. Contingent Valuation. In K.-G. Mäler, & J. V. Vincent, *Handbook of Environmental Economics* (pp. 821-936). Elsevier.

Chong, A. and La Ferrara, E. 2009. Television and divorce: Evidence from Brazilian Novelas. *Journal of the European Economic Association* 7 (2-3): 458-468.

CIA World Factbook. 2014. 2014 Estimates.

Devicienti, F., I. Klytchnikova and Paternostro, S. 2004. Willingness to Pay for Water and Energy: An Introductory guide to contingent valuation and coping cost techniques. *Energy Working Notes* No. 3, World Bank, Washington D.C.

Dinkelman, T. 2011. The Effects of Rural Electrification on Employment: New Evidence from South Africa. *The American Economic Review* 101 (7): 3078-3108.

FAO, Food and Agriculture Organization of the United Nations. 2000. Applications of the contingent valuation method in developing countries: A survey, FAO.

References

Fisher-Vanden, K., Mansur, E.T., and Wang, Q.J. 2015. Electricity shortages and firm productivity: Evidence from China's industrial firms. *Journal of Development Economics* 114: 172-188.

Grimm, M., J. Peters, and M. Sievert. 2013. Impacts of Pico-PV Systems usage using a Randomized Controlled Trial and Qualitative Methods. Final Report on behalf of the Policy and Operations Evaluation Department (IOB) of the Netherlands Ministry of Foreign Affairs. Available at http://www.iob-evaluatie.nl/resources/impacts-pico-pv-systems-usage-using-randomised-controlled-trial-and-qualitative-methods.

Grogan, L. and Sadanand, A. 2013. Rural Electrification and Employment in Poor Countries: Evidence from Nicaragua. *World Development* 43: 252-265.

Hausman, J. 2012. Contingent valuation: from dubious to hopeless. *The Journal of Economic Perspectives*: 43-56.

Jensen, R. and Oster, E. 2008. The power of TV: Cable television and women's status in India. *Quarterly Journal of Economics* 124 (3): 1057-1094.

Khandker, S.R., Barnes, D.F. and Samad, H.A. 2012. The Welfare Impacts of Rural Electrification in Bangladesh. *The Energy Journal* 33 (1): 187-206.

Khandker, S.R., Barnes, D.F. and Samad, H.A. 2013. Welfare Impacts of Rural Electrification: A Panel Data Analysis from Vietnam. *Economic Development and Cultural Change* 61 (3): 659-692.

Kremer, M., Leino, J., Miguel, E. and Zwane, A.P. 2011. Spring cleaning: rural water impacts, valuation, and property rights institutions. *The Quarterly Journal of Economics* 126 (1): 145-205.

La Ferrara, E., Chong, A. and Duryea, S. 2012. Soap Operas and Fertility: Evidence from Brazil. *American Economic Journal: Applied Economics* 4 (4): 1-31.

Lenz, L., Munyehirwe, A., Peters J. and Sievert, M. 2016. Does Large Scale Infrastructure Investment Alleviate Poverty? Impacts of Rwanda's Electricity Access Roll-Out Program. *World Development*, forthcoming.

Lipscomb, M., Mobarak, A.M. and Barham, T. 2013. Development Effects of Electrification: Evidence from Topographic Placement of Hydropower Plants in Brazil. *American Economic Journal: Applied Economics* 5 (2): 200-231.

National Bureau of Statistics. 2012. Census.

Olken, B.A. 2006. Corruption and the costs of redistribution. Micro evidence from Indonesia. *Journal of Public Economics* 90 (4): 853-870.

Peters, J. and Sievert, M. 2016. Impacts of Rural Electrification Revisited – The African Context. *Journal of Development Effectiveness* 8 (3): 327-345.

Peters, J., Sievert, M. Munyehirwe, A. and Lenz, L. 2014*b*. The provision of grid electricity to households through the Electricity Access Roll-out Programme. Final Report on behalf of the Policy and Operations Evaluation Department (IOB) of the Netherlands Ministry of Foreign Affairs.

Peters, J., Sievert, M. and Strupat, C. 2015. Impacts of a Micro-Enterprise Clustering Program on Firm Performance in Ghana. *European Journal of Development Research* 27 (1): 99-121.

Peters, J., Vance, C. and M. Harsdorff. 2011. Grid extension in rural Benin: Micro-manufacturers and the electrification trap. *World Development, 39* (5): 773-783.

Peters, J., Strupat, C. and Vance, C. 2014. Television and Contraceptive Use – A Weak Signal? *Journal of Development Studies* 50 (11): 1538-1549.

Peters, J. and Vance, C. 2011. Rural Electrification and Fertility – Evidence from Côte d'Ivoire. *Journal of Development Studies* 47 (5): 753-766.

PMORALG, Prime Minister's Office Regional Administration and Local Government. 2013. Kagera Regional Investment Profile, 2013.

Rud, Juan P. 2012. Electricity provision and industrial development: Evidence from India. *Journal of Development Economics* 97 (2): 352-367.

Ramachandran, V., Gelb, A.H. and Shah, M.K. 2009. Africa's Private Sector: What's Wrong with the Business Environment and what to Do about it. CGD Books.

SE4All, Sustainable Energy for All Initiative. 2015. Progress Toward Sustainable Energy – Global Tracking Framework 2015. Sustainable Energy for All. World Bank, International Energy Agency. Washington DC. Available at http://trackingenergy4all.worldbank.org/~/media/GIAWB/GTF/Documents/GTF-2105-Full-Report.ashx

UN, United Nations. 2014. Open Working Group Proposal for Sustainable Development Goals. Open Working Group of the General Assembly on Sustainable Development Goals. New York: Division for Sustainable Development. Available at https://sustainabledevelopment.un.org/content/documents/1579SDGs%20Proposal.pdf

van de Walle, D., Ravallion, M. and Mendiratta, V. and Koolwal, G. 2013. Long-term impacts of household electrification in rural India. *World Bank Policy Research Working Paper* 6527.

Wamukonya, N. and Davis, M. 2001. Socio-economic Impacts of Rural Electrification in Namibia: Comparisons between Grid, Solar and Unelectrified Households. *Energy for Sustainable Development* 5 (3): 5-13.

Whittington, D. 2002. Improving the performance of contingent valuation in developing countries. *Environmental and Resource Economics* 22: 323-367.

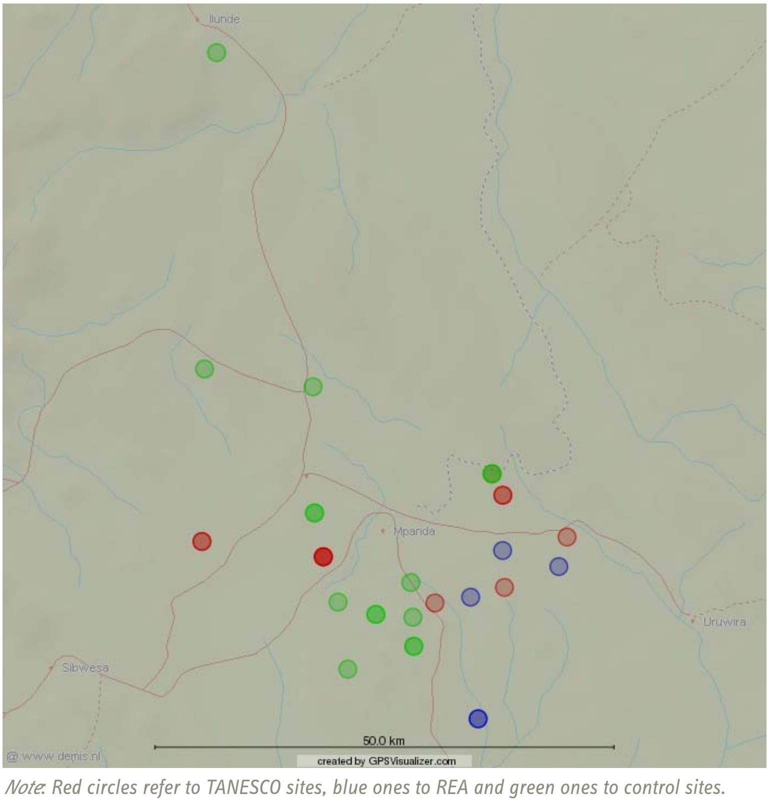
References

World Bank. 2013. World Development Indicators.

Appendix

Figure A1

Location of treatment and control sites for the case of Mpanda



Note: Red circles refer to TANESCO sites, blue ones to REA and green ones to control sites. Darker circles represent places with multiple survey sites (e.g. more than one sub-village of one village has been sampled).

Source: own representation using GPSVisualizer.com