Implementation Brief

Cost-effectively Capturing non-Household Electricity Demands Catalytic to Rural Growth

A Columbia World Projects Initiative carried out by
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Enumerator Training in Mbale, Uganda. CWP & Agriworks Uganda

Quadracci SUSTAINABLE ENGINEERING LAB.

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

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Motivation

Columbia World Projects (CWP) launched the *Using Data to Catalyze Energy Investments* initiative five years ago that aims to address a gap in rural electrification planning by providing comprehensive data on non-household energy demands. Without such data, policymakers and stakeholders are challenged to effectively and efficiently plan energy investments to support livelihood and income growth. A key concern among planners and policymakers is cost-effective expansion of electricity access, whether through extension of the national electric grid, or additions of electric minigrids or stand-alone solar systems. Another area where data can help is in supporting financing for small rural businesses that rely on productive uses of energy (PUEs), particularly those which may benefit from switching from diesel to electric power. These goals dovetail with Uganda's Parish Development Model (PDM), a development initiative launched in 2022 to increase household incomes and target investments throughout the country's rural parishes.

The Quadracci Sustainable Engineering Lab (QSEL) at Columbia University worked with the Government of Uganda to survey productive uses of energy throughout all rural areas of the country. The effort focused on shops, markets and irrigation, and the catalytic role that electricity could play in enabling rural economic growth (e.g. agro-processing, irrigation, cold-chains, markets). This initiative is distinct from past efforts of this nature which were generally limited to household demands, targeted small project areas, or relied on projections of demands from remote sensed imagery, and so have not generally provided a nationally representative picture of non-household demands. In contrast, this project provided a detailed, ground-verified and geo-located dataset for productive uses throughout rural areas nationwide.

The detailed data from this survey is available on our Data Dashboard, which includes all the information discussed in this brief. For further exploration, please visit the dashboard.

Project Activities

In 2018, President Bollinger, the former President of Columbia University, and Columbia World Projects, convened a forum of energy experts to present and discuss innovative and creative interventions to address energy challenges around the world. The first CWP Forum on the topic of Energy Access led to the launch of several Columbia World Projects, including this initiative. At the start of the project, the team initiated a dialogue with the Government of Uganda who were in the process of preparing for a large World Bank electrification loan and therefore keen for this information to inform future planning. While data insights were shared with the Government in real-time, this document is the first of a series of public facing briefs and reports that will capture methods, practical implementation, guidance documents, district-level data, insights and policy implications.

Initial efforts of the project centered around convening an inter-ministerial working group of Ugandan stakeholders to define the priority needs and perceived data and information gaps.

These consultations ensured close alignment of project activities with national goals, a critical one being provision of data that could be useful for planning investments under Uganda's PDM.

The field work took place in Uganda during 2022/23 post-Covid. This phase focused on field surveys that captured rural productive uses of energy such as agro-processing, cold storage facilities, irrigation clusters, markets along with farmer interviews. The surveys collected estimates of energy demands to shape electrification technology choices and investments, including whether PUE activities could be carried out efficiently with electricity as an alternative to existing energy use.

A critical aspect of this project was its efficiency. The survey covered the entire country while visiting relatively few locations, perhaps one percent of what a household census would require. Given the comprehensive national scale and need for cost-effective ground truthing, the team set a target to gather lean but precise information across tens of thousands of locations at a cost of around $10 per location. To achieve this, a combination of innovative surveying methodologies and strategies, logistical planning, and technologies were employed. These tools and methods are described below.

Elements of efficient execution

Focused Geographic Targeting for Productive Energy Use in Rural Areas

To optimize data collection, it was critical to target specific geographic areas. The survey focused exclusively on rural areas with active cropland and excluded urban, peri-urban and non-cultivated zones. This targeted approach saved significant time and resources by avoiding costly and unnecessary transportation and surveys in uninhabited areas. The team utilized machine learning, combining satellite imagery and mapping layers for population density, vegetation, temperature, and land cover analysis to categorize areas into three broad classes: cropland, buildings, and forests. This helped identify relevant populated rural regions, ensuring survey efforts focused only on high-relevance areas.

Surveying for key rural energy demands required different strategies for PUE businesses and irrigated farm plots. Every effort was undertaken to reach all PUE businesses across rural Uganda, meaning the survey was, in effect, a census of these businesses. In contrast, because irrigated plots are somewhat rare in Uganda, the irrigation survey required a sampling approach. First, the rural cropped areas previously identified by machine learning were divided into 2.5 x 2.5 km cells. Then, a sample of these cells were surveyed such that between one and three sample areas were visited, depending on the total area of the parish. This sampling approach ensured coverage of all rural parishes, a critical adaptation of the surveying program to address the urgent needs of Uganda's Parish Development Model.

GPS-Enabled and Smartphone-Based Data Collection

A key component of the fieldwork was the use of GPS-enabled smartphones by field survey enumerators. These smartphones were pre-loaded with digital maps indicating survey target areas thus enabling enumerators to cross-reference their locations and navigate complex rural

landscapes without wasting time or resources. The survey interviews were conducted using Kobo Collect, a versatile, paperless tool developed by QSEL at Columbia University. Kobo Collect minimizes costs and errors associated with printing and manual data entry, thereby enhancing data accuracy and efficiency. Kobo Collect also includes an offline mode, such that, even in areas with limited internet connectivity, data can be saved to the phone's memory, and uploaded to a cloud-based system once enumerators reach an area with connectivity, ensuring no data loss.

Enumerator Training for Efficiency:
Surveys were fine-tuned through multiple rounds of tests to ensure efficient capture of key information. Enumerators in Uganda received thorough training from Agriworks Uganda, a local survey firm, in spatial tools such as QGIS, Kobo Collect, and field navigation using digital maps and GPS enabled phones. This training improved logistical efficiency, minimized errors, and avoided the need for re-surveys. Field rehearsals in real locations closely monitored by supervisors further prepared them for actual survey conditions.

Use of Motorbikes for Local Travel:
Enumerators relied on motorbikes instead of more costly vehicles, such as land cruisers, for travel in rural survey areas. This not only lowered travel expenses but also allowed access to more remote areas which often suffer from very poor road access. Local motorbike 'taxi' drivers were identified in local markets and hired on a day-to-day basis. These drivers also acted as informal guides, providing efficient navigation to targeted cropland survey sites and advising on how to efficiently reach markets and other areas with PUE businesses.

Local Guides and Assistance:
Upon reaching a survey location, local village guides helped enumerators locate farms, businesses, and irrigation clusters quickly, avoiding prolonged searches for, among other things, farmers for interviews about their farming practices.

Government Coordination for Smooth Fieldwork:
CWP collaborated with Uganda's Ministries of Energy and Mineral Development (MEMD), Agriculture, Animal Industry and Fisheries (MAAIF), Water & Environment (MWE), and Local Government (MOLG) to understand local planning priorities and access important local data and information. CWP also worked closely with MEMD and Uganda National Council for Science and Technology (UNCST) to obtain pre-approvals for the surveys letters endorsing the survey, which helped with logistical challenges and ensured cooperation with local stakeholders.

This pre-approval process also enabled the team to adapt its methodology to align with the government's developmental priorities, particularly those of the Parish Development Model—a framework focused on strengthening local economies and improve the quality of life for Ugandans by moving households from subsistence farming to the money economy.

Real-Time Monitoring for Rapid Course Correction

The data collected in the field was monitored in real-time by supervisory teams at three levels: field supervisors worked closely with individual enumerator teams operating in each of Uganda's different language regions; the national Agriworks team based in Mbale, Uganda oversaw the operations of the separate enumerator teams; and QSEL members in New York integrated the separate incoming datasets and provided oversight for data quality. This three-tier monitoring system allowed for real-time course correction and oversight, ensuring that the survey remained on track and aligned with project objectives.

In Summary:

This project offers a replicable model for conducting cost-effective, large-scale data collection to support rural electrification planning in other developing regions. Essential techniques that contributed to an efficient program and favorable outcomes included; 1) sustained coordination with government to build consensus around the project objectives, identify key data gaps of interest, and ease logistics; 2) targeted geographic sampling focused on pre-identification of areas of interest and loads (e.g. irrigated cropland and productive energy uses; 3) GPS-enabled smartphones and tools to assist with efficient field navigation and data capture (using Kobo Collect); 4) survey pilots and enumerator pre-training that ensured efficient questionnaires and interview procedures; 5) local guides—both motorbike drivers and village guides—that provided essential navigation and local knowledge, allowing for quicker, more precise site visits and; 5) real-time monitoring by skilled supervisory and data teams that facilitated rapid adjustments, maintaining data quality and alignment with project objectives. Most essential to the endeavor was alignment of the goals through a strong partnership and information sharing with the Government.

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Focal Points Within Government of Uganda

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Participants in Working Group or other supplementary discussions

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- Uganda Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)
- Uganda National Meteorological Authority (UNMA)
- Uganda Ministry of Water and Environment (MWE)
- Uganda Ministry of Local Government (MOLG)
- Uganda Electricity Distribution Company Limited (UEDCL)
- UMEME (https://www.umeme.co.ug/)
- Uganda Energy Credit Capitalisation Company (UECCC)

Other Key Stakeholders

World Bank:
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Private Sector Energy Project Developers:
Aptech, AMEA, A2EI & Imara Tech, Azuri, Catalyst Off Grid, Cross Boundary, EnerGrow, Engie, Equatorial Power, Mandulis Energy, M-Kopa, PowerGen, SolarNow, Sun Culture, Tulima Solar, UMEME, Village Power, Winch Energy

Entities Consulted and Invited:
African Forum for Utility Regulators, Agsol, Air Water Earth (AWE) Engineers, Clean Cooking Alliance, GOGLA, Digital Green Investment Agency, FAO Uganda, GEAPP, GIZ, International Solar Alliance (ISA), Kilimo Trust, Open Capital/UOMA, Power Africa, Power For All, Rockefeller Foundation, Second Stream, SEforALL, SELCO, The Policy Practice, Uganda Association of Impact Assessment, UNREEA, USAID, WRI

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