Consilience: The Journal of Sustainable Development
Iss.27 (2024)

CONSILIENCE
THE JOURNAL OF SUSTAINABLE DEVELOPMENT

A User-Centered Account of Urban Energy Transitions in Kampala, Uganda

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Abstract

The rapid and complex effects of urbanization are shifting energy production and consumption patterns on the African continent. Energy poverty is manifesting to an increasing degree and in diverse forms in low-income, vulnerable urban populations like informal settlements and/or "slums." This photo essay shows the lived realities of the urban energy transitions unfolding across Kampala, Uganda's many informal communities. Though residents are almost universally connected to the grid, 97% of households and businesses rely on expensive and polluting charcoal. Electricity access is precarious and residents develop personalized fuel-stacking strategies to balance the competing demands of affordability, health, convenience, etcetera. Redundancy, hybridity, and improvisation are key features of the strategies that low-income communities use to meet their daily energy needs in the face of an unreliable, unaffordable, or inaccessible grid. This essay contributes to a growing body of research that aims to center users within discussions of urban energy transitions and sustainable development broadly.

Keywords: Energy access, Informal settlements, Electrification, Energy transitions, Urban poverty

Introduction

Clean and affordable energy is an essential input to sustainable development in the rapidly urbanizing Global South. Urbanization on the African continent has produced dramatic shifts in the form and density of human settlement patterns and the distribution of (energy) poverty (Mahumane & Mulder, 2022). Existing cities are growing and densifying, often sprawling far beyond their administrative borders. New cities and towns are emerging, often as a single node in a larger mega-agglomeration or conurbation (OECD et al., 2022). Cutting across these is a tendency for settlements to emerge informally and for vulnerable populations to be concentrated in urban spaces (Ravallion et al., 2007; United Nations High Commissioner for Refugees, 2023). These trends pose new challenges for meeting the Sustainable Development Goal (SDG 7) to "ensure access to affordable, reliable, sustainable and modern energy for all" (United Nations Department of Economic and Social Affairs, n.d.).

The infrastructure needed to provide clean energy to urbanizing communities has not kept pace with demographic trends in many places in sub-Saharan Africa (SSA) and beyond (Falchetta et al., 2020). The conventional model of urban energy transitions holds that people transition to cleaner fuel sources (especially electricity) over time as their incomes increase and as these sources become more available and affordable (Price, 2021). However, in SSA, these transitions have proceeded unevenly and often inequitably (Fall et al., 2008; Karekezi & Majoro, 2002; Pandey et al., 2022; Yaguma et al., 2024). This is clear in the case of the electricity grid, which researchers have shown provides services of often poorer quality and higher expense to disadvantaged users (Degani, 2022; Graham & Marvin, 2001; Jacome et al., 2019; Kersey et al., 2023; Silver, 2015).

This insight is troubling for the future of sustainable urban development. The current model of urban energy transitions in SSA hinges on the densification and extension of the central electricity grid to deliver low-carbon and wide-scale access across an increasingly low-income user base (J. H. Williams & Ghanadan, 2006). However, electricity has only been partially adopted in many low-income urban communities and reliability and affordability continue to be significant barriers to its uptake beyond basic uses like lighting and phone charging (Blimpo et al., 2020; Blimpo & Cosgrove-Davies, 2019). Smoky fuels like charcoal and firewood continue to be important fuel sources for urban families and entrepreneurs, to the detriment of community health and the local environment (Clean Cooking Alliance, ICLEI, 2023; Kansiime et al., 2022). By 2030, an estimated 60% of cooking needs in urban SSA will still be met with biomass or fossil fuel sources (Stoner et al., 2021).

A deeper understanding of how the electricity grid is (or is not) meeting the needs of low-income urban users, and the layered strategies and fuel sources that these populations use to cope, is important to chart a more equitable path for sustainable urban development. Informal settlements and "slums," which are the focus of this study, are home to some of society's most vulnerable groups (Dodman et al., 2018). They are also the urban majority. Of the total urban population in SSA of 600 million, 62% live informally in overcrowded conditions, poverty, insecure housing tenure, and poor access to basic services (UN-Habitat, 2016). More critical pieces of literature have long recognized that these communities are "more than simply places of dwelling…these 'cities within cities' also accommodate commerce, cultural production, politics, education, and much more" (Werthmann & Bridger, 2015). They host strong informal economies built around providing small-scale goods and services and disproportionately employ women

(Brown & Roever, n.d.). Barbershops, motorcycle taxi drivers, salons, kiosks, and other diverse businesses all depend on energy.

Among research that has contributed to the debate around the nature and trajectories of urban energy transitions, there has been a call to better center users and their experiences (Castán-Broto et al., 2017). This is part of a wider agenda of socially-inclusive research, much of it based in informal settlements, which has also animated activities around participatory data collection (Lundine et al., 2012). This aims to give end users, particularly those from disadvantaged communities, a seat at the table in making decisions that will impact their communities. This aligns with procedural elements of energy justice frameworks which emphasize inclusive participation and more opportunities for communities to engage meaningfully in decisions of energy governance (Sovacool & Dworkin, 2015). It also includes approaching conversations around energy access and infrastructural adequacy from a perspective of user aspirations particularly based on education, health, and wellbeing (Parikh et al., 2012).

This photo essay seeks to contribute to these discussions by visually contextualizing the urban energy transition in 25 informal communities in Kampala, Uganda. The photos are intended to convey the infrastructural experiences of the residents of the communities. They show the heterogeneity of electricity service provision in terms of the physical infrastructure and the informal service arrangements that users negotiate with local supply intermediaries. Some are snapshots of the mundane ways that energy intersects with everyday lives and livelihoods. Others depict items or pieces of infrastructure that community members pointed out to the research team as representative of a certain issue or challenge.

In these ways, this work aims to provide a grounded and human-centered perspective on energy access in Kampala's low-income communities. As a visual medium, the aim is to make these narratives more accessible to the diverse policy, social, planning, and technical communities of practice working at the various intersections of urban energy transitions in Kampala and cities of the Global South more broadly.

Materials and Methods

These photographs were taken by the author during fieldwork related to the Spotlight Kampala initiative in Kampala, Uganda, between October 2022 and January 2023. They were taken with an iPhone X, which has a lens of 28 mm f/1.8 and 52 mm f/2.4. This camera type was practical for this setting and felt more comfortable for research participants. The images have not been processed or corrected.

During the fieldwork period, the research team conducted 66 interviews and 500 surveys, and installed power quality sensors in 150 homes and businesses (Kersey et al., 2023). All three activities took place across 25 informal communities. Figure 1 shows the location of Uganda in East Africa and the locations of all informal settlements in Kampala. The names and exact locations of participating communities are withheld for the sake of data privacy at the request of NGO partners.

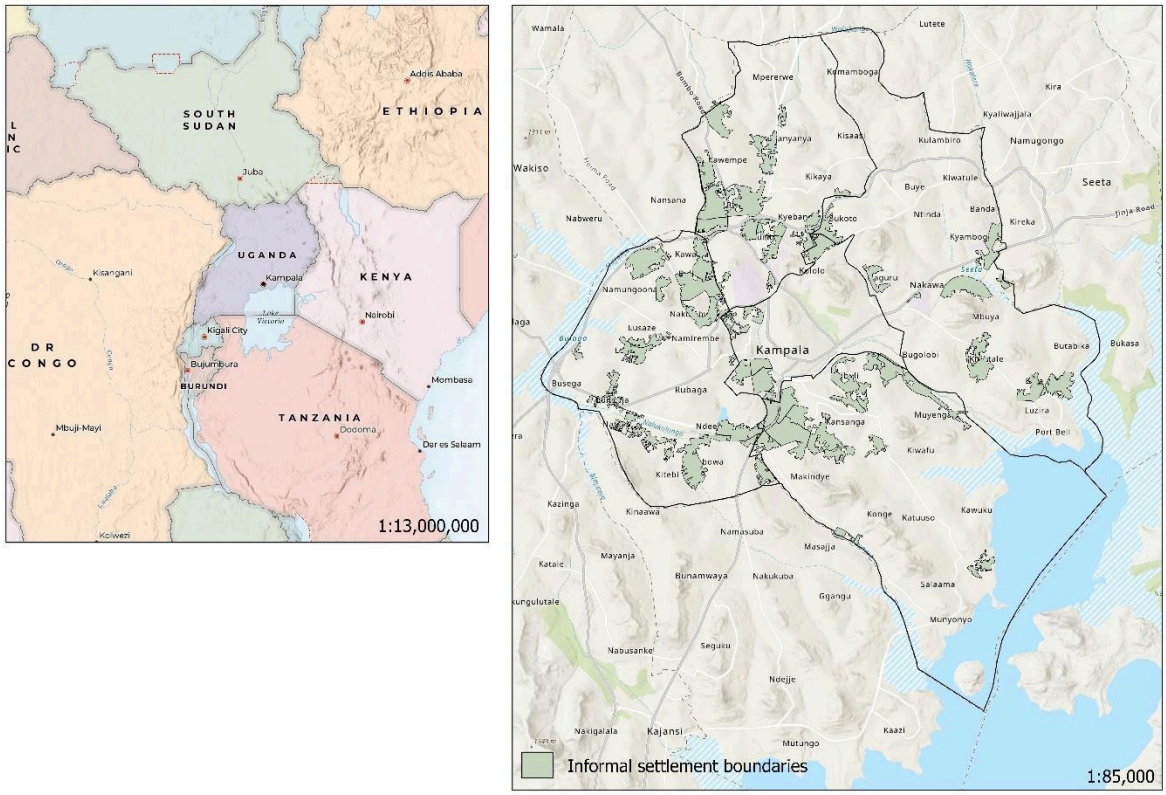

Figure 1. Maps showing the location of Uganda and Kampala within the East African region (left), and the locations of roughly 60 informal settlements within Kampala City.

These photos were captured during these research activities and other informal interactions and movements with community members. The exact procedures varied by the method, but for all activities representatives from ACTogether Uganda and the National Slum Dwellers Federation of Uganda facilitated introductions with the local council (LC) leadership in partner communities. LC leaders at the parish and/or zone level consented to collaborate in the research and many then designated a guide to accompany the research team. The photos are supplemented by quantitative and qualitative insights from surveys and interviews.

The study protocol was approved by the Institutional Review Board of the University of California, Berkeley under protocol 2022-07-15500 and the AIDS Support Organization under reference number TASO-2022-141. The project is registered with the Uganda National Council for Science and Technology under registration number SS1437ES. All people who are recognizably featured in the photos consented to be photographed and for the photos to be used as part of research efforts.

Essay

In Kampala, a majority (62%) of residents live in informal settlements (Richmond et al., 2018). Of these roughly one million people, 73% are estimated to live below the national poverty line of $1.90 per person per day (Wanyama et al., 2019). These communities face intersectional vulnerabilities related to land tenure, food security, and unpredictable earnings (Dimanin, 2012). They also face disproportionate environmental hazards (D. S. Williams et al., 2019). In Kampala's

case, flooding is a recurring issue (Kwiringira et al., 2016). Informal communities occupy the low-lying valleys between the hills, which host commercial and wealthy residential zones (Hemerijckx et al., 2020). **Photo 1** shows an informal community in Kampala from the vantage point of a nearby footbridge that crosses a highway. It gives a sense of the scale of the community, which is one of over sixty in Kampala City (ACTogether Uganda, 2014).

Photo 1. An aerial view of an informal community in the rainy season following a storm. The spatial arrangement of the community pictured is common. A variety of small businesses, like mobile money agents and shops, usually operate along the larger roads. Households are clustered in the middle ground behind the shops. Utility poles carrying low-voltage distribution lines are visible along the road, as well as high-voltage transmission lines in the background.

Electricity grids are the main way of delivering electricity to these economically and socially dense neighborhoods. Access rates are nearly universal at 95%. **Photo 2** shows a typical neighborhood and the electrical infrastructure that serves it. The white boxes on the electricity pole in the right background are part of the pre-paid *Yaka* metering system which controls power supply to customers. The other piece of the pre-paid meter is a customer interface unit (see **Photo 3**) located within the premises of each registered user. It shows the amount of electricity credits remaining and allows users to reload by entering numeric tokens that can be purchased locally or via mobile money.

Photo 2. This cluster of households is representative of housing conditions for lower-income residents. Homes are commonly arranged around a common area. These spaces fulfill different social and economic purposes throughout the day, such as a play space for children, laundry, household and commercial food preparation, socializing, and more. These structures are likely owned by a common landlord and rented to their occupants.

However, most connections do not conform to the utility's standard configuration. Barriers to applying for a connection, mostly related to the cost and landlord permission, prevent many from registering for their own connection. Users circumvent these barriers by sharing a common electrical circuit and meter among multiple users. This is particularly common as a way for landlords to provide electricity services to multiple rental units. Local electricians, known as *kamyufus*, can also illegally provide a connection to the grid by bypassing metering systems or tapping nearby distribution lines. They operate a parallel infrastructure below the formal utility grid which serves around a quarter of users in informal settlements (Kersey et al., 2023). **Photos 3-5** demonstrate this heterogeneity as it manifests in diverse metering systems. **Photo 6** shows a utility pole that supports multiple types of connections.

Photos 3-5. Three different metering systems were observed among users. The top left shows the most common one, which is a pre-paid *Yaka* meter customer interface. The top right shows a "ready board" system offered by the then-Rural Electrification Agency as part of an initiative to connect low-income users. It provides a light and several outlets. In practice, it was common for users to plug in an extension cable and run it to other parts of the home or business. The bottom photo shows a landlord's electrical set-up for her tenants. Submeters meter the use of her individual units and the main supply comes from the prepaid metering system. This arrangement was somewhat rare because of the cost of the materials and wiring involved.

Photo 6. An LC leader pointed out this utility pole, commenting that "the tree [pole] is tired." He is referring to the damage to the pole from *kamyufus* and utility workers, who use spiked metal boots to climb them and access the meter boxes at the top. On the pole, it is noticeable that the number of service lines is much greater than the number of meter boxes. These could be abandoned lines, but are more likely to be unmetered connections.

These non-standard connections increase the inclusivity of electricity supply by allowing disadvantaged users to access the grid. However, they can also be precarious, restricted, and unsafe in ways that impact all grid users. **Photo 7** shows a physical precarity in the form of an improvised grid extension. **Photo 8** shows the challenge of power quality, which manifests as appliances that prematurely break due to chronically low voltages or instantaneous voltage spikes. Reliability is also poor, mostly because of overloaded distribution transformers. **Photo 9** shows a circuit breaker with damage from an electrical fire which was specifically pointed out by community guides. **Photos 10** and **11** depict the improvised nature of electric wiring, which community members pointed to as a significant safety hazard.

Photo 7. A household connection with a bare splice in the line. It is possible that this was done intentionally to make the line easy to disconnect. This might be done by a *kamyufu*, for example, so that the line can be concealed in the case of an enforcement raid by the utility and law enforcement. The ability to easily disconnect might also be desirable for landlords, who tend to use electricity as leverage and often cut the electricity supply if rent is not paid on time.

Photo 8. A headmistress at a primary school holds up a grinder that had been used to prepare meals for the children. In her interview, she reported that it had recently broken and she suspected it was due to voltage spikes. This is one appliance that she chose from multiple others which were broken and collected in a corner of the room. These *appliance graveyards* exist in many homes and institutions in Kampala (and in many other contexts, in the author's experience). Broken appliances are stored because they can later be sold, repaired, or used for parts.

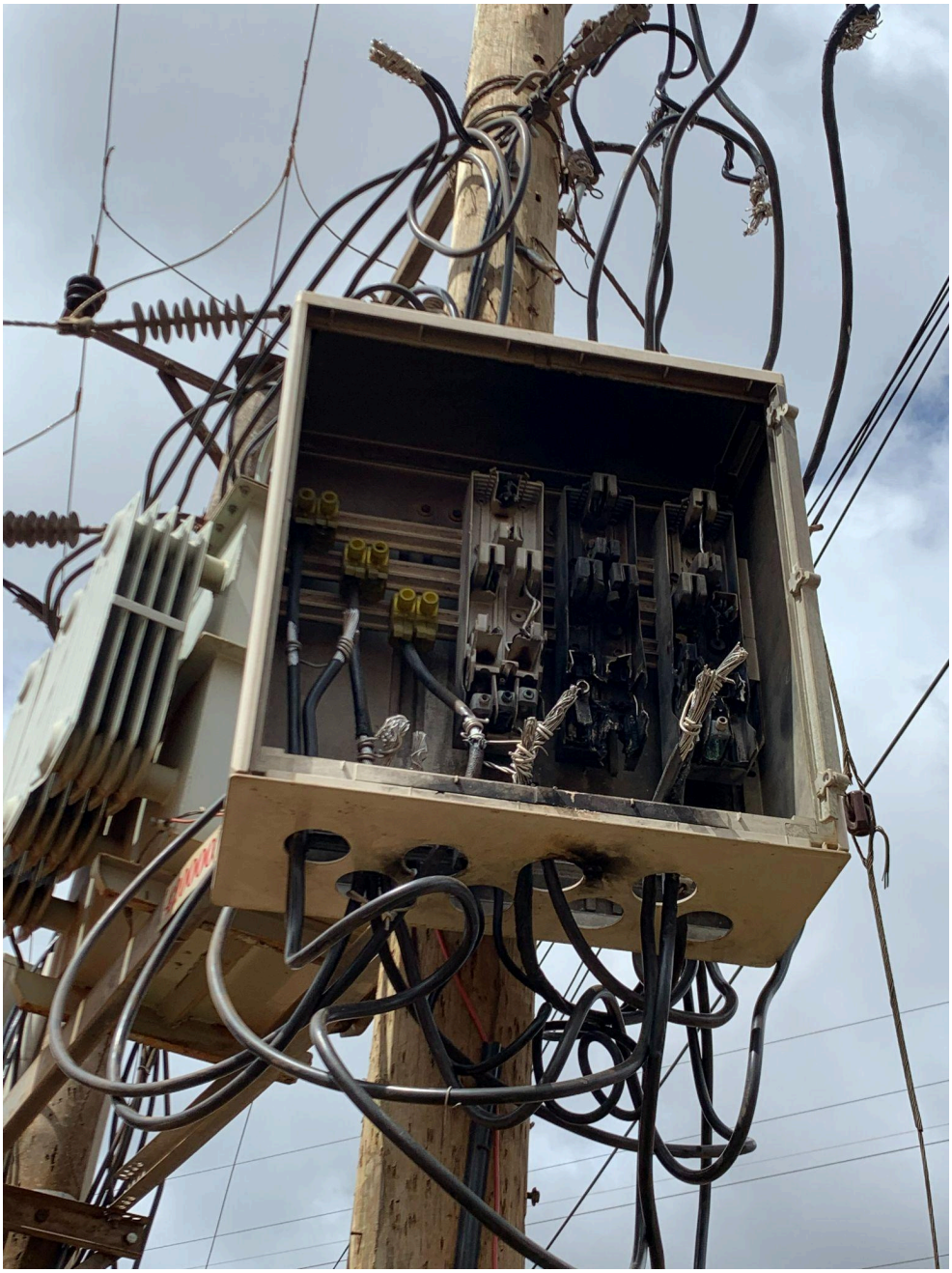

Photo 9. A breaker box that is controlling the power supply from a distribution transformer. The black, melted hardware on the right is evidence of an electrical fire. Community members narrated that this circuit breaker was constantly tripping from overcurrent because it was not designed for the load. They noted that after it burned, Umeme personnel did not replace it or upgrade the transformer but simply bypassed the breaker. One interviewee estimated that this was a common occurrence because although one transformer should serve around 200 households in reality they served around 1,000. As one *kamyufu* interviewee put it, "Each pole should have 10 connections, but each wire coming off can have 5-7 houses."

Photo 10. An example of improvised household wiring. This was the home of a family with two young children. The *Yaka* meter is visible to the left of the doorway but may be shared with nearby households. A family of this size uses electricity primarily for lighting, TV, phone charging, and other consumer electronics. Ironing and boiling water are other common household uses of electricity. The cables above the doorway show how wiring is extended ad hoc. Though the utility performs a wiring inspection as part of the registration process, internal wiring is usually added as money is available to purchase additional cables and outlets. Extension cables and power strips are often used as permanent wiring. The cost of internal wiring for a dwelling like this is around 30 USD. Because of this expense, it is common for renters to provide their own electrical wiring, which they usually remove and bring from their previous residence.

Photo 11. An electricity cable emerging from the ground and entering the wooden home above. This is also a footpath, and the concrete block was likely placed over it to protect it from bypassers, and vice versa. Undergrounding is the best way of disguising an illegal connection, but is dangerous. Several interviewees noted that underground cables like this used to cause several fatalities per year, but this practice is now less common. As one *kamyufu* explained, "If a wire gets damaged and is exposed especially in this place that floods when it rains, we have to be careful and advise [people] to switch off electricity when it rains, because this water can even kill people so we strive hard to switch it all off when it rains, and connect back when it stops."

Despite these challenges, energy underpins many local economic activities. **Photos 12-14** show examples of small businesses that use energy to generate income. It was clear from conversations with community members that they desired to use electricity for more purposes. However, affordability was a day-to-day challenge. When asked how they would use electricity if it were more affordable, many community members mentioned uses related to cooking. But, as one woman summarized, "everyone wants to use it [electricity] for cooking but when they weigh its price they decide that using charcoal is the better [option]."

Photo 12. A local storefront where the research team installed a power quality monitor provided by nLine (Klugman et al., 2021). The proprietor's earnings came from selling small electrical gadgets and charging customers to screen movies or play the gaming consoles shown on the shelf. This is a very modern example of a business based on the productive use of electricity.

Photo 13. Another example of a small business based in part on the sales of refrigerated and frozen products. It is common for community members to purchase secondhand appliances. Though more affordable, these appliances are also less energy efficient which can make them more costly to run. Refrigerators were challenging for local businesses to power affordably. A small number (7%) of surveyed users thus had two connections: one metered and one unmetered. The unmetered line is used for higher-consuming appliances like refrigerators because the *kamyufus* who manage the connection usually charge a flat monthly rate, which is much cheaper than the per-kWh rate billed on a metered connection.

Photo 14. An older *mzee* (gentleman) shows his charcoal iron. Charcoal is placed and lit within the metallic body of the iron. The metal plate on the bottom transfers the heat into the clothing. Ironing is a culturally important use of energy within Uganda, where well-pressed clothes are a sign of respect. Ironing is also an important livelihood strategy for some for many given that 26% of community members take clothing to a local "*dobbi*" for washing and pressing (Yaguma et al., 2024). As this *mzee* explained, he had used the iron to provide for his family for over 40 years

Nearly all (97%) of surveyed households and businesses use charcoal as their primary source of cooking fuel. Residents also spend over double on charcoal (12%) compared to electricity (5%) as a percentage of monthly expenditures. It is clear that charcoal meets a significant percentage of energy needs in these communities, and is deeply embedded in everyday practices and livelihoods. **Photo 15** shows cookstoves on display for purchase. Photo **16** depicts charcoal being dried and shows how biomass fuels are quite visible in community spaces. **Photo 17** depicts a charcoal vendor at her place of business.

Photo 15. Local cookstoves, known as *sigiri*s, are on display for purchase by a local vendor. In the foreground are traditional models which are less energy efficient, compared with the blue improved SmartHome cookstoves in the back (Rojas, 2018). Improved cookstoves (ICS) like these offer a cooking efficiency gain of 20 to 40% over traditional models, which translates directly to fuel savings (Memon et al., 2020). *Sigiri*s are used to cook many foods, particularly local staples like beans, *matooke* (banana), and *posho* (maize meal). The manufacturing and sales of improved cookstoves like the SmartHome are a growing market in East Africa (Clough, 2012). The traditional models are manufactured locally by small businesses at a scale of less than 100 stoves per month (Global Alliance for Clean Cookstoves, n.d.).

Photo 16. Charcoal spread over plastic bags to dry in the street. Damp or wet charcoal burns at a lower efficiency and produces more smoke (Kansiime et al., 2022). This leads to higher levels of household and ambient air pollution, which are already chronic health challenges in these communities. Keeping charcoal storage areas dry is difficult because most of these areas are low-lying, and flood quickly during storms. Community members felt that the timing and predictability of the rainy seasons were becoming increasingly unpredictable. According to climate scientists, extreme rainfall events are part of a changing Ugandan climate trending towards hotter and drier overall conditions (Nsubuga & Rautenbach, 2018). Urban researchers are increasingly concerned that informal communities will disproportionately face climate burdens while being among the least prepared to adapt and respond (Borg et al., 2021).

Photo 17. A charcoal vendor gives a tour of her storage shed. She stores the charcoal here but sells it in small quantities at the nearby market which is one of the largest in Kampala. Lower-income households pay more on average because they buy charcoal in much smaller quantities, often just enough to cook a meal. A coordinator from the National Slum Dwellers Federation of Uganda later commented that her 10-person household used one sack per month at a cost of 120,000 UGX (~30 USD). To put this in perspective, an average household in our survey reported earning 180 USD per month.

Conclusion

This visual exploration of energy in Kampala's informal communities shows that residents have various, complex ways of navigating and adapting existing energy systems to meet their needs. Redundancy, hybridity, and improvisation are themes that emerge in the photographs. Though most residents have a connection to the electricity grid, the high cost of electricity, poor quality and reliability, and threat of disconnection by intermediaries are daily realities that restrict, discourage, or prevent its use. Electricity is used as it is available/affordable/allowed, and charcoal, firewood, and manual labor fill the substantial gap.

The patterns of fuel stacking provide a window into users' preferences, constraints, and needs. Given the precarity of grid connections (to outages, disconnections/supply cuts, voltage spikes, etc.), it is necessary to have multiple redundant fuel sources. Most households have access to electricity, charcoal, firewood, candles, and solar light kits. They make daily decisions about what fuel to use based on, for example, the amount of money they earn that day. Biomass sources still dominate for end uses like cooking. Electricity has only entered kitchens for basic uses like boiling water. Finding ways to displace charcoal and firewood are important and urgent areas of policy action for the Government of Uganda and its partners (CIRCODU, 2023).

Communities in Kampala, as elsewhere, have developed hybrid models of electricity service provision over time (de Bercegol & Monstadt, 2018; Silver, 2023; Smith, 2019; Yaguma et al., 2022). These are a response to the high cost and administrative requirements of the connection process, which preclude many people from applying for formal service from the utility (Singh et al., 2015). Strategies like tapping distribution lines, sharing meters, or installing submeters–which are normally mediated by a landlord, neighbor, or *kamyufu*–have emerged as ways to make formal systems more inclusive (Buyana, 2022). However, the quality and safety of the electricity provided by these connections are typically worse (Kersey et al., 2023).

The photos also convey a sense of dynamism in access to electricity via the grid. In economically, physically, and socially dense urban spaces, people and their built environments are constantly changing. Electricity poles are erected but others fall. A transformer's circuit breaker is blown and it is bypassed. A tenant does not pay the rent and her landlord disconnects them. The precarity of grid connections, and resulting cycles of connection and disconnection, is not something that is recognized in the technical frameworks favored by practitioners and policymakers to track progress toward SDG 7 (Bhatia & Angelou, 2015; Nussbaumer et al., 2012). It is, however, one of the many barriers that encourage the continued use of polluting fuel sources and must be reconciled if electricity is to drive clean energy transitions in Kampala.

The insights from informal communities in Kampala surface important questions around equity within urban energy transitions. The current model of electrification is based on the extension and densification of the central utility grid (IEA, 2023). However, even in cities where grid coverage is high, electricity provision is precarious, inaccessible, or unaffordable to many. Residents have improvised a range of strategies to overcome these challenges which hybridize elements of "formal" electricity services with informal terms and agreements that better suit their needs. Echoing other authors, a fruitful area of future work will be to experiment with new service provision paradigms that embrace this hybridity while still ensuring a minimum level of safety and service (Silver, 2023). Emerging decentralized solar technologies have not traditionally been marketed to this demographic,

but could create interesting opportunities for renewably-based and locally-governed clean energy integration (Alstone et al., 2015).

To conclude, existing modes of clean energy provision (i.e. the grid) in Kampala do not meet the needs of the city's lowest-income and most vulnerable users. User accounts underscore a desire to transition to cleaner fuel sources, but also a profound reliance on "traditional" sources of energy like charcoal. This must be acknowledged within policies aimed at improving energy access to avoid impacts like those seen with a recent "charcoal ban" which disrupted the livelihoods of many in Northwestern Uganda (Abet, 2023; Munro & Bartlett, 2019). Policies and interventions must be informed by a thorough understanding of the everyday energy practices, challenges, and aspirations of communities. This entails a commitment to participatory approaches to ensure that the voices of the most vulnerable are heard and prioritized within broader agendas of sustainable urban development.

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