New frontiers of electricity capital: energy access in sub-Saharan Africa

Lucy Baker

To cite this article: Lucy Baker (2023) New frontiers of electricity capital: energy access in sub-Saharan Africa, New Political Economy, 28:2, 206-222, DOI: 10.1080/13563467.2022.2084524

To link to this article: https://doi.org/10.1080/13563467.2022.2084524

© 2022 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

Published online: 18 Jun 2022.

Submit your article to this journal

Article views: 2963

View related articles

View Crossmark data

Citing articles: 2 View citing articles
New frontiers of electricity capital: energy access in sub-Saharan Africa

Lucy Baker
Science Policy Research Unit, University of Sussex, Brighton, UK

ABSTRACT
While recent years have seen the rapid growth of off-grid solar power, ten per cent of the world’s population, the majority in sub-Saharan Africa, still lack access to electricity. Meanwhile, standalone solar home systems using pay as you go (PAYGO) mobile money have been proposed as a key solution to meeting the target of universal access to energy under Sustainable Development Goal 7. These systems are being deployed in various regions of the global South, including East Africa and to a lesser extent West Africa. I investigate how through PAYGO, off-grid solar electricity in sub-Saharan Africa is being transformed into a cash flow, a financial asset and a conduit for consumer debt. In so doing I analyse evolving relationships between some of the key actors and institutions involved in this process, including mobile banking platforms such as M-Pesa, ‘next generation utilities’ such as M-KOPA and BBOXX, and powerful mobile network operators such as Safaricom and MTN. Theoretically I conceptualise energy access as a new frontier of ‘electricity capital’, a developing field from political economy and energy geography, which is concerned with the way in which technological developments in the electricity sector are reconfiguring relationships between different institutions of the state, industry, finance, and users.

KEYWORDS
Energy access; solar home system (SHS); PAYGO; mobile money; electricity capital

Introduction
The realisation of universal access to low-carbon, affordable, reliable and modern energy services by 2030 is a key target of Sustainable Development Goal 7 (SDG7), the Sustainable Energy for All Initiative (SEforAll)1 and the 2015 Paris agreement on climate change. Yet despite significant progress towards this target in recent years, the current pace of electrification is considered insufficient to meet it and has been further exacerbated by the Covid pandemic. By 2018, 789 million people, approximately 10 per cent of the world’s population lacked access to electricity, of which 70 per cent in sub-Saharan Africa and the majority in rural areas (IEA et al. 2020, p. 15). Sub-Saharan Africa has the lowest per capita access to modern energy and electricity in the world, at a rate of just 47 per cent. Off-grid electricity generation from solar photovoltaic (PV) systems is anticipated to play a key role in closing this access gap and transform the ‘first rung’ of the energy access ladder (IEA et al. 2020, p. 4). Now worth $1.75 billion, the off-grid solar PV market has grown rapidly over the last two decades and particularly in the last five years and now serves 420 million users globally (Lighting Global et al. 2020, p. 2).

CONTACT
Lucy Baker  l.h.baker@sussex.ac.uk

© 2022 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.
A major component of this market and the key focus of this paper is the ‘pay-as-you-go’ (PAYGO) model for solar home systems (SHS), now widespread in East Africa and slowly gaining ground in West Africa. PAYGO SHSs have been facilitated by rapidly co-evolving processes of financial and technological innovation (FinTech\textsuperscript{2}), including digital infrastructures, mobile money, geospatial planning and big data (ESMAP 2019, p. 24). These processes are seen as transformative for their potential to help meet the goal of universal access to affordable, low-carbon and modern energy services; challenge established infrastructural and institutional configurations of centralised electricity; and incorporate the previously unbanked into new circuits of capital and systems of accumulation, including via the acquisition of consumer data and credit scores.

The financial inclusion of low-income energy users through ‘flexible payment methods’ has become central to the narrative of PAYGO SHSs (Ndung’u 2018, Barry and Creti 2020, p. 2). Indeed, the significance of financial and digital inclusion in the realisation of the UN SDGs is now well-established (Demirgücü-Kunt et al. 2017, GSMA 2021) and has been widely celebrated for enabling innovative and exciting possibilities to tackle energy poverty (Alstone et al. 2015). Such assumptions are often accompanied by aspirational corporate discourse such as ‘closing the digital gap’ and ‘empowering the last billion’ (Bransfield-Garth 2017). However, a more cautionary perspective warns that the blind optimism of the ‘fintech-philanthropy-development complex’ and the SDGs ‘should be understood against the backdrop of rapid growth of a digital underworld that feeds available data into opaque algorithmic processes that are increasingly used to organise economic life (Pasquale 2015)’ (in Gabor and Brooks 2017, p. 424).

Emerging academic literature has started to examine the efficacy of PAYGO SHSs in alleviating energy poverty, particularly in East Africa, the region in which this model is most established to date (Bisaga and Parikh 2018). However, much of this literature has taken what has been described as a techno-optimist approach (cf Radley and Lehmann, 2022), and been relatively uncritical with regards to the broader contemporary dynamics of socio-technical systems and finance-led capital accumulation. As Ockwell et al. (2019, p. 2) point out ‘PAYG business models are very new and very little critical analysis of their actual and potential implications for delivering against the SDGs has been conducted’.

With this in mind I undertake a critical inquiry into the assumed transformative capacities of PAYGO SHSs in sub-Saharan Africa, exploring how beyond a socio-technical system for energy access, these systems are being transformed into a cash flow, a financial asset, a conduit for consumer debt and a mechanism for the acquisition of consumer data. My study includes an analysis of the key actors involved, notably next-generation utilities such as BBOXX and MKOPA and the investors behind them, mobile banking platforms such as M-Pesa, and mobile network operators such as Safaricom, MTN and Orange. My investigation is guided by the following questions: (i) how are technological and financial innovations transforming the nature of electricity provision? (ii) through which processes has off-grid energy access become a new site of accumulation? and (iii) what new financial and institutional relationships are emerging in this space?

Theoretically I conceptualise energy access as a new frontier of electricity capital, an emerging field of analysis from energy geography and political economy which has been defined as the relationship between electricity as a socio-technical system, and finance as a set of economic, social and political relationships through which electricity provision is transformed into a site of capital accumulation (Luke and Huber, under review). While there is a growing body of research into electricity capital at the utility-scale in the global North (Knuth 2018, Harrison 2020) and to a lesser extent in relation to the global South (Kennedy 2018, Baker 2021), critical scholarship into rapidly evolving off-grid electricity systems in low and middle-income countries has been less forthcoming and a gap that this paper seeks to address.

The methodology for this paper is firstly based on an extensive qualitative desk-based review of academic and grey literature which has included: (i) industry-specific publications such as Afrik 21, ESI-Africa, RenewablesNow, African Business, Africa Energy Portal, Infrastructure investor, Africa-energy.com and Greentech media; (ii) company and industry association reports from the off-grid renewable
energy industry; and (iii) national policy and planning documents on energy, telecommunications and mobile money. Secondly, I undertook a quantitative analysis of loan and investment data in off-grid renewable energy systems in sub-Saharan Africa by development finance institutions, the Crunchbase database, and international energy institutions such as IRENA, REN21 and the IEA. Finally, this desk-based analysis was supplemented by six online semi-structured interviews with representatives of the off-grid renewable energy industry undertaken between October and December 2020, as well as participant observation at sessions of the online Africa Utility Week in May 2020, and the online Africa Digital Energy Festival in October and November 2020. The institutional and personal identity of those cited in this paper has been kept anonymous in the interests of commercial sensitivity.

The structure of this paper is as follows. The second section introduces analytical perspectives on energy access as a new and rapidly evolving fraction of electricity capital. The third section explores the process through which PAYGO SHSs have evolved from a socio-technical system for energy access into a new FinTech platform. The fourth section examines the changing nature of finance and ownership in the SHS PAYGO sector and the transformation of entrepreneurial start-ups into ‘next generation’ utilities. The fifth section concludes with suggestions for further research in this rapidly evolving field.

Energy access as a new frontier of electricity capital

Following Hughes’ (1983) seminal work on the sociology of technology, conventional electricity has been conceptualised as a large-scale networked infrastructure and a complex, interconnected and interactive system of artefacts and technologies. This perspective has contributed to a burgeoning literature on socio-technical transitions, which has called for deep structural changes in the electricity system in the interests of climate change mitigation and sustainability (Smith et al. 2005, Markard et al. 2012).

Beyond this socio-technical focus, more recent critical perspectives on the political economy of the energy transition have emerged from development studies and geography, which conceptualise energy as a social relation that is bound up with political, economic and social forces and historical processes. These perspectives situate electricity infrastructures within systems of capital accumulation, including in post-colonial contexts. As Lohmann (2020, p. 1) defines, energy is ‘a colonial process of reorganising living human and nonhuman territories into hierarchies favourable to capitalism’. Similarly, in Electricity Capitalism, McDonald (2009) explores how the reorganisation of electricity is intrinsically linked to the reorganisation of economic activity and systems of capital accumulation in various countries in sub-Saharan Africa. Related literature has examined how utility-scale grid-connected electricity, as with other network industries such as roads and ports, has been key to the formation and territorial control of the nation-state and is seen as a symbol of modernity and socio-economic development (Ahlborg 2018, Balls and Fischer 2019).

Perspectives on the geographical political economy of energy have taken a specifically spatial turn in order to account for how electricity infrastructure provision can be highly uneven, ‘available and accessible for some but not for all, with patterns of provision reflecting wider currents … of class division, racial discrimination, state restructuring and demands of capital accumulation’ (Bridge et al. 2018, p. 81). A growing body of work on energy transitions in the global South (Castán Broto et al. 2018) puts forward a diversity of socially, culturally, politically and spatially aware analyses from a variety of geographical settings (e.g. Rignall 2016, Baptista and Plananska 2017, Osumnuyiwa et al. 2017). Studies from within this field have also emphasised that any energy transition must be pro-poor (Ahlborg 2018, Ockwell et al. 2019), while others have rejected mainstream concepts of the energy transition in LMICs as an endeavour based on the import of foreign finance and technologies with little regard for local realities (Simmet 2018).

Building on these critical perspectives, electricity capital as an emerging field of analysis, is concerned with the way in which technological developments in the sector are reconfiguring
relationships between different institutions of the state, industry, finance, and users. Key studies to date include Luke and Huber (under review) who describe how electricity capital emerges from the ‘nexus of state, regulatory, and financial relationships that shape private accumulation through electricity provision’; Harrison (2020, p. 2), who explores relationships in the US which ‘have a mutual shaping effect on each other, with the financial dimensions of the electricity industry changing alongside the technological and regulatory’; and Knuth (2018), who examines the linkages between a rising FinTech sector and renewable energy deployment in the US. Important to this analysis is that the logic of finance, which in the case of electricity capital and capital for infrastructure in general, ‘have an outsized influence on how, when and where electricity infrastructure is built, and where it is not’ and dictate ‘what sort of payback is expected’ (Harrison 2020, p. 4). Importantly, while finance is often presented as neutral and technically determined, it is instead, ‘a bundle of political, economic and social relationships whose internal conflicts create its direction of travel’ (Lohmann and Hildyard 2014, p. 68).

Thus far, however, there are minimal studies to date on renewable energy as a new and emerging asset class, in light of which Castree and Christophers (2015, p. 379) have called for analysts and policy-makers to understand how the financing of major new infrastructure in the context of anthropogenic climate change currently functions, so that it can be shaped ‘to realise important non-economic goals’. Existing studies of electricity capital have given more focus to high-income country contexts, with exceptions including Kennedy (2018) and Baker (2015, 2021), who, in exploring the procurement of renewable energy in Indonesia, and South Africa and Mexico respectively, have found that the priorities of finance have often served either to create new forms of marginalisation, exclusion and indebtedness or to reinforce existing ones. Yet despite the fundamental contribution of the above literature to critical thinking on the relationship between finance, renewable energy technologies, and uneven development, thus far there have been no explicit studies on the contradictions of capital within rapidly evolving off-grid electricity systems in the global South.

The growing energy access sector can be seen as a new frontier of electricity capital that has been enabled by new socio-technical and institutional configurations of off-grid solar PV, digital ecosystems of mobile money, telecommunications, data and finance that are central to the implementation of PAYGO SHSs, and the new forms of consumption that these systems have started to facilitate. In this sense the digital economy, described by Baldwin (2018, p. 2) as ‘businesses that rely upon the speed and flows of information technology, the internet and data’, has become integral to the realisation of energy access.

In order to develop further conceptual insights, I draw from critical scholarship that challenges the idealised notions that ‘digital-based’ financial inclusion (Gabor and Brooks 2017) and the FinTech that facilitates it (Knight and Wójcik 2020, Langley and Leyshon 2021) will automatically lead to the empowerment of those previously excluded from conventional forms of finance. This literature interrogates the growing popularisation of these processes as a development solution and their expected potential to reduce poverty and explores how they may also, or instead, be contributing to uneven development (Bateman et al. 2019). Related studies have unpacked the assumptions associated with these terms for misleadingly constructing ‘poverty as a problem created by a lack of finance (for example, Weber 2004, Taylor 2012)’ … and therefore obscuring … ‘the ways in which structural relations of power, including circulations of credit and indebtedness, contribute to the creation of poverty in the first place’ (in Bernards 2016, p. 606). As recent work has concluded, many of the ‘miraculous poverty-reducing powers’ of the mobile money platform M-Pesa, which has subsequently been central to the establishment of PAYGO SHSs, have been exaggerated or misleading (Bateman et al. 2019, p. 482).

Just as FinTech and big data have been presented ‘as a new panacea for poverty reduction and local development’ (Bateman et al. 2019, p. 49), so has it more recently been put forward as a solution for the reduction of energy poverty (Butu et al. 2021, Koomson and Danquah 2021). In this sense, poverty, including energy poverty and by implication, the field of energy access, can be ‘understood as a new frontier for profit-making and accumulation’ (Gabor and Brooks 2017, p. 424). The discourse
of technological disruption in off-grid solar PV and FinTech has celebrated the role of entrepreneurs, start-ups, impact investors, venture capital and billionaire philanthropy, embraced by among others, the Gates Foundation and Mark Zuckerberg (cf Knuth 2018, Social Impact Club 2018). Such a discourse often assumes that in addition to increasing energy access for low-income consumers, the introduction of off-grid solar facilitated by mobile money will automatically result in the four ‘D’s of decentralisation, democratisation, digitisation and decarbonisation, including the increased autonomy and independence of local communities.

Despite its essential contributions, the critical literature on FinTech and financial inclusion has yet to investigate the rapidly developing domain of off-grid electricity, perhaps because it is a relatively new sector but perhaps also because as Knight and Wójcik (2020, p. 1492) point out, ‘FinTech research is fashionable but still niche. Mainstream literature is only waking up to its challenges and has not yet come to terms with its significance’. In conceptualising energy access as a new site of electricity capital I therefore respond to Langley and Leyshon’s (2021, p. 10) call for further critical social science research to examine ‘the distinct and related processes of reintermediation, consolidation and capitalisation’, which have shaped the FinTech sector and sit at the heart of the financial inclusion agenda.

**From energy access to FinTech**

A PAYGO SHS is a small-scale standalone system that provides electricity to consumers who pay for it using mobile banking (Alstone et al. 2015, p. 311). By converting solar irradiation to electricity through PV technologies, these systems generate direct current (DC), which can be used directly or converted to alternating current (AC). Despite their relatively minor contribution to overall electricity generation capacity so far, SHSs are one of the fastest-growing off-grid electricity sectors in sub-Saharan Africa, with PAYGO having replaced previous finance mechanisms of hire purchase schemes, microfinance and/or cash payment models which had little success in extending rural electricity access (Lighting Global et al. 2020, pp. 152–3, Rolffs et al. 2015).

In order to set up a PAYGO SHS contract, the customer needs a mobile banking account, an ID card and an upfront payment of 10–20 per cent of the total equipment price. After the equipment is installed, users make small, regular top-up payments in local currency wherever they can access a phone signal. If payment is not made, the consumer is disconnected (Barry and Creti 2020, pp. 2–3). Over 90 per cent of SHSs operate using a lease-to-own model meaning that once the cost of the system has been repaid, generally over one to three years depending on the size of the system, the device is permanently unlocked, and ownership granted to the consumer (IRENA 2020). By spreading the otherwise prohibitively high upfront costs of a SHS, PAYGO is credited with enabling low-income energy users to ‘afford a [solar home] system that they could not previously pay for in cash’, particularly those who would not be able to access credit from conventional banking (Rural Electrification specialist, conference observation 201112). Most SHSs are monitored and managed remotely by providers using hardware that enables activation on receipt of payment, and/or remote locking or disconnection in the case of a payment default.

PAYGO for SHSs in sub-Saharan Africa began in Kenya in 2012, driven in large part by ‘high mobile-money penetration, a positive regulatory model, governmental support, and general ease of doing business’ (Lighting Global et al. 2020, p. 127). By 2016, 80 per cent of Kenya’s population had a mobile telephone (Chengo et al. 2019). The sector quickly expanded into neighbouring countries in East Africa, including Zambia, Rwanda, Uganda and Ethiopia (Lighting Global et al. 2020, p. 54). Progress in West Africa is predicted to be slower given that there are lower levels of both mobile telephone penetration and therefore mobile money in the region, excepting Ghana (Snel 2019). Between 2012 and 2019 sub-Saharan Africa received 75 per cent of total global investment in PAYGO SHS, of which 76 per cent went to companies operating in East Africa and 22 per cent to companies in West Africa, particularly Ghana, and to a lesser extent Côte d’Ivoire, Benin, Senegal, Togo and Burkina Faso (Lighting Global et al. 2020, p. 128, see Figure 1).
Five sub-classifications have been developed for electricity systems for energy access in the context of the SEforAll initiative, of which Tiers 1–3 apply to SHS and Tiers 4 and 5 to mini grids. Tier 1 includes a PV module and a lithium-ion indoor battery unit to power two lights and phone charging, while Tier 3 systems of 200 Watts or more enable the use of larger household appliances such as digital televisions, hair clippers and fans (Adwek et al. 2020, p. 3903, Lighting Global et al. 2020, p. vii). The increasing availability and affordability of PAYGO SHSs have been facilitated in part by the mass production of solar PV and battery technologies (Bisaga and Parikh 2018) as well as the introduction of VAT exemptions for imported solar products in many countries across the continent and the removal of subsidies on kerosene products (IRENA 2020).

As mentioned above, the implementation of PAYGO SHSs has been made technologically possible by the widespread diffusion of mobile telephones in many parts of sub-Saharan Africa to areas that landlines could not reach, and the introduction of banking services via mobile digital payments into previously predominantly cash economies (PWC 2017). Until recently, overcoming ‘the last mile’ by extending the electricity transmission and distribution grid to connect remote, unserved populations was a key obstacle to the realisation of universal electrification given the logistics and high costs involved. This, in addition to the volatile costs of imported diesel for generators and kerosene for cooking and lighting (Barrie and Cruickshank 2017, AfDB 2021). Because SHSs do not require the same supporting networked infrastructure of generation, transmission and distribution and capital-intensive construction as centralised power generation, the recent introduction of SHSs has upended previous understandings of electrification. As a result, these systems are now seen as the most realistic and efficient option for many unconnected rural populations (McBain 2019).

While large-scale electricity systems have in general been shaped and governed through state-regulated capital investment, off-grid solar PV by comparison including PAYGO SHSs, has often been developed beyond the oversight of conventional institutions of electricity governance, such as the utility, the systems operator, government departments and the regulator, particularly in the sector’s early stages (Baker et al. 2021). Such institutions are now playing catch up in a number of countries, for instance, through rural electrification policies and the regulation of mobile network operators and mobile banking (PWC 2016, p. 16).

The promotion of PAYGO SHS companies as the new intermediaries of energy access (Waldron 2017) sits in direct tension with established state-owned incumbent utilities such as Kenya’s
Power and Lighting Company (KPLC) and has resulted in something of a dysfunctional dichotomy with regards to electricity provision (Kazeem 2020). In a number of sub-Saharan Africa countries, there has been strong resistance by many state-owned utilities and their institutional allies, to both the liberalisation of the centralised monopoly and the introduction of renewable electricity generation by the private sector, at both the off-grid and the utility-scale (Pedersen and Nygaard 2018, Boamah 2020). A key reason for this resistance is the significant loss of political and economic control that this privatisation and decentralisation implies, including of revenue generation, strategic political control over large-scale baseload power generation, and the political capture of voter loyalties through the grid electrification of the previously disconnected (MacLean et al. 2016, Chengo et al. 2019). However, resistance by some parts of government often runs alongside active support and facilitation by the private sector and other parts of government for off-grid initiatives. As electrical engineer 1 surmised (in interview 19 November 2020),

What you have is a delineation between the private sector, equated to off-grid, and the public sector … Nowhere in the world do power sectors function well where there is that delineation. Why? Because you can’t have the private sector saying, we are going to supply the people who can pay but we have no idea who is going to deal with the rest.

Most of the top 10 SHS companies in the sector (see Figure 2) have well-established distribution networks in multiple countries (Lighting Global et al. 2020, p. 77), working through shops, companies and agents who distribute the systems, maintain the products and services, and educate and encourage users. The nature of this distribution is significant given that many customers will be new to both mobile money and the SHS itself. As industry employee (2) stated (conference observation 12 November 2020) ‘A lot of customers prior to using PAYGO haven’t used mobile money and PAYGO companies are doing a lot of work to help people learn how to use it’.

Not only is PAYGO a flexible platform for the companies that are centrally managing a large pool of dispersed electricity consumers (Adwek et al. 2020) but also has immense value for mobile network operators (MNOs) (see Table 1). Through their established partnerships with SHS companies, MNOs have played a major role in new off-grid modes of electricity provision at the same time as expanding their customer base (REN 21 2020, p. 155). These large multinational companies include MTN, listed and headquartered in Johannesburg; Safaricom, Kenya’s dominant mobile network operator of which 40 per cent is owned by the UK’s Vodafone and 30 per cent by the

![Figure 2](image-url)
### Table 1. Top 10 PAYGO SHS companies by investment commitments.

| Company | Operation area | Company HQ | Founded | Partnerships with MNO | Claimed impact (no of people) | Debt financing | Lead investors and commercial partners |
|---------|----------------|------------|---------|-----------------------|--------------------------------|---------------|--------------------------------------|
| Zola electric (Off-grid electric). Formerly M-Power | Tanzania, Rwanda, Ghana, Nigeria, Côte d’Ivoire | Netherlands | 2011 | Vodacom Tanzania; | 1.1 million | SunFunder | Tesla, General Electric, EDF Energy, DBL Ventures, Helios Investment Partners and Total Proparco; Inspired Evolution Investment Management |
| d.light | Kenya, Haiti | US | 2006<sup>a</sup> | Safaricom | 100 million | European Investment Bank; SunFunder; Developing World Markets; SIMA; CDC; Stanbic; FMO; Norfund; EDF; Mitsubishi Corporation; AIM | CDC |
| M-Kopa Solar | Kenya, Uganda, Tanzania | Kenya and UK | 2012 | Safaricom | 3.7 million | Lion’s Head Global Partners; Togolaïse de Banque; Essential Capital Consortium | CDC |
| BBOXX | Including: Rwanda, DRC, Kenya, and Togo | UK | 2011 | MTN; Orange Energie (in Senegal and DRC) | Plus 1 million | EDF; Mitsubishi Corporation; AIM | EDF; Mitsubishi Corporation; AIM |
| Mobisol (acquired by Engie Energy Access) | Kenya, Rwanda, Tanzania | France/Germany | 2011 | MTN | 1 million | FinnFund | Engie Energy Access; IFC |
| Nova Ludos | Nigeria, Côte d’Ivoire | The Netherlands (Nova Ludos Netherlands Holding BV) | 2012 | MTN | | OPIC; Pembani Remgro; CDC | OPIC; Pembani Remgro; CDC |
| Greenlight Planet | Kenya, India | US | 2009<sup>b</sup> | | | SIMA; NorFund; FMO; ResponsAbility; ARCH Emerging Markets Partners Standard Chartered; TRINE, Electrification Financing Initiative | Sima; NorFund; FMO; ResponsAbility; Arch Emerging Markets Partners Standard Chartered; Trine, Electrification Financing Initiative |
| Azuri Technologies | 12 countries in SSA, including Kenya | UK | 2012 | | | SunFunder; ResponsAbility; Bamboo Capital Partners | SunFunder; ResponsAbility; Bamboo Capital Partners |
| Kingo | Colombia, Guatemala | Guatemala | 2013 | | | | |
| SolarNow | Uganda, Kenya | SolarNow registered in Uganda, subsidiary of SolarNow B.V, registered in the Netherlands | 2011 | MTN, Airtel | | | |

Source: Author’s own from publicly available information and Crunchbase.

<sup>a</sup>This earlier founding date is explained by the fact that d.light’s original product was a standalone solar lantern before it the company diversified into PAYGO SHSs which were distributed by M-Kopa. This also explains why the company has claimed to impact so many more lives than other companies.

<sup>b</sup>Greenlight Planet’s original product was also solar lamps.
government of Kenya (see Bateman et al. 2019, p. 487); and Orange of which 23 per cent is owned by the French state and the remainder by shareholders. The telecommunications industry group, the GSMA is also an important actor in this field, working in partnership with PAYGO SHS companies and as part of its UK-financed ‘Mobile for Development (M4D) Utilities’ programme, which it launched in 2013 (GSMA 2016).

From M-Pesa to M-Kopa and beyond

PAYGO for SHSs emerged out of M-Pesa, the Kenyan technological mobile banking platform and the world’s flagship FinTech company, with ‘M’ meaning mobile and ‘Pesa’ meaning money in Swahili (Suri and Jack 2016, Bateman et al. 2019). M-Pesa was formally launched in March 2007 by Safaricom in partnership with the Kenyan Commercial Bank of Africa. Since 2020 M-Pesa has been owned by a joint venture between the UK’s Vodacom and Safaricom (Vodacom 2020) and as of September 2021, had 50 million monthly active customers across Kenya, Tanzania, Mozambique, the DRC, Lesotho, Ghana and Egypt, ‘cementing its position as Africa’s largest fintech platform’ (Gavaza and Maeko 2021).

M-Pesa’s original intention was to help microfinance borrowers to make and repay loans via a mobile telephone, including those without a bank account (Rolffs et al. 2015, Barry and Creti 2020, p. 3). This intention was made possible in large part through Safaricom’s partnering with 25 banks and over 700 businesses since 2009 (Ndung’u 2018). In changing ‘the traditional holding of currency outside of banks and the preference of cash’ (Ndung’u 2018, p. 45), M-Pesa quickly developed across Kenya into a platform for the payment of numerous consumer goods and services such as airtime, salaries, taxi rides, school fees and utility bills (Faris 2015), as well as financial services such as insurance, pensions, virtual savings accounts in commercial banks, cross-border payments and international remittances.

M-Pesa now processes over half of Kenya’s GDP, has played a key role in the transformation of the country’s banking system and is credited with ‘banking the unbanked’, particularly those with a low and/or irregular income living a long distance from a bank or financial services point. The proportion of Kenya’s adult population included in formal financial services increased from 26.4 per cent in 2006 to 75.3 per cent in 2016 (Ndung’u 2018, p. 49). One apparent reason for M-Pesa’s success was that it was able to operate as an unchallenged monopoly for some time due to the absence of a legal framework for mobile money (Kaminska 2015), something which was eventually introduced in 2014 in the form of National Payment Systems Regulations (Greenacre 2018).

The first PAYGO SHS company M-Kopa was set up to rely on M-Pesa’s technological platform and credits itself with kickstarting the market. M-Kopa was launched commercially in October 2012 by its British and Canadian founders the ‘M-trepreneurs’ Nick Hughes and Jesse Moore³ (Faris 2015). Now present in Kenya, Nigeria and Uganda, M-Kopa’s SHSs are more competitive than the interest on a microfinance loan, despite charging relatively high interest. As discussed in the following section, M-Kopa was soon followed by a number of other entrepreneurial start-ups that are now increasingly consolidated in ownership (see Table 1).

Like M-Pesa, M-Kopa and other PAYGO SHS companies have also diversified into numerous secondary products and services beyond electricity, including mobile telephones, televisions, fridges, loans, fuel-efficient stoves, bicycles, and rainwater storage tanks (REN 21 2020, p. 155). As with M-Pesa, SHSs have also become a gateway to other financial products and services. Some companies have further moved into ‘productive use’, such as solar irrigation installations, cooling, and agro-processing products which are offered with an insurance scheme that provides cover for unexpected crop losses (REN 21 2020, p. 155). Such diversification is a key strategy of many PAYGO SHS companies and their investors, firstly to secure customers for electricity and secondly, to develop a financial rather than a traditional retail relationship with them (Waldron and Hacker 2020, p. 2). Thirdly, this relationship allows the consumer to build up a credit history and the company to generate consumer data (Lighting Global et al. 2020, p. 8).
However, existing research suggests that this diversification has taken place at the same time as many PAYGO SHS companies have shifted away from small-scale Tier 1 systems aimed at the energy poor to larger systems that are of greater benefit to wealthier customers and productive users. In this sense, PAYGO SHS companies have moved away from a mission of energy access and the realisation of SDG7, towards increasing opportunities for profit. Many systems are now beyond the reach of low-income households considered to be at the ‘bottom of the pyramid’, particularly in rural areas (Barry and Creti 2020, Groenewoudt et al. 2020). In Kenya, for instance, PAYGO SHSs have thus far had limited impact on the country’s energy access figures given that the majority of sales have been to customers that meet certain credit thresholds, are located in already electrified and often urban areas, and are using SHSs as a complementary solution to the centralised grid, albeit a grid with unreliable supply (Boamah 2020, p. 156, Ulsrud 2020). As Muchunku et al. (2018, p. 6) discuss, PAYGO SHS in Kenya are currently serving households ‘in the $6–40/ day income range, who would not typically be at the bottom of the pyramid’.

Although some PAYGO SHSs have been installed in areas of low population density without access to the centralised distribution grid, or where the grid may be unreliable or unaffordable, as Bisaga and Parikh (2018) describe in the case of Rwanda, SHSs in Tanzania ‘are still accessible only for the richer minority’, according to Ahlborg (2018, p. 269). Moreover, in Tanzania and Senegal, they are generally considered an ‘interim’ measure for many households waiting to connect to the expanding distribution grid, which as well as being technically more capable of supporting energy-intensive domestic appliances, is often perceived as culturally superior and a powerful symbol of modernity (Ahlborg 2018, Jaglin and Guillou 2020). More scathingly, electrical engineer 1 (in interview 19 November 2020) implied that the main interest of SHS PAYGO companies is to supply those who can afford it:

‘these [off-grid, SHS] companies fly banners: “carbon neutral, SDG goals, supplying the 600 million, universal access” … but they don’t supply the poorest of the poor, they supply people who meet their credit threshold’.

Of debt and data

While the extension of access to electrical appliances, consumer credit and financial services through PAYGO SHSs has been framed as an essential opportunity for socio-economic development for low-income and marginalised consumers (Waldron and Hacker 2020), the flip side of financial inclusion is that of the significant increase in domestic indebtedness as the experience of M-Pesa in Kenya and other microcredit and FinTech institutions has demonstrated (Bateman et al. 2019). The nature of indebtedness has yet to be considered in relation to PAYGO SHSs in any critical depth.

In addition, data has become ‘the new kind of raw material’ (Srnicek 2017, p. 38) of the digital economy that is being extracted and exploited’ (in Baldwin 2018, p. 6) and therefore forms an important dynamic within this new frontier of electricity capital. Originally a by-product of the industry, the generation of digital customer data trails and credit scores for analysis now holds significant value for any PAYGO SHS (Ndung’u 2018) as it does for other digital platforms. Off-grid electricity providers are seen as uniquely placed to generate and capture consumer finance because of their ‘broad and diverse customer bases, rich customer data, established payment channels, and collateral’ (Waldron and Hacker 2020, p. 1). Not only is data being used to upsell non-energy products and services but is also being made available to multiple lenders to assess the risk profile of the consumer (PWC 2016, p. 12, Muchunku et al. 2018, REN 21 2020, p. 155). However, there are numerous ethical concerns in this area which echo previous examples of data extraction and analysis from other sectors, or ‘digital mining’ of the poor as witnessed in the case of M-Pesa (Bateman et al. 2019, p. 486). Moreover, as industry employee (1) discussed (in interview, 1 December 2020):

A massive amount of [personally identifiable] data is generated by the PAYGO model, from the product and how it is used, from the payment histories, the mobile money wallet and also the ‘know your customer’ data that
companies collect. If people are judged based on their age, gender, where they live, ethnicity etc then there is a risk of discrimination, deliberate or otherwise, for instance in terms of the customer being charged a higher amount. So, it can be quite difficult to unpick what is sound risk profiling vs discrimination.

From entrepreneurs to next generation utilities

Though the emerging market for PAYGO SHSs in the early 2010s consisted of numerous entrepreneurial start-ups, the increasingly mature sector has now been categorised into first-, second- and third-generation companies. First-generation companies including M-Kopa are now increasingly established and consolidated. Based on available data up to end August 2020, the top 10 companies received nearly 80 per cent of all investments between 2012 and 2019 (See Table 1, Figure 2, Lighting Global et al. 2020, pp. 122–7). Referred to as ‘next generation utilities’, these companies are dominant in terms of geographical reach, product offering and investment volume (REN 21 2020, pp. 156–7). They are typically vertically integrated and participate in multiple segments of the value chain, especially hardware design, software development, marketing and distribution, consumer finance, and after-sales support (Lighting Global et al. 2020, p. 72). Next-generation companies tend to source their hardware products directly from various Sino-international manufacturers such as Trina Solar, First Solar and Canadian Solar (Lighting Global et al. 2020, p. 72).

The smaller and more recently established second and third generation companies are generally focussed on specific and separate segments of the value chain (Waldron 2017), for instance as solar manufacturers, local distributors or financial intermediaries who then act in partnership with each other. Three examples of such companies are Persistent Energy Ghana (PEG), OULU and Easy Solar, which are most active in West Africa. Another major player in this area is US-based Angaza, which provides PAYGO hardware and portfolio management software to potential financiers (Waldron 2017).

Beyond these categorisations, there is also a large market for ‘non-affiliated’ products, low-quality systems in terms of design, performance, durability, or even just fake (Groenewoudt et al. 2020). While such products are poorly understood (see Groenewoudt et al. 2020, Samarakoon et al. 2021) and the market share of affiliated to non-affiliated SHS products varies significantly from country to country (Ibid., p. 7), they are likely to be more affordable to low-income households at the bottom of the pyramid. Since 2015 the term ‘affiliated products’ refers to branded products for SHS kits of up to 100 Watts that meets the quality standards of Lighting Global (Lighting Global et al. 2020, p. 5).

In the sector’s early days, many first-generation companies relied on impact investors, early to late-stage venture capital, Series A-D funding and venture rounds, and to a lesser extent, grant funding. For instance, in 2013 BBOXX raised $1.9 million in a series A funding round from US-based Khosla Impact, a ‘financier of entrepreneurs in the developing world’. Larger investors such as private equity funds, traditional asset managers and strategic corporates have for the most part come in at a later stage and undertaken ‘limited but prominent transactions’ (Lighting Global et al. 2020, p. 122). An example of one such transaction is a $31 million private equity investment in BBOXX by Africa Infrastructure Investment Managers through its AIIF3 Fund in January 2019 in exchange for a minority stake in BBOXX’s operations in Rwanda, Kenya and DRC (Digest Africa 2019). Development finance institutions have played various roles, including through by direct investments in the more mature off-grid companies as well as investing in impact investors, venture capital companies, specialised debt providers and local banks which have in turn invested in the sector (Lighting Global et al. 2020, p. 21).

Having reached a certain economy of scale, since about 2015 many first-generation SHS companies started to attract higher levels of commercial debt capital (GOGLA 2020a,b) from a variety of different players, including the UK’s Commonwealth Development Corporation (CDC) lending to Nova Lumos, and M-Kopa in which it also holds an equity stake; specialised debt providers such as Zurich-based ResponsAbility and US-based SunFunder, both of whom are lead investors in Zola
Electric (SunFunder 2018); and social investment manager, US-based SIMA Funds, which has provided debt financing and equity to d.Light and debt financing to Greenlight Planet (see Table 1). Local banks have been less involved in the sector to date though it has been suggested that the increasing availability of local currency financing and hedging instruments may encourage them to do so in future (Lighting Global et al. 2020, p. 122).

Increasingly large and complex debt deals have also taken place, including the largest debt transaction to date in the solar sector in October 2017, when M-Kopa secured $80 million in debt from a large consortium of development banks, impact investors and commercial banks, including the CDC ($20 million), FMO ($13 million), Norfund ($13 million), Stanbic Bank ($9 million), and $25 million from ResponsAbility, Symbiotics, and Triodos Investment Management (CDC Group, 2017, SEforAll and BNEF 2020, p. 86, Lukhanyu 2017). Of note, however, is that development finance institutions became most involved in the sector when it had already proven to be viable and that public finance forms less than 5 per cent of overall investment in the sector (Interview, Industry employee (1), 1 December 2020).

More recently next-generation utilities have started to form investment and/or commercial partnerships with larger-scale decentralised electricity developers and established global utilities who are diversifying from their original geographical and infrastructural focus. For example, French-owned Engie Energy Access, at once a strategic corporate investor in SHSs and a mini-grid developer, recently acquired Mobisol, Fenix International and Simpa Networks (Dizard 2019). Another French utility, EDF, acquired a 50 per cent stake in BBOXX Togo in 2018 and a 23 per cent stake in BBOXX Kenya in February 2021. Together with US General Electric, EDF also participated in a series D investment round in Zola Electric in January 2018 (CrunchBase database).

Due to the increasingly consolidated and mature nature of the market, equity investment and grant capital are now limited in availability at the same time as the risk appetite of PAYGO SHS companies and investors has decreased (Muchunku et al. 2018, p. 12). Such a development has made it harder for second- and third-generation companies to enter the market and has consolidated the control of first-generation companies (Lighting Global et al. 2020, p. 126).

Given the relative control that first-generation companies now have over the SHS PAYGO market in East Africa, competition has since moved to West Africa. Ghana is the country with the most dynamic PAYGO SHS sector in the region, where second-generation utility PEG currently licenses SHSs from M-KOPA and has started to expand into Senegal and Côte d’Ivoire (GSMA 2016, 2021). However, the top 10 companies still dominate in this region in which Nova Lumos and ZOLA Electric currently account for 65 per cent of all investments to date and only BBOXX and Azuri Technologies have raised capital specifically designated for the region (Lighting Global et al. 2020, p. 128). Limited capital has gone to dozens of other smaller second- and third-generation companies, for instance, Oolu Solar, whose sole focus is Senegal and Mali (Energise Africa 2021).

Finally, as the SHS PAYGO market becomes increasingly mature, examples are now emerging of the financialisation of the sector, with the conversion of PAYGO SHS loans into securities which are then sold on to investors. The clearest example of this so far is that of BBOXX, which closed the sector’s first-ever securitisation deal with Dutch investment firm Oikocredit International for £500,000 worth of SHSs in Africa. Through this deal, which follows the model of third-party solar companies such as the US company Solar Capital, BBOXX Ltd created a special purpose vehicle subsidiary through which it bundled and sold approximately 2500 customers’ contracts into asset-backed notes to Oikocredit. These notes, called Distributed Energy Asset Receivables, are denominated in Kenyan shillings and guaranteed by the future payments represented by the contracts. The notes had an interest rate of 21 per cent and a maturity of 30 months, equivalent to the remaining tenor of customers’ three-year contracts. The customers in question were selected for their low likelihood of default, based primarily on repayment history. Such a move has succeeded in securitisising the credit risk of the unbanked and is one example of the use of consumer data as a new site of accumulation (Guay 2015, Aidun and Muench 2018, Muchunku et al. 2018, p. 7).
Conclusion

As this paper has discussed, discursive efforts for the realisation of SDG 7 are being carried out through an evolving set of socio-technical and financial relationships that are shaping capital accumulation through electricity provision. Under the banner of energy access, the off-grid solar PV sector has moved away from its original mission into new areas of consumption and larger systems. The provision of off-grid electricity through PAYGO SHSs is being bundled with goods and services, resulting in new relationships of credit, consumption and debt between users and service providers, and the generation of data as a new site of accumulation. PAYGO SHSs are therefore an example of the incorporation of electricity systems and their users into ‘global strategies of capital accumulation through digital footprints’ and the creation of new development and energy asset classes (Gabor 2020, p. 24). Given the significance of universal energy access for SDG7 and SEforAll, this research has important implications for sustainable development in definition, policy and practice which in this instance has turned to increased consumption and indebtedness as a proxy for socio-economic development and parallel assumptions that financial inclusion is synonymous with social inclusion. With this in mind, I offer the following three conclusions.

First, increasingly determined by digitisation and FinTech, the implementation of PAYGO SHSs as a new socio-technical configuration of electricity and a new site of electricity capital in sub-Saharan Africa and elsewhere, has both constructive and destructive potential for its socio-economic and environmental outcomes. Constructive, in terms of the potential contribution to increasing low-carbon energy access to those for whom a grid connection would have been unobtainable, to increasing mobile communications to those otherwise disconnected, as well as to increasing access to financial and other services to the previously unbanked. Destructive, in terms of the increase in consumer debt and the creation of new long-term financial dependencies, to the exploitation of consumer data that may in turn result in discriminatory practices or the perpetuation of patterns of uneven development, as well as new forms of exclusion in light of existing evidence which suggests that many PAYGO SHSs are not aimed at households at the bottom of the energy pyramid.

Second, in analysing energy access as a new frontier of electricity capital, this research takes place within the context of changing technological definitions of electrification, which can now be realised without the centralised mediation of the transmission or distribution grid. This in turn has huge implications for conventional electricity governance which in the off-grid space is no longer controlled by incumbent institutions of the state such as the regulator, the utility and the ministry of energy, but instead a nexus of multinational MNOs, mobile banking platforms and first-generation utilities. While the rationale behind power sector liberalisation has been to unbundle the state-owned monopoly, as this paper has identified, new private-sector monopolies, mostly foreign-owned and/or backed by sources of international finance and investment, are becoming increasingly consolidated in the off-grid space. This consolidation follows Langley and Leyshon’s (2021, p. 385) assertion that ‘platform reintermediation seeks to produce new market structures that will secure new oligopolistic and monopolistic positions’.

The evolving role of FinTech in the energy access space has therefore created new tensions not only between incumbent, state-owned or partially liberalised monopoly utilities such as KPLC and international, privately financed next-generation utilities such as M-Kopa but also between traditional finance and banking and new forms of mobile money facilitated by increasingly powerful and international MNOs. To a certain extent, the state has been excluded from this new site of capital accumulation and its role in resisting and/or facilitating the implementation of off-grid electricity as much as mobile money is a key dynamic that deserves much greater attention.

Indeed, while analyses of electricity capital to date have tended to focus on the role of the state in actively creating and/or resisting electricity regimes at the utility-scale (Harrison 2020, Luke 2021) SHSs, as small-scale, off-grid systems have often been developed in the absence of comprehensive state regulation or oversight. Similar to Baldwin’s (2018, p. 4) description of bitcoin, a cyber-libertarian narrative can also be found in the discourse of digitisation and energy access which suggests that
there is no need to trust or rely on centralised, state-owned electricity utilities and energy regulators. Yet despite the technological decentralisation of the system, which some have assumed will be accompanied by democratisation and the increased empowerment and autonomy of energy consumers in the energy access market, there remains a huge distortion of power relations and consolidation of ownership, through which ‘ultra-modern digital networks conceal very traditional consolidation of power and capital’ (Baldwin 2018, p. 1). How these ownership structures and networks of corporate power evolve as PAYGO SHS companies seek new market opportunities in West Africa is another area for further research.

Finally, this paper also makes a call for greater theoretical engagement between heterodox economics and geography on the political economy of financial inclusion, FinTech, and the energy transition in order to understand the diversification of energy access in the global South as a new asset class and a new frontier of electricity capital. This theoretical engagement is needed to understand the evolution of off-grid energy access both within the ‘wider political economy of the global financial industry’ (Bateman et al. 2019, p. 486) as well as that of the political economy of electricity finance (Baker 2021). Such research should include nationally and sub-national specific studies that evaluate the granular impacts of the deployment of such systems and situate off-grid electricity development within a specific political, economic, social and cultural context.

Notes
1. A global framework launched by the UN in 2012 which aims to reconcile the agendas of climate change and energy access. It has three inter-linked objectives for 2030: (i) Universal access to modern energy services; (ii) Doubling the global rate of energy efficiency improvement; and (iii) Doubling the share of renewable energy in global energy mix.
2. Both ‘Fin’ and ‘Tech’ are capitalised because following Knight and Wójcik (2020) this presentation better highlights the combination of finance and technology.
3. Prior to setting up M-Kopa, Moore previously worked for the GSMA Development Fund.
4. Series A to D investments refers to the funding rounds through which external investors are given the opportunity to invest in a startup company in exchange for equity, or partial ownership. Each round represents an increased level of market maturity and expansion, capital valuation and reduced level of investment risk.

Acknowledgements

The funding for this research was provided by a generous fellowship from Maria Sibylla Merian Centres Programme of the Federal Ministry of Education and Research Germany under the grant number 01 UK1824A. Thank you to all of the research participants who generously gave me their time and insights. And thank you also to all my fellow fellows on the IFG4 MIAASA fellowship (September to December 2020) for the enlightening discussions, advice and thoughts on sustainable energy transitions: Naaborle Sackeyfio, Paul Munro, Diran Soumoni, Rasmus Pedersen, Paul Osei-Tutu, Salimata Berté, Gordon Crawford, Aba Crentsil, Norbert Edomah, Abena Oduro, Philipp Späth, Michael Pregernig, Simon Bawakyillenuo, Agnes Schneider-Musah.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by Maria Sibylla Merian Centres Programme of the Federal Ministry of Education and Research Germany [grant number 01 UK1824A].

Notes on contributor

Lucy Baker is a senior research fellow in the Science Policy Research Unit, University of Sussex, and a visiting associate professor in the DST/NRF/Newton Fund Trilateral Chair in Transformative Innovation, The Fourth Industrial Revolution
References

Adwek, G., et al., 2020. The solar energy access in Kenya: a review focusing on pay-as-you-go solar home system. Environment, development and sustainability, 22, 3897–938.

African Development Bank (AfDB), 2021. Kenya: last mile connectivity project. Available from: https://projectsportal.afdb.org/dataportal/VProject/show/P-KE-FA0-013.

Ahlborg, H., 2018. Changing energy geographies: the political effects of a small-scale electrification project. Geoforum; journal of physical, human, and regional geosciences, 97, 268–80.

Aidun, C. and Muench, D., 2018. Securitisation: unnecessary complexity or key to financing the DESCO sector? Persistent energy. Available from: https://persistent.energy/wp-content/uploads/2018/11/Securitization.pdf.

Alstone, P., Gershenson, D., and Kammen, D., 2015. Decentralized energy systems for clean electricity access.

Aidun, C. and Muench, D., 2018. Changing energy geographies: the political effects of a small-scale electrification project. Geoforum; journal of physical, human, and regional geosciences, 97, 268–80.

Baker, L., 2015. Renewable energy in South Africa’s minerals-energy complex: a ‘low carbon’ transition? Review of African political economy, 42 (144), 245–61.

Baker, L., 2021. Procurement, finance and the energy transition: between global processes and territorial realities. Environment and planning E: nature and space, February.

Baker, L., Hook, A., and Sovacool, B.K., 2021. Power struggles: governing renewable electricity in a time of technological disruption. Geoforum; journal of physical, human, and regional geosciences, 118, 93–105.

Baldwin, J., 2018. In digital we trust: bitcoin discourse, digital currencies, and decentralized network fetishism. Palgrave communications, 4, 14.

Balls, J.N. and Fischer, H.W., 2019. Electricity-centered clientelism and the contradictions of private solar microgrids in India. Annals of the American Association of Geographers, 109 (2), 465–75.

Baptista, I. and Plananska, J., 2017. The landscape of energy initiatives in sub-Saharan Africa: going for systemic change or reinforcing the status quo? Energy policy, 110 (Suppl. C), 1–8.

Barrie, J. and Cruickshank, H.J., 2017. Shedding light on the last mile: a study on the diffusion of pay as you go solar home systems in central east Africa. Energy policy, 107, 425–36.

Barry, M.S. and Creti, A., 2020. Pay-as-you-go contracts for electricity access: bridging the “last mile” gap? A case study in Benin. Energy economics, 90, 104843.

Bateman, M., Duvendack, M., and Loubere, N., 2019. Is Fin-Tech the new panacea for poverty alleviation and local development? Contesting Suri and Jack’s M-Pesa findings published in Science. Review of African political economy, 46 (161), 480–95.

Bernards, N., 2016. The International Labour Organization and the ambivalent politics of financial inclusion in West Africa. New political economy, 21 (6), 606–20.

Bisaga, I. and Parikh, P., 2018. To climb or not to climb? Investigating energy use behaviour among solar home system adopters through energy ladder and social practice lens. Energy research & social science, 44, 293–303.

Boamah, F., 2020. Emerging Low-carbon energy landscapes and energy innovation dilemmas in the Kenyan periphery. Annals of the American Association of Geographers, 110 (1), 145–65.

Bransfield-Garth, S., 2017. Digital divide to digital dividend: empowering the last billion. Speech at World’s Top Innovators conference, 27–29 September London. Available from: http://azuri.wpengine.com/about/#Azuri.

Bridge, G., et al., 2018. Energy and society: a critical perspective. London: Routledge.

Butu, H.M., et al., 2021. Leveraging community-based organizations and FinTech to improve small-scale renewable energy financing in sub-Saharan Africa. Energy research & social science, 73.

Castán Broto, V., et al., 2018. Energy justice and sustainability transitions in Mozambique. Applied Energy, 228, 645–55.

Castree, N. and Christophers, B., 2015. Banking spatially on the future: capital switching, infrastructure, and the ecological fix. Annals of the association of American geographers, 105 (2), 378–86.

CDC Group, 2017. M-KOPA (Kenya). Available from: https://cdc.dusted.digital/en/our-impact/investment/m-kopa-kenya/.

Chengo, V., et al., 2019. Understanding the sustainable development prospects of mobile-enabled solar home systems in Kenya. Climate Resilient Economies Working Paper no. 006/2019. Available from: https://www.ash-net.org/wp-content/uploads/2019/06/Working-Paper_Understanding-the-sustainable-development-prospects-of-mobile-enabled-solar-home.pdf.

Demirgüç-Kunt, A., et al., 2017. The Global Findex database 2017: measuring financial inclusion and the FinTech Revolution. Washington, DC: World Bank. Available from: https://globalfindex.worldbank.org/.

Digest Africa, 2019. AIIM invests $31M into BBOXX for a minority stake in its E. Africa business. 14 January. Available from: https://digestafrica.com/aiim-invest-bboxx-stake/#XD2ySVUzYdU.

Dizard, 2019. Mobisol: a cautionary tale for impact investors. Financial Times, 3 May. Available from: https://www.ft.com/content/8832bffc-f319-36fa-a720-fadaaf86e4f4.
Energise Africa, 2021. Website. Available from: https://www.energiseafrica.com/investments.

ESMAP, 2019. Mini grids for half a billion people [online]. Available from: https://openknowledge.worldbank.org/bitstream/handle/10986/31926/Minigrids-for-Half-A Billion-People-Market-Outlook-and-Handbook-for-Decision-Makers-Executive-Summary.pdf?sequence=1&isAllowed=y

Faris, S., 2015. The solar company making a profit on poor Africans. Bloomberg Businessweek, 2 December.

Gabor, D., 2020. The Wall Street consensus. SocArXiv, 2 July. Available from: https://osf.io/preprints/socarxiv/wab8m/.

Gabor, D. and Brooks, S., 2017. The digital revolution in financial inclusion: international development in the FinTech era. New political economy, 22 (4), 423–36.

Gavaza, M. and Maeko, T., 2021. News analysis: M-Pesa dominates African fintech as it hits 50-million users. Business Day, 13 September. Available from: https://www.businesslive.co.za/bd/companies/telecoms-and-technology/2021-09-13-news-analysis-m-pesa-dominates-african-fintech-as-it-hits-50-million-users/.

GOGLA, 2020a. Investment data. Available from: https://www.gogla.org/access-to-finance/investment-data.

GOGLA, 2020b. Off-grid solar investment trends: key takeaways from the GOGLA deals database 2019 to August 2020. Available from: https://www.gogla.org/sites/default/files/resource_docs/off-grid_solar_investment_trends_2019-2020.pdf.

Greenacre, J., 2018. Regulating mobile money: a functional approach. Pathways for Prosperity Commission background paper series; No. 4. Oxford. Available from: https://pathwayscommission.bsg.ox.ac.uk/sites/default/files/2019/09/regulating_mobile_money.pdf.

Groenewoudt, A., Romijn, H., and Alkemade, F., 2020. From fake solar to full service: an empirical analysis of the solar home systems market in Uganda. Energy for Sustainable Development, 58, 100–11.

GSMA, 2016. Mobile for development utilities, unlocking access to utility services. Available from: https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/07/Mobile-for-Development-Utilities-Unlocking-access-to-utility-services-The-transformational-value-of-mobile.pdf.

GSMA, 2021. State of the industry report on mobile money. GSMA. Available from: https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2021/03/GSMA-State-of-the-Industry-Report-on-Mobile-Money-2021_Full-report.pdf.

Guay, J., 2015. The world’s first securitization of off-grid solar assets. Green Tech Media, 17 December. Available from: https://www.greentechmedia.com/articles/read/the-worlds-first-securitization-of-off-grid-solar-assets.

Harrison, C., 2020. Electricity capital and accumulation strategies in the U.S. electricity system. Environment and planning E: nature and space.

Hughes, T.P., 1983. Networks of power: electrification in western Society 1880–1930. Baltimore, MD: Johns Hopkins University Press.

IEA, IRENA, UNSD, World Bank, WHO, 2020. Tracking SDG 7: the energy progress report. Washington, DC: World Bank. Available from: https://www.irena.org/publications/2020/May/Tracking-SDG7-The-Energy-Progress-Report-2020.

Jaglin, S. and Guillou, E., 2020. Decentralized electricity solutions: innovation in essential services is no substitute for policy. Field Actions Science Reports, Special Issue 22. Available from: http://journals.openedition.org/factsreports/6326.

Kaminska, I., 2015. Mpesa: the costs of evolving an independent central bank. Financial Times, 15 July. Available from: https://www.ft.com/content/a09870cb-771e-3d3d-bc16-2b429af647aa.

Kazeem, Y., 2020. Solar providers in Africa are on a collision course with struggling national grid companies. Quartz Africa, 11 December. Available from: https://qz.com/africa/1944668/solar-power-providers-face-increased-regulation-in-kenya/. 

Kennedy, S., 2018. Indonesia’s energy transition and its contradictions: emerging geographies of energy and finance. Energy research & social science, 41, 230–7.

Knight, E. and Wójcik, D., 2020. Fintech, economy and space: introduction to the special issue. Environment and planning A: economy and space, 52 (8), 1490–7.

Knuth, S., 2018. “Breakthroughs” for a green economy? Financialization and clean energy transition. Energy research & social science, 41, 220–9.

Koomson, I. and Danquah, M., 2021. Financial inclusion and energy poverty: empirical evidence from Ghana. Energy economics, 94, 105085.

Langley, P. and Leyshon, A., 2021. The platform political economy of FinTech: reintermediation, consolidation and capitalisation. New political economy, 26 (3), 376–88.

Lighting Global, GOGLA and ESMAP, 2020. Off-grid solar market trends report. Available from: https://www.lightingglobal.org/wp-content/uploads/2020/03/VIVID%20OCA_2020_Off_Grid_Solar_Market_Trends_Report_Full_High.pdf.

Lohmann, L., 2020. Heat, time and colonialism. Unpublished.

Lohmann, L. and Hildyard, N., 2014. Energy, work and finance. Cornerhouse briefing, March.

Luke, N., 2021. Powering racial capitalism: electricity, rate-making, and the uneven energy geographies of Atlanta. Environment and planning E: nature and space.
Luke, N. and Huber, M., under review. Introducing the uneven geographies of electricity capital, introduction to accepted special issue on the uneven geographies of electricity capital. *Environment and planning E: nature and space.*

Lvkhanyu, M., 2017. Pay-as-you-go solar firm M-KOPA raises $80 m to finance solar installations for one million plus homes. *TechMoran.* Available from: https://techmoran.com/2017/10/10/pay-as-you-go-soalr-firm-m-kopa-raises-80m-to-finance-solar-installations-for-one-million-plus-homes/.

MacLean, L.M., et al., 2016. The construction of citizenship and the public provision of electricity during the 2014 World Cup in Ghana. *The journal of modern African studies,* 54, 555–90.

Markard, J., et al., 2012. Sustainability transitions: an emerging field of research and its prospects. *Research Policy,* 41 (6), 955–67.

McBain, W., 2019. Renewable energy powers growth in Senegal. *African Business.* Available from: https://africanbusinessmagazine.com/region/west-africa/renewable-energy-powers-growth-in-senegal/.

McDonald, D., ed., 2009. *Renewable energy powers growth in Senegal.*

McBain, W., 2019. Renewable energy powers growth in Senegal. *African Business.* Available from: https://africanbusinessmagazine.com/region/west-africa/renewable-energy-powers-growth-in-senegal/.

Ulsrud, K., 2020. Access to electricity for all and the role of decentralized solar power in sub-Saharan Africa. *REN 21, 2020.*

Waldron, D., 2017. Renewable energy powers growth in Senegal. *African Business.* Available from: https://africanbusinessmagazine.com/region/west-africa/renewable-energy-powers-growth-in-senegal/.

Waldron, D. and Hacker, S., 2020. *Electric bankers: utility-enabled finance in sub-Saharan Africa.* May. CGAP.