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Post-, pre- and non-payment: Conflicting rationalities in the digitalisation of energy access in Kibera, Nairobi

Prince K. Guma [b,*], Jochen Monstadt [a], Sophie Schramm [c]

[a] Department of Human Geography and Spatial Planning, Utrecht University, the Netherlands
[b] Social Sciences and Humanities, British Institute in Eastern Africa, Nairobi, Kenya
[c] Department of International Planning Studies, Technical University Dortmund, Germany

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ABSTRACT

Energy infrastructures are on the cusp of digitalisation processes. This paper builds upon scholarship on prepaid meters and debates on conflicting rationalities within urban studies to provide a more nuanced examination of the ways in which different actors contribute to the deployment, appropriation and use of digital prepaid systems. We focus on Kibera, Nairobi, to examine Kenya Power's "rationality" for the deployment of the digital-technologies, and the ways in which actors incorporate social relations into these systems and negotiate them through these systems. Specifically, we consider the politicians, donors, residents of Kibera and informal power distributors. We show how upon the deployment of the digital systems in Kibera, residents and informal power distributors enact rationalities that conflict with those of the utility provider, donors and politicians. These conflicting rationalities make the formalisation of electricity provision in slum areas through "technological fixes" a particularly daunting task. Ultimately, we contend that this study of actors' conflicting rationalities in the deployment of digital prepaid electricity systems is an important contribution to studies of digital geography as it explains the complexities relating to digital interventions and offers critical perspectives on their hybrid outcomes and politics within contested urban geographies in the global South and elsewhere.

1. Introduction

Although centralised energy grids are important elements of energy provision across urban geographies of the global South, urban dwellers generate and access energy in various ways other than direct connection to the centralised grids of official power distribution companies. In Nairobi, energy supply and access by no means reflect the "modern infrastructure ideal" of uniform and centralised citywide networked infrastructure providing energy for the entire population (Graham & Simon, 2001). Instead, urban residents draw on multiple options. Even where the centralised electric grid may be available for a neighbourhood or household, its high cost and unreliability (i.e. in terms of frequent outages and low voltage) mean that it may not be feasible to rely on it for all energy purposes (Butera, Adhikari, Caputo, & Facchini, 2015). Hence, urban residents are forced to spend significant portions of their incomes on alternative off-grid solutions such as backup diesel generators, rechargeable batteries, solar systems and paraffin (ibid.; Godinho & Eberhard, 2019), traditional fuels such as firewood or scrap wood scavenged for use as fuel, and charcoal (or energy derived from carbonised wood) for cooking, and other biomass residues and especially for lighting and cooking (Butera et al., 2015). Although the use of off-grid solutions is apparent in the city's rich and poor areas and in planned and unplanned geographies, it is most common in slum areas where most low-income residents live. Residents in the rich and planned areas and in middle-class areas mostly rely on electricity, use gas for cooking and often have a diesel generator as a back-up.

Kenya Power, the main electricity transmission, distribution and retail company in Kenya, seeks to universalise its centralised electricity networks and thereby achieve formal status as a territorial monopolist. In order to reach these goals, Kenya Power has turned to digital systems such as prepaid technologies. These allow access to electricity that has been paid for in advance through a mobile phone or digitally produced voucher. Digital prepaid technologies have become a popular modality of supply and access in Nairobi (Guma, 2019; Guma & Monstadt, 2021), with Kenya Power following the path of many utilities across African cities in employing them as a "technological fix" to solve the challenges of cost recovery and limited network coverage (Guma, 2019; Baptista, 2015b). Over the last decade, Kenya Power has deployed prepaid

* Corresponding author at: Social Sciences and Humanities, British Institute in Eastern Africa, Nairobi, Kenya.
E-mail addresses: prince.guma@biea.ac.uk (P.K. Guma), j.monstadt@uu.nl (J. Monstadt), sophie.schramm@tu-dortmund.de (S. Schramm).

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technologies, taking a cue from South Africa which since 1988 has been the leader in prepaid technological innovation in the global South including the African continent. In Nairobi, the prepayment model has evolved over the years and become increasingly adopted by the city's residents. It has become employed as a strategic business concept, digital technological solution and operational best practice for tackling infrastructural challenges of low access and non-payment. Prepaid technology has become the "new logic of delivery" (Van Heusden, 2012), which some have touted as "the way of future" (Ruiters, 2007: 493) for public utilities determined to expand their own centralised networks and territorial monopolies. Its implementation in slum areas is at the heart of current and ongoing digital interventions aiming at utility electricity supply and access in the city.

In this paper, we examine the prepaid metering project as a digital operation that allows prepayment and the use of mobile telephony for billing, payment, recharging and querying purposes. We combine insights into digital and prepaid systems with the concept of conflicting rationalities to provide a more nuanced and differentiated understanding of the ways in which urban actors make sense of, deploy, adopt or reject digital prepaid technologies. Our lens reveals the complex and precarious nature of Kenya Power's seemingly straightforward project of slum electrification in the digital age. We examine Kibera, Nairobi's largest slum as a "zone of encounter and contestation" (Watson, 2009: 2270). Kibera is a highly contested urban geography, where extremely conflictual and complex relationships exist between Kenya Power, residents and intermediary actors. Thus, we examine "the differences in world-view between the various parties involved" in deploying and adopting digital prepaid technologies and how different "conflicting rationalities" materialise in relation to electricity access and provision (De Satgé & Watson, 2018; Watson, 2003). Accordingly, we examine: Kenya Power's notion that extending its grid to Nairobi's slums requires a "technological fix"; the "informal power distributors" determination to constantly reposition and reinvent themselves; some residents' resistance to (pre)pay for Kenya Power's electricity and desire for negotiated and alternative channels of access; politicians' goal to deliver on campaign promises; and donors' motivations to deliver on performance-based investment funding by raising the household connection rates to formal utilities. We argue that at the heart of these different rationalities are two prime misconceptions held by Kenya Power. Firstly, the mistaken idea that it can effortlessly foresee or even control informal power distributors' reasoning and activities. Secondly, the notion that the residents of slums are a rather homogeneous mass that will welcome a technological artefact designed to provide better quality and affordable electricity access. These misconceptions, we argue, are rooted in a deeper lack of understanding of slum areas and the manner in which residents in Kibera form strategic coalitions with informal power distributors who are willing to strategically change their status. And yet, as our study further finds, Kenya Power does not seem to fundamentally question or revisit its approach to expanding the physical connectivity to networks and socio-spatial access to electricity services in the slum. Instead, the electricity company is determined to deploy more advanced "smart systems" as a new technological fix to counter the challenges of prepaid deployments.

For this article, we conducted four rounds of data collection between October 2014 and April 2018. Our empirical material covers data ranging from strategy-related documents pertaining to focal aspects of prepaid deployments, project-related memos, Kenya Power's minutes and presentations, to newspaper and magazine articles about the deployment of prepaid meters in Nairobi. We also conducted 12 semi-structured interviews with engineers and social scientists from Kenya Power, personnel from the World Bank and UN-Habitat, and experts including consultants and academics based in Nairobi. Moreover, we supplemented these data with 25 interviews with residents, including prepaid electricity users (15) and the multifaceted informal power distributors (6) and other recruits from Kibera of Kenya Power (4) in Kibera. Kibera has been variously described as an informal settlement, a squatter community and a slum. As one of the few affordable settlements close to the city centre, many residents of Kibera live in extremely precarious situations shaped by hierarchical informal power structures through which actors manage unequal access to land, housing and infrastructure such as electricity (Schramm, 2017; Guma, 2021). We chose Kibera because since the early 2000s it has been subjected to repeated attempts to formalise housing and infrastructure access. We used the snowball sampling method to identify key informants and executives with knowledge of the deployment of prepayment systems for electricity.

This paper is structured as follows. In the next section we examine scholarship on prepaid technologies from urban studies and geography, showing prepaid meters as critical sites of engagement for conceptualising infrastructural politics, power and control. In the third section, we introduce the concept of "conflicting rationalities" as an additional contribution and analytical tool that adds relevant work specific to digital and prepaid systems in the African context and elsewhere to explain the different ways in which diverse actors make sense of electricity provision in general and of digital prepaid systems in particular, and how their different and dissenting rationalities make collective action to provide a basic infrastructure service extremely complex. We argue that the concept of conflicting rationalities (see, De Satgé & Watson, 2018; Watson, 2003) is imperative in providing a more nuanced picture of digital and prepaid electricity systems in a context where various actors' practices speak of radically different ways of sense-making in relation to infrastructure provision and access. The fourth section explains informal power distribution in Nairobi's slums as a reflection of the various and often conflicting views of citizenship and access to services as enacted through the provision of and tinkering with electricity networks by different actors. The fifth section examines the attempts by the utility provider, donors and politicians to digitalise energy access and deploy prepaid meters as a technological fix to counter challenges of energy access in slum areas. The sixth section focuses on the articulations of conflicting rationalities by different actors, including Kenya Power, politicians, donors, slum residents and the multifaceted informal power distributors. We conclude that studying actors' conflicting rationalities in the deployment of digital and prepaid metering project makes an important contribution to digital geography because it explains not only the nature of contestations public service providers face when extending their territorial monopoly to slum areas, but also the hybrid outcomes and politics of their development plans and interventions within the context of contested urban geographies of the global South and elsewhere.

2. Debates on prepaid technologies for service provision in Southern cities

The rise of prepaid systems for the provision of infrastructure services in Southern cities has led to a wide-ranging body of research at the intersection of politics, geography, anthropology, and science and technology studies (STS). At its most strident, it has examined prepaid meters as artefacts that are neither neutral nor closed-ended. As such, the technology is widely viewed as one that is "endowed with 'political qualities'" (Baumgardt, 2018: 47). Much of this literature has engaged with the artefacts as tools of politics, power and control, reflecting the extent to which these artefacts exploit and are exploited by the wide array of social, political and economic actors and processes (Steen, 2015) in urban geographies.

Within this literature, some STS scholars have investigated how as an artefact, the prepaid meter, is intricately entangled with politics and power dynamics (Baptista, 2015a). The concept of "technopolitics" has thus become a focus in energy studies to account "for the ability of competing actors to envision and enact political goals through the support of technical artefacts" (Gagliardone, 2014: 3). Technopolitics can be defined as "hybrids of technical systems and political practices that produce new forms of power and agency" (Edwards & Hecht, 2010:

619) whereby political action is expressed through technological design and tinkering rather than through explicit political debates in the "traditional" political sphere (cf. Schnitzler and Antina, 2016). An example can be taken from Nairobi, where De Bercegol and Monstadt (2018) situate the politics of extending electricity networks to slums by examining state strategies to control and regulate electricity supply in the urban area and local resistance to them. In their paper, prepaid meters are viewed as tools or mechanisms for "formalising" the informality of slums, thereby affirming the state's hegemonic power over slum residents (ibid.). Guma (2019) demonstrates that while framed along narratives of spatial justice as 'pro-poor' deployments, prepaid deployments must contend with socio-spatial and micro-political dynamics and implications within the context of a splintered city. Another example can be taken from South Africa, where Schnitzler and Antina (2016) demonstrates how the state, utility companies and citizens engage in conflicts and contestations via the deployment and appropriation of prepaid technologies. Von Schnitzler convincingly maintains that it is through these processes that different ideas of citizenship are enacted and struggled over.

Within this context, scholars consider the prepaid meter as a technology that blurs conventional areas of responsibility of the state, energy providers, and citizens and users and that devolves responsibilities from the provider to the user. Scholars have shown how the prepaid meter allows the state (i.e. through public utility companies) to delegate key responsibilities to urban citizens (also, Foster, 2018; Van Heusden, 2012; Von Schnitzler, 2013). Ruiters (2007: 501) considers the prepaid meter a form of "neoliberal responsibilization," with its users being expected to take on roles and responsibilities that were traditionally designed for the state. Hence, the prepaid meter is viewed as an artefact that makes new demands of the user (also, Van Heusden, 2012), reworking normative conceptions of relationships between providers and consumers.

Furthermore, scholars of infrastructure studies have viewed the prepaid meter as a technology that enables utility companies to extend networks to areas where regular payments by users are not a given (Baptista, 2015b; Jaglin, 2008). Thus, the prepaid meter has served the purpose of extending the formal monopoly of universal and centralised large-scale systems and of universalising and homogenising service provision within the context of increasingly splintered cities. As this kind of technology, it has become a mechanism of entry into "non--networked" geographies by public agencies, inherently accommodating, rather than countering, geographies of urban diversity and differentiation (Guma, 2019). Hence, in light of the segregated temporalities of many Southern cities, the prepaid meter is viewed as a tool that reflects a significant shift towards differentiated service provision (Jaglin, 2008; Schwartz et al., 2017).

By extension, a debate has emerged around the prepaid meter as a "disciplining" technology with governing, ordering and controlling powers over everyday urban processes. For instance, Baptista (2015a: 1017) shows how in Maputo, prepaid meters have forcefully shaped a kind of "disciplined autonomy" whereby household members have no choice but to regulate and restrain themselves, individually or collectively (ibid.: 1015). Hence, the prepaid meter facilitates "control over electricity consumption" in part, by requiring "constant estimation and calculation of when and how much can be bought and consumed" (ibid.: 1005). This is, for instance, shown in the ways in which the prepaid meter demands and mandates incremental, cyclical payments, encouraging responsible self-management of household finances (Schubert, 2018), or what Donner (2015: 123) referred to as a "metered mindset" in which users must regularly check the balance of their accounts. As this kind of technology, the prepaid meter "becomes reified" and "attains a governing power over ordinary rhythms, imposing itself on prior habits" and patterns of electricity use (Jacome & Ray, 2018: 265; Van Heusden, 2012; Ruiters, 2007). While this view is particularly poignant, it is partially deterministic as it considers prepaid meters as a transformative tool that determines user practices. As such, it ignores or underestimates the complexities of geographies relating in particular to the agency of users and other subaltern actors in shaping and appropriating new digital technologies.

The above criticism speaks to wider critiques of extant debates on prepaid technology that that barely acknowledge the actual and highly differentiated rationalities of a multiplicity of stakeholders at play. Therefore, it becomes important to examine the different rationalities premised upon the ubiquitous role and logics of digital technologies in shaping infrastructure landscapes within contested urban geographies of the global South. Examining these rationalities would go a long way not only for better understanding of how urban energy infrastructure domains are being reconfigured in the digital age as well as the multiple and indeed contradictory rationalities of the different actors within contested geographies of the global South and elsewhere. The paper builds upon extant scholarship and relevant work specific to electrification and digital and/or prepaid metering in Africa and elsewhere to make an additional contribution that engages with the concept of conflicting rationalities. Accordingly, the following section introduces this concept as one that is imperative for achieving this objective.

3. Understanding conflicting rationalities in the deployment of digital prepaid systems

This paper employs the concept of conflicting rationalities introduced and articulated by Watson (2003, 2009), also De Satgé & Watson, 2018). The concept refers to the central tension which plays out in cities "between, on the one hand, techno-managerial, modernising and marketised systems of state planning, administration and service provision, in various forms of alliance or collusion with other actors […] and on the other hand, marginalised and impoverished urban populations surviving largely, but not only, under conditions of informality or 'illegality'" (De Satgé & Watson, 2018: 29). As an analytical tool, the concept instigates a particular frame of conceptualising new planning and development interventions within situated urban spheres of the global South. Here, the modernising ambitions of the state often clash with the highly different world views and divergent social and cultural contexts of the shack dwellers, who themselves are fragmented and conflictual (ibid.: 3). Planners and administrators may underestimate these differences and assume a shared rationality in the modernising ambitions where there is none. The concept thus provides a "way of making sense" of the agency of users, and the suite of values or world views that encompasses multiple stakeholders' motivations within a particular urban geography (ibid.: 26). It highlights that a Southern perspective on planning and development interventions "not only implies an understanding of the processes of colonialism, postcolonialism, imperialism, and capitalism" (Galland & Elinbaum, 2018: 15), but also recognition that these are subject to varied and sometimes conflictual logics and "rationalities enacted by urban dwellers in organizing social life" (Baptista, 2015a, 2015b: 1008). As a result of these conflicting rationalities, "modernising"projects of international development agencies and national and urban governments often have ambivalent and unintended outcomes that may be contrary to their original designs (Harrison, 2006: 328).

In recent decades, conflicting rationalities have been examined in different ways to capture the contradictory and conflictual demands and responses of various actors in urban planning practice. In an earlier account, Harrison has discussed conflicting rationalities in broader planning theory debates, using Johannesburg as a prism for looking at and understanding the multiple logics that shape urban planning in the global South, with a view of constructing "an 'other way' of thinking that is situated both within and outside dominant representations" (Harrison, 2006: 319). Recently, Makhale and Landman (2018: 130), focusing on gated communities in the city of Tshwane, have demonstrated how communities in the city "highlight the challenges facing the planning practice and the consequent tensions [that emerge] due to conflicting rationalities and deep differences between the various stakeholders where planners are caught in the middle." Baptista's

(2015a) work, examining the everyday practices surrounding prepaid electricity use in Maputo, has revealed "the multiple rationalities implicated in the use of the electricity infrastructure via prepayment" (ibid., 1005). And Massey (2013) has investigated urban planning rationalities of the in situ upgrading of the informal settlements in Cape Town, and the contradictory practices and implications of such rationalities for specific groups in these settlements, including women's social networks. Altogether, these contributions have particularly been central in understanding how different rationalities coalesce and sometimes conflict irreconcilably in a specific context, undermining developmental ambitions. For planners who work within or for state agencies and for public utilities and international donors it can be "frustrating, as planned interventions, more often than not, have outcomes that are unintended, unexpected and, even, quite contrary to original designs. There are copious examples of planned interventions that come up against logics that are unfamiliar to the policy-maker, or against conflicts between divergent rationalities" (Harrison, 2006: 328).

In the following, we use the concept of conflicting rationalities to understand the logics at play that shape the varied demands, responses and agencies of local stakeholders within attempts to deploy digital prepaid systems within slum areas in Nairobi. So, by applying the concept of conflicting rationalities to the deployment and appropriation of digital technologies, this paper offers a "way of seeing" or "making sense" of complex digital geographies in the making, highlighting varied actors' different and conflicting rationalities at play. Through empirical and real-world accounts, we provide evidence of how universal, technocratic and top-down digital infrastructures are being translated and applied in situated urban geographies amidst varied contestations from differentiated actors and stakeholders (including national and local governments, private and public institutions, international corporations, collective actors and urban residents) who reside in cities where socio-spatial inequalities are firmly entrenched. As such, the concept shapes an emergent discourse on politics and power dynamics of urban infrastructure systems that are being mediated and reconstructed through digitalization processes.

4. Informal power distribution in Nairobi's slum areas

Nairobi's slum areas have for a long time been bypassed and ignored by urban planners on a large scale. In the postcolonial era, municipal authorities, state bureaucrats and utility companies have refused to recognise them or even provide services for them. This has been on the grounds that land tenure for the slum dwellers has not been secured, which is why they lie outside the established parameters of formal urban and infrastructure planning. As slum populations have grown, little or no effort has been made to supply these areas with "public" services. This echoes the policy approach adopted in the colonial period when Nairobi municipal officials simply anticipated that such slum areas like Kibera "would disappear altogether in a relatively short time" (Mortimer, 1945). However, instead of disappearing, Nairobi's slums have grown exponentially, with this trend continuing today. Successive governments have recognised the increasing value of the land on which some of Nairobi's older slum slum areas sit and have made some attempts to acquire it, albeit with limited success (Schramm, 2017). Thus, both colonial and post-colonial governments have failed to enact consistent policies regarding the city's slum areas, neither formally recognising them nor successfully clearing them (Guma, 2021).

Until the early 2000s, the authorities prohibited the construction of permanent housing in slum areas (ibid.) and the provision of infrastructural services such as electricity to these slum areas (Njenga, 2011). Nonetheless, many residents stayed and created new modalities of unregulated access, with the result that informal electricity distribution has become one of the most prevalent forms of providing electricity access in the slum areas. In this way, Nairobi's slum areas have come to possess intricate "quasi-legal" (Majale, 2002) regulatory structures where local chiefs regulated the construction of infrastructure and access to housing. They have come to constitute a kind of "gray space" (Yiftachel, 2009), where dwellers constantly act outside formal laws and regulations.

In Nairobi, Kenya Power is the formal electricity provider. Incorporated in the early 1920s, Kenya Power has operated post-paid supply, through electromechanical and fixed-billing meters. Under this arrangement, customers consume electricity and pay their bills after their meters have been read by Kenya Power employees (KPLC Strategic Plan, 2011). Being largely analogue, for Kenya Power and its customers this process entails large amounts of paperwork to handle multiple procedures, and tools and spreadsheets to record the operation of the electricity meters. This has regularly led to delays and errors on the part of consumers and staff. Billing processes for electricity access are error-prone, induce confrontation between Kenya Power staff and clients, and are sometimes usurped by individuals posing as Kenya Power's field staff, breeding suspicion among residents. Some residents actively subvert the formal system of electricity supply, for instance by deliberately shutting out meter readers by caging their meters or locking them behind residential gates on weekdays (Njenga, 2011). Others falsify meter readings by reversing the counting wheels or bypassing them. Yet others reconnect their supply, leading to both energy and financial losses. Most forms of subversion and resistance (at least for Kenya Power) take the form of processes and practices aimed at recalibrating or bypassing the centralised system.

In the slum areas, practices of subversion, falsification and bypassing have materialised through enterprising groups which we to refer in this paper as informal power distributors (Majoro, 2014). These informal power distributors have come to constitute a type of syndicate in different parts of the city, redistributing electricity via a makeshift tangle of cables and wires strung above the shacks on repurposed poles Up to 30 households in a settlement can be connected by a single informal power distributor whose connection (tapped from an electricity transformer or household in an adjacent estate) would have been sufficient (in terms of watts) for just one household (own observation).

As a result of these practices, informal power distributors have created the de-facto power grid for residents (ibid.). Their rise has been driven by the "spectral state" (i.e. present but barely active) and populist politics (see, Guma, 2021). For example, between 1978 and 2002, for populist and political gains Daniel Arap Moi's government supported the *kadogo* ("small", or frugal and survivalist) economy – sustained by the *jua-kali* sector (i.e. informal, small-scale entrepreneurship) which constituted Moi's strongest political base. By the early 1990s, this sector had become the "glue" that was holding the urban economy together by providing the basic necessities of everyday life, including electricity (Widner, 1992). As part of this rising sector, informal power distributors in the slum areas became increasingly powerful and emboldened in their capacity to provide certain sociotechnical services such as electricity. Their prominence has been highly bewildering for Kenya Power (see e.g. Kang'Arua, 2016). The reasons for that lie not only in the difficulties of managing electricity loads, stabilising electricity grids and establishing safety standards for their customers, but also in the undercutting of Kenya Power's revenue base and cost recovery. The remainder of this paper examines the electricity digital metering project in Kibera, Nairobi. Accordingly, we consider the politicians, donors, informal power distributors and residents of the Kibera slum to show how within this contested urban geography, actors' different rationalities conflict due to actors' radically different understandings of the digital infrastructure development intervention in question.

5. Digitalisation and the deployment of prepaid systems in Kibera

In the preceding section, we explained the informal power distribution in Nairobi's slum areas as enacted through redistribution of and tinkering with electricity networks by different actors, including informal power distributors. In this section, we examine the innovation and design of prepaid meters, the digital technological aspects of

prepaid systems, the motives and strategies of Kenya Power, the World Bank, politicians, and telecommunications complanies, and the role of informal power distributors in deploying electricity networks in Kibera.

5.1. Innovation typology and design of prepaid meters

The type of innovation and installation set-up of the digital prepaid systems in Kibera constitutes a "ready board" (see also, World Bank, 2015; De Bercegol & Monstadt, 2018), namely a cost-efficient system typically mounted inside (but sometimes outside) the user's dwelling (see Fig. 1), in a visible and accessible location that enables the user to have better access to and control over it. The ready board is normally installed as a single set for each household, serves as the electricity dispenser and incorporates a keypad in addition to associated accessories (see Fig. 1). It consists of internal wiring, a free compact fluorescent tube holder and at least one socket. The ready board design is a simple and user-friendly set-up that is intended to enable slum residents to light their homes, charge their phones and use basic electronic appliances such as radio and TV. Through beeps and blinking lights, it alerts the user when the credit balance is low. Once the credit is entirely consumed, the user is automatically disconnected.

The prepaid meters deployed have also been adapted to the living situation in Nairobi's slum areas to enhance their functionality in low-income households (see Fig. 1). For instance, their accompanying technologies have been adjusted to slum conditions by Kenya Power and the World Bank (World Bank, 2015) and include low-cost aluminium wiring as opposed to copper electrical wiring that is regularly stolen in slum areas (see e.g. De Bercegol & Monstadt, 2018). Kenya Power has also started using concrete poles and raising the height of the power lines to prevent theft of electricity (Interview 5, 2017). Both the security standards and the regulations concerning these technologies have been minimised. As one Kenya Power official pointed out: "A few years ago, we had policies where if you decided, 'I have a shelter on the road, I need electricity', this would not work because we already have our policy which can't allow us to give electricity to such a structure. You had to show proof of ownership of the land before you were supplied. But this has been waived specifically for the informal settlement places" (Interview 1, 2017). The design of distribution networks and prepaid systems were thus adapted to the sociospatial conditions of slum settlements. This adaptation reflects Kenya Power's aim to consolidate and extend its monopoly by expanding its centralised grid to slum settlements which had hitherto been bypassed. Hence, prepaid systems have become a standard means for formalising electricity access in Nairobi's slum areas.

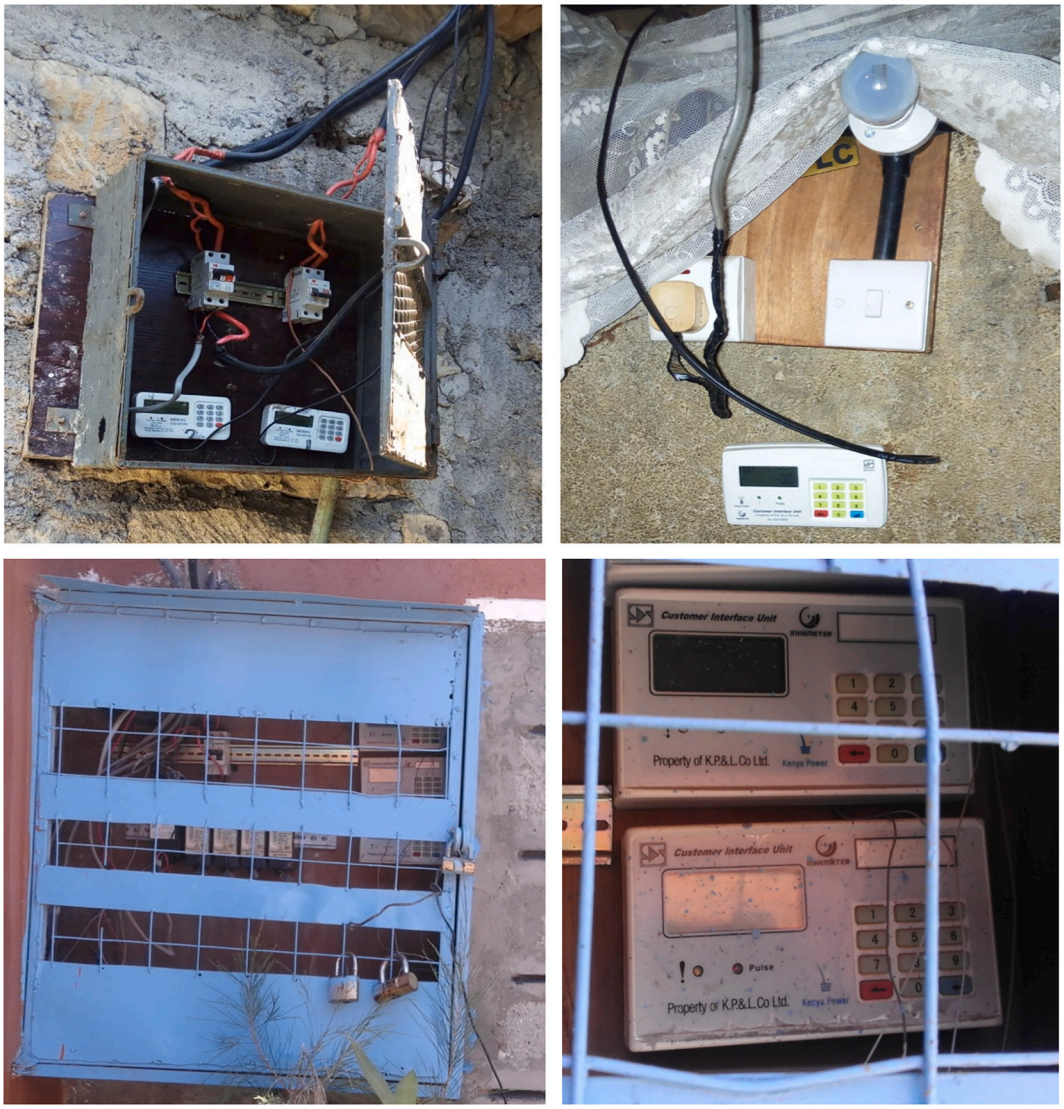

Fig. 1. Outdoor and indoor ready boards and customer interface units. Images by lead author, Kibera, 2016.

5.2. Digital technological aspects of prepaid sysytems

The standard processes of purchasing prepaid electricity tokens and the associated manual loading are similar to the processes of buying airtime credit from a scratch card or a digital voucher from selected stores for a mobile phone. Electricity tokens are purchased in the same way as mobile phone or SIM-card vouchers: by acquiring prepaid alphanumeric codes that are typically 20 digits long, otherwise referred to as "tokens" (Guma, 2019). This code is then transformed inside the electricity meter into a token, and the token is understood by the meter as an amount of KWH electricity units. The tokens are bought either from a designated point-of-sale – for example a petrol station, shopping mall, bank or supermarket – or from small shops, vending machines or kiosks distributed across the city and its outskirts. The customer provides the local electricity dispenser number and the amount of electricity they want to buy. The agent hands over the "token" in the form of an encrypted, digitally produced and meter-specific code for the customer to load or punch into the customer interface unit (see Fig. 1). As this token code is encrypted, when punched into the meter, the meter accepts (or rejects) it by use of Standard Transfer Specification technology, which is a the technology that confirm the correct or wrong code and prevents the generation of fraudulent codes or vouchers. When confirmed, the code instantly loads in real time. The process of purchasing tokens is also facilitated through centralised Kenya Power token-vending systems using an authorised automated data network. In addition to this vending system, Kenya Power also has introduced mobile-phone-based payment and crediting components, with the goal of enhancing payment options for its users, especially the urban poor, most of whom live in slum areas like Kibera.

According to Kenya Power, the preferred option for purchasing prepaid tokens is via mobile phone (Interview 5, 2017). Mobile systems such as Safaricom's M-Pesa ("M" stands for mobile and "Pesa" is Swahili for money) in Kenya are popular for purposes such as purchasing services, making payments and settling electricity bills (Guma, 2019). They are popular because they do not require a physical presence, as they work through an integrated SMS-based mobile service that enables subscribers to use money transfer services to purchase prepaid electricity units. This process thus relies upon short message service (SMS) and encrypted supplementary service data (USSD) sessions, supported by a subscriber identity module (SIM) card. The two major mobile phone networks used for purchasing tokens in Nairobi are Safaricom's "Lipa Na M-Pesa" ("Pay with M-Pesa") and Airtel's "Airtel Money" (ibid.). Kenya Power employs these platforms to collect and receive its revenues remotely. For their part, the mobile service provider gains from transaction fees and users receive their purchased tokens immediately.

Wishing to increase the success of prepaid systems, Kenya Power has introduced additional digital components to the prepaid system. One such system is the frugal mobile soft-loan facility "Okoa Stima" ("Okoa" is Swahili for rescue and "Stima" means electricity). Launched in April 2015 through an alliance with Safaricom, Okoa Stima prevents clients with prepaid meters from having their power cut off if they unexpectedly or unavoidably run out of credit. It capitalises on one of the prepaid system's major challenges: prepaid meters have had the reputation of literally leaving their users in the dark due to non-prepayment, delinquency and lack of planning (for example, if shops with point-of-sale for credit are closed or the client lacks credit to purchase electricity tokens through "mobile money"). The size of the loan that a Safaricom or Kenya Power client can receive depends on a pre-determined credit limit based on past undertakings with the telecommunication company and comes at a facility fee that is payable within seven days (Guma, 2019).

For Kenya Power, the above modes of digital of payment and crediting were essential for providing reliable avenues for collecting money from slum residents. At the same time, the adaptability of these packages to the living situations in slum areas has made it possible for Kenya Power in Nairobi to extend facilities to individuals who lack financial "footprints", or have no credit rating or cannot afford electricity access on an everyday basis. Hence, these packages align strongly with the *kadogo* ("frugal") economy, enabling cash-constrained prepaid electricity consumers to cope with the challenges of unforeseen and often untimely blackouts when they run out of credit. Some residents in Kibera told us that they welcomed these initiatives in their household and appreciated their deployment in the slum, arguing for instance that they were happy that the system's self-billing, self-monitoring and self-regulation applications empowered them and allowed them the much-needed space for them to be in control (Interview 10, 2016) and not be harassed by state officials or informal power distributors (Interview 11, 2016). However, some were not comfortable with these mechanisms for payment and crediting, especially as for many, not using them would mean they would be denied electricity (e.g. Interviews 6, 2016; 7, 2016; 8, 2016). Yet, others were unhappy that these options failed to take account of the fact that many residents in the slum areas lack access to steady flows of income (ibid.).

5.3. Motives and strategies in the deployment of digital prepaid systems

Kenya Power deployed prepaid systems with the aim of enrolling slum residents into state-driven programmes and solving some of the challenges it had experienced with the post-paid system. This deployment followed the broader shift from thinking about slum areas as temporary settlements that should disappear and therefore not be served to seeing them as potential "markets" for infrastructure services to be tapped by the state and parastatal actors. Prepaid meters were presented as a technological fix for achieving automation, facilitating payments and attracting more consumers who had been uncomfortable with the bureaucratic processes of the former technology (Interview I, 2017). First, Kenya Power saw prepaid meters as an opportunity for recovering operational costs by curbing and replacing illegal connections and the heterogeneous modalities of electricity access assembled by syndicates that existed mostly in slum areas (see e.g. Kang'Arua, 2016). Second, slum areas "made sense as a business strategy" for the utility company as one expert argued: "Kenya Power needed connections. Slum areas can give you the fastest connections. […] You have your very high target to achieve and you know that there's a huge population in the slum areas. Electrify the slums and you get your numbers" (Interview 3, 2017). Third, and most importantly, the new government led by president Uhuru Kenyatta and deputy president William Ruto that came into power in March 2013 put Kenya Power under increased political pressure, as Kenyatta and Ruto were determined to honour their election campaign pledge to extend electricity services to all Kenyans: an "annual target of one million new connections" and an electrification access rate of 80% by the year 2020 (Interview 2, 2016).

The World Bank provided substantial funding for the enrolment of slum residents, plus support through the International Development Association (IDA) and the Global Partnership for Output Based Aid (GPOBA) within its performance-based investment funding for the utility and financial incentives for low-income customers (Dave, Smyser, & Koehrer, 2019; World Bank, 2016). The total funding allocated by the World Bank between May 2009 and December 2017 was USD 28 million for the scheme, which was a subcomponent of the Kenya Electricity Expansion Project that cost a total of USD 406 million (Kenya Power, 2015). This funding and support allowed Kenya Power to maintain affordable lifeline tariffs for the urban poor (see, World Bank, 2016). Through lifeline tariffs, the World Bank sought to support the Government's initiatives of realising "full electricity access" in the country by 2020 (see, Dave et al., 2019; Kang'Arua, 2016: 11) and to extend the monopoly of their centralised grid to underserved urban areas. By mid-2016, a total of 1.14 million new low-income customers, including 524,813 households, had been connected since piloting in 2014 (Herbling, 2016; World Bank, 2016). However, despite the success achieved in connections, the distribution component of the slum electrification programme in general has not been very successful, particularly with regard to the actual use of the prepaid meters in Kibera households.

5.4. Role of informal power distributors in deployment processes

To realise its goal of connecting new digital technological systems and disconnecting illegal connections or what Kenya Power referred to as a "'clean-up' of the old and unregulated systems," Kenya Power put together teams of engineers and technical staff. Kenya Power also employed informal power distributors with the goal of enhancing the acceptability of prepaid meters in slum areas: members of informal power distributors were hired temporarily to install the technology and were trained to disconnect the illicit "spaghetti" lines and to erect poles and install meters under Kenya Power's direction and supervision. By so doing, Kenya Power sought to transform informal power distributors from illegal vendors of electricity into Kenya Power contractors paid to install formal distribution grids, household connections and meters. In this way, the informal power distributors became important actors in excavating all elements of the non-prepaid "single-wire" electricity connections via underground cables or overhead lines with the use of shovels, hoes and spades, and replacing these connections with the new digital prepaid systems. One of the strategies adopted in the process was to "keep removing the illegal, unregulated connections until they [the informal power distributors] get tired" (Interview 9, 2016). These operations included forceful measures with culprits and victims fined and arrested with help from the police and other security operatives.

However, this approach later turned out to be unsustainable, partly because once the the deployment of digital prepaid systems was completed, the informal power distributors lost their temporary jobs with Kenya Power. Intent on finding other sources of revenue, the informal power distributors began to mobilise residents dissatisfied with Kenya Power's technologies by illicitly diverting, manipulating and circumventing the same prepaid meters that they had helped to deploy in the slum areas. Thanks to the skills acquired from Kenya Power during their involvement in the deployment, the informal power distributors possessed the capability and equipment required not only to tap and redistribute electricity from Kenya Power transformers, but also to purchase from the power provider electricity meter boxes and other miscellaneous electrical equipment such as transformers, conductors and cables. Moreover, they knew how to break into and reassemble electricity systems. In some cases, they retained Kenya Power uniforms and the necessary apparatus and outfits required to climb concrete poles to reconnect some slum residents. The strategies they employed included placing a powerful magnet next to or inserting a metallic or non-metallic object into the meter box, tampering with the sensor magnetic cores through saturation or disabling the meter completely (Interview 11, 2016).

According to our interviews, many residents welcomed these practices because they had not appreciated their status being unilaterally changed by Kenya Power from people "paying informal power distributors" to "prepaying Kenya Power clients". Others did not like the often extreme strategies employed in the deployment process. The residents we spoke to said they felt like they were being "pushed against the wall" (Interview 8, 2016). Others believed that the informal power distributors had connived with Kenya Power by taking away their connections to the informal power distribution. One interviewee, for instance, told us that she now perceived informal power distributors to be the same as state employees – interested only in taking away from the likes of her (Interview 10, 2016). Thus, while highly welcomed by some, the informal power distributor's reinvention from actors serving Kenya Power to actors serving residents (through recalibrating the digital prepaid systems to allow for free, tampered or negotiated access to electricity) was deprecated by many in the slum. The next section, based on the different actors' particular frames of reference as we highlight the conflicting rationalities of the different actors in Kibera.

6. Conflicting rationalities and the move toward "smarter" systems

Thus far, we have examined the different actors that have contributed to the deployment, adoption and appropriation of digital and prepaid systems in Kibera. We have described the attempts of the utility provider, donors and politicians to formalise electricity access in Nairobi's slum areas by installing prepaid meters as a technological fix and the flexibility slum residents have exhibited by reappropriating new technologies. We have further demonstrated that Kenya Power and the World Bank have tried to adjust to the contested nature of Kibera: for example, Kenya Power has employed innovative approaches such as engaging informal power distributors as intermediaries in the slum, introducing subsidies and lifeline tariffs below those which slum residents had to pay to the informal power distributors and adapting the technologies to better target the urban poor. These approaches show that the deployment of digital and prepaid systems in Kibera has been largely pragmatic and contextually specific in its search for win-win solutions intended to drive informal power distributors out of the slum areas by offering a better service. And yet it is evident today that many residents are still either not yet connected to the prepaid meters, or are connected but do not use Kenya Power's electricity, or – most commonly – are increasingly misusing the meters with help from the informal power distributors. The informal power distributors have been successful in mobilising residents, especially those who have generally been dissatisfied with Kenya Power and the World Bank's interventions in the slum. To the puzzlement of Kenya Power and the World Bank, an initiative whose architects had assumed would provide a service superior to that provided by informal power distributors in these slum areas has resulted in residents responding by appropriating, subverting and rejecting the digital prepaid systems. As such, it begs the question as to why an allegedly win-win solution for slum residents has turned out to be a failure. Below, we reveal that part of the reason for this outcome has to do with the fact that the differences among Kenya Power, donors, informal power distributors, slum residents, governments, politicians and regulators create conflicting rationalities, leaving service providers at a crossroads with regard to striking a balance between the different actors and stakeholders, and between planning ideals and practice. Table 1 below presents a differentiated view of how the rationalities enacted by the different actors and stakeholders in the deployment, appropriation and use of the digital prepaid technologies conflict.

As demonstrated in Table 1 above, the efforts of the World Bank attest to its goal of "[accelerating] progress towards universal access [by] improving the performance of utilities in Sub-Saharan Africa, [and] making electricity connections and consumption more affordable while minimising utilities' financial losses" as expressed by the former Vice President of the World Bank for Africa, Diop (2009). At the heart of this goal lies the rationality that universal access can only be reached by the expansion of formal energy services. Hence, the World Bank believes that for universal and affordable energy access and cost-efficient energy supply to be achieved, it is imperative to order, formalise and regularise service provision and use (ibid.; Interview 4, 2017). As the table further highlights, this rationality aligns with the rationalities of politicians, governments and regulatory authorities in their desire to push "illegal" distributors out of the "market," as well as to increase the influence of the state and allow for better control or regulation by the state (Dave et al., 2019). It speaks to their goal of scaling up and consolidating centralised networks and their urge to establish and enforce territorial monopolies of Kenya Power in slum areas which have hitherto been bypassed or underserved by state-driven agencies.

The rationalities of Kenya Power and the World Bank, and of politicians, governments and regulatory authorities conflict with the rationalities of the users and, even more, with those of informal power distributors. For example, some Kibera residents see the World Bank's rationality as problematic and would rather have different alternatives and "markets" for energy access in their communities (Interviews 10,

Table 1
Conflicting rationalities.

Actors	Rationalities	Conflicts
IPDs	Extract surplus and redistribute electricity (by selling illicit electricity) for profit without covering the overall costs of electricity generation, transmission and distribution. Earn a livelihood by charging fees for illicit power distribution and metering manipulations and circumventions that allow slum residents to access electricity without having to pay for it.	Conflict with KP's rationality of being the sole electricity provider in the slum. KP undercuts the revenue base of the IPDs with its new installations.
Slum residents	Access electricity without having to pay or pre-pay for electricity from KP; many residents contend that electricity should be free for poor users. Negotiable terms for access; manoeuvring by physically disturbing the wiring integrity of the electricity meter, circumventing connections and repurposing cables.	Conflict with KP's rationality for collecting and receiving its revenues. Strategies employed to realise these rationalities undercut KP's revenue base.
World Bank	Deliver on performance-based investment funding; secure access for all citizens to eliminate "energy poverty" in urban areas; and raise the household connection rates to formal utilities.	Conflict with the local modalities of access in slums provided by IPDs and slum residents.
Politicians and the Government	Deliver on political campaign promises, i.e. realising one million new connections every year. Deploy large-scale solutions for urban problems. Align to donors' conditionalities.	Conflict with locally-based, small-scale modes of access in slums provided by IPDs, slum residents, and gatekeepers determined to maintain their own heterogeneous and informal electricity systems.
Kenya Power	Extend, universalise and formalise the electricity network in Nairobi's slums. Increase cost recovery and align to political goals. Achieve former status as a monopolist in local electricity distribution. Curb and replace illegal connections.	Conflict with local actors in the slums – i.e. IPDs, and the slum residents who are always seeking room for manoeuvre.

2016; 11, 2016). As we have shown, despite the World Bank's subsidies and lifeline tariffs aimed at removing barriers of affordability for residents, some residents were still unwilling to pay for the service and later to prepay. Other residents thought that the monthly connection fees, which rolled over to the next month if not paid, were indebting them so much so that they began to perceive the whole project as a means for Kenya Power to take money away from them (e.g. Interviews 6, 2016; 7, 2016; 8, 2016). Moreover, the wider view shared by many residents was that Kenya Power was more interested in serving the project's proponents (among them the World Bank) rather than its intended beneficiaries (ibid.). The residents argued that Kenya Power's interest was to achieve economic gain. This was at odds with their perception of Kenya Power in relation to its role as a state-driven provider of a basic service. These residents were beginning to believe that Kenya Power's main goal was explicitly to enhance revenue collection by "taking away from the poor", rather than to provide a community service for the urban poor (Interview 6, 2016). The dissatisfaction some of these residents expressed about Kenya Power's intervention makes apparent that when it comes to electricity provision, their way of thinking differs fundamentally from that of Kenya Power and the World Bank: for example, Kenya Power and World Bank have economic and political motives, whereas residents view electricity as a social service. As such, they see it as product that the state should provide for free rather than in subsidised form. Apart from the remaining affordability challenges of electricity supply (even if subsidised), the inflexible payment modalities of the connection fees and the costs/kWh leave little leeway for negotiation and cannot be adapted to the fluctuating incomes of many residents.

Some residents therefore feel justified to take matters into their own hands and to be civilly disobedient by misappropriating power lines and manipulating prepaid systems with help from the informal power distributors (e.g. Interviews 7, 2016; 8, 2016). Also, some residents, as we have further revealed, think that it is preferable to pay for power provided by the informal power distributors even if informal power distributors are exploitative and charge higher prices for their electricity than Kenya Power. The rationale behind these users' preference is that electricity obtained via the informal power distributors is negotiated and allows for different kinds of social and human interface between users and informal power distributors than is the case with the prepaid systems whose interface is mostly automated (ibid.). Indeed, the informal power distributors have further exploited this situation by presenting themselves as actors no longer serving Kenya Power but the residents. Aware that due to povery levels of Kibera, many slum residents are unable (or unwilling) to pay for electricity from Kenya Power, and that other residents are keen to manipulate and circumvent their prepaid meters, informal power distributors have sought to recover their lost territories from Kenya Power (interviews 7, 2016; 11, 2016). As such, while residents espouse a survivalist rationality, the informal power distributors espouse a rationality driven by profit-seeking logic – and both rationalities are inherent to the urban informal economy.

Ultimately, these processes have affected the success of Kenya Power's, state authorities' and donors' efforts to deploy digital and prepaid systems. As a result, Kenya Power is now considering installing "smart meters"—as Internet of Things (IoT) devices that would measure and transmit data about electricity consumption in real time—as another technological fix that could remotely detect meter tampering and fraud, as emphasised by one of Kenya Power's engineers: "With the new smart systems, if a meter is bypassed, it will indicate that it is being tampered with. So, the new meters now have the capacity to help us to deal with revenue protection to more easily identify people who are stealing power" (Interview 12, 2017). According to Kenya Power: "Once such an interference appears, the meters go into 'tampering [sic] mode.' The meter is able to detect that there is power in this installation that is not basically moving into this meter. The meter will then display a bypass and it can even lock itself" (Interview 13, 2017). The move to deploy new "smarter" systems for Kenya Power is seen as an innovative business model and one way of countering the puzzles presented by prepaid deployments (Interview 14, 2018), and can be seen as a response to the limitations constraining Kenya Power and the World Bank from expanding centralised networks, rooting out informal power distributors, and allowing remote monitoring and balancing of electricity supply and demand, and more reliable service for lower operational costs. It speaks to Kenya Power's further rationalisation and regularisation of electricity supply as a way of universalising service provision in slum areas.

7. Conclusion

In this paper, we have examined the deep and abiding conflicts of rationalities between electricity providers, politicians, donor agencies, residents and other informal power distributors in the deployment and appropriation of digital prepaid systems in electricity provision in Kibera as a contested urban geography. Building upon scholarship on prepaid meters and debates on conflicting rationalities within planning and urban studies, we have provided a more nuanced and differentiated

account of the various actors and stakeholders involved, and how they enact contradictory visions and rationalities within the context of a contested urban geography. Notably, what becomes apparent in this account is how the multiple and indeed countervailing interests and necessities of the different actors and stakeholders involved reflect the unpredictability of slum residents' employment of different practices for appropriating new technologies. Thus, our account reveals an extremely complex interface between the utility company (and donors such as the World Bank) and urban residents (including intermediaries such as the informal power distributors). Moreover, this complexity is partly explained by the reality in which Kibera's poverty remains a substantive obstacle to access to electricity—whether with prepaid meters or not—werein residents not only appropriate new technologies, but also sometimes reject them by reverting to post-payment or non-payment options and by so doing enact rationalities that conflict with those of the other actors and stakeholders involved including service providers and donors. Thus, our account suggests a different course from Baptista's (2015a) findings in Maputo, where residents in informal settlements appreciated the deployment of prepaid meters as recognition and acknowledgement of their citizenship by the state and associated them with more decent, dignified and "modern" urban living in the city.

In contrast, we have argued that despite the mixed effectiveness outcomes of prepaid metering, the way Kenya Power and the World Bank have implemented their electrification programme has been praiseworthy. For example, they have adapted their strategies to local contexts by employing informal power distributors, engaging experts and intermediaries, integrating adaptive and frugal technologies, and incorporating significant subsidies and lifeline tariffs. These strategies, we argue, demonstrate considerable progress from Kenya Power in acknowledging the slum residents' energy needs and the necessity of using and building on residents' extant rationalities and informal practices to further enhance physical connectivity. However, as our findings demonstrate, the deployment of digital and prepaid systems in slum areas cannot be appraised by solely considering the physical side of connectivity to electricity access, but by also gaining a better understanding of the social access to and the actual use and appropriation of the prpepaid systems. Here, the manipulations and circumventions of the digital technologies, and the continued illicit practices of informal power distributors in tampering and bypassing systems reveal a complex story.

As outcomes of conflicting rationalities underpinning the deployment, appropriation and use of prepaid meters in Kibera, these processes have been used to explain Kenya Power's response as an attempt to improve its metering technologies by considering the deployment of smarter systems. However, as a policy-oriented recommendation, we argue that although smarter metering technologies might be effective for addressing some of the challenges of electricity networks that are subjected to tampering, successful and viable deployment of prepaid systems requires greater engagement with the slum residents' rationalities and livelihoods. In the long term, it might be beneficial for Kenya Power to abandon or reduce the fixed monthly connection fees that users must pay before being able to upload credits for actual electricity use. Moreover, Kenya Power needs to take seriously the variegated realities and rationalities of slum residents, who are not a homogeneous group and should not be treated as such. As debates on conflicting rationalities (e.g. Harrison, 2006) have demonstrated, infrastructure plans and development interventions need to build more strongly on existing practices and acknowledge the (co-)existence of informal arrangements and protocols. However, the answer to the question of whether existing informal power distributors should be further integrated into Kenya Power's provision activities depends on practical and ethical considerations. On the one hand, informal power distributors could act as intermediaries between Kenya Power and local residents, have in-depth knowledge of local conditions and practices and could either facilitate Kenya Power's access to slum residents or considerably undermine Kenya Power's activities. On the other hand, they put residents under considerable pressure to remain users of their services and, as economic beneficiaries, they have an interest in consolidating an unjust system of splintered formal access to electricity at the expense of residents, Kenya Power and the World Bank.

Summing up, this sudy's contribution to digital geography lies not only in its explaination of the complexities relating to digital metering projects, but also it critical perspectives to the hybrid outcomes and politics of digital infrastructure plans and development interventions within the context of a contested urban geography. What we learn from a differentiated use of the concept of conflicting rationalities as an analytical frame is that it allows us to better explain the different logics and rationalities that drive different actors and stakeholders to act the way they do in the deployment, appropriation and use of digital prepaid systems. The concept of confilicting rationalities allows us to better conceptualise and make sense of electrification processes in Southern urban communities in particular, beyond a simplistic state–citizen frame. It reminds us that urban residents cannot and should not be seen as constituting a homogeneous mass that will enact common concerns about central plans or development interventions but will tend to employ different practices in the appropriation of such plans and interventions particularly in ways that reflect complex and localized power dynamics.

Finally, our study demonstrates that the general presumption that planning should engage more closely with conflicting rationalities and contribute to their strategies for the variegated informal practices (e.g. De Satgé & Watson, 2018; Harrison, 2006) produces exceptionally complex tasks for planners, utility managers and regulators. In electricity systems, small interventions in one place may interfere with the larger functionality of the overall system. Planning a functional and consistent urban electricity system that combines networked, off-grid solutions and informal network extensions, that aligns public utilities with multiple co-providers and that tailors tariffs and socio-technical solutions to the spatially variegated user needs, financial capabilities and practices in a city is extremely challenging. In particular, the deployment of the digital metering project in Kibera as part oc a wider electrification project in Kenya raises multiple, yet unanswered, questions: technically, with regard to organizing grid stability and balancing electricity loads; politically and economically, with regard to the overall (re-)allocation of costs for lifeline tariffs and incremental network extensions; and institutionally, with regard to the governance of urban electricity systems that are fundamentally technically, organizationally and spatially hybrid. The task for future research and planning practice is thus to explore ways to engage more productively with conflicting rationalities *within* and *across* different neighbourhoods and, at the same time, assure greater functionality and sustainability of electricity systems and other networked infrastructures.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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