Impact Evaluation of the AfDB supported
Kenya Last Mile Connectivity Project, Phase I:
Technical Annexes

Impact evaluations

October, 2021
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ANNEX 1: Estimation Methodologies

To identify the impact of the program on beneficiaries, we exploit the spatial discontinuity in the eligibility for the LMCP, namely the sharp change in access to the subsidized connection at 600 m (cable) distance from the eligible transformers. Specifically, we compare eligible households within the 600 m boundary to control households just outside the eligibility border. With this sharp discontinuity, while not completely arbitrary, we can assume locally that the location of a household on either side of the 600 m cutoff is "as good as random. The identification assumption is that households on the two sides of the cutoff are comparable in every aspect except for their eligibility for the LMCP program. Specifically, if the running distance from the transformer affects the outcomes, such a relationship must be continuous in the proximity of the cutoff.

One lesson we learned from the field is that the 600 m threshold was not always followed by the contractors during the implementation of LMCP Phase I. As a result, some households that received the LMCP program lived beyond the 600m threshold. This implied that we are not able to conduct a sharp regression discontinuity design. Instead, we conducted a "fuzzy RD", which is analogous to the initial design, except that the discontinuity is in the probability of receiving the LMCP (see Asher and Novosad (2020) for a recent application). In practice, we conduct the so-called "donut-hole" design whereby we exclude observations just above the 600 m threshold (between 601 and 699 meters) that recorded the most manipulation (see Almond and Doyle (2011), Cohodes and Goodman (2014), and Bachas and Soto (2021)).

Let $Dic$ be the normalized distance from the household to the transformer; specifically, the distance to the eligibility border, and $Eic \equiv 1(Dic \leq 600)$ the eligibility or RD indicator equal to 1 when a household lies within 600 m of an LMCP transformer. We implement the fuzzy RD with a quadratic fit using a two-stage instrumental variables specification. A fuzzy RD is equivalent to a two-stage least square regression model, with treatment assignment based on the running variable as the instrument. In our settings, this means that the eligibility dummy, which is equal to 1 if a household is within 600 m of the transformer and zero otherwise, is used as an instrument for LMCP status. Our main estimating equations at the household level are:

$$LMC_{ic} = \alpha + b \cdot Eic + c \cdot Dic + d1 \cdot Eic \cdot Dic + d2 \cdot Eic \cdot Dic^2 + n0 + X'ic \cdot g + Tc + eic$$ (1)

$$yic = \alpha + \beta \cdot LMC_{ic} + \theta \cdot Dic + \psi1 \cdot Eic + \psi2 \cdot Eic \cdot Dic^2 + \eta0+ X'ic \cdot \gamma + \delta c + \epsilon ic$$ (2)

where $yic$ is the outcome of interest of household $i$ in community $c$, community fixed effect (FE) $\delta c$, and covariates $Xic$, which we specify below. We implement the "donut-hole" design by excluding the 601–699 bin by including a dummy variable $n0$ and $n2$ in equations (1) and (2) respectively, indicating that the observation is in that bin. In all specifications, we cluster standard errors at the transformer community level to account for potential correlation in outcomes for a community. At the individual level, the second stage equation is:

$$yyic = \alpha + \beta \cdot LMC_{ic} + \theta \cdot Dic + \psi1 \cdot Eic \cdot Dic + \psi2 \cdot Eic \cdot Dic^2 + \eta0+ X'ic \cdot \gamma + Z'ic \cdot \rho + \delta c + \epsilon ic$$ (3)

where $yyic$ is the outcome of interest of individual $j$ in household $i$ in community $c$ and $Zic$ is a set of individual-level covariates such as gender, age, and, for regressions involving only adults, education, which are also included in the first stage of the individual level regressions. Appendix A in the Technical Report presented the ordinary least squares (OLS) results for reference.

While the evaluation’s sampling protocol aimed at identifying treatment households connected through the LMCP and unconnected control households, in practice there could be some exceptions. In fact, households be unconnected if the house did not exist at the time of program design, if the household was not present during the project’s implementation, or if the contractor failed to connect them for some other reason. Similarly, households in the control areas could be connected if they privately extended the line provided by the LMCP or if they were connected before the program because the maps shared with us by KPLC were incomplete.

Choice of covariates and balance checks

Prior to the completion of data collection, a Pre-Analysis Plan (PAP) was written to pre-specify a list of outcome variables to be included in our analysis as well as a list of covariates to be used as controls. The set of covariates to be included in the household level regression includes variables representing...
household characteristics before the program, in March 2016. Table A1.1 reports balance checks for these variables.

### Table A1.1: Balance checks

<table>
<thead>
<tr>
<th></th>
<th>Control (1)</th>
<th>LMCP (2)</th>
<th>(1) vs. (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing quality index (2016)</td>
<td>-0.07</td>
<td>0.08</td>
<td>-0.15*</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.06)</td>
<td>(0.08)</td>
</tr>
<tr>
<td>Same house as 2016</td>
<td>0.86</td>
<td>0.90</td>
<td>-0.04***</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Had solar system (2016)</td>
<td>0.15</td>
<td>0.14</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Had generator (2016)</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Had rechargeable battery (2016)</td>
<td>0.04</td>
<td>0.03</td>
<td>0.01*</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Asset ownership index (2016)</td>
<td>-0.02</td>
<td>-0.02</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.08)</td>
<td>(0.11)</td>
</tr>
<tr>
<td>N types of appliances (2016)</td>
<td>3.64</td>
<td>3.96</td>
<td>-0.32***</td>
</tr>
<tr>
<td></td>
<td>(0.04)</td>
<td>(0.05)</td>
<td>(0.06)</td>
</tr>
<tr>
<td>Connected to KPLC grid (2016)</td>
<td>0.05</td>
<td>0.04</td>
<td>0.01*</td>
</tr>
<tr>
<td></td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>N</td>
<td>2817</td>
<td>2318</td>
<td>5135</td>
</tr>
</tbody>
</table>

**Notes:** Standard errors in parenthesis. * $p < .10$, ** $p < .05$, *** $p < .01$.

Overall, we reject the null hypothesis of no differences between treatment and control households as the treatment group appears to have had higher house quality before the program, a higher number of appliances, and lower probability of having rechargeable batteries than the control group. Moreover, the treatment group has a higher probability of living in the same house as before the program. Including these variables as controls in our analysis will reduce the bias that might originate from these differences in observable characteristics. To address this lack of balance, we include these variables in the regressions as control.

However, it is important to note that our identification strategy does not require balance in observable and unobservable characteristics across the entire sample, but only in the proximity of the cutoff. If the distance from the transformer affects the outcomes in some ways, the identification assumption is only violated if this relationship is not continuous at the cut-off. Figure A1.1 shows the “donuthole” RD version of these balance checks. In these graphs, we can see that, except for appliances owned in 2016, these variables present no discontinuity at the cutoff.

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1 During the household survey, respondents were asked to think about their lives and housing situation in March 2016, 5 years before the endline survey and a few months before the program started. We recognize that these variables might suffer from recall bias. However, given that they are not directly related to the program, we expect the bias to be the same for the two groups (LMCP and control).
First Stage

In this section, we present the first stage of our identification strategy; the spatial regression discontinuity design. Figure A1.2 the probability of being an LMCP beneficiary as a function of the distance to the transformer, normalized by the eligibility threshold. We assume a quadratic fit on both sides of the discontinuity. We clearly see a significant drop in the probability of receiving the program after the 600 m threshold. The gray dot represents the excluded bin in our donut-hole specification.

Figure A1.2: Probability of LMCP and distance to the 600 m eligibility threshold in each 100-meter bin.
The distance to the transformer is normalized by the eligibility threshold. We assume a quadratic fit and plot the 95% confidence intervals. Each dot represents the proportion of LMCP beneficiaries in the 100 m it belongs to. The gray dot represents the excluded bin.

ANNEX 2: Descriptive statistics from household survey data and qualitative surveys

Descriptive results

Table A2.1 presents the summary statistics for a set of pre-specified outcome variables in the control and treatment households. The outcomes are organized in five major categories: energy outcomes, productive use outcomes, time use outcomes, household characteristics outcomes, and other major outcomes with a view to set a stage for discussions and analyses in the subsequent sections.

Looking at the first panel of energy outcomes, 53% of the control group reports using some electricity in the 30 days prior to the survey including solar power (excluding solar lanterns), rechargeable batteries, generators, and KPLC grid electricity. In comparison, 90% of treated households report using electricity in the past 30 days. Although all LMCP beneficiaries are connected to the KPLC grid by definition, 8% do not have electricity while at least 2% have not used electricity in the 30 days prior to the survey. Importantly, 14% of the control group is also connected to the KPLC grid. These are households that obtained their connection directly from KPLC, paying a fee. In terms of other sources of electricity, 63% of the control group has solar power, including solar lanterns, lighting systems, and power systems, compared to 27% of the treated group. Solar systems (excluding solar lanterns) are used by 34% of the control and 13% of the LMCP beneficiaries. Only 7% of control households have rechargeable batteries, and an even lower percentage (2%) of LMCP households have them. Generators are rare in both groups (1%). LMCP households are less likely to use non grid electricity sources (mainly solar) for daily activities such as lighting and charging mobile phones compared to the control group. It is interesting to note that 20% of control households report that they use KPLC grid electricity to charge their phones although they have no KPLC connection. This is because they have access to KPLC electricity by sharing with neighbors connected through the LMCP. Similarly, 18% of control households report using KPLC grid electricity for lighting, also from neighbors. Sharing electricity is relatively common, either for free (10%) or for a fee (13%), as is documented.

With respect to the productive use outcomes, 8% of the control group own a business (i.e., are self-employed), while only 3% own a business that is connected and 2% need electricity to operate. Similarly, 9% of treatment households own a business, 4% have a connected business, and 3% report that they need electricity to operate.

Average household size in our sample is around four persons. Average consumption is 34-35 USD per month per person. Around 64% of children under the age of 16 are enrolled in a school. We define employed as either having done a paid job in the last seven days or owning a business. Around 23% of adults are employed, and 11% of adult females are employed. Looking at Table A2.1, which presents the number of people with a job in the last seven days by sector and by treatment status, most of these jobs constitute casual work in three main sectors: (i) agriculture, forestry, and fishing, (ii) construction, and (iii) transportation and storage.

<table>
<thead>
<tr>
<th>Table A2.1: Household level summary statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
</tr>
<tr>
<td>(1)</td>
</tr>
<tr>
<td><strong>Energy Use Outcomes</strong></td>
</tr>
<tr>
<td>Any Electricity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Total Spending on Electricity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>KPLC with electricity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>KPLC without electricity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Use Light KPLC</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Productive Use Outcomes</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Owns business</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Connected Business</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Business Needs Electricity</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Kitchen Appliances</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Climate Appliances</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Other Appliances</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Time Use Outcomes</td>
</tr>
<tr>
<td>Sleep/Rest</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Work</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Farm Work</td>
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<td></td>
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<tr>
<td>Chores</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Chores by Other</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Leisure</td>
</tr>
<tr>
<td></td>
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<tr>
<td>HH Characteristics Outcomes</td>
</tr>
<tr>
<td>Size</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Female Head</td>
</tr>
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</table>
### Housing Quality Index

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treatment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Housing Quality Index</td>
<td>-0.03</td>
<td>0.04</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.07)</td>
</tr>
</tbody>
</table>

### Asset Ownership

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treatment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.07)</td>
<td>(0.10)</td>
</tr>
<tr>
<td>Asset Ownership</td>
<td>-0.07</td>
<td>0.02</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
</tbody>
</table>

### Migration

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treatment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Migration</td>
<td>0.22</td>
<td>0.23</td>
<td>-0.00</td>
</tr>
<tr>
<td></td>
<td>(0.07)</td>
<td>(0.07)</td>
<td>(0.10)</td>
</tr>
</tbody>
</table>

### Savings Increase

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treatment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Savings Increase</td>
<td>0.50</td>
<td>0.51</td>
<td>-0.00</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.02)</td>
</tr>
</tbody>
</table>

### Borrowing Increase

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treatment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>Borrowing Increase</td>
<td>0.53</td>
<td>0.57</td>
<td>0.04*</td>
</tr>
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</table>

### Major Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treatment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Consumption</td>
<td>3376.94</td>
<td>3470.27</td>
<td>93.34</td>
</tr>
<tr>
<td></td>
<td>(69.53)</td>
<td>(78.86)</td>
<td>(104.85)</td>
</tr>
<tr>
<td>Proportion Enrolled</td>
<td>0.62</td>
<td>0.64</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Proportion Employed</td>
<td>0.23</td>
<td>0.24</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Proportion Employed (women)</td>
<td>0.11</td>
<td>0.11</td>
<td>-0.00</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Health Index</td>
<td>0.00</td>
<td>0.00</td>
<td>-0.00</td>
</tr>
<tr>
<td></td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Life Satisfaction Index</td>
<td>-0.03</td>
<td>0.12</td>
<td>0.15**</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.05)</td>
<td>(0.07)</td>
</tr>
<tr>
<td>Awareness Index</td>
<td>-0.25</td>
<td>0.30</td>
<td>0.55***</td>
</tr>
<tr>
<td></td>
<td>(0.08)</td>
<td>(0.08)</td>
<td>(0.11)</td>
</tr>
</tbody>
</table>

### N

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Treatment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>2817</td>
<td>2318</td>
<td>5135</td>
</tr>
</tbody>
</table>

**Notes:** The table reports summary statistics, means and standard errors (in parenthesis) for the main household level outcomes analyzed in this report and other variables of interest. Column (3) reports the mean difference (LMCP – Control). * p<.10, ** p<.05, ***p<0.01.

### Table A2.2: Sector of Employment in the Last Week

<table>
<thead>
<tr>
<th>Sector</th>
<th>Control</th>
<th>Treatment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture, forestry, and fishing</td>
<td>264</td>
<td>283</td>
<td>547</td>
</tr>
<tr>
<td>Mining and quarrying</td>
<td>12</td>
<td>16</td>
<td>28</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>21</td>
<td>14</td>
<td>35</td>
</tr>
<tr>
<td>Electricity, gas, steam, and air conditioning supply</td>
<td>12</td>
<td>10</td>
<td>22</td>
</tr>
<tr>
<td>Water supply; sewerage, waste management and remediation activities</td>
<td>5</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Construction</td>
<td>92</td>
<td>112</td>
<td>204</td>
</tr>
<tr>
<td>Wholesale and retail trade; repair of motor vehicles and motorcycles</td>
<td>33</td>
<td>32</td>
<td>65</td>
</tr>
<tr>
<td>Transportation and storage</td>
<td>77</td>
<td>78</td>
<td>155</td>
</tr>
<tr>
<td>Accommodation and food service activities</td>
<td>21</td>
<td>22</td>
<td>43</td>
</tr>
<tr>
<td>Information and communication</td>
<td>5</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Financial and insurance activities</td>
<td>18</td>
<td>14</td>
<td>32</td>
</tr>
<tr>
<td>Real estate activities</td>
<td>7</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Professional, scientific, and technical activities</td>
<td>21</td>
<td>26</td>
<td>47</td>
</tr>
<tr>
<td>Administrative and support service activities</td>
<td>32</td>
<td>22</td>
<td>54</td>
</tr>
<tr>
<td>Public administration and defense; compulsory social security</td>
<td>22</td>
<td>37</td>
<td>59</td>
</tr>
<tr>
<td>Education</td>
<td>126</td>
<td>137</td>
<td>263</td>
</tr>
<tr>
<td>Human health and social work activities</td>
<td>21</td>
<td>19</td>
<td>40</td>
</tr>
<tr>
<td>Arts, entertainment, and recreation</td>
<td>7</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Activities of households as employers; undifferentiated goods and services, products.</td>
<td>58</td>
<td>69</td>
<td>127</td>
</tr>
<tr>
<td>Activities of extraterritorial organizations and bodies</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
Other Service Activities (Hairdresser, gym instructors) & 18 & 23 & 41 \\
Repair of motor vehicles and motorcycles & 11 & 10 & 21 \\
Refused to answer & 9 & 18 & 27 \\
Other (Specify) & 78 & 79 & 157 \\
Don’t know & 13 & 12 & 25 \\
Total & 984 & 1,053 & 2,037 \\

Notes: The table reports the number of individuals employed by sector of employment. Only individuals that report working for others are considered (18.6% of the sample).

Figure A2.1: Year of connection by county

Figure A2.1 shows the timing of connection by county. Although in all the counties surveyed, LMCP connections started in 2016 and continued until 2021, there appear to be substantial differences in the dates of connection. While in most counties 50% of the sample or more got connected by 2017, in Kitui, most of the connections took place in 2018 (over 45%).
ANNEX 3: Protocol for sample selection

For each LMCP transformer (see Figure A3.1, below, for an illustration):

1) We drew a buffer of 800 m radius around the transformer. This constitutes the overall catchment area of a transformer, or a transformer community. The choice of 800 m buffer was based on the observation that most of the treated households were located within a 400 m buffer from the transformer.\(^2\) Therefore, an 800 m buffer was thought to be appropriate to delimit the sampling area as it would ensure the control group households were not sampled too far from the transformer.

2) From that 800 m buffer, we excluded:
   - A buffer of 100 m of the transformer to avoid sampling households located too close to a market centre or another location of interest as they might be systematically different. The 100 m threshold was chosen based on observations from the Kakamega maps. We noticed that most of the structures located within 100 m of the transformers were likely to be already connected prior to the program or to be structures other than homes (e.g, schools, businesses etc.).
   - A buffer of 40 m of pre-existing lines to exclude, to the extent possible, households that were connected before the program. Based on information provided from KPLC, 40 m is the maximum distance between a connected house and a pole.
   - A buffer of 600 m around other LMCP transformers to exclude households that are also treated by other transformers or the control for other LMCP transformers in the sample. The 600 m threshold was based on the observation that, in most communities, both treatment and control households were located within 600 m of the transformer.\(^3\)

3) The sampling area for treatment households included a buffer of 40 m around the LMCP cables in the transformer community.\(^4\)

4) The sampling area for control households includes a buffer of 300 m around the LMCP cables in the transformer community if it falls within the 800 m buffer from the transformer. The choice of the 300 m threshold was based on the observation that most treated households were located within a 400 m buffer to the transformer. Given that the first 100 m were excluded for the reasons explained above, the treatment group was approximately located within a 300 m buffer from the excluded area. Therefore, assigning a 300 m to the control group would maximize the sample available in the proximity of the threshold. In Taita Taveta County it was noticed that a large number of LMCP transformers were located in sparsely populated areas, which made it difficult to identify a control group of sufficient size within the 300 m buffer. Therefore, the buffer was extended to 600 m in this county.

5) Transformers that have “too few” structures (from the CIESIN database) in either the treatment or the control area are excluded from the sample. The initial protocol, implemented in Kakamega County, implied excluding all transformer communities with less than 40 structures in either the treatment or the control area. This threshold had to be significantly reduced to 20 or 15 in the other counties given the impossibility to identify enough transformer communities.

6) Transformers that have too many “other lines” within their catchment area are excluded.\(^5\)

---

\(^2\) This is because the 600 m rule applied to cable distance, not straight-line distance.

\(^3\) We have manually verified that this choice ensured we had no overlap between transformers. In the few cases in which this was not the case we either decided to drop the transformer from the sample or we dropped the set of households connected to neighboring transformers as well as unconnected households in their proximity.

\(^4\) The final sample includes 14 transformer communities in Kericho county for which LMCP lines were originally labeled as “other lines”. The availability of geocoded LMCP meters allowed us to re-code these lines as LMCP so that these communities could be included.

\(^5\) In very few cases in which few “other lines” were present near the border of the catchment area, the transformers were kept as part of the sample and the structures neighboring such lines were excluded.
7) The pool of structures (from the CIESIN database) that lie within the treatment and control sampling areas was ranked randomly. With the ranked list, the structures were validated by a team of GIS technicians using satellite images on Google Earth to determine whether they are real households or not. During the field survey, enumerators physically checked the structures one by one until a maximum of 31 treatment and 31 control valid households were identified, the first 21 of which will constitute our main sample, and the remaining 10 will be our back-up sample in case the field visit to that household is unsuccessful. In the last phase of data collection, including Kitui, Taita Taveta, and part of Kericho county, the target sample size per transformer was reduced to 25 households per transformer community, in both treatment and control groups.

Figure A3.1: Example of sampling outcome for a transformer community in Nakuru County.

Note: The red lines represent pre-existing lines, while the green lines represent the lines constructed as part of the LMCP. The treatment area is shaded in blue, while the control area is shaded in green. The blue dots indicate treatment households, while the red dots indicate control households. Finally, the blue diamond indicates the LMCP transformer, and the blue circle is the 800 m buffer around it, delimiting the sampling area.

It is important to note that the evaluation’s selection protocol yields a random sample of treatment and control households within a transformer community, but not a random sample of transformers. The necessity to find a suitable unconnected control group might yield a selected sample of transformers that are for example in less densely populated areas or have fewer transformers in place. This issue needs to be considered when assessing the external validity of our results. However, since our identification strategy is within a transformer community, the random sampling of the households within a community that matters is sufficient to guarantee that our results are internally valid.
## ANNEX 4: Empirical Results

### Table A4.1: Energy Outcomes

#### Panel A

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
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<tbody>
<tr>
<td>Use KPLC Light</td>
<td>KPLC</td>
<td>Light Non-KPLC</td>
<td>Use KPLC Mobile</td>
<td>Charging Mobile Non-KPLC</td>
<td>Solar</td>
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<tr>
<td>LMCP</td>
<td>0.851***</td>
<td>0.834***</td>
<td>-0.173***</td>
<td>0.699***</td>
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<td>-0.508***</td>
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<tr>
<td>(0.0691)</td>
<td>(0.0762)</td>
<td>(0.0624)</td>
<td>(0.0893)</td>
<td>(0.0554)</td>
<td>(0.104)</td>
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</tr>
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<td>Observations</td>
<td>4,824</td>
<td>4,824</td>
<td>4,824</td>
<td>4,824</td>
<td>4,824</td>
<td>4,824</td>
</tr>
<tr>
<td>FDR-adjusted q-value</td>
<td>.001</td>
<td>.001</td>
<td>.057</td>
<td>.001</td>
<td>.057</td>
<td>.001</td>
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<tr>
<td>Mean Control</td>
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<td>.09</td>
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<tr>
<td>Transformer FE</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>2016 Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>F-test</td>
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#### Panel B

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<tr>
<td>Total no. Light Bulbs</td>
<td>KPLC Bulbs Share</td>
<td>Generator Battery</td>
<td>KPLC Spending</td>
<td>Total Energy Spending</td>
<td>Total Energy Spending (exl. Electricity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMCP</td>
<td>1.876***</td>
<td>0.797***</td>
<td>0.0227*</td>
<td>-0.120***</td>
<td>241.7***</td>
<td>319.3</td>
<td>-272.8</td>
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<tr>
<td>(0.516)</td>
<td>(0.0983)</td>
<td>(0.0118)</td>
<td>(0.0427)</td>
<td>(43.31)</td>
<td>(361.3)</td>
<td>(332.9)</td>
<td></td>
</tr>
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<td>Observations</td>
<td>4,307</td>
<td>2,877</td>
<td>4,824</td>
<td>4,824</td>
<td>4,355</td>
<td>3,211</td>
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<td>FDR-adjusted q-value</td>
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<td>.001</td>
<td>.194</td>
<td>.057</td>
<td>.001</td>
<td>.686</td>
<td>.69</td>
</tr>
<tr>
<td>Mean Control</td>
<td>1.99</td>
<td>.28</td>
<td>.01</td>
<td>.07</td>
<td>58.74</td>
<td>605.75</td>
<td>542.74</td>
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<tr>
<td>Transformer FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2016 Controls</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>98.67</td>
<td>52.74</td>
<td>116.7</td>
<td>116.7</td>
<td>111.5</td>
<td>63.78</td>
<td>71.15</td>
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Notes: Robust standard errors in parentheses, clustered at the transformer community level. *** p<0.01, ** p<0.05,
Table A4.2: Income and Employment Outcomes

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<th>(1)</th>
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<th>(5)</th>
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<th>(7)</th>
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<tr>
<td></td>
<td></td>
<td>Business</td>
<td>Self-Employed Earnings</td>
<td>Self-Employed Profits</td>
<td>Employing Workers</td>
<td>Agricultural</td>
<td>Non-Agricultural</td>
</tr>
<tr>
<td>LMCP</td>
<td>-0.00287</td>
<td>605.5</td>
<td>683.2</td>
<td>-0.179</td>
<td>-179.2</td>
<td>446.2</td>
<td>48.12</td>
</tr>
<tr>
<td></td>
<td>(0.0717)</td>
<td>(720.7)</td>
<td>(430.9)</td>
<td>(0.423)</td>
<td>(311.1)</td>
<td>(927.7)</td>
<td>(816.1)</td>
</tr>
<tr>
<td>Observations</td>
<td>4,824</td>
<td>4,824</td>
<td>4,824</td>
<td>421</td>
<td>4,805</td>
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<td>4,824</td>
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<td>Transformer FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2016 Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>F-test</td>
<td>116.7</td>
<td>116.7</td>
<td>116.7</td>
<td>3.457</td>
<td>115.9</td>
<td>115.9</td>
<td>116.7</td>
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Notes: Robust standard errors in parentheses, clustered at the transformer-community level. *** p<0.01, ** p<0.05, * p<0.1

Table A4.3: Consumption Outcomes

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<th>VARIABLES</th>
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<tr>
<td></td>
<td>Average Consumption</td>
<td>Total Consumption</td>
<td>Food Durables</td>
<td>Total Consumption Non-Durables</td>
</tr>
<tr>
<td>LMCP</td>
<td>1,704**</td>
<td>249.4</td>
<td>473.3</td>
<td>1,525**</td>
</tr>
<tr>
<td></td>
<td>(776.4)</td>
<td>(235.5)</td>
<td>(2,514)</td>
<td>(726.3)</td>
</tr>
<tr>
<td>Observations</td>
<td>4,559</td>
<td>4,824</td>
<td>4,677</td>
<td>4,652</td>
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<td>FDR-adjusted q-value</td>
<td>.124</td>
<td>.551</td>
<td>.954</td>
<td>.148</td>
</tr>
<tr>
<td>Mean Control</td>
<td>3375.67</td>
<td>1122.76</td>
<td>3634.23</td>
<td>3230.47</td>
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<td>Transformer FE</td>
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<td>Yes</td>
<td>Yes</td>
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<tr>
<td>2016 Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>F-test</td>
<td>111.9</td>
<td>116.7</td>
<td>110.9</td>
<td>115</td>
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Notes: Robust standard errors in parentheses, clustered at the transformer community level. *** p<0.01, ** p<0.05, * p<0.1
### Table A4.4: Productive Use Outcomes

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1) Connected Business Needs</th>
<th>(2) Electricity used for agriculture</th>
<th>(3) Kitchen Appliances</th>
<th>(4) Climate Appliances</th>
<th>(5) Other Appliances</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMCP</td>
<td>0.0685** (0.0380)</td>
<td>0.0519 (0.0362)</td>
<td>0.172** (0.0816)</td>
<td>0.154** (0.0708)</td>
<td>0.00726 (0.0148)</td>
</tr>
<tr>
<td>Observations</td>
<td>4,824</td>
<td>4,824</td>
<td>4,820</td>
<td>4,824</td>
<td>4,824</td>
</tr>
<tr>
<td>FDR-adj q-value</td>
<td>.216</td>
<td>.347</td>
<td>.148</td>
<td>.124</td>
<td>.8181</td>
</tr>
<tr>
<td>Mean Control</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Transformer FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2016 Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>F-test</td>
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<td>116.7</td>
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<td>116.7</td>
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Notes: Robust standard errors in parentheses, clustered at the transformer community level. *** p<0.01, ** p<0.05, * p<0.1

### Table A4.5: Time Use Outcomes (Hours)

<table>
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<tr>
<th>VARIABLES</th>
<th>(1) Sleep/Rest</th>
<th>(2) Work</th>
<th>(3) Farm Work</th>
<th>(4) Chores</th>
<th>(5) Other Chores by Leisure</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMCP</td>
<td>-0.944* (0.552)</td>
<td>-0.972** (0.397)</td>
<td>-0.100 (0.383)</td>
<td>-0.262 (0.650)</td>
<td>3.359 (2.488)</td>
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<td>2,203</td>
<td>2,203</td>
<td>2,203</td>
<td>2,203</td>
<td>4,824</td>
</tr>
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<td>FDR-adjusted q-value</td>
<td>.267</td>
<td>.099</td>
<td>.928</td>
<td>.838</td>
<td>.404</td>
</tr>
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<td>Mean Control</td>
<td>3.14</td>
<td>.53</td>
<td>1.61</td>
<td>4.36</td>
<td>3.08</td>
</tr>
<tr>
<td>Transformer FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2016 Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>F-test</td>
<td>72.99</td>
<td>72.99</td>
<td>72.99</td>
<td>72.99</td>
<td>116.7</td>
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Notes: Robust standard errors in parentheses, clustered at the transformer community level. *** p<0.01, ** p<0.05, * p<0.1

### Table A4.6: Education Outcomes

<table>
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<th>VARIABLES</th>
<th>(1) Hours Studying</th>
<th>(2) Hours (Night) Studying</th>
<th>(3) Study at night</th>
<th>(4) KCPE Score</th>
<th>(5) KCSE Score</th>
<th>Z-Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMCP</td>
<td>23.51 (13.94)</td>
<td>9.432* (5.024)</td>
<td>0.464** (0.220)</td>
<td>0.0148 (0.282)</td>
<td>0.998** (0.485)</td>
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<td>Observations</td>
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<td>863</td>
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<td>.929</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>45.84</td>
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Notes: Robust standard errors in parentheses, clustered at the transformer community level. *** p<0.01, ** p<0.05, * p<0.1

Table A4.7: Household Characteristics and Wealth

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<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Size</td>
<td>Fertility</td>
<td>Female Head</td>
<td>Housing Quality Index</td>
<td>Migration</td>
<td>Savings Increase</td>
<td>Borrowing Increase</td>
</tr>
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<td>LMCP</td>
<td>0.039</td>
<td>0.0537</td>
<td>0.092</td>
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<td>0.088</td>
<td>8</td>
<td>0.378</td>
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<td>4,824</td>
<td>4,824</td>
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<td>.551</td>
<td>.74</td>
<td>.945</td>
<td>.827</td>
<td>.767</td>
</tr>
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<td>Mean Control</td>
<td>3.59</td>
<td>.23</td>
<td>.22</td>
<td>- .03</td>
<td>.22</td>
<td>.5</td>
<td>.54</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2016 Controls</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>116.7</td>
<td>116.7</td>
<td>116.7</td>
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Notes: Robust standard errors in parentheses, clustered at the transformer community level. *** p<0.01, ** p<0.05, * p<0.1

Table A4.8 Women Empowerment

<table>
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<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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</thead>
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<tr>
<td></td>
<td>Woman Working</td>
<td>Own Savings</td>
<td>Financial Decision Making Index</td>
<td>Proportion Enrolled</td>
<td>Girls</td>
<td></td>
</tr>
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<td>LMCP</td>
<td>0.148</td>
<td>-0.0900</td>
<td>-0.161</td>
<td>0.0358</td>
<td></td>
<td></td>
</tr>
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<td>4,824</td>
<td>4,824</td>
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<td></td>
</tr>
<tr>
<td>FDR-adjusted q-value</td>
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<td>.453</td>
<td>.928</td>
<td>.54</td>
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<td></td>
</tr>
<tr>
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<td>-.02</td>
<td>.08</td>
<td></td>
<td></td>
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<td>Transformer FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016 Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F-test</td>
<td>73.68</td>
<td>116.7</td>
<td>116.7</td>
<td>116.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Robust standard errors in parentheses, clustered at the transformer community level. *** p<0.01, ** p<0.05, * p<0.1

Table A4.9: Wellbeing Outcomes

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Life Satisfaction Index</td>
<td>Self reported happiness</td>
<td>General life satisfaction</td>
<td>Financial satisfaction</td>
<td>Perceived safety</td>
<td>Awareness Index</td>
</tr>
<tr>
<td>LMCP</td>
<td>-0.294</td>
<td>-0.168</td>
<td>-0.638</td>
<td>-0.560</td>
<td>-0.795</td>
<td>1.772*</td>
</tr>
<tr>
<td></td>
<td>(0.456)</td>
<td>(0.170)</td>
<td>(0.446)</td>
<td>(0.452)</td>
<td>(0.482)</td>
<td>(0.951)</td>
</tr>
<tr>
<td>----------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Observations</td>
<td>4,824</td>
<td>4,794</td>
<td>4,742</td>
<td>4,735</td>
<td>4,749</td>
<td>4,824</td>
</tr>
<tr>
<td>FDR-adjusted q-value</td>
<td>.74</td>
<td>.592</td>
<td>.347</td>
<td>.453</td>
<td>.275</td>
<td>.194</td>
</tr>
<tr>
<td>Mean Control</td>
<td>-.04</td>
<td>2.27</td>
<td>5.22</td>
<td>4.83</td>
<td>6.52</td>
<td>-.23</td>
</tr>
<tr>
<td>Transformer FE</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2016 Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>F-test</td>
<td>116.7</td>
<td>114.6</td>
<td>123.3</td>
<td>122.2</td>
<td>125.1</td>
<td>116.7</td>
</tr>
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</table>

Notes: Robust standard errors in parentheses, clustered at the transformer-community level. *** p<0.01, ** p<0.05, * p<0.1
ANNEX 5: Financial Performance of KPLC since 2016

The financial situation of KPLC has deteriorated over the past years, given the rising cost of maintaining the electricity network. Table A5.1 shows that the profit of KPLC has declined since the implementation of the LMCP commenced in 2016. Specifically, between 2016 and 2019, the net profits decreased from KES 7,431 million to KES 261 million, a reduction of around 97%.

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit before tax</td>
<td>12083</td>
<td>10912</td>
<td>3089</td>
<td>334</td>
<td>-7042</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(loss)</td>
</tr>
<tr>
<td>Net profit</td>
<td>7431</td>
<td>7266</td>
<td>1917</td>
<td>261</td>
<td>-939</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(loss)</td>
</tr>
</tbody>
</table>


To improve its financial sustainability, KPLC launched a New Business Model in 2016. The model provided opportunities for partnership with both private and public business entities and set up separate legal entities as a diversification strategy and in line with world market trends. Some strategic initiatives were implemented to improve financial recovery, namely, a new tariff which includes incentives such as the time of use tariff, which was expected to drive an increase in electricity demand and revenue. Other measures focused on the timely recovery and collection of electricity receivables as well as reducing transmission and distribution losses. The available evidence suggests that these measures have not successfully improved the financial situation of KPLC. In 2019, the company still had a lower financial performance compared to 2018, the main reasons being an increase in non-fuel costs and in transmission losses. In particular, the 2019 financial report highlights that the available resources to support the operation and maintenance activities were reduced, increasing technical losses.

In 2020, the company incurred a loss in earnings of about KES 7,042 million (profit before tax, PBT). The introduction of safety measures and the negative Gross Domestic Product (GDP) growth affected the company’s electricity sales and revenue collection. In addition, revenue collection from electricity consumers was affected as customers were unable to meet their bill payment obligations on time (KPLC, 2020) while technical losses also remained high. In particular, the report argues that ‘aggressive connectivity and grid reinforcement programmes necessitated by the Government’s target of achieving universal access by 2022’ affected its financial situation.

Altogether, the current financial situation of KPLC is likely to affect the sustainability of the LMCP since it may lack the resources required for the maintenance of electrical installations. Such maintenance is essential to ensure that the projects funded by the Bank (and other donor partners) continue to provide development outcomes to beneficiaries after project completion. It is also likely these issues will compromise the reliability and quality of electricity received by LMCP households. In turn, insufficiently reliable electricity will likely limit the socio-economic impact of electrification and discourage future customers from purchasing tokens, further deepening KPLC’s commercial losses.

In this regard, the Bank did not appropriately assess the potential adverse effects of aggressive electrification programmes on the financial sustainability of the public utility. Findings from interviews with stakeholders reveal the urgent need for technical assistance targeted at supporting KPLC to overcome its financial sustainability challenges.