Policy brief
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Potential links between electrification and education

In brief

- Tanzania currently experiences low levels of electrification, whereby the 2014 average electricity rate was 36%, and as low as 11% in rural areas. Current government plans aim to increase electricity access to 50% in 2020 and 75% in 2035.
- Electrification is expected to bring a number of social and economic benefits including improvements in security through street lighting, increased access to communication technologies, and increased outcomes in areas related to public service delivery including health and education.
- This policy note looks specifically at the potential links between electrification and educational outcomes and reviews recent research on the topic following on from a recent IGC co-sponsored event on the same topic.
- The authors conclude that although increasing electricity access can improve educational outcomes, it must be combined with investments that improve the learning environment more generally and that increase 'effective demand'.
- The authors further outline several policy recommendations for increasing electricity rates in Tanzania as well as improving service delivery in education through the gains made.

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Introduction

Electrification is expected to bring a number of social and economic benefits. These include improvements in security (e.g., due to street lightning), access to communication technologies (radio, television, internet), and increased opportunities for economic development/income. It is also expected to lead to improvements in education and health outcomes based on better public service delivery at schools, clinics, and hospitals, but also in the individual households based on, for example, less exposure to kerosene smoke from lanterns and more study time with light after school hours (World Bank, 2016). Research supports the assumption that electrification can lead to improvements in outcomes related to female employment (Dinkelman, 2010) and health (Barron and Torero, 2014).

This policy note focuses specifically on potential links between electrification and educational outcomes and reviews recent research on the topic. This was also the theme of a conference on 21 June 2017 that IGC Tanzania co-hosted with the President's Office for Regional Administration and Local Government (PO-RALG) who oversees the administration of primary and secondary schools in Tanzania. In this policy note, Tanzania is used as a reference country as is also the case in two new IGC-funded studies (Seo, 2017, and Bold et al., 2017) on the topic.

The policy note makes these overall points:

- Electrification is expected to bring several social and economic benefits and the lack of access to affordable and reliable electricity in Tanzania is an impediment to economic development.
- Looking specifically at the potential links between electrification and educational outcomes, the evidence is mixed and focuses on the assumption that light enables students to study after school hours, thereby improving educational outcomes.
- Two new IGC-funded studies (Seo, 2017, and Bold et al., 2017) try to fill the gap in the literature on the link between electrification/solar power and education using Tanzania as a case study.
- The Bold et al. study finds a number of positive effects of solar power installation at the household level, including on income, health, etc. In terms of educational outcomes, the study finds a positive impact on math and Swahili test scores for younger children but no or negative impact for older children. Despite the long list of positive effects of solar power, the study estimates a low willingness-to-pay for solar-powered energy.
- The GivePower study conducted by Seo and advised by Michael Greenstone estimates how electrifying school facilities may affect educational outcomes. The study finds that electrification by itself had little impact on educational outcomes. Second-year results will be evaluated this year,
- It seems plausible that improving energy access can help to support

better outcomes in education as well as in a number of other sectors such as health. However, it is unclear whether investments in energy can directly and cost-effectively improve educational outcomes, without being also combined with investments to increase the *effective demand* on the part of the students, teachers, and educational stakeholders for using electricity toward educationally productive applications.

- Overall, it seems useful to understand energy's links with education and to factor in these benefits when considering the overall development impacts of increasing energy access.

Current electricity landscape in Tanzania

In Tanzania, electricity is provided mainly by the national grid owned by the state utility, TANESCO, covering large urban centres and major road-side areas; several isolated mini-grids and various off-grid solutions also serve some rural areas (AFDB, Tanzania Country Profile, 2015). In 2014, the average electricity rate in Tanzania was 36%, and as low as 11% in rural areas.[1] The Government identifies the lack of access to affordable and reliable electricity as a barrier to economic development and increasing electricity access is a key priority (National Energy Policy, 2015). The ambition is to increase to the electricity access to 50% in 2020 and 75% in 2035 (National Electrification Program Prospectus, 2014). In its national electrification programme, the Government identifies four approaches to increase electricity access: a) connection of new customers in already electrified areas, b) electrification by new connections to the grid, c) electrification by off-grid investments, e.g., hydro plants, and d) development of distributed technologies, e.g. solar power and other renewable technologies. Points C and D are collectively referred to as off-grid electrification. The distributed technologies are often considered as 'pre-electrification technologies', i.e. to be used while waiting for the grid. In Tanzania, the distributed technologies, particularly solar home systems and solar lanterns, have been either donor-funded or purchased by households on the market (National Electrification Program Prospectus, 2014).

The institutional setup is such that TANESCO is responsible for electricity generation, distribution, transmission, and sale of electricity, including the connection of new customers to the grid, and takes the lead on urban electrification. The Rural Electrification Agency (REA), established in 2005, is in charge of rural electrification and implements grid extension in rural areas and supports private sector small scale rural power generation projects – both on-grid and off-grid (World Bank, 2016).

The geographic vastness of Tanzania, combined with low population density in most regions, makes grid extension both a challenging and

1. Others report a number as low as 6%. Figures vary due to different definitions of electricity access and data availability.

expensive way to electrify the rural areas of Tanzania. The Rural Electrification Investment Prospectus specifically estimates that mini-grids and off-grid options might be more cost-effective for serving about half of the rural population (AfDB, Tanzania Country Profile, 2015).

With Tanzania's high levels of solar energy and the low infrastructure investment requirements of solar power, it is increasingly being promoted as a cost-efficient and clean alternative to conventional grid expansion in remote areas. The Tanzanian market for solar power electrification is large and several firms operate and create frontier technologies for this market (World Bank, 2016). Realising this, the Government has removed value-added tax and import tax on the main solar components.

Based on the listed potential benefits of electrification and the description of the current electricity landscape in Tanzania, the following two sections of this note explains the potential links between electrification and education and reviews the evidence on whether solar lightning and/or other forms of energy access can improve educational outcomes.

The potential links between electrification and education

It has often been argued that providing bright, clean lighting can help children do their homework more effectively than alternatives such as dim kerosene candles or no lighting source. Some of the potential pathways that could explain a link between household energy access and educational outcomes include:

- **Lighting enables studying after school hours.** Solar lamps might help children focus on homework better compared to kerosene candles which are dim, pollutant, and have high marginal costs. A common reason students report for not finishing their homework is the lack of kerosene.
- **Energy improves the productivity and efficiency of other work**, so more time is available for education and studying.
- **Energy can power devices or IT services that enable learning** (educational media, etc.).
- **Energy can improve educational outcomes indirectly through improving health and well-being**. Solar lamps may improve indoor air quality and health, for instance, making children better able to study and attend school.

Overview of the existing literature

To date, not many studies have rigorously explored the potential links between electrification/solar lighting and education (Glewwe et al., 2015) and most have focused only on the first pathway listed above. Some of the main existing studies and results are summarised below. Overall, the evidence on a potential link between electrification/solar lighting and education is mixed.

Less optimistic results include:

- **Household access to off-grid solar power did not increase time spent studying in India.** This randomised experiment found that electricity access decreased expenditures on kerosene, however, no educational benefits were detected. The research did not find any improvements in time spent working, business creation, savings, or other measures of socio-economic development (Aklin et al., 2017).
- **Solar lamps did not improve learning outcomes in Uganda.** A randomised experiment on 204 students in Uganda tested the effects of solar LED lamps on student educational outcomes over five months and found no significant positive benefits from the lamps (Furukawa, 2014). A surprising result is that children with the lamps report spending 30 more minutes on their homework, however, their test results are no better. This may be partly due to flickering of the light when the battery is low if the recharge is not done adequately. The findings are consistent with the nationally representative Uwezo Uganda Learning Assessment Survey which finds that children with solar lamps do not improve literacy or numeracy skills any faster than those with kerosene lighting. However, the studies cannot rule out the possibility that solar lamps could boost learning outcomes under better conditions (e.g. brighter, higher-quality lamps).
- **Solar home systems did not increase time spent on studying or other productive activities in Uganda**. A large evaluation found that households using D. Light's system reported a higher number of hours with high-quality lighting access and high levels of satisfaction with the products, but there were no significant impacts on studying, working, or socio-economic status (D. Light et al., 2015).
- **Solar lighting enabled children to shift study time from day to night, but total study hours did not increase in rural Rwanda.** This study also found that within households, children under twelve were the main user of pico-PV lights only 5% of the time (Grimm et al., 2016).

And some more positive results are:

- **Solar home system adoption in Bangladesh led to an increase in children's evening study time**. Both boys and girls studied for 7-8 minutes more with the systems. The systems also lowered kerosene consumption and provided health benefits for household members, particularly women (Samad et al., 2013).
- **Access to grid electricity in rural Vietnam helped to improve educational outcomes**. This World Bank study of over 1,000 households over three years found that rural electrification helped to increase school attendance for both boys and girls. The research also found that grid access boosted household incomes (Khandker et al., 2013).
- **Solar lighting increased study hours in India**. An early study in India estimated that using a 5-7 watt panel almost doubled the average number of study hours per night from 1.5 to 2.7 hours. However, this

was a relatively expensive solution costing $88 (Agoramoorthy and Hsu, 2009).

- **Teachers report improvements in performance, attendance, and motivation from solar lighting in Tanzania and Kenya.** This is reported by SunnyMoney; however, these impacts were not quantified (SolarAid, SunnyMoney, Impact Report, autumn 2015).

The existing research has some limitations. Some of these studies test solar products that may not be the best options available. Also, many of the studies rely on households to report the amount of time they spent using lamps and studying, and these recollections may not be very accurate. Moreover, some of the studies have small samples and/or only evaluate results over a short time period.

New IGC-funded research

Two new IGC-funded studies try to address some of the gaps in the existing literature and further explore the potential links between solar lightning and improvements in educational outcomes. The two beforementioned studies by Bold et al. and Seo (advised by Michael Greenstone), respectively, were both presented at the IGC Tanzania conference on 21 June 2017[2].

At the conference, Tessa Bold's co-investigator, Anna Aevarsdottir, presented their research on willingness-to-pay for solar power as well as the impact on solar power at the household level, not only on educational outcomes but also more broadly on labour supply, income, health, etc., along the lines of the fourth pathway listed above. In partnership with the NGO GiveWatts which was also represented at the conference, the research team have designed a randomised field experiment with a sample size of almost 2,000 households. First, they randomly selected 70 schools in the Magu district in Northern Tanzania, and then they visited the schools and randomly selected students from a roster. Next, the parents of the selected students were invited to the school and after agreeing to take part in the study, they were given the chance to receive a discount voucher to purchase solar powered lamps (0%, 25%, 50%, or 100% discount voucher). The voucher introduces a degree of randomness in the price of lamps offered to each household, allowing the researchers to estimate the impact of solar lamps, taking differences across households into account. Based on this research design, they then conducted household surveys in August-October 2015 (baseline), February-March 2016, and August-October 2016 (final).

Their results show an immediate impact with significant reductions in

2. A third presentation was given by the Tanzania-based social enterprise, Ubongo, which produces edutainment for kids. While Ubongo's focus is primarily on education, they contributed to the energy-related discussions at the conference based on the challenges they encounter when trying to screen their educational cartoons in rural areas with limited access to electricity.

fuel, light, and mobile phone charging expenditure. Intermediate impacts include more adult labour outside the household (19%), increased mobile money use, and improved air quality. Among the reported final outcomes is increased household income (around 20%), mainly due to changes in household labour supply and improvements in health. Looking specifically at educational outcomes, the study finds a positive impact on math and Swahili test scores for younger children but no or a negative impact for older children. The explanation might be that older children are now doing more work at home because the parents are increasingly working outside the home. The study also provides evidence on the willingness-to-pay for solar powered energy by comparing take up across different subsidy categories. Despite all the improvements found from electrification via solar power, the households still have a low willingness-to-pay, with just over half of them choosing to purchase the lamp at a 50% discount and nobody in the sample choosing to at full price.

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While most of the existing studies have focused on household level electrification, the Greenstone study is the first (that the IGC is aware of) to estimate how electrifying school facilities may affect educational outcomes, as measured by performance on national examinations. At the conference, Greenstone's advisee, Samuel Seo, presented their first-year evidence from a solar-energy-enabled study[3] with Tanzanian secondary schools. In the study, 170 schools secondary schools without electricity in northern Tanzania were randomly assigned into five treatment groups and one control group at the start of the experiment in 2015: (G1) schools receiving solar lights[4] and TVs ('facilities') only; (G2) schools receiving facilities and English videos; (G3) schools receiving facilities and bilingual videos; (G4) schools receiving English videos only; (G5) schools receiving bilingual videos only; and control schools, which did not receive anything. The data, covering a final sample size of over 10,000 students, included form 4 outcomes in 2016, form 2 (pre-test) scores from 2014, gender, school educational behaviour survey (solar/videos/after-school usage), battery meter scans, and average characteristics of the schools.

Their results indicated little evidence that providing solar power alone (G1) or videos alone (G4, G5) had an impact on educational outcomes. G2 schools (solar and English videos), despite watching videos significantly more, also posted little outcome gains. Lastly, while estimates are imprecise, G3 schools (solar and bilingual videos) saw more students use electricity after school and realised large pass rate gains (5.9 percentage points (10%)) and modest average test score gains (0.08 σ). Second year results are being awaited this year. This analysis suggests the following policy lesson: without effective demand for putting energy

"Without effective demand for putting energy to productive use, it may take a long time before the growth potential of electrification can be translated into high rates of realised return."

3. Samuel Seo also briefly presented a second study in which they look at mathematics performance of 9th-grade students in the 170 schools, targeting schools where pass rates on 11th-grade mathematics examinations have remained below 10%. This study cross randomises the provision of cash incentives (G1), solar lights, TVs, math textbooks, and videos (G2), and a combination of both (G3). First year results were insignificant but promising.
4. On average, the designed intervention provided two solar systems to each school.

to productive use, it may take a long time before the growth potential of electrification can be translated into high rates of realised return.

The programme also showed clear limitations. Pass rates may have improved but not test scores. Giving some lights and videos were not enough to encourage broader achievement gains, such as in the science subjects. Educationally, the results did suggest that giving students more opportunities to actively engage and struggle with the materials themselves, and making these materials more approachable and conducive to self-study, may be more effective than encouraging passive viewings of videos alone.

Key issues and policy recommendations

The research on the potential links between electrification and educational outcomes can help inform policy making on rural electrification and educational programmes in Tanzania by helping answer questions such as what are the challenges, potential, benefits, and limitations of off-grid electrification such as solar-powered energy and where should the government focus its resources.

At the conference, relevant government stakeholders, energy sector regulators and energy providers, researchers, NGOs, and development partners had the opportunity to discuss current policy challenges at the intersection of energy and education based on the research presentations and to generate ideas for next steps. Some of the main points discussed were:

- Is lack of electricity the real constraint in terms of improving educational outcomes? There is a trade-off and a lot of other constraints in the education sector. Other issues include student-teacher ratios, class room infrastructure, and quality of teachers, etc.
- There was general agreement that off-grid solutions are key in rural areas but also a discussion of the financing and distribution mechanisms, electricity uptake and willingness-to-pay, and the sustainability of off-grid solutions.
- The role of the private sector in providing off-grid electricity and the need for transparency on taxation rule. It was also raised that the government's and development partners' interventions should be careful not to destroy the private sector market for off-grid technology.

The research and the policy discussions led to a number of overall recommendations concerning rural electrification and education policy:

- As the research shows, electricity alone is not enough to improve educational outcomes; there is a need to improve the learning environment more generally.
- There is a need to think through the regulation for private sector provision of off-grid technologies, including improvement of import processes and enforcement of existing tax and duty regulations as well

as means of sustainably financing public investments in off-grid electric systems.
- Estimations show that the willingness-to-pay for solar powered energy is low; there is a need to increase the awareness of the benefits of solar power in rural communities and consider designing solar payment plans for rural households (e.g., through public-private partnerships).

In conclusion, it seems plausible that improving energy access can help support better outcomes in education as well as in a number of other sectors such as health. However, it is unclear whether investments in energy can directly and cost-effectively improve educational outcomes, without being also combined with investments to increase the *effective demand* on the part of the students, teachers, and educational stakeholders for using electricity toward educationally productive applications.

Existing research shows that the large growth potential of electrification can only be translated into high rates of real economic returns when facilitated by increased demand on the part of the users for using electricity toward productive applications. Overall, it seems useful to understand energy's links with education and to factor in these benefits when considering the overall development impacts of increasing energy access.