Electrifying urban Africa: energy access, city-making and globalisation in Nigeria and Benin

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Abstract : Electricity access has become a crucial issue in global South cities. While demand is growing, conventional grids are failing or insufficient, especially in Africa. Urban dwellers therefore have to develop a wide range of (in)formal infrastructures to meet their daily electricity needs. Building on recent studies on urban electricity in the global South, this paper aims to contribute to the debates on hybrid forms of electricity provision by analysing the diffusion of solar panels and generators in two cities, Ibadan in Nigeria and Cotonou in Benin. Although neighbouring and relatively similar, these two cities illustrate distinct daily electrical lives. In Nigeria, an electricity-exporting country, people face daily power outages. In Benin, a country that depends on Nigeria for its supply, there is electricity but it is difficult to connect to the grid because of connection costs. Based on an empirical study, the article shows that Ibadan's inhabitants use generators as a complement to a conventional grid that is almost universal but unreliable. In Cotonou, solar energy is an alternative until they can connect to the grid. Generators and solar panels have become the material markers of urban Africa, providing information on inequalities in access to electricity.

Keywords: electricity access, energy consumption, city-making, globalisation, Nigeria, Benin

Introduction

'I better pass my neighbour' is the nickname given by Nigerians to the small, cheap but very noisy generator causing the smell and noise pollution in the streets of both Lagos and Ibadan. In Nigeria this device is used to cope with the recurrent power cuts that add fuel to many daily conversations. At Cotonou, the economic capital of Benin, residents exchange tips on solar panels to cope with the difficulty of high bills and with getting connected to the grid. Nigeria and Benin are two neighbouring countries yet their situations, problems and attempts to address inadequate services are different.

World energy demand keeps rising, especially under the impetus of urban demographic growth, 95 per cent of which will be concentrated in the countries of the South in the coming decades (Unesco, n.d.). Today one-third of Africa's population lives in cities, but by 2040 more than half of it will (Moriconi-Ebrard et al., 2016). On this continent, where in 2018 nearly half of Africans did not have access to electricity (IEA, 2019), the pace of urbanisation is such that facilities cannot keep up with it (Blimpo and Cosgrove-Davies, 2019). Meeting the consumption needs of an emerging middle class and universalising services do not seem to be achievable by following the conventional reticular and centralised model (Jaglin, 2014, 2016, 2019). The technical electrification options are not limited to the grid. On the contrary, they are diverse and increasingly accessible thanks to technological innovations, lower prices for renewable energies and storage batteries, and the development of new payment solutions facilitated by growing access to mobile phones and the internet. There are millions of African consumers who are poorly served by failing national power grids or not at all. As a result, they turn to market players for electrification or supply-securing solutions (Rateau and Jaglin, 2020). Thus, off-grid and low-cost technologies are markers of the growing integration of urban economies into global trade (Jaglin, 2019).

While most of the studies on electricity access in Africa have focused on rural areas, recent research has underlined the crucial nature of this issue in cities (Castán Broto, 2017; Castán Broto et al. 2017; de Bercegol and Monstadt, 2018; Ghanem, 2018; [AQ1] Jaglin, 2014, 2016, 2019; Munro, 2019; Rateau and Jaglin, 2020; Silver, 2014, 2015; Smith, 2019). This paper aims to contribute to these current debates, examining how urban residents use a wide range of informal and formal infrastructures to carry out their daily lives. Taking its inspiration from the 'materiality turn' in social sciences (Latour, 1991) and the 'follow-the-thing' approach (Cook, 2004), and adopting a sociotechnical reading of the provision of networked electricity services and market offerings of off-grid technologies, this article seeks to draw on the materiality of accessing electricity to reflect on the production of the urban in Africa (Lawhon et al., 2017; Parnell and Pieterse, 2014; Graham and McFarlane 2015; Simone, 2006). At a time when it is becoming difficult to identify those who make the city since actors and scales have multiplied to a considerable extent (Brenner, 2019), we seek to draw on what makes the city, namely, the wires and the networks. This method allows us to understand how the energy services and by extension the production of the urban today is the result of political choices, social practices and inequalities, competition and complementarity between the networks of conventional electrification actors and those of global trade.

Two neighbouring cities in border countries have been chosen for case studies: Ibadan in Nigeria and Cotonou in Benin, where extended empirical fieldwork was carried out in 2017 and 2018.[1] The data was collected during qualitative interviews involving 160 households, twenty-one institutional electricity and urban planning players, ten community representatives and local authorities, as well as market players and researchers. These cases illustrate that modes of access can be diverse, hybridising the conventional grid and other modes of off-grid electrification. The article shows that in two relatively similar urban contexts the ways of accessing electricity vary enormously.

[1] This article is the result of ongoing doctoral research by Mélanie Rateau which was started in 2017 under the supervision of Sylvy Jaglin (Latts, Université Gustave Eiffel) and Armelle Choplin (University of Geneva). This research is part of the Hybridelec ANR program: 'Electric hybrids: emerging forms of the energy transition in cities of the global South' (https://hybridelec.hypotheses.org).

In Nigeria – an electricity-exporting country – energy services exist but are not reliable. People have to deal with power cuts on a daily basis. In Benin – a country that depends on Nigeria for its supply – there is power but the network is insufficient. It is difficult to connect to the grid because of connection costs and long distances. In these two contexts, generators and solar panels are used to counterbalance the failing networks but their diffusion is not systematic or the same. Urban dwellers in Nigeria are using generators in addition to a near-universal but unreliable conventional grid. In Benin, solar is used as an alternative until it is possible to connect to the grid.

The first part of the article will seek to highlight the reciprocal relationships between electricity supply, urbanisation and globalisation in a context of new consumer demands. The second one will show the different ways of accessing electricity by using the examples of Ibadan and Cotonou. Finally, we will follow the solar panels and generators in question from their places of use all the way to their places of manufacture – mainly in China – in order to understand how these everyday objects end up on West African markets and thereby establish new links with global market circuits.

Electricity, urban consumption and globalisation

Incremental urbanisation and technical networks

The history of technical networks and that of urbanisation are intimately linked. The urban transition of Western countries that began in the nineteenth century has been marked by the paradigm of organising urban services into big centralised technical networks. This conventional network is reflected in a set of large-scale, centrally managed, interconnected facilities which provide a homogeneous service and contribute to the solidarity of the area they cover (Coutard and Rutherford, 2016). This network model spread worldwide both in the cities of the global North and South during colonialisation. Following independence, postcolonial governments perpetuated this model for water, sanitation, electricity supply and waste management services with the financial and technical support of international partners by means of international loans (Lawhon et al., 2017). However, the deployment of network services has not been able to achieve its goal of universal provision in cities where homogeneity and universality are not part of the main urban experience. On the African continent, nearly three-quarters of rural households do not have access to electricity because of their distance from the grid, compared with one-quarter of urban households, mainly in unplanned settlements (IEA 2019).

Urbanisation has been incremental (Silver, 2014; Clerc et al. 2017; Silver, Van Noorloos et al., 2019), [AQ2] occurring in a piecemeal, day-by-day fashion which is dependent on government-planned urban policies as well as on autonomous and subaltern urbanism which emanates from urban practices (Roy, 2011; Simone, 2006). This incrementality also pertains to the material spread of network services which struggle to keep up with the physical expansion of cities, population growth, but also urban heterogeneity. Services are deployed first and foremost in areas where urban development is planned and stabilised, leaving uncertain areas outside conventional networks. Technical networks are designed to last for the long term. They are irreversible and static by virtue of the technical and financial means needed to extend them (Coutard and Rutherford, 2016). Thus, the duality between planning and spontaneous urban practices

inherent in the urban fabric leads to inequalities in the opportunity to connect to network infrastructures and constant competition over resources. Faced with the absence of conventional networks, city dwellers have to make their own infrastructures.

Studies on technical networks in the cities of the global South agree in that they go beyond a simple opposition between formal and informal technical networks (Castán Broto, 2017; Castán Broto et al. 2017; de Bercegol and Monstadt, 2018; Furlong, 2014; Ghanem, 2018; Jaglin, 2014, 2016, 2019; Lawhon et al., 2017; Munro, 2019; Rateau and Jaglin, 2020; Silver, 2014, 2015; Smith, 2019). Castán Broto's work places research on energy challenges at the heart of the urban, whereas traditionally considered a rural issue (Castán Broto et al. 2017). Based on a reflection on energy sovereignty in Maputo, the author demonstrates the cultural and territorial anchoring of energy in the daily lives of city dwellers and questions their potential participation in urban energy planning (Castán Broto, 2017). Our research is a continuation of this reflection on urban, daily life and territoriality more specifically for the electricity sub-sector, to which we add the literature on infrastructure. The work done by Furlong (2014) has sought to extend the theories related to the transition of infrastructures to the context of the cities of the global South which are marked by hybrid and precarious infrastructures. Looking at water services, he has advocated recognising the coexistence of sociotechnical systems (rainwater storage, running-water networks, wells, etc.) as opposed to presuming the universality and uniformity of centralised networks. In the same vein, while noting the informal extension of power grids in the slums of Accra, Silver (2014) has argued that infrastructures are incremental. According to him, they are the product of social collaboration and material configurations through which city dwellers seek to generate access to new infrastructural worlds (Silver, 2014). Following the same logic, Lawhon et al. (2017) have put forward the concept of 'heterogeneous infrastructure configurations' in order to analyse the risks and power relations involved in the various types of access to sanitation services in an informal district of Kampala. Hybridisation therefore is intended as an angle of analysis which can help us understand the great heterogeneity of the ways in which urban services are supplied and accessed (Rateau and Jaglin, 2020).[2]

Thus, the emphasis laid on urban technical networks and their materiality becomes an entry point for an analysis of the networks of urbanisation actors. Infrastructure has become more and more social and relational. The provision of urban services requires a multiplicity of material objects whose development, availability in given areas, use and connection or purchase costs are the result of a multiplicity of actors and negotiations. National governments are not the only ones who make cities and their services. They negotiate their power to regulate and intervene within a network ranging from the micro-local to the global scale.

Urbanisation and an accelerating demand for electricity

In West Africa urban areas extend far beyond cities' administrative boundaries. They spread along the main roads which carry the many commercial traffic flows that sustain cities and their activities. In West Africa this spontaneous urban sprawl has formed a coastal urban corridor (Figure 1) along the Abidjan–Lagos artery and, by extension, Abidjan–Lagos–Ibadan (Choplin and Hertzog, 2020). This corridor is characterised by a succession of major metropolises where power and wealth but also many problems are

[2] See for example the Hybridelec group research project https://hybridelec.hypotheses.org/

concentrated – poverty, structural deficiencies in services and infrastructure, etc. This corridor is structured around a road infrastructure which, over nearly 900 km, allows goods and individuals to move. Big cities comprising millions of residents –Abidjan, Accra, Lomé, Cotonou, Porto-Novo, Lagos, Ibadan – are a few hundreds of kilometres apart. Between these dense centres, intervening spaces are filled with thousands of shops and houses under construction or barely completed as well as markets that come alive every day, thereby blurring the boundaries of each urban area. This corridor is expected to become the continent's largest urban concentration by 2050 (Moriconi-Ebrard et al., 2016).

The diffuse urbanisation dotted along the corridor reminds us that this is a space of circulation (of goods, merchandise, people) before being a space of production (agricultural or industrial). The wealth produced in and by these cities – most of them port cities – is above all linked to trade, import/export, and, more generally, service activities, while little of it is reinvested in production tools. Seventy-five per cent of the economic activities of these countries (BAD, 2016) [AQ3] are concentrated in this artery which allows the movement of 44 million people and 130 million tonnes of goods each year (ASH, 2015).

This urban corridor is therefore an area of intense exchanges; it helps to establish networks, it connects. And yet, at night, it is plunged into darkness – only the metropolises' city centres are lit. Conventional technical networks are unable to meet the needs of millions of urbanised people who nowadays need energy to light their nights but also to charge their mobile phones or plug in their televisions and fans. With the growth of the middle classes (Jaglin, 2019), particularly urban ones, new needs emerge which consume a lot of energy. In these humid tropical areas fridges are needed to store perishable foodstuffs, water pumps are often essential for the proper use of water networks, and air conditioners become sought-after as soon as they can be afforded – and this over and above the usual electronic and household appliances (gas cookers, freezers, water heaters). This growing use of household appliances raises questions insofar as it is not very frugal or sustainable (Lwasa, 2014).

This diffuse urbanisation requires networks to be extended, while the increase in individual demand for electricity forces an increase in the production capacity of the power grid. Network infrastructures, even incremental ones, are unable to meet this ever-increasing demand. In these African cities and their suburbs – these 'spaces of unconspicuous globalisation' (Choplin and Pliez, 2015) – millions of city dwellers live and demand to consume and have access to electricity in one way or another. They thus turn to commercial solutions (Rateau and Jaglin 2020): generators, back-up battery systems, solar panels, charging cabinets... The latest technologies are spreading by means of numerous development programmes and via global trade networks.

Among the corridor's metropolises, Ibadan and Cotonou – the two West African cities selected for this research, which are 250 km apart – have very different characteristics. Ibadan, once the largest precolonial sub-Saharan city (Chokor, 1986), is the capital of Oyo state in south-west Nigeria and the country's fourth largest city; its population was nearly six million in 2014 in a country of more than 191 million and with a GDP per capita of $1,962 (AfDB, 2018).[3] Lying on the Atlantic coast, Cotonou is the economic capital of Benin. Its urban area exceeded two million inhabitants in 2017, in a

[3] Population figures from https://www.populationdata.net/

country with eleven million inhabitants and a GDP per capita of $806 (AfDB, 2018). Although these two cities are physically close, they have two very different types of electricity supply.

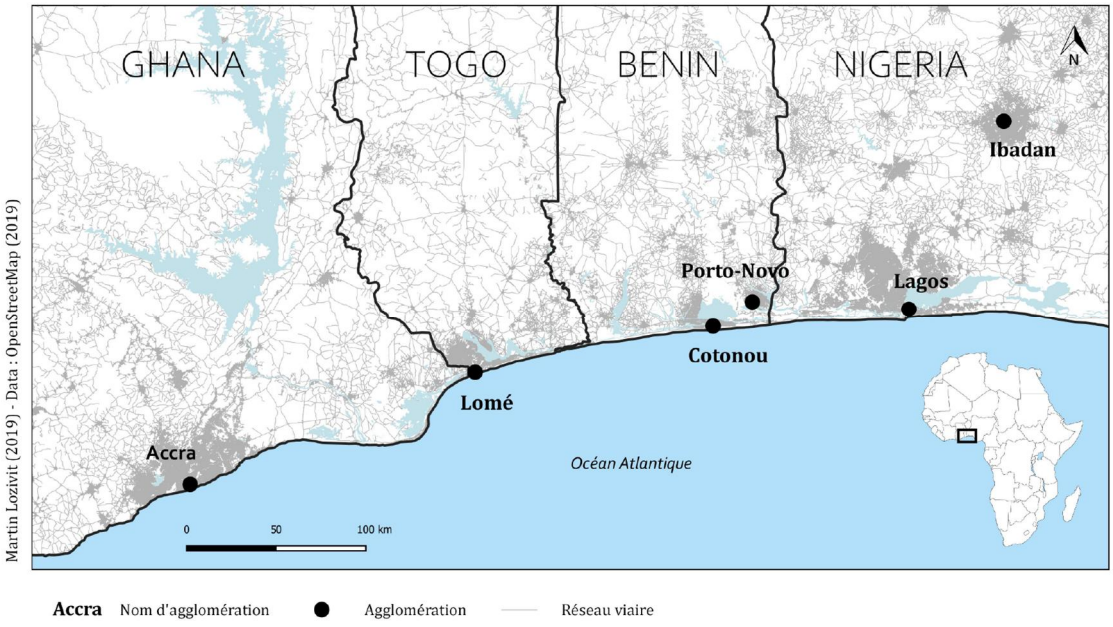

Figure 1 Map of the West African coastal urban corridor from Accra to Ibadan

Low-tech and smart grid in African cities

In order to meet the needs of the emerging middle class in sub-Saharan Africa and as part of a strategy to conquer a market of millions of poor people, companies are innovating to offer products adapted to local constraints (Haudeville and Bas, 2016). Multinationals are coming up with strategies to win over middle-class and 'bottomof-the-pyramid' (BoP) consumers. Market players are betting on the emergence of these future consumers and court them by lowering the prices of their products and offering payment facilities (Cholez and Trompette., 2013). Many of the innovations now on offer are inspired by the low-tech movement (Bihouix, 2014) and the Indian concept of *jugaad* (Radjou et al., 2012) which often translates into frugal innovation. This type of innovation aims to enable access to new technologies at low investment costs by focusing on do-it-yourself and local initiatives. Other terms also come close to this low-cost, good-enough movement – bottom-up innovations, innovations by usage, creole technologies (Edgerton, 2017) – and see the countries of the South as 'the world's future innovation lab' (Huet et al., 2013).

This type of innovations can be found precisely in the field of electricity access. It is even supported by development aid players who, in their electrification programmes for rural areas, rely on off-grid and branded technologies, even if local markets already offer low-cost and unbranded technologies (Grimm and Peters, 2016). On this subject, the work conducted by Grimm and Peters (2016) in several African countries shows that unbranded products that are criticised by electrification programmes for their poor quality are certainly inferior in terms of durability, but not necessarily in terms of service levels. As a consequence, the poorest households equip themselves with these low-cost products

because the short durability is compensated by the considerably lower purchase prices. Conversely, the solutions put forward for the urban environment are more high-tech and large-scale. West African states are developing the interconnection between their power grids in order to create a subregional electricity market: the West African Power Pool (WAPP). At the same time they support the production of electricity from renewable energy sources. Since these energies are intermittent, governments and their partners are developing ideas on smart grids for urban areas (Africa Progress Panel, 2017) in order to better coordinate all the links in the electricity network (production, distribution, consumption and possibly energy storage).

However, it is in these same urban areas where this high-tech logic is often barely accessible to most people and where the conventional grid does not provide electrification for everyone that heterogeneous technologies coexist. That is why, although they are promoted as an electrification solution adapted to rural African contexts, off-grid technologies can be found on the electrification market for city dwellers. In Benin, a recent study has surveyed more than 10,000 consumers of solar technology paid for via mobile banking services (pay as you go). This emphasises that the target clientele must be solvent. Therefore, the majority of customers are in electrified urban areas, far from the objective of rural electrification (Barry and Creti, 2020). And more generally, off-grid technologies are often adopted first in urban environments and then they spread to other areas (Jaglin, 2019). On urban markets we can find at one and the same time automatic-ignition generators, manual-ignition generators, domestic solar systems designed to electrify an entire home, solar lamps that only provide lighting, mini solar kits for preset uses, back-up batteries for storing electricity, etc. Urban electrical configurations are powered by complementary and sometimes contradictory dynamics: low-tech/high-tech, formal/informal, grid/off-grid, market/non-market, etc. Thus, different ways of accessing electricity are combined and hybridised. In the areas where we conducted our fieldwork, the electrification solutions visible in the urban space are various but, in the middle of this heterogeneity, some local specificities stood out. Power grids are the most common way of accessing electricity in the households we came across in both Ibadan and Cotonou, while the off-grid markets differed. In Ibadan generators are everywhere, while in Cotonou solar panels are increasingly visible.

Nigeria and Benin: neighbours with distinct network services

Inherited colonial electrification

The beginnings of electrification in Nigeria date back to the British colonial era, while in Benin to the French colonial era (Ohwofasa and Kumapayi, 2013; Sotindjo, 2010). At the time, electricity services were limited to their respective colonial capitals – Lagos and Cotonou – for the benefit of a mainly European population.

Electricity came to Nigeria through Lagos in 1896 and it was only after the merger of the protectorates of northern and southern Nigeria in 1914 that other cities set up their own electricity supply services (Awosope, 2014). In this context, Ibadan's power grid was not inaugurated until 1940 (Falola, 2012). The production and distribution of electricity were decentralised until the creation in 1951 of the Electricity Corporation of Nigeria and the setting up of the first power line between the power plants of Ijora in Lagos and Ibadan (Utazi and Obuka, 2014). The Niger Dams Authority was then founded

with the aim of building hydroelectric dams. In 1972 the merger of the Electricity Corporation of Nigeria with the Niger Dams Authority gave rise to the National Electric Power Authority (NEPA) (Utazi and Obuka, 2014). NEPA was responsible for the production, transmission, distribution and supply of electricity. The NEPA acronym is still used in everyday language to refer to the electricity from the conventional grid.

In Cotonou the first electrical equipment was installed by the colonial administration in 1926 (Sotindjo, 2010) when Benin was still called Dahomey. The first overhead power line connecting Cotonou to Porto-Novo was only built in 1952 (SBEEDES, 2014). In 1955 the installations which had until then been publicly managed were entrusted to a French limited company: the Compagnie Coloniale de Distribution d'Énergie Électrique (EDF, 1949). Following the independence of Dahomey in 1960, the Compagnie Coloniale kept its acronym CCDEE but was renamed Compagnie Centrale de Distribution d'Énergie Électrique, then the Compagnie Centrale de Distribution d'Eau et d'Énergie (SONEB, 2013). In 1973, under a revolutionary MarxistLeninist-inspired regime, the Dahomean government nationalised the company. In this way the electricity sector passed from the hands of the French company into those of the Beninese government (Djogbenou, 2017). In 1973 the Société Dahoméenne d'Électricité et d'Eau was created, then renamed the Société Beninoise d'Électricité et d'Eau to reflect the change in the country's name. In 2003 this company was split in two: the Société Nationale des Eaux du Benin for the water component and the Société Beninoise d'Énergie Électrique for the electricity component.

The development of the power grid in the areas we looked at has always been planned by a central authority which was first connected to the colonial power, then to the federal government in Nigeria or the state in Benin. The infrastructure not only supports the electricity flow, it is also a manifestation of the central power. Larkin (2008) uses the phrase 'colonial sublime' to refer to 'the use of technology to represent an overwhelming sense of grandeur and awe in the service of colonial power' (Larkin, 2008, 7). According to this researcher, these links between the figurative logic of the infrastructure and the show of centralised power intensified with independence. However, in the areas we looked at electricity infrastructure policies [AQ4] have taken two distinct directions. In Nigeria – an electricity-exporting country – the sector has been privatised and decentralised, while in Benin – a country that depends on Nigeria for its supply – it remains public and centralised.

Privatisation and decentralisation of an erratic service in Ibadan

The year 2005 is a key one for the Nigerian electricity sector. It was marked by a reform which saw the sector's privatisation and decentralisation with substantial support from the World Bank (Ohwofasa and Kumapayi, 2013; Taccoen and Legrand, 2016). NEPA was replaced by a transitional company: the Power Holding Company of Nigeria which resumed its activities during negotiations with investors. In 2013 the negotiations ended successfully and the transitional company was broken up and privatised (Ley et al., 2015). Today Nigeria's electricity sector includes six generation companies, a transmission company of Nigeria, eleven distribution companies, a Nigeria bulk energy trader which manages agreements for buying and selling electricity, and a regulatory body known as the Nigerian Electricity Regulatory Commission (DG Trésor, 2016). Reforms in the sector are continuing, particularly with the encouragement of technical and financial partners (World Bank, European Union, German cooperation, etc.), in order to make the

transition to renewable energies.

In this context, the electricity supply service in Ibadan is provided by the Ibadan Electricity Distribution Company (IBEDC) which was created on 1 November 2013; its main investor is a Nigerian company chaired by General Abdulsalami Abubakar, Nigeria's former head of state. The management of IBEDC was delegated to a Philippine company as part of a technical services partnership (Energy Mix Report, n.d.). Despite privatisation, the quality of the service remains erratic. IBEDC frequently complains on social networks that it does not receive enough electricity to fully satisfy demand from its subscribers. However, this accusation has been contested by the federal minister for energy who has pointed out weaknesses in the distribution companies that have led them to refuse a part of the electricity they are given (AllAfrica, 2018). IBEDC has explained that it does refuse it in order to prevent electricity theft and thus avoid further loss of income (Olajedo, 2017).

This theft of electricity should be qualified in view of our findings in the field. Indeed, a household wishing to connect to the grid has two official options. It can either apply for a meter, which is a slow and expensive process, an application for a residential meter costing between N24,000 (€60) and N54,000 (€135)[4]. Or it can simply make a connection application to the IBEDC field agent. This procedure is not illegal or informal since the household is recorded in the customer files and receives an estimated monthly bill. This billing method is regulated by the Nigerian Electricity Regulatory Commission. However, given the very poor quality of service, consumers consider that the estimated bills do not reflect their actual consumption and decide to pay only a part of it. Nevertheless, the whole billed amount is due; the portion not paid by a subscriber is carried over to subsequent bills, thereby increasing their debt to IBEDC which treats the debt as electricity theft.

In Ibadan it is more difficult to be supplied with electricity than to be connected to the grid. Our field surveys show that the connection to the conventional grid is almost universal: only one household interviewed was not connected to it and this was by choice. On average, IBEDC provides this service for less than seven hours a day (IEWI, n.d.). During the long hours of power cuts, households try to get their electricity from individual electrification devices. Thus, the self-production capacity per generator exceeds the production capacity of the conventional grid which is limited to 4,500 MW because of the disrepair of many installations (World Bank, 2014). A recent US study has estimated that the electricity production capacity of small generators (less than 4 kVa) is eight times greater than the capacity of the conventional power grid. Faced with recurrent outages, Nigerians in Ibadan as elsewhere have little confidence in the electricity service and more broadly in the state. These failures in networked electrical service are the tip of the iceberg and hide more important political failures. Electrical unreliability has its origins in deep-rooted structural and political causes, as the Nigerian economist Erik Ogunleye suggests (2017). He gives several explanations including the long-lasting monopoly and overregulation of the sector by the government, the state of insecurity in the country, the weak political will to invest in the sector, the strong ties between industrial and political sectors and so on. Indeed, the NEPA acronym is often ironically changed by Nigerians to 'Never Expect Power Again'.

[4] https://www.ibedc.com/help/understand-your-meter/get-a-meter/ [AQ5]

A centralised but inaccessible public network service in Cotonou

Since 1 January 2019 the national electricity company SBEE has increased its remit. Up until that point it had operated exclusively within the country, leaving the negotiation of purchase agreements and the production and transnational transmission of electricity to the Communauté Électrique du Benin which is a joint two-state enterprise with neighbouring Togo. Today the main activity of this organisation is managing the transmission network coupled with the continued operation of certain power generation sites that supply both countries. The purchase and production of electricity meant for Benin is therefore the remit of SBEE (Edorh, 2018). This centralisation has taken place in parallel with reforms undertaken under the aegis of a US aid programme administered by Millennium Challenge Account. This programme aims to improve the quantity and quality of the electricity supply service while developing renewable energies by means of institutional reforms, reinforcing production and distribution facilities and promoting access to off-grid electricity (MCC, 2015).

Millennium Challenge Account is not the only development project involved in Benin's electricity sector. Thus, its programme includes a coordination component to ensure that the various contributions from technical and financial partners are complementary. One of the many partners is the Agence Française de Développement (AFD) which has been running a project for building a solar power plant in Pobé (around 100 km north of Cotonou). These production contributions are explained by Benin's heavy dependence on electricity imports from Nigeria. When this latter main supplier encounters difficulties, repercussions are felt in Benin (Agbon, 2019). The country is therefore seeking to become electricity independent. In order to ensure a steady supply until development projects materialise, the current government – elected in 2016 – has negotiated a 60 MW purchase agreement with a Nigerian producer and leases generators with a total capacity of 150 MW (FAD, 2017). For the moment, this solution – unsustainable over time – has doubled the network's maximum peak capacity of nearly 200 MW in 2013 (MERPMDER, 2015). The residents of Cotonou acknowledge that the situation has improved since 2016. A household that was interviewed illustrates this improvement in the supply of electricity from the conventional grid by giving this example: 'My generator? It is for sale. I've only used it for ten hours in four years' (interview, Cotonou, 21 April 2018).

In this context, in Cotonou the first difficulty encountered by households in terms of benefiting from the electricity service is not so much the poor quality of the service as the difficulty in getting connected to the grid. Authorities estimate that the access rate to the conventional grid in Cotonou is 99 per cent since their calculation method only takes into account the population living in electrified areas (MCA-BÉNIN II, 2016). This does not reflect the realities on the ground at the level of households. Connecting a home to the conventional grid is expensive. A connection application costs at least CFA 90,000 (€137) (interview, Cotonou, 20 July 2017), the equivalent of two minimum wages. In practice, the whole procedure easily amounts to CFA 200,000 (€305) (interview, Cotonou, 28 June 2017). And this is not the only hurdle to getting connected. To be eligible, the home must be located close to the conventional grid which covers only planned urban areas. In the unplanned areas of Cotonou, the inhabitants face similar obstacles to those faced by the rural population: either electricity may not be physically available in the local area or the high initial costs that the consumer must pay for a

connection to the grid are unaffordable. Thus, if the cost of electricity is a significant barrier, the cost of connecting is another big deterrent (Golumbeanu and Barnes, 2013).

Outside this, households practise arrangements tolerated by SBEE. Some people apply for a meter and install it outside their homes as close as possible to the grid, then cobble together a connection using unsafe materials locally called a 'makeshift network' or a 'spider's web'. Others choose to buy grid electricity from a reseller who bills them on a flat-rate or kWh basis. Consumers connected in this way are exposed to the risk of accidents and fires. In addition, they have to put up with higher prices and reduced quality of service which limits their use of household appliances. These 'spider's webs' are tolerated because electricity is not stolen from the SBEE, unlike other forms of informal networks such as those described in Kenya. De Bercegol and Monstadt (2018) have observed in Nairobi that informal electricity resellers connect directly to transformers to supply a large number of customers. The authors describe an electricity resale mafia that steals electricity from the power utility.

Thus, the power grid infrastructure involves the institutions officially in charge of the service, development partners from the international community, as well as local informal resellers, field agents and households. This incremental infrastructure reflects a central power limited to a few planned urban districts, leaving room for micro-local power games but also the appropriation of a globalised commercial offer of electricity-self-generation technologies.

Generator and solar panel: two markers of the urban landscape

'I better pass my neighbour' generator in Ibadan

Entire sectors of Ogunpa market as well as many other markets in Ibadan are dedicated to the sale of generators of all brands, all power types, new or second-hand. They are displayed in their boxes or unpacked, inside and outside shops. Generator frames strung around posts indicate the presence of a workshop which is most often made of sheet metal. Repairmen also do maintenance work (Figure 2). They can be found in all neighbourhoods which goes to show the economic importance of this sector. Shops specialising in household appliances also sell generators for households, which are always new. Nigeria is the biggest market for these devices with more than half of its households owning one (Douet, 2015). The prevalence of petrol or diesel generators is clearly linked to the cheap subsidised oil in Nigeria which is the leading hydrocarbon-producing country on the African continent. The subject of fuel subsidies is very political and conflictive. Every time the subsidies are modified, the federal government exposes itself to protests in which city dwellers and trade unions demonstrate their anger against politics and corruption, sometimes leading to deadly riots (BBC News, 2012; Mark, 2012).

The urban landscape is marked not only by generators for sale but also by those used daily by businesses and for different activities. The Mokola area in Ibadan is a working-class district known for being the home of the city's printers. It is also known for its decibels produced by the drone of the many generators scattered along the roads. The more a district is working-class, the less it will be connected and have access to electricity services, and the louder the noise of small and therefore noisy generators will

be. While shops' generators clutter Ibadan's pavements and roads, households install theirs out of sight, often in the backyard. The wealthiest use self-igniting units which take over from the back-up battery systems that extend the supply of electricity from the grid. Most emerging-class consumers have a generator which they switch on in the evenings during power cuts and when they can afford the fuel. Among the less well-off, it is the mini set nicknamed 'I better pass my neighbour' with a power equal to or less than 1 kVA which is the most widespread (Nicolas, 2018). In Nigeria generators act as social markers. The power, age, size and quality of a generator provides information on the rank and success of its owner, as reflected in the bestselling Nigerian author Chimamanda Ngozi Adichie's novel *Americanah* in its passages on Lagos (2013).[5]

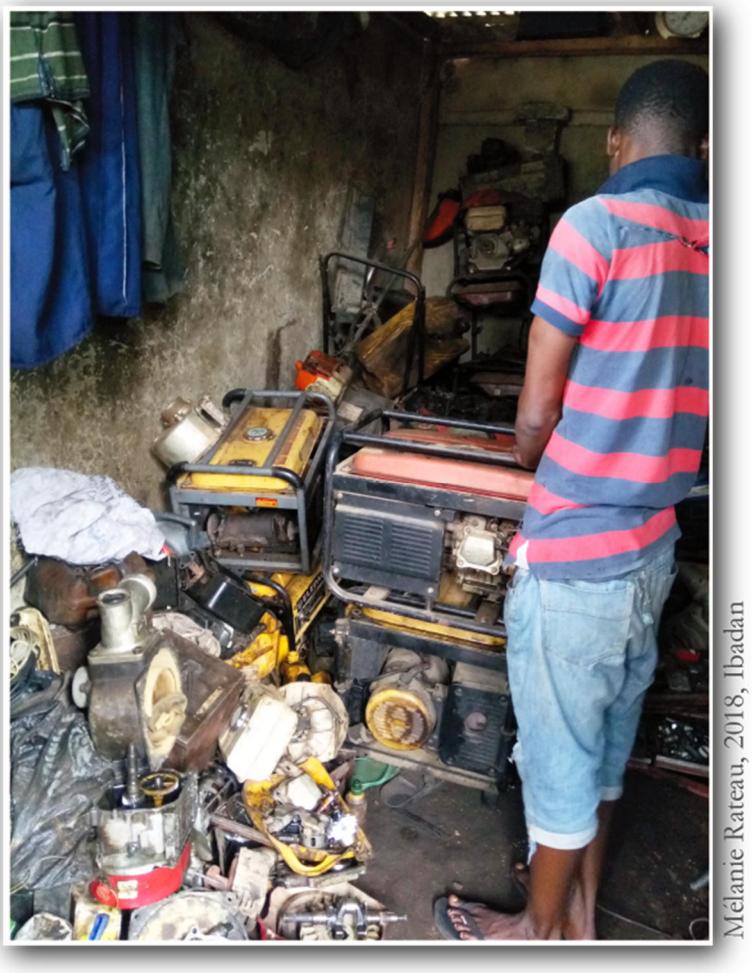

Figure 2 Workshop of a generator repairman where old engines and spare parts mix

The generator market is sufficiently segmented to adapt to different needs and types of purchasing power. The biggest generators of several thousand kVA are intended for large industries, while medium-sized engines are targeted at small industries and service companies. Some wealthy households are also equipped with the latter but the largest part of the market for households is made up of small portable sets of 1 to 8 kVA.[9]

[5] '"Her generator is as big as my flat and it's completely noiseless", Ranyinudo said. "Did you notice the generator house on the side of the gate?' […] This was what a true Lagosian should have noticed: the generator house, the generator size' (Ngozi Adichie, 2013, 485).

However, 'I better pass my neighbour' generators are now banned from being commercially imported in order to limit urban pollution,[6] and this has angered consumers. Journalist Omotola (2015) reports the words of one of them: 'How will we be able to pay a bigger one? […] This gen is cheap and does not consume much fuel. If I buy N400 (€1) fuel, it will last me 8 hours, unlike the bigger one which consumes N500 (€1,25) worth of fuel in less than 2 hours'.

Thus, generators are a central part of Nigeria's daily life. Authorities are trying to regulate their trading by limiting their importation. It should be noted that the subsidies for the fuel used to power generators represent between 3 per cent and 5 per cent of government expenditure (A2EI, 2019) and, at the same time, the electricity sector is in deficit because of non-payment. In Benin, where petrol costs twice as much as in Nigeria, solar panels are most visible in urban landscapes.

Default solar panels in Cotonou

An urban motorcycle-taxi ride from the major Godomey interchange to the central node of Etoile Rouge offers an overview of the wide range of solar panels on offer in Cotonou. Under the interchange, at around 10 o'clock in the morning informal traders spread their solar goods on trestles or cardboard laid on the ground. The offer is very diverse. It ranges from solar lamps through all-in-one kits (CFA 20,000 – €30) to solar panels, converters and assemble-yourself batteries. But the seller reassured us the connections were very easy to do. He even showed us how by using cables with clamps at the end. And the quality? He explained it was German quality, even though the devices came from China and their packaging boxes proudly displayed the Eiffel Tower under the name 'Palis' in a nod to Paris (interview, Cotonou, 21 June 2018).

A little farther on the same road other solar panels were displayed on the pavement outside shops selling household appliances, hardware, audio-visual equipment, etc. Here there were no specialised sellers. They offered equipment based on customers' purchasing power but not their energy needs. In order to get an energy diagnosis customers needed to go a little farther to a specialised shop. Sellers here were specialists in this sector. They provided advice and easily redirected customers to a technician or installer working for the shop. They sold solar lamps (CFA 17,000 – €26), kits (CFA 80,000 – €122), and all the equipment needed for a home solar system, namely, solar panels, batteries, voltage regulators and converters (all from CFA 500,000 or almost €800).

The solar equipment in this shop was subsidised by the German Cooperation [AQ6] (GIZ) in Benin as part of its ProMaBiP [AQ7] project. It was also 'Lighting Africa'-certified – a joint programme between the International Finance Corporation and the World Bank which seeks to promote the solar lighting market through certification. These kits were supposed to support a rural electrification plan and yet they were found on the stalls of the economic capital. The prices displayed, although subsidised, are higher than those of informal sellers. But this specialist [AQ8] succeeded in attracting emerging-middle-class customers thanks to pay-asyou-go payment facilities. Customers make a down payment and then continue to pay monthly via Mobile Money – they thus make the payments using their mobile phones and receive a code they need to enter in the equipment in order to reactivate it (interview, Cotonou, 2 August 2017 and 04 August

[6] The individual importation of these mini-generators is still allowed, see Pulse (2015).

2018). However, these payment facilities do not target the poorest. A sales manager for a brand of solar kits explained to us that the amount required for the first payment was deliberately high in order to exclude customers who could not keep up with their payments (interview, Cotonou, 28 July 2018).

Figure 3 Informal sellers of solar equipment under the Godomey interchange in Cotonou

Although the supply of solar panels is highly visible in the urban landscape, household adoption is less so. A few well-off households which are well served by the conventional grid have had solar panels installed to control their energy costs and thus reduce their bills. Their generators remain silent. In the case of emerging-middleclass households, it is not common practice to use a solar system in addition to the grid. Rather, these devices compensate for the lack of a reticulated supply in urban pockets and peri-urban areas which neither the conventional grid nor misfortune networks manage to reach. Households equip themselves gradually so as to spread out the costs. For example, one owner explained to us that she first bought a CFA 50,000 (€76) panel, then a CFA 40,000 (€61) battery for lighting, and another which cost CFA 220,000 (€336) to power the television and fans (interview, 12 June 2018). She made her purchases 'on the road, they sell it everywhere'. Just like the other households electrified by a solar home system, she said she had chosen solar power while waiting for the grid to arrive. She would have liked to use a refrigerator but could not afford the necessary solar investment. She was also forced to control her consumption during the rainy season so that the batteries could last throughout the evening. Currently households using solar home systems are forced to consume frugally while their desire for 'unlimited' consumption means they hope for the grid's arrival in the near future.

The solar device offers available on the Cotonou markets involve distinct globalised networks: development aid actors for subsidised equipment, multinational companies for BoP strategies such as Pay As You Go, and commercial networks of

'unconspicuous globalisation' (Choplin and Pliez, 2015) for equipment sold on informal stands. These solar panels and generators – mostly made in China – are thus markers of the integration of these spaces into globalisation.

Following the 'electric' thread of globalisation: local markets, global networks

In November 2016 Cotonou hosted a China–Benin summit at the Chinese Centre for Economic and Commercial Development, a large new building located in the city's oldest district. Traders came mainly from Ningbo – a large port city in China's eastern coastal area – and their travel costs had been paid by the municipality. One of them explained in English he was 'on tour': 'We are doing fairs: two days in Lagos, two days in Cotonou and two days in Lomé'. All sorts of products were on display: hair extensions, artificial tinsel and Christmas trees, but also and above all, solar panels and generators. In Cotonou as elsewhere in the region products 'Made in China' – considered low-end and poor quality – suffer from a poor image. Local sellers generally tend to hide the Chinese origin of their products. The manager of a solar shop in Cotonou who sold Sun King brand kits assured us: 'The kits are of good quality because they are made in the United States' (interview, 14 July 2018). However, during a second meeting a year later, he confided that his container from China had been blocked for three months at the port of Cotonou. He then felt the need to justify himself: 'The kits are only packed in China'. The American company GreenLight Planet which owns the Sun King brand clearly states on its website that it 'designs, distributes, and finances solar home energy'.[7] However, its manufacturing plants are not in the States but in China.

The port is not the only gateway for electrification technologies in Benin. Generators and solar panels come from Nigeria by road, sea or lagoon thanks to certain populations such as the Yoruba and the Toffins who move between Cotonou and Lagos. This movement of goods along the Benin–Nigeria border explains why the most advantageous purchase prices can be found at the Porto-Novo market and rural border markets (in Ifangni or Adjarra). Just like the adulterated petrol known locally as Kpayo which is produced in Nigeria and used to power most motorcycles, cars and generators in Benin, these products often cross the border fraudulently by bypassing (or working in cahoots with) customs posts, which gives rise to high political tensions. Indeed, Nigeria closed its border with Benin from September 2019.

In Ibadan, street names such as Lebanon Street are a reminder that, just as with construction and motorised equipment, the importation of generators is linked to the long-standing presence of the Lebanese diaspora which is very visible and powerful in the Gulf of Guinea (Falola, 1990; [AQ9] Akyeampong, 2000; [AQ10] Rosenfeld, 2018). These Levantine businessmen supply shops with new Tiger, Elepaq and Firman brands of generators imported from China (Figure 4). Today it is also possible to buy generators from online trading sites such as Jumia or Alibaba. These new generators made in China face direct competition from the 'newcomers' – second-hand Western-brand generators (Honda, Yamaha, Mitsubishi) coming from Europe for a second life in Africa. Thus, for the same price, some argue that it is better to buy a second-hand 'gen' from Europe, whose brand is supposed to guarantee a longer life than a new generator newly arrived from

[7] https://www.greenlightplanet.com/sun-king-greenlight-planet/

China (Grimm and Peters, 2016). As for the spare-parts market, this is largely monopolised by the Igbo, the Nigerian group which fled the Biafran war (1966–1970) and the instability that has characterised that region ever since. The Igbos – who think 'the world is a marketplace' as an Igbo saying goes (*uwa bu ahia*) (Agozino and Anyanike 2007; [AQ11] Chukwuezi, 2011) [AQ12] – have a monopoly over the spare-parts sector throughout West Africa.

Thus, these solar panels and generators – objects of Africa's commonplace everyday life – suggest a complex interweaving of trade networks which connect this world's both large urban markets and poor peripheries with Asian and Western production spaces.

Figure 4 Shop selling Chinese-brand generators and water pumps

Towards a frugal and/or (fr)agile electrification?

Power grids, generators and solar panels provide a better understanding of the production of the urban in West Africa. These objects and electrical wires – symbols of globalisation connecting Africa to Asia – are a material manifestation of this megacity region under construction (Choplin and Hertzog, 2020) and the unequal development between and within countries and cities. Solar panels and generators can be seen as material and

symbolic indicators of 'the post-colonial electricity geography that is emerging in Africa' as Munro (2019 [AQ13]) explains: the electric lives of urban dwellers are more linked to the Sino-African trade roads than to the national grid.

Our research underlines different relations to these national grids. In Ibadan, connection to the conventional grid is almost universal among the households interviewed, but the electricity supplied is of poor quality mainly due to long hours of power cuts. Every day, electrical appliances function thanks to generators which secure access to electricity. In Cotonou, some households face dissuasive connection costs or the absence of the grid which prevents access to electricity through the conventional grid. As a result, they arrange to make 'spider's webs' or buy solar technologies while waiting for a grid solution.

Generators and solar panels show that globalisation and its carriers – development partners, big companies and small consumers alike – are adapting to local ways of accessing electricity. Commercial technologies – including the solar equipment promoted by development programmes – and living practices that combine several modes of access make it to some extent possible to overcome the failures or absence of networks. Globalisation also brings international standards such as the development of renewable energies together with sets of reforms. But the hybridisation of these logics fails to conceal the urban inequalities of access to energy services related to electricity consumption. Because in Africa, as elsewhere, to be connected is to exist. In an urban context, it is also a way to express one's belonging to the city and to become a citizen (Pilo', 2020). Therefore, the high demand for electricity from millions of poor people and emerging classes is not only related to needs – it is also symbolic. These growing desires and needs obviously raise crucial environmental questions in these times of climate crisis. It is an important issue in Nigeria where people are equipping themselves massively with generators in order to cope with an intermittent supply of grid electricity. And this has consequences for the environment and health, as pointed out by Adesina (2012, 8): 'Another major environmental hazard associated with globalisation is the influx of generating sets, commonly called generators in Nigeria'. Generating sets make the city unpleasant through their noise and odour nuisance, but above all they cause harmful and dangerous pollution. In an urban context, they aggravate the concentrations of fine particles which frequently exceed the thresholds set by the WHO because of domestic fires, the use of domestic charcoal for cooking, the driving of out-of-date vehicles running on adulterated petrol and the burning of waste in the open air (Evans et al., 2018). This massive use of generators is indirectly subsidised by the federal government through fuel subsidies. This point underlines the government's accountability and its decisive role in improving the situation. Rather than substituting generators with the grid, which seems an unachievable utopia in the immediate future, the discussion should focus on reducing the pollution emissions from the generators already in use, which are essential to securing access to the grid.

At the same time, the growing use of solar panels raises a number of questions. As an off-grid and branded technology, solar energy is supported by the development aid community and presented as the green and ecological solution to limit the carbon footprint. However, the production of lithium batteries that power solar panels is a sensitive issue. What about lithium extraction? And what happens to these batteries and solar systems once they no longer work and when the network arrives? As dry batteries from torches dumped in inappropriate places, batteries will raise environmental and health problems if no waste management is planned (Bensch et al., 2017). The issue is all

the more crucial for low-end, unbranded solar technologies that are less durable. Will they end up in those huge e-waste dumps like the one sadly known in the Agbogbloshie district of Accra? On the one hand, the question of the development of off-grid technologies inspired by the low-tech movement, the Indian concept of *jugaad* and frugal innovation is interesting and calls for new reflections. But, on the other hand, low-tech should not become a default solution. The risk is reducing low-tech to low-quality products and low-cost solutions, turning these countries and cities in the global South into connected but second-rate places offering cheap, disposable, low-quality services, objects, networks and technologies (Jaglin, 2019). As Bensch et al. (2018) suggest, electrification programmes and subsidies for branded products would be justified by an end-of-life management argument for these technologies, due to a lack of convincing quality/price compromises for the poorest inhabitants. Supporting low-tech but also 'better-quality' products could become an anti-poor policy.

Meanwhile, it is likely that in Benin as in Nigeria people will continue to follow the news about electricity just as those in Europe do about rain and good weather. One can safely assume that the novelist Chimamadah Ngozie Adichie (2015) will continue for quite some time to ask her gateman 'How has light been?'.

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