SUSTAINABILITY, INCLUSIVENESS AND GOVERNANCE OF MINI-GRIDS IN AFRICA (SIGMA) RESEARCH PROJECT

Of monopolies and mini grids: case studies from Kenya, Tanzania, Nigeria and Senegal

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ABSTRACT

Recent advances in decentralised renewable electricity systems have undermined long-held assumptions that electricity access and rural electrification can only be achieved via the extension of the national grid. Renewable energy and solar hybrid mini grids are being promoted as one low-cost option to meet Sustainable Energy for All's commitment to universal energy access by 2030, because of their potential to connect low-income, rural and/or dispersed communities for whom the cost of extending the main grid is considered too expensive. As this paper discusses in relation to four countries in sub-Saharan Africa: Kenya, Tanzania, Nigeria and Senegal, in recent years new private sector actors in renewable energy mini grids have started to emerge, marking a shift away from large-scale diesel or hydro mini grids run by government utilities, and small-scale mini grid development previously led by bi-lateral donors and community organisations on a project-by-project basis. However, there have been considerable governance and regulatory challenges to the development and deployment of renewable energy mini grids at scale, which has often taken place in the absence of national regulation rather than because of it. Moreover, some state-owned electricity utilities and associated institutions have been resistant at once to new private sector actors and decentralised systems. Meanwhile, the term 'mini grid' lacks a common definition and is simultaneously associated with energy access as well as productive use, despite the often-competing objectives of these end uses. This paper unpacks some of these dynamics through an extensive desk-based study of grey and academic literature and a regulatory comparison of the four case study countries. Building on scholarship from development and energy geography, we argue that a more granular analysis is needed in order to account for the complex and evolving processes of electricity decentralisation in low- and middle-income countries.

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Acronyms

AC	Alternate current
AMDA	Africa Minigrid Developers Association
ANER	L'Agence Nationale d'Energies Renouvelables
ASER	L'Agence Sénégalaise d'électrification rurale (Senegalese Agency for Rural Electrification)
CRSE	La Commission de Régulation du Secteur de l'Électricité
DC	Direct current
DisCos	Distribution companies
DFI	Development finance institution
EPRA	Energy and Petroleum Regulatory Authority
EPSRA	Electric Power Sector Reform Act (Nigeria)
ERC	Energy Regulatory Commission
ERIL	Electrification Rurale d'Initiative Locale
ESMAP	Energy Sector Management Assistance Program,
EWURA	Energy and Water Utilities Regulatory Authority
FCDO	Foreign Commonwealth and Development Office
GenCos	Generating companies
GW	Gigawatt
IEA	International Energy Agency
IPD	Independent Power Distributor
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
KPLC	Kenya Power and Lighting Company
kW	Kilowatt
LPDSE	La Lettre de Politique de Développement du Secteur de l'Energie
MoEP	Ministry of Energy and Petroleum
MPE	Ministère du Pétrole et des Energies
MW	Megawatt
NEP	National Electrification Project
NEPA	National Electric Power Authority (Nigeria)
NERC	Nigerian Electricity Regulatory Commission
NGO	Non-governmental organisation

PHCN	Power Holding Company of Nigeria
PSE	Plan Sénégal Emergent
PV	Photovoltaic
REA	Rural Electrification Agency (Kenya, Nigeria)
REA	Rural Energy Agency (Tanzania)
REF	Rural Electrification Fund (Nigeria)
REMP	Renewable Energy Master Plan
RESIP	Rural Electrification Strategy and Implementation Plan
SDG7	Sustainable Development Goal 7
SEforAll	Sustainable Energy for All
Sénélec	Société nationale d'électricité du Sénégal
SHS	Solar home system
SPP	Small power producer
TANESCO	Tanzania Electric Supply Company Limited

1. Introduction

In recent years significant progress has been made towards achieving Sustainable Development Goal 7 and the UN Sustainable Energy for All (SEforAll) initiative to provide universal access to electricity by 2030. According to the IEA, the number of people without access to electricity stands at 770 million, a figure which has declined steadily since 2013 (IEA 2019). Of this, approximately 580 million people live in sub-Saharan Africa, accounting for nearly 50 per cent of the continent's inhabitants. However, the realisation of universal access is unlikely to be met if current trends are followed and has been further undermined by the Covid-19 pandemic (IEA 2020). Moreover, many households that are counted as having an electricity connection suffer from an unreliable and poorly functioning supply. While the World Bank's multi-tier framework has gone some way to account for this (World Bank 2015), conventional measurements still dominate global statistics on electricity access (Ulsrud 2020).

It is well-acknowledged that tackling the energy access gap requires nothing short of a socio-technological transformation in which decentralised and off-grid renewable electricity generation, including mini grids, will play a key role (Peters et al 2019, Odarno et al 2017). According to the IEA, the construction of 100,000–200,000 mini grids could serve an estimated 140 million rural Africans by 2040, while an additional 80 million people could be served by off-grid systems (IEA 2019). These new systems are anticipated to displace or at least compete with the centralised electricity system of generation, transmission and distribution, which is dependent for the most part on conventional thermal and large hydro-electric sources (Ockwell and Byrne 2016).

To date, mini grids in sub-Saharan Africa have been built, owned and operated under various models by various entities including state-owned utilities, public sector agencies, NGOs, local communities, the private sector, or some or all of the above depending on the political and socio-economic context of the country or region in question and the size and structure of the mini grid (Knuckles 2016). Some of the largest developers of mini grids to date have been national utility companies, including TANESCO in Tanzania and KPLC in Kenya, where mini grids have for the most part been hydro or diesel-powered respectively. However, in recent years there has been a growing shift to solar powered or 'third generation' mini grids by private sector developers and investors, who are anticipated to drive future growth in the industry (ESMAP 2019:26). This shift which began in Kenya in 2011 is now evolving elsewhere on the continent (Pedersen and Nygaard 2018).

Despite a diversity of definitions as discussed in Section 3, the term mini grid refers to a low-voltage or medium voltage generation and electricity distribution network which can operate in isolation from the main grid, but also connect to it should the network expand (Tenenbaum et al 2014). The nature of a mini grid is such that power can be generated much closer to the point of consumption, thereby reducing the probability of service failure and energy losses often experienced on the distribution or transmission network. Mini grids are often conceptualised as a disruptive innovation (Verbong and Geels 2010) given their potential to radically change the way in which electricity is produced, consumed, purchased, regulated, financed and owned. Because they are technologically flexible and modular, mini grids can cater to needs at multiple scales, from basic services such as lighting, mobile phone charging and small appliances e.g fans and radios; to productive uses such as grain milling, water purification and fish drying; and institutional electricity needs e.g schools, clinics and businesses.

While the extension of the national electricity grid was the dominant strategy for electrification until recently; technical, logistical, and economic limitations make it difficult or even impossible to reach remote, dispersed, low-income communities (Boamah and Rothfuß 2020). And though grid extension programmes continue, innovations in renewable, decentralised and standalone systems of varying size and scale are starting to disrupt electricity landscapes across sub-Saharan Africa (Ahlborg 2018). As discussed in Section 3, these innovations, including geo spatial planning and digital technologies, are co-evolving with rapidly declining costs and economies of scale across the solar PV value chain. According to IRENA, the cost of electricity generated by mini grids is anticipated to decline significantly in the coming years, ultimately becoming fully competitive with electricity from the centralised grid and diesel generators, particularly in countries with low levels of access (IRENA 2019).

For such reasons third generation mini grids are seen as a potential game changer for cost-effective, pro-poor, low-carbon, universal electrification (Sesan 2021) and have been proposed as a "third alternative to rural electrification, coming between the option of large-scale grid extension and pico-scale stand-alone solutions like solar home systems or solar lanterns" (Pedersen 2016). Such systems are seen as better able to reach remote, dispersed and/or informal settlements, including in urban areas, and where the cost of connection to the centralised national grid is prohibitive.

Despite this positive narrative there are considerable governance and regulatory challenges inherent in the roll out of mini grids. Mini grid development has often taken place in the absence of regulation rather than because of it and many countries with low levels of electricity access and/or high levels of inequality either lack clear procedures for such integration or are still in the process of developing them. Moreover, because mini grids are at once power producers and power distributors, with the potential to 'spatially reorganise' the electric grid, they have met with resistance from existing institutions of centralised electricity because of the threat that they pose to their political and economic control (Boamah 2020).

Our study responds to calls from development and energy geographers for a more "refined categorisation and contextualisation" of the decentralisation of electricity (Rothfuß and Boamah 2020:165), and for a deeper understanding of the evolving conflict and co-existence between the extension of the national electricity grid, and decentralised and off grid systems (Jaglin and Gillou 2020, Jaglin 2019). These calls are in turn a response to scholarship on rural electrification and energy access in low and middle-income countries to date which has been dominated by perspectives from engineering and economics and tended to privilege the technological and financial barriers. Such perspectives are often focussed on definitions of 'business models' (cf Pedersen 2016, Muchunku et al 2018), rather than considerations of the political and economic complexities of regulation and governance. As Ahlborg (2017, 2018) argues, energy access interventions are too often framed as neutral welfare schemes when in fact they are inherently political.

With this in mind we undertake a comparative analysis of how mini grids are regulated and governed, and the key challenges to their introduction in Nigeria, Kenya, Tanzania and Senegal. The latter three countries are considered leading markets for mini grid regulation, having developed frameworks to attract and support private sector investment, and require mini grids to adhere to grid-compatible technical standards (ESMAP 2019:32-34). More than half of the planned mini grids in Africa, of which the majority will be solar PV generated, will be developed in Senegal (1,217) and Nigeria (879) (ESMAP 2019:5-6).

Our study is guided by the following questions for each country: i) *What are the key institutions, actors and processes involved in electricity governance at the national level? ii) What regulatory and policy frameworks for mini grids have been introduced thus far? And iii) What key regulatory challenges remain for the future deployment of mini grids?*

Our study is based on a critical review of peer-reviewed academic literature in English, and French in the case of Senegal, on electricity governance and decentralised electricity systems in the case study countries, mainly retrieved from Scopus and Google scholar. Approximately 80 academic articles were read in detail. The academic literature was supplemented and triangulated with grey literature and publicly available sources, including from international institutions such as the World Bank, ESMAP, USAID (Power Africa), the International Renewable Energy Agency (IRENA), and the International Energy Agency (IEA); national policy and other government documents; civil society reports; and national and international media sources.

The structure of this paper is as follows. Section 2 situates the emergence of mini grids within the broader historical context of electricity governance and the academic literatures to which this study contributes. Section 3 explores how mini grids as a rapidly evolving set of technological assemblages have been defined and become a term with multiple meanings and explains the growth of third generation mini grids as a key focus of this paper. Section 4 explores mini grid regulation in each case study country, within the national context of electricity governance. Section 5 concludes.

2. Governing electricity: of monopolies, mini grids and beyond

As a large-scale networked infrastructure and a complex, interconnected and interactive system of artefacts and technologies (Hughes 1983, Rip and Kemp 1998, Smith et al 2005), electricity is not easily governed. Electricity is subject to vested interests and uncertainty in the adoption of new technologies and co-determined by factors such as the nature of domestic industrial, agricultural and residential electricity demand, national varieties of capitalism, and national and sub-national systems of governance (Baker et al 2021).

In the first half of the twentieth century the electricity sector, in countries where it was established, was generally a state-owned, vertically integrated monopoly. However, by the 1980s and 1990s the 'standard model' of power sector reform was established as a global blueprint, in keeping with the neo-liberal economic orthodoxy of the time. In developing countries this model was promoted by the World Bank and related consultants and endorsed by other multi-lateral lending institutions as part of loan and debt relief conditionalities under structural adjustment programmes (Baker et al 2021). The model was informed by the experiences of a small group of countries including the USA, UK, Norway and Chile and followed the assumption that state ownership was unable to meet the high levels of investment required by the electricity sector (Gratwick and Eberhard 2008). According to such an assumption, state-owned utilities should therefore be unbundled into private generation, distribution and transmission companies, with a significant role for wholesale markets and ultimately, retail competition (Sen 2014). The creation of a strong independent regulator to "regulate the monopoly prone parts" of the industry was also prescribed (Victor and Heller 2007:7).

Despite the apparent simplicity of the standard model, its implementation was more complex in practice, resulting in various forms of failure, partial implementation, and stranded assets from surplus generation capacity. Given the role of the centralised electricity sector as a strategic source of "revenue, political power, and influence" these donor-driven power sector reforms have often faced resistance from various government departments (Godinho and Eberhard 2019). The model has also been criticised for its generalised assumptions about the capacity of the state to implement it and attract investment, regardless of country context (Sen 2014). In addition, national regulators have rarely been as empowered as per the model's prescriptions, have faced significant political challenges, and struggled to negotiate the complex contractual and regulatory terms of power sector liberalisation (Baker et al 2021).

While many principles of electricity liberalisation remain influential, other socio-technical dynamics have come into play in recent years, not least the deployment of renewable electricity at multiple scales including mini grids. This deployment has been accompanied by the emergence of new players and the reconfiguration of old ones; changes in national electricity policy, planning and regulation; and shifting trends in global investment and technological innovation. As Baker and Phillips (2018) discuss, debates over the governance of electricity have gone beyond the simplified dichotomy of state versus market to include competition and co-existence "between different scales and configurations of centralised and decentralised electricity". Moreover, developments in decentralised and off grid renewable systems mean that electricity can now be generated and accessed without the centralised mediation of the transmission or distribution grid (Brisbois 2020).

In many countries in sub-Saharan Africa as elsewhere, there are growing tensions between on the one hand state-owned, incumbent utilities which are largely dependent on conventional technologies, and on the other hand, new institutions and actors in the renewable energy space which are often private sector led (Boamah 2020). Indeed, the potential of renewable, privately-owned and operated mini grids is often discursively pitted by the mini grid industry against that of the ageing, indebted, corrupt, capital-intensive, inefficient, vertically integrated, state-owned utility, supplying an increasingly expensive and unreliable source of electricity, from coal, gas-fired or large hydroelectricity, to a low-consuming user base (Trimble et al 2016, AMDA 2020). Such a discourse is accompanied by an assumption that only the 'dynamism of the private sector'[25] can push forward the roll out of renewable electricity generation at scale.

Research on the political economy of electricity has provided critical empirical insights into shifting models of electricity ownership, including in various countries in sub-Saharan Africa. This research has emphasised how electricity as a socio-technical system interacts and co-evolves with multiple political, economic, social and cultural interests at different geographical scales (Baker 2014, 2021, van den Bold 2021, Godinho and Eberhard 2018). However, this scholarship has largely focussed on reforms to the centralised system of generation, transmission and distribution and has yet to address the rapid and recent emergence of decentralised systems in any great depth. While there has been some research on donor-driven, village level mini grids (cf Pedersen and Nygaard 2018), an understanding of evolving regulation and the rapidly developing private sector investment in the sector in sub-Saharan Africa is limited given its recent emergence.

With this in mind, we add to contributions from energy and development geography which emphasise the need to understand interactions between socio-cultural, economic, ecological, political and technological forces that influence and challenge the realisation of sustainable energy access (Ockwell et al 2018, Gollwitzer et al 2018, Ulsrud et al 2018, Zimmerer 2011). This understanding includes a focus on the significance of scale and spatial contexts, the formation of new 'energy landscapes', and the 'embeddedness' of the electricity system within specific national, local and geographical contexts (Bridge et al 2013, Castán-Broto and Baker 2018, Rothfuß and Boamah 2020). The concept of the 'embeddedness' of electricity within "an evolving set of political relationships" is further developed by Balls and Fischer (2019:474), and Ulsrud et al (2018) who explores how factors such as population density, settlement patterns and socio-economic conditions, as well as the significance of political ideologies on the role of the state, markets and institutions, all condition electricity supply and demand in important ways.

This literature has further explored how large-scale, grid connected electricity is often seen as a symbol of modernity and development, has been key to the formation of the state in many post-colonial countries, as well as being of immense

[25] Romain Py, Chief Investment Officer, Africa Infrastructure Investment Managers, South Africa, Africa Utilities Week, 11 May 2020 (publicly available conference)

significance to politics, citizenship and democracy (Ahlborg 2018; Balls and Fischer 2019). For instance, in many contexts, a connection to the centralised electric grid as opposed to an off-grid or decentralised alternative can also be an indicator of socio-economic status and class and is therefore closely connected to political patronage and voter loyalty (Rothfuß and Boamah 2020). Moreover, given the potential of electricity for revenue generation there is a significant relationship between the control of large-scale and increasingly small-scale electricity systems, and political and economic power by both the state and/or private actors (McDonald 2009, Baker 2014, Silver 2016). Despite the promise of mini grids, such dynamics are important considerations in the various types of resistance.

3. Mini grids in context: between energy access and productive use

Mini grids in themselves are nothing new and were the earliest form of electrification for most industrialising economies and former colonies during the late 19th and early 20th century (ESMAP 2019:12, Odarno et al 2017). Diesel-fuelled and hydro-powered mini grids are well-established in various number of countries, including Indonesia, the Philippines and China where they remain an important source of generation (PWC 2016:7, Peters et al 2019). In Tanzania for example, hydro-powered mini grids were set up in the 1950s and 1960s by large industrial and agricultural companies as well as missionaries (Jaglin and Gilou 2020). What is new however, is the growth of solar powered or so-called 'third generation' mini grids, particularly in sub-Saharan Africa, which in many instances are starting to replace diesel-generated systems and under certain circumstances can provide a more cost effective and efficient alternative to the extension of the transmission and distribution grid. A second new development is the evolution of regulatory and financial arrangements aimed at the scale up of renewable energy mini grid deployment, as well as the formation of new actors and institutions in the sector. Such regulation however has often taken place in the wake of mini grid development rather than in advance of it.

Sometimes referred to as the 'missing middle' or 'missing link' between the centralised electricity grid and standalone solar home systems (SHSs) (GGGI 2017, Pedersen and Nygaard 2018), there is no universally agreed definition of a mini grid in terms of size, scale, technical features, ownership structure, service area, and customer base. It is therefore a term with multiple meanings, purposes and functions and one through which the often-competing objectives of productive use, energy access and rural electrification are conflated. Indeed, the lack of a common language on this topic has been identified as a barrier to the comprehensive understanding of the challenges and appropriate responses to meeting SDG7. In the case of Kenya and Tanzania for instance, Pedersen (2016:16) identifies a contradiction between the discourse which proposes mini grids as a solution for delivering energy to low-income households in rural areas, and the national level realities which prioritise large urban mini grids for energy security and productive use.

ESMAP defines a mini grid as an electric power generation asset (e.g hydro turbine, solar panel, battery, inverter) and distribution system (wires, poles etc) that can "provide electricity to just a few customers in a remote settlement or bring power to hundreds of thousands of customers in a town or city" (ESMAP 2019:3). Following ESMAP's definition, a mini grid has to serve multiple customers. Therefore, a decentralised electricity system that serves a single entity such as a hospital, university campus, mine, military base or industrial facility does not qualify. This definition differentiates a mini grid from an 'on-site solar' or captive power project for commercial and industrial (C&I) users, particularly mining and manufacturing. These on-site projects are increasing across the continent, with the largest markets in Nigeria and Kenya, and are usually installed in the interests of reliability and/or reduced electricity costs (BloombergNEF 2019). In such cases, the electricity generated is directly consumed by the host and in contrast to a mini grid, less beholden to national regulations and tariffs. Despite the different categorisation, the C&I and mini grid sectors tend to develop in parallel given the evident crossovers and interlinkages between them in terms of operation and maintenance, technological capabilities and the companies involved.

The installed capacity of a mini grid can also vary considerably depending on the context and the country, but typically falls within a range of 10 kW to 10 MW (Muchunku et al 2018:7). This, as compared to that of a micro grid which is usually between 1-10 kW (Ibid). Mini grids can also be differentiated from solar home systems (SHSs), which are based on Direct Current (DC) and largely deployed for the provision of energy access such as lighting, radio and mobile telephone charging using mobile payment technology. For further perspective, while SHSs sit under tiers one to three of the UN SEforAll categories (see Table 1), mini grids generally sit in tiers four and five (PWC 2016:9) and can be converted to Alternate Current (AC). Mini grids are therefore perceived as better able to support productive use in addition to energy access (Bhattacharyya and Palit 2016, Peters et al 2019).

While a small-scale mini grid may be aimed at village level rural electrification and comparable to a SHS, a large-scale mini grid is often sited either in an urban or peri-urban area where it can depend on a large number of medium to large electricity users with greater ability to pay (Peters et al 2019:28). Or, if in a rural area it is usually situated near to a large consuming 'anchor client' with a long payback period in the interests of predictable demand and revenue (Pedersen 2016:16, Knuckles 2016). Though mini grids have recently become cheaper and quicker to install than utility-scale projects in many parts of sub-Saharan Africa, in order to be financially viable they generally depend on a high number of medium to large electricity consumers who can afford the tariff, such as users of refrigerators, freezers, electrical machinery and tools e.g for grinding, cutting, drilling, welding and milling. While mini grid tariffs may be cheaper than the cost of power generation from diesel generators, in many countries they are still more expensive than tariffs from the centralised grid (Muchunku et al 2018:8), as we discuss below.

ESMAP (2012:12) has summarised mini grids into three generations. First generation refers to the early electrification systems installed by industrialising countries during the late 19th and early 20th centuries, which were eventually interconnected. Second generation refers to mini grids built between the 1980s to early 2000s which were typically “small and isolated, powered by diesel or hydro, and built by local communities or entrepreneurs to provide access to electricity to households, primarily in rural areas” far from the main grid (ESMAP 2019:12).

Third generation mini grids which have started to emerge in very recent years are typically solar PV or solar PV hybrids. Alongside SHSs, they are being promoted as a low-cost option to meet SEforAll’s universal energy access commitment by 2030, connecting dispersed or rural communities in low-income settings where the cost of extending the main grid is considered too expensive (ESMAP 2019:14). Third generation mini grids have characteristics of both electricity utilities and SHSs, which presents both challenge and opportunity. Like utilities they have the potential to provide a constant supply of electricity and support productive loads such as agricultural milling and water irrigation pumps, as well as to operate as a rural distribution network. But like utilities, they also have large sunk capital costs (ESMAP 2019:13). Like SHSs, mini grids share the potential for very rapid expansion under the appropriate market conditions, but unlike some SHSs mini grids have been subject to greater regulatory oversight and tariff structures. It is perhaps for this reason that SHSs have had greater traction than mini grids. Meanwhile, the growing interconnection of multiple SHSs is anticipated to contribute to the growth of mini grids.

Third generation mini grids have been enabled by geospatial analysis and digital technologies and have been designed to incorporate smart meters and remote monitoring systems (Moner-Girona et al 2016). The economies of scale created by utility-scale solar PV, SHSs and the development of capabilities in lithium-ion batteries in electric vehicles have been another important driver. Between 2010 and 2018, the capital costs of mini grid key technological components fell by 62 to 85 per cent and are predicted to fall yet further in the coming decade (ESMAP 2019:22-25).

Table 1: Multi-tier energy access framework

	Tier 1	**Tier 2**	**Tier 3**	**Tier 4**	**Tier 5**
Indicated minimum technology or system	Pico-products e.g solar lamp and lantern; nano-grid; micro-grids; entry level SHS.	Basic capacity SHS to medium capacity SHS	Medium to high capacity SHSs, with lead acid or lithium ion battery; Micro grids.	High capacity SHS; Mini grids	Mini grids, or central grid
Power capacity ratings in Watt	Min 3 W	Min 50 W	Min 200 W	Min 800 W	Min 2 kW-10 MW
Power capacity ratings in daily Watt hours	Min 12 Wh	200 Wh	Min 1.0 kWh	Min 3.4 kWh	Min 8.2 kWh

Availability hours per day	Min 4 hours	Min 4 hours	Min 8 hours	Min 16 hours	Min 23 hours
Availability hours per evening	Min 1 hour	Min 2 hours	Min 3 hours	Min 4 hours	Min 4 hours
Examples of appliances connected	2 lights, mobile phone charging	4 lights, mobile phone, radio	4 lights, phone, radio, TV, sewing machine, fridge, fan, computer	Washing machine, hair dryer, microwave	Water heater, electric cooker

Source: Adapted from Lighting Global et al (2020:268 and vii) and PWC (2016:9)

Third generation mini grids are generally owned and operated by private, international companies or consortiums whose interest is to generate large-scale investment portfolios rather than develop one off projects. Recent years have seen the considerable growth of these companies operating in sub-Saharan Africa. Key players including Engie Energy Access, PowerGen, PowerHive and Rensource. The mini grid value chain, including technology supply is for the most part internationally owned. Mini grid financing is also evolving in parallel, with various modes of finance and investment now coming from a combination of multi-lateral and bi-lateral donors; impact investors such as Rockefeller, Acumen and Ceniarth; commercial financiers such as CrossBoundary Energy Access and SunFunder; and strategic investors such as Sumitomo Corporation and Toyota (SEforAll and BNEF 2020:90). Results-based financing under which developers receive a grant from host governments once they can prove that their mini grid is operational and supplying electricity to end users[26], has also become an increasingly popular mechanism with commercial financiers (SEforAll and BNEF 2020:94).

The institutions involved in third generation mini grids are increasingly organised, as illustrated by the formation of the African Mini Grid Developers' Association (AMDA) in 2018. Supported by donors such as the UK's FCDO, USAID and Germany's KfW, AMDA plays an advocacy role in pushing for policies and regulations that favour private sector investment in various countries. Another example is that of the Green Mini Grids (GMG) partnership, a consortium of over 320 institutions including investors, development banks, bi-lateral donors, industry and other renewable energy networks founded in 2014 under the auspices of SEforAll.

4. Country case studies

In this section we undertake an analysis of electricity governance in each country, the key institutions involved, and the state of play regarding mini grid regulation, as summarised in Tables 2 and 3.

[26] The grant is often paid for with assistance from development finance

Table 2: General statistics Kenya, Tanzania, Nigeria and Senegal				
	Kenya	**Tanzania**	**Nigeria**	**Senegal**
Population	52.5 million	58 million	206 million	16.7 million
GDP per capita	$1816.5	$1,122.1	$2229.9	$1446.8
GDP overall	$87.9 billion	$63.18 billion	$432 billion	$24.6 billion
Urban population (percentage of total population)	28%	37%	51%	48%
Proportion of population with electricity access	84.5%	38%	60%	69%
Electricity connectivity access: urban	100%	73%	86%	93%
Electricity connectivity access: rural	65.7%	18%	34%	47%
People without electricity access	**8.1 million**	**36 million**	**77 million**	**4.8 million**
Generation capacity	2819 MW	1602 MW	4000 MW	1555 MW

Sources: WB indicators; Power Africa (based on available information at the time of writing)

Table 3: Institutions and processes of electricity governance and regulation											
Country	**Utility**	**Transmission**	**Distribution**	**Generation**	**Regulator**	**Rural electrification agency**	**Renewable energy agency**	**Responsibility for electricity policy**	**Key plans, policies and legislation**	**Capacity threshold for licencing exemption**	**Tariff**
Kenya	KPLC	KPLC and KETRACO (est 2008)	KPLC (licence to distribute power to whole country)	KenGenLtd and 12 IPPs	ERC: Energy Regulatory Commission (est 2007) succeeded by Energy and Petroleum Regulatory authority (EPRA) in 2019	Rural Electrification Authority (REA), established 2006. Replaced in 2019 by Rural Electrification and Renewable Energy Corporation (REREC);	REREC	Ministry of Energy and Petroleum (MoEP)	Electric Power Act (1997); Energy Act (2012); Energy Act (2019); Kenya National Electrification Strategy (KNES) (2018). Least Cost Power Development Plan (LCPDP) (2021 – 2030)	100 KW	Uniform tariff for all customers. Customers linked to mini grids pay same as electricity consumers from main grid. Some recent flexibility for private investors.
Tanzania	TANESCO	TANESCO	TANESCO	TANESCO, IPPs and SPPs	EWURA: Energy and Water Utilities Regulatory Authority	Rural Energy Agency (REA), established 2005. Rural Energy Fund (provides grants to co-finance the hardware).	Tanzania Renewable Energy Association	Ministry for Energy	Rural Energy Act (2005); Electricity Act 2008; Small Power Producers Framework (SPP) (2008, revised 2015); Scaling up Renewable Energy Programme (SREP) (2013); TEDAP (2011); Electricity Supply Industry Reform Strategy and Road Map (2014–2025)		Determined by EWURA
Nigeria	Unbundled since 2013. Formerly PHCN	PHCN	Eleven distribution companies (disco)	Six private generation companies	NERC: Nigerian Electricity Regulatory Commission (est 2007)	REA (Rural Electrification Agency)	REA (Rural Electrification Agency)	Ministry of Energy; Federal Ministry of Power	Electric Power Sector Reform Act (2005); REMP (2006), updated (2011); Nigeria Electrification Project; Regulatory framework for mini grids (2018); National Electric Power Policy (NEPP); National Renewable Energy and Energy Efficiency Policy (NREEEP)	1 MW	

Senegal	Senelec (Société Nationale d'électricité du Sénégal)	Senelec	Senelec	Senelec (just under 50%) and IPPs	CRSE: Electricity Sector Regulatory Commission, established 1998	ASER (L'agence Sénégalaise d'électrificati on rurale), created 1999	ANER (L'Agence Nationale d'Energies Renouvelab les), established 2013	Ministry of Petrol and Energy	Renewable Energy Law (2010); Programme Nationale D'Electrification Rurale du Sénégal; Lettre de Politique de Développement du Secteur de l'Energie, LPDSE (2019-2023)	50 KW	

4.1 Kenya

Kenya has the highest levels of electricity access and one of the most ambitious power sectors in East Africa, as enshrined in its 'Kenya Vision 2030' plan. Launched in 2008, the plan aims to achieve 100 per cent electricity access by 2022 and middle-income country status by 2030. Kenya's electricity connectivity rate has since risen from 20 per cent of the population in 2013 to almost 75 per cent in 2021 (see Table 2). Urban and rural electricity access now stand at approximately 100 per cent and 65.7 per cent respectively (Power Africa 2022a). This increase has been achieved largely through donor-supported, government-run rapid grid extension programmes, and to a lesser extent through the introduction of SHSs (IEA 2019). One example of such a programme is the Last Mile Programme, launched in 2015 and implemented by the state utility, the Kenya Power and Lighting Company (KPLC) with support from the World Bank and African Development Bank. However, given that this programme only targets residential consumers situated within a 600-metre radius of existing transformer stations, many households in more peripheral areas have been excluded from it (Boamah 2020, Ulsrud 2020).

Total generation capacity in Kenya stands at 2,819 MW, of which 826 MW from hydroelectricity, 828 MW from geothermal, 749 MW from thermal, 331 MW from the rapidly developing onshore wind sector, 51 MW of solar and 28 MW from biomass (Power Africa 2022a). While the country is one of the world's most successful markets for off-grid solar PV (Ockwell and Byrne 2016) and a global leader in pay-as-you-go (PAYGO) mobile payment schemes for SHSs alongside Tanzania (Onsongo and Schot 2017, Onsongo 2019), thus far Kenya's mini grid sector is much less developed despite some recent and significant regulatory developments (Pedersen and Nygaard 2018).

Despite recent progress, 8.1 million people in Kenya are still without electricity access, of which there is a wide disparity reflecting the dispersed settlement patterns between and within the country's 47 counties (Boamah 2020:151). The transmission and distribution grid are unreliable in many parts of the country even where installations are new, partly because the costs of grid maintenance in poor rural areas are far higher than the revenue collected from low-income users (Ulsrud 2020:59). Until recently rural electrification efforts had largely prioritised industrial and productive sectors, with demand from low-income rural households considered too low to be financially viable (Pedersen and Nygaard 2018). However, under the 2018 Kenya National Electrification Strategy (KNES), soon to be replaced by the Integrated National Electrification Plan (INEP), the government reaffirmed its intention to achieve universal electricity access by 2022, including through the strategic use of on-grid, off-grid and small-scale solutions to bring power to remote rural and/or underserved peri-urban locations (World Bank 2018).

Following power sector reforms initiated in 1990s, Kenya's state-owned electricity sector was partially privatised. The Kenya Power Company, originally founded in 1945, was split into: KenGen PLC, which is responsible for the majority of the country's hydro-electric generation; the Kenya Power and Lighting Company (KPLC) which owns the transmission grid, is the single buyer of electricity and remains the sole distributor and retailer of electricity; and KETRACO, the state-owned transmission company which shares transmission ownership and operations with KPLC. Both KenGen PLC and KPLC are listed on the Nairobi Securities Exchange with the former owned 70 per cent by the Kenyan government and 30 per cent by private investors, while KPLC is 50.1 per cent government-owned and the remaining shareholding with private investors (Godinho and Eberhard 2019).

The 2019 Energy Act introduced further reforms of the sector, including the updating of a renewable energy feed-in tariff, and paving the way for the introduction of mini grid regulations, that had been drawn up by the regulator, in 2021 (EPRA 2021a). However, the 2017-2037 Least Cost Power Development Plan (LCPDP) which is the central planning document for Kenya's electricity sector and was updated in 2021, has given limited consideration to mini grids (EPRA 2021b, Day and Kurdziel 2019) meaning that there is some inconsistency of regulation.

Kenya's Ministry of Energy and Petroleum (MoEP) is responsible for setting sector policies and overseeing the country's utilities. The Energy Regulatory Commission (ERC) established in 2007 was responsible for regulation until the 2019 Energy Act when it was replaced by the Energy and Petroleum Regulatory Authority (EPRA). The regulator has faced various challenges over the years (Godinho and Eberhard 2019), including tensions with KPLC. According to Pedersen and Nygaard, despite the regulator's apparent independence, it is in reality "dependent on being given clear policy frameworks by the MoEP in order to make cases that create precedents regarding regulatory issues" (Pedersen and Nygaard 2018:214). Meanwhile, the MoEP has been reluctant to stand up to KPLC and lacks political support (Ibid).

Kenya's rural electrification agency (REA) was established in 2007 to take over the implementation of rural electrification projects from KPLC as part of what Foster and Rana have described as a 'second wave' of more successful home-grown power sector reform (Foster and Rana 2020:83). REA was mandated to establish 25 mini grids in small towns to be handed back to KPLC after commissioning (Godinho and Eberhard 2019). REA was changed to the Rural Electrification and Renewable Energy Corporation (REREC) following the 2019 Energy Act, in a move which brought together rural electrification and renewable energy under one authority (Day and Kurdziel 2019:10).

A key challenge to the introduction of mini grid regulation in Kenya has been the resistance of KPLC to private and decentralised players in electricity, which it sees as a threat to the monopoly that it holds over the distribution sector. According to Ulsrud (2020), KPLC tends to act in the interests of its shareholders and revenue generation and has prioritised higher consuming urban and industrial customers. KPLC has also reportedly claimed that grid electricity is superior to that of decentralised systems on the basis of the costs it would need incur to upgrade the grid in order to accommodate mini grids (Pedersen and Nygaard 2018, Ulsrud 2020, Boamah 2020).

Despite KPLC's resistance, the regulator (formerly ERC now EPRA) has been actively pursuing private sector-led mini grids and hybrid public private models (Pueyo and DeMartino 2018). In 2017 with the support of GIZ, ERC developed a draft framework for mini grids of up to 1 MW which established a government-regulated, uniform tariff for all customers, made possible by a high level of cross subsidy from main grid to mini grid customers (Pedersen and Nygaard 2018). These draft regulations were updated in April 2021 in collaboration with industry stakeholders to include licensing requirements, operating guidelines, and performance and reporting requirements (EPRA 2021a, ESI-Africa 2021). Projects that do not sell power to Kenya's electricity grid do not require a generation permit or licence from the regulator. However, projects with a capacity of 1MW now require both a generation *permit* and *licence*, at a cost of 10,000 Kenyan shillings (EPRAa 2021).

Until recently NGOs and community organisations had been involved in the delivery of small-scale, village level mini grids. Meanwhile, government/KPLC and donor support to mini grids had focussed on urban or peri-urban areas where demand is growing due to population growth and increasing productive activities (Pedersen 2016:16). But both of these models are shifting towards one in which private companies, including PowerGen Renewable Energy and Powerhive, are playing an increasingly important role in the form of portfolio investments (Herbert and Phimister 2019). Diesel-fuelled mini grids belonging to KPLC are gradually being replaced by third generation hybrid systems and allocated to independent power producers (IPPs) or independent power distributors (IPDs) (Jaglin and Gillou 2020). However, in the case of the latter there is still considerable regulatory uncertainty. For instance, if a mini grid developer acquires a licence for a restricted area, they will not be granted exclusive rights because KPLC still retains the right to construct facilities within the same area.

Uniform tariffs have been imposed on mini grids larger than 1 MW, as well as on KPLC-operated diesel-fuelled rural mini grids, though in the case of the latter the cost of diesel is often government subsidised. Given that such tariffs are often seen as too low to be attractive to private investors, the Kenyan government has granted the private sector some flexibility. For instance, the developer Powerhive was recently granted permission to charge its own rates (Herbet and Phimister 2019).

Despite some positive moves therefore the implementation of mini grid regulation in Kenya still lacks clarity and has faced considerable resistance by KPLC.

4.2 Tanzania

With one of the lowest electrification rates in East Africa, less than 40 per cent of Tanzania's 60 million population had access to electricity in 2019 (see Table 2). Electricity supply is unstable, and the transmission grid only extends to certain parts of the country. There are large areas, particularly in the sparsely populated western and southern regions where the grid does not reach (Dagnachew et al 2020:3). Electricity generation capacity stood at 1,764 MW in 2022 and is dominated by large hydroelectricity (581 MW) and natural gas (876 MW), though the former has been challenged by regular droughts (Power Africa 2022a). Meanwhile there are significant plans for the scale up of coal-fired power (Power Africa 2022a, IEA 2018). Of those with electricity access, 25 per cent are supplied by the grid or mini grids and eight per cent from SHSs (IEA 2019, URT 2020). According to SEforAll and BNEF (2020:140) Tanzania has 209 known operational mini grids, with a total installed capacity of 231.7 MW, accounting for approximately 15 per cent of the country's total capacity. Of these projects, almost one-third are third generation and are dwarfed by older hydro and diesel projects in terms of installed capacity.

Despite previous attempts at privatisation in the late 1990s, electricity generation, transmission and distribution in Tanzania are still dominated by the vertically integrated, state-owned monopoly utility TANESCO (Tanzania Electric Supply Company Limited), governed under the Public Corporations Act of 1992 and the Companies Act of 2002 (Godinho and Eberhard 2018). However various reforms along the lines of the standard model of power sector reform (discussed in Section 2) have been implemented. These include: the introduction of an independent regulator in 2007, the Energy and Water Utilities Regulatory Authority (EWURA) which sets electricity tariffs and oversees licensing; and following the 2008 Electricity Regulation Act, the formation of various IPPs and small power producers (SPP), including mini grids, with whom TANESCO has power purchase agreements (Godinho and Eberhard 2018).

Tanzania's 2014–2025 Electricity Supply Industry Reform Strategy sets out plans for the unbundling of the electricity sector, although key steps within this were subject to delay (Godinho and Eberhard 2018). Similar to Senegal's Plan Sénégal Emergent (Section 4.4), and Kenya's Vision 2030 plan (Section 4.1), this reform strategy is driven by the Tanzanian Development Vision, which seeks to achieve middle-income country status by 2025.

The most relevant government institutions responsible for electricity are: the Ministry of Energy, until 2017 the Ministry of Energy and Minerals, which holds overall responsibility for energy policy and the governance of TANESCO; and the Rural Energy Agency (REA), which was established in 2007 under the 2005 Rural Energy Act with a mandate to scale up rural electrification and electricity access. The REA reports to the Ministry of Energy.

Despite the incomplete liberalisation of its electricity sector, Tanzania's regulatory environment for the encouragement of decentralised renewable energy systems through private participation, including mini grids, is considered relatively advanced. This regulation has been developed with significant support and technical assistance from development finance institutions (DFIs) and donors (Odarno et al 2017:43, Peters et al 2019:28, IRENA 2018:68). As in the case of Kenya, Tanzania has also been heralded as a success story for the deployment of SHSs (Odarno et al 2017). The country's mini grid regulation largely evolved out of its 2008 Electricity Regulation Act and related initiatives, including the small power producers' (SPP) framework, introduced in 2008 and revised in 2015. The first iteration of the SPP framework saw a technology neutral fixed feed-in tariff under which fifty-two mini grid projects with a combined capacity of 67 MW were commissioned (Odarno et al

2017:40). The majority of these projects were hydro and biomass mainly because of the technology neutrality of the SPP framework which discouraged mini grids from solar PV and wind due to their higher upfront costs.

The SPP framework was revised in 2015 to reflect different technology costs, plant sizes, and site-specific characteristics (Odarno et al 2017:40). Feed-in tariffs have now been set for hydro, biomass, wind and solar projects of 0.1-1 MW, while a competitive bidding process is required for wind and solar projects of 1-10 MW (Odarno et al 2017:44-48). The current framework has also removed barriers for mini grid projects of up to 10 MW: isolated mini grids of up to 1 MW are not required to apply for a licence, do not need regulatory approval and need only register with the regulator (Pedersen 2016:14); and systems with a capacity of 0.1 to 10 MW are allowed to feed into the grid. The revisions further pegged tariffs to the US dollar, a move which may incentivise international developers with access to international debt finance but deter local developers seeking finance in Tanzanian shillings. This move may also mean that TANESCO ends up absorbing the additional cost of any currency depreciation of the shilling against the dollar for electricity supplied by IPPs and SPPs.

Other initiatives for the promotion of mini grids in Tanzania include the off-grid component of the World Bank funded Tanzania Energy Development and Access Project (TEDAP), launched in 2011 and managed by the REA with funding from the World Bank (Pedersen 2016, SEforAll and BNEF 2020); and the Scaling-up Renewable Energy Programme (SREP), launched in 2013 to catalyse the large-scale development of renewable energy and mini grids with commercial anchor clients.

Despite Tanzania's mini grid regulations being considered relatively advanced, the sector's development has in recent years been hampered by an 'overly complicated implementation process', government opposition, and the increasing insolvency of TANESCO (Odarno et al 2017:50). Moreover, "issues concerning implementation and enforcement, as well as elements within the regulations themselves, have recently restricted private-sector investment in mini grids" (ESMAP 2019:33). Since 2016 TANESCO has been unable to meet its financial obligations to IPPs and SPPs, partly because the government has not allowed the regulator to raise TANESCO's tariff. As a result, the government has bailed out TANESCO for several years.

The institutional governance of the Tanzanian power sector is such that the president and his appointees have significant political power over planning and operations in the sector which, "unchecked by a disempowered technical and managerial staff, has also allowed for corruption in the sector on a grand scale" (Godinho and Eberhard 2018:7). There is also a long-standing national ideological suspicion of private sector involvement and foreign interference (Ibid). According to Aly et al (2019), in recent years the government has grown increasingly obstructive and unpredictable which has created uncertainty for infrastructure investors such as InfraCo Africa, developers and bi-lateral donors. Developers have become frustrated with a lack of regulatory coordination, including cases where the national power grid has been extended into a mini grid area. As Jaglin and Gilou (2020:60) explain "it is not unusual for [developers] to discover that the grid is about to arrive, just months after installing their equipment in a locality". High mini grid tariffs have also led to wealthier users moving back to the national grid, while poorer users, who are not considered profitable for private sector developers, remain as captive clients. The Tanzanian regulator is working on regulations to deal with circumstances in which the grid is extended to the same distribution area as a mini grid, which would mean that if the mini grids meet national standards, they can either choose to become bulk distributors, or negotiate selling their infrastructure to TANESCO.

For reasons discussed above, the UK's Department for International Development (DFID), now Foreign Commonwealth and Development Office (FCDO) closed its contribution to the Green Mini-Grid's Tanzania programme in March 2019, although the programme, which uses a form of Results-Based Financing (see Section 3) and is led by the REA and jointly funded with Sida, has continued (Hunt 2019). However, since the inauguration of President Hassan in March 2021, there is now a cautious optimism regarding the future of the mini grid sector in Tanzania.

4.3 Nigeria

With approximately 206 million people, Nigeria is predicted to become the world's third most populous country by 2050. According to Power Africa (2021), approximately 60 per cent of the population has an electricity connection, of which 86 per cent in urban areas and 34 per cent in rural areas (see Table 2). Biomass and waste currently make up the majority of Nigeria's primary energy supply and only 15 per cent of the population have access to clean cooking. The remainder rely on polluting and inefficient cookstoves (Sesan 2021).

Nigeria has the most unreliable electricity supply on the continent (BloombergNEF 2019:10). Though its potential generation capacity stands at approximately 16,000 MW from existing plants, actual dispatchable output is only around 4,000 MW, of which the majority from gas and to a lesser extent hydroelectricity (Power Africa 2022c Edomah et al 2021). The majority of the country's electricity consumers therefore depend on costly self-generation from small and medium-scale diesel generators. Reasons for the shortfall in generation capacity are complex and long-standing but include: problems with gas and water supply; high technical losses; financial shortfalls within the utility; poorly maintained infrastructure; energy theft; and corruption throughout the electricity value chain (Roche et al 2020, Edomah et al 2021, Roy 2020). Periodic increases in electricity tariffs are often met with resistance from the public and labour unions, partly reflecting the low purchasing power of the majority, but also public perceptions of the power sector as corrupt and untransparent (Ibid).

Nonetheless, Nigeria has been promoted as a 'frontier' country in terms of the comprehensiveness of its mini grid regulations, including on licensing, retail tariff setting, and arrangements for the arrival of the main grid (ESMAP 2019:9). By the end of 2019, the country's estimated installed mini-grid capacity was about 2.8MW, with

59 projects serving rural consumers. Solar with battery and solar diesel hybrid mini grids, as well as SHSs are anticipated to play a key role in replacing Nigeria's diesel generators (Roche et al 2020). The majority of solar hybrid mini grids installed thus far are being operated by private sector developers backed by DFIs and bi-lateral donors (SEforAll and BNEF 2020:146-147).

The Energy Commission of Nigeria is nominally responsible for overall energy policy but in recent years the Federal Ministry of Power has become the dominant state actor over electricity policy. The electricity sector was previously dominated by the state-owned monopoly utility the National Electric Power Authority (NEPA). However, after the 2005 Electric Power Sector Reform Act (EPSRA) introduced the relevant legal and regulatory arrangements for power sector liberalisation, NEPA was transformed into the Power Holding Company of Nigeria (PHCN). By 2013 the PHCN had been unbundled into eleven private regional distribution companies (DisCos) and seven private generating companies (GenCos) and sold on (Edomah 2015). The single transmission company remained in the hands of the federal government and was concessioned to the Canadian firm Manitoba Hydro. This concession expired in 2016 and the company's management is now back in the hands of the federal government which is considering the outright privatisation of company (Oni 2020, Jeremiah 2021).

Two other key institutions that were established out of the EPSRA were the Nigerian Electricity Regulatory Commission (NERC) in October 2007, and the Rural Electrification Agency (REA) in 2006 (Edomah 2015). NERC is responsible for the issuing of licenses and permits to private companies in the electricity sector and ensuring the compliance of rules and regulatory guidelines. An implementing agency of the Federal Ministry of Power, REA has a core mandate to "promote, support and provide rural electrification through Public and Private Sector Participation" and administer the rural electrification fund (REF)" (REA, no date).

The EPSRA also led to the introduction of various instruments for the promotion and development of mini grids, which for the most part were designed with technical assistance from bi-lateral and multi-lateral donors. These instruments include firstly the renewable energy master plan (REMP), introduced in 2006 and updated in 2011, which seeks to increase the supply of renewable electricity to 23 per cent of total electricity generation by 2025 and 36 per cent by 2030 (IEA/ IRENA 2013). Secondly, in July 2016 the rural electrification strategy and implementation plan (RESIP) was introduced, in which mini grids are anticipated to play a significant role. In parallel, Nigeria's national climate plan has pledged to work towards installing 13 GW of solar power by 2030 (Federal Government of Nigeria 2015).

Thirdly, NERC introduced a regulatory framework in 2017 under which mini grids of 1 MW or below may either be isolated, to be deployed in an area within a DisCo's network where there is no existing distribution system or interconnected to a DisCo's network in an underserved area (SEforAll and BNEF 2020:146). In the case of the latter, operators must enter a tripartite contract with the community and the DisCo and gain NERC's approval (NERC 2018, Aigbomian 2019). There are different requirements for different sizes of mini grid as follows:

i) projects below 100 kW are only required to obtain a simple registration with NERC but may still choose to obtain a permit voluntarily because this will qualify the project for exit compensation should the distribution grid arrive (ESMAP 2019:33-34);

ii) projects between 100 kW and 1 MW must obtain a permit and adhere to minimum network technical and safety standards. Should the main distribution grid arrive and displace the mini grid's operations, the permit holder will then be entitled to compensation equivalent to the depreciated value of the mini grid's network investment, plus one year's worth of revenue (NERC 2018); and

iii) generation projects larger than 1 MW are governed by the provisions of the EPSRA.

Fourthly, the National Electrification Project (NEP) was introduced in 2018 alongside grid expansion plans (Edomah et al 2021). One of its four core components is for 'solar hybrid mini grids for rural economic development' (NERC 2018, Aigbomian 2019, REA 2019). The component is being implemented by REA on behalf of the federal government and aims to leverage large-scale private sector investments for electricity access for off-grid households, and micro, small and medium enterprises (O'Sullivan 2018:7). It is the largest mini grid programme in Africa with a target of 850 projects and an approximate capacity of 3,000 MW by 2025 across 250 sites in four states: Niger, Sokoto, Ogun, and Cross River (REA 2019; ESMAP 2019:37). A loan for this component, prepared with support from ESMAP and approved in 2019, consists of $150 million from the International Development Association (IDA, the World Bank's low-income lending arm) and $200 million from the African Development Bank. The loan is anticipated to leverage $220 million in private sector investment through a performance-based grant and minimum subsidy tender for renewable energy mini grid developers (GMP 2019).

However, notwithstanding the apparent comprehensiveness of the much-lauded NERC regulations and other measures, mini grid progress has thus far been hampered by various factors including: insufficient policy and limited government follow up on existing policies; conflicts between DisCos and potential developers (Akinyele et al 2019, Arowolo et al 2019); a longstanding inability on the part of NERC to agree appropriate tariff structures with small-scale developers (Kemabonta et al 2019); high investment costs which have been exacerbated by the lack of long-term patient capital and domestic commercial financing; and challenges to the creation of national technological capabilities. Tenders for isolated and interconnected mini grids that are in the process of being issued have also experienced delays, in no small part due to Covid-related interruptions.

Moreover, mini grid projects in Nigeria tend to be self-selecting in that they are typically implemented in areas where prior demand has been established; specifically, communities where people are accustomed to using paraffin and/or diesel generators to meet their energy needs. While these communities invariably experience significant reductions in their energy expenses by switching to solar or hybrid mini grids, they still pay much more for electricity than do grid-connected communities (Ibid). The resolution of the tariff issue could therefore prove critical to the ability of mini grids to scale up beyond a small number of communities.

Consequently, and as Akinyele et al (2019 and Arowolo et al (2019) argue, more proactive government support and involvement could help the existing mini grid regulations to translate into substantial improvements in electricity access. Measures to achieve this could include bottom-up strategies such as engaging communities in the design of mini grid projects, and more top-down approaches such as strengthening the capacity of state and market actors to implement the projects.

4.4 Senegal

Until very recently Senegal experienced regular and prolonged electricity blackouts and load-shedding, accompanied by rising electricity tariffs. However, since 2012 electricity security and access have improved in line with the government's commitment to achieve universal access to electricity by 2025 and increase the country's installed capacity to 2,500 MW by 2030 (Get.Invest 2020). Installed capacity increased from 500 MW in 2012 to 864 MW in 2018 and the electricity connectivity rate now stands at 69 per cent of the population (Power Africa 2022d). While 75 per cent of the country's generation still depends on diesel generators, renewable energy is becoming an increasingly established niche sector.

As in the case of Kenya and Tanzania, infrastructure development, power sector reform, the reduction of electricity tariffs and the overhaul of the generation mix are key components of Senegal's national economic development strategy, the Plan Sénégal Emergent (PSE) which seeks to achieve middle-income country status by 2035 (Gouvernement de la République du Sénégal 2014). The deployment of solar PV is at the core of the PSE which includes a target for renewables to meet 20 per cent of all power production by 2017 (Ministère de l'Energie et du Développement des Energies Renouvelables and ECREEE 2015:8). This target was eventually achieved at the end of 2019[27].

However, despite such progress there is considerable disparity between an urban and rural electrification rate of 93 per cent and 47 per cent respectively which reflects more general inequalities in the country (Power Africa 2022d, Table 2). While the national grid, owned and managed by the state power utility Société Nationale l'Électricité du Sénégal (Sénélec), reaches most of the country's urban centres and large rural habitations, the energy poor in the hardest to reach communities are still largely dependent on biomass such as wood fuel, crop residue and animal dung. Senegal has the highest electricity tariffs in sub-Saharan Africa after Ghana (BloombergNEF 2019).

Senegal's electricity sector is now partially liberalised and overseen by the Ministère du Pétrole et des Energies (MPE) which holds overall responsibility for strategy and policy. Sénélec holds the monopoly on transmission and distribution and just under

[27] https://www.aner.sn/solutions/energie-solaire/

half of generation, with the remainder coming from IPPs that sell exclusively to the utility (IDA 2016). The process of power sector liberalisation began in 1998 with the passing of the Electricity law no 98-29 (CRSE 1998) and has included:

- a strategy to increase private sector engagement in the sector;
- the creation of the energy regulator, La Commission de Régulation du Secteur de l'Électricité (CRSE), which is responsible for setting tariffs and licensing standards;
- the updating of the governing policy of the energy sector, La Lettre de Politique de Développement du Secteur de l'Energie (LPDSE), to include key objectives for private participation and institutional reform[28]; and
- the creation in 2013 of an autonomous agency within the MPE to promote rural electrification and grant technical and financial assistance to enterprises working in the sector, L'Agence Sénégalaise d'électrification rurale (Senegalese Agency for Rural Electrification, ASER) (Ministère du Pétrole et des Energies 2020).

As part of the liberalisation process, in 1998 the government also divided the country's rural regions into ten large concession areas for electrification, called Programmes Prioritaires d'Électrification Rurale ((PPER) priority rural electrification programmes), managed by ASER (RECP, no date). Under a bidding programme supported by DFIs and bi-lateral donors, international developers operating in partnership with Senegalese companies have bid for concessions to construct a mix of grid extension and off-grid electrification for supply to local populations using a variety of technologies, including mini grids, under a 25-year mandate. However, there have been various challenges to the implementation of these programmes including bureaucratic issues and a lack of capacity in key agencies, as a result of which there have been significant delays in awarding the concessions (Ba 2018, SEforAll and BNEF 2020:78). Four out of the ten concessions have yet to be allocated to private sector companies and are still under the management of Sénélec (Get.Invest 2020). Second, the tariffs for this electrification have been capped at below cost and vary across concessions, which has deterred private investors, despite the fact that government has offered to cover up to 70 per cent of capex through subsidies.

In parallel to the concessionary system, the Electrification Rurale d'Initiative Locale (Locally Initiated Rural Electrification, ERIL), also managed by ASER, allows private micro-utilities to supply electricity to local communities through the implementation and operation of stand-alone third generation mini grids. These systems must either be situated outside of the ten larger regional concessions discussed above and/or in communities in which there are no plans for grid-based electrification for the next three years (SEforAll and BNEF 2020:78). Under the ERIL scheme, 80 per cent of the mini grid investment cost is financed by the German bi-lateral donor GIZ, 10 per cent by customers, and 10 per cent by the private operator (RECP, no date). As with the concession scheme however, only a small number of mini grids have been

[28] the LPDSE was released in 1997 and subsequently updated in 2002, 2008, 2012 and for the period 2019-2023 (Bas 2018)

developed under the ERIL scheme thus far. In a potentially progressive move, in March 2019 ASER signed a contract with the German company GAUFF Engineering to install an additional 300 mini grids, and in January 2020, ASER invited bids for the construction of mini grids in an additional 133 villages (Get.Invest 2021).

In 2004 a renewable energy procurement programme for IPPs was implemented, with whom Sénélec is now forced to compete. This partial privatisation process was met with significant opposition, including a major strike by the trade union Syndicat Unique des Travailleurs de l'Électricité and the imprisonment of its leader (Havard 2018:94). Despite this opposition, the country adopted its Renewable Energy Law in 2010 of which objectives include: increasing renewable energy generation to 20 per cent of total installed capacity by 2017; reducing the cost of electricity generation and the tariff for households and companies; and increasing the share of renewables in the energy mix in order to improve the national energy security (ECREE 2018). A further step was the creation of a dedicated renewable energy department (ANER) within Sénélec (ECREE 2018). Various other agencies for rural electrification also emerged after 2010, including the National Ecovillage Agency. However, following Jaglin and Gillou (2020), there has been mission overlap and a lack of coordination and accountability between these multiple agencies.

A more recent outcome of the liberalisation process that has been considered more successful has been a programme for the procurement of utility scale renewable energy from IPPs, including with support from the IFC's Scaling Solar. According to IRENA (2021), by end 2020 there was 246 MW of renewable energy generating capacity installed in the country with more in the pipeline. Of this, an estimated 171 MW is from utility-scale solar PV of between 20 and 30 MW and 50 MW from wind (CAMCO Clean Energy 2020).

Reforms to clarify the complex regulation that currently exists for renewable energy at both the utility and decentralised scales are under consideration. For instance, legislation was passed in December 2018 to subsidise concessionaires and allow them to bring rates down to the state-owned utility Sénélec's grid retail tariffs, a measure which would in principle increase the share of the rural population able to pay the high tariffs for mini grid-generated electricity (SEforAll and BNEF 2020:78). While Senegal lacks detailed regulations regarding grid arrival in the vicinity of established mini grids, in practice, compensation for developers has been carried out across the board. Below 50 kW, mini grid developers do not require a licence (SEforAll and BNEF 2020:84).

Until recently, diesel-generated mini grids in Senegal were largely government-owned, and operated by Sénélec. However, since the government introduced regulation to allow for private sector participation, private companies have become more involved in the sector. According to SEforAll and BNEF (2020:46), as of 2019 Senegal had 272 mini grids installed of which 63 projects had been built under the rural electrification component of the Energising Development (EnDev) programme, which has run since 2005 is funded by GIZ and other donors. However, it is not clear how many of these grids are currently operational. A further 1,217 mini grids are planned, which it is anticipated will be largely solar-PV generated (ESMAP 2020, 2019:48).

Finally, despite recent developments, existing bi-lateral support and the fact that mini grids are anticipated to play a key role in meeting the government's targets for universal access and renewable energy, numerous challenges remain. These include hesitancy on the part of the private sector to invest and the lack of a clear and targetted regulatory framework. According to Ulsrud, the government has been reluctant to allow tariff setting regulations that could enable solar mini grid developers to be economically sustainable in areas where the national grid is not yet established: "New regulations for uniform tariffs and cross-subsidisation to companies operating in remote areas were suggested by government officials but were not likely to be finished soon" (Ulsrud 2020:59). Private investment has therefore been discouraged by the government's position that everyone should pay the same tariff, whether they receive electricity from the national grid, mini grids or other off-grid provision (Ulsrud et al 2018:38). Investors have further been discouraged by the current legal requirement that mini grid operators should withdraw under all circumstances once a locality is connected to the national grid given the ERIL's requirement that systems cut the supply once a daily quota is exceeded (Jaglin and Gillou 2020).

5. **Conclusion**

As this paper has discussed, the positive narrative behind third generation mini grids has led to them being seen as a game changer for the realisation of the goal of universal access of SEforAll and SDG7. Because of their technological versatility mini grids have been championed, particularly by the private sector and DFIs, as a way to bypass failing, often indebted, crisis-ridden, large-scale, capital-intensive monopoly utilities in many low- and middle-income countries (LMICs). However, as the case studies have illustrated, despite the potential of mini grids they are not necessarily the panacea for energy access that they are often promoted as. Thus far, many citizens on a low-income are still excluded from both the centralised grid and/or decentralised alternatives. Moreover, the deployment of these new technological configurations is far from straightforward, and they have faced a variety of technical, economic, political and social challenges. While some of these challenges are specific to the countries in question, others are common across contexts. With this in mind, we offer the following five conclusions.

First, in examining the case of mini grids in the four case study countries, this paper has identified evident tensions between: state and private sector ownership of the electricity sector; centralised and decentralised systems; and priorities for energy access and productive use. In the case of Kenya, Tanzania and Senegal in particular and perhaps less so Nigeria, there has been an ambiguity and/or a resistance by some government institutions, in particular state-owned utilities, towards mini grid development. On the one hand, national regulatory frameworks and policies for mini grids and the participation of private actors are being put in place by government institutions responsible for energy, particularly the regulator.

On the other hand, there is still a strong national political discourse regarding the extension of the electric grid and support to the centralised utility. This internal conflict appears particularly strong in the case of Tanzania. Such tensions are enhanced by multiple and at times bewildering overlapping processes and institutions, at once for power sector liberalisation and the introduction of mini grid regulation, and between whom coordination is not entirely clear. This confusion has contributed to the regulatory uncertainty which appears to have discouraged investors in the case study countries.

A second conclusion relates to the extent to which mini grid regulation is nationally-owned and in whose best interests these regulatory frameworks are being introduced. Such a question relates back to the standard model of power sector reform discussed in Section 2, a process which has been far from straightforward and in many instances has resulted in an incomplete liberalisation process. This question may also relate to the fact that in Kenya, Tanzania, and Senegal, the reform of the power sector and the introduction of renewable energy forms part of a wider national goal to attain middle income status. As the case studies have illustrated, the development of third generation mini grids has been largely backed by an international private sector with a portfolio-based approach to investment and ownership. Indeed, the mini grid value chain, including technology supply, is for the most part internationally-owned. This private sector has in turn been supported by technical assistance and financial leverage from DFIs and bi-lateral donors who have played a key role in supporting national regulators with the design of the relevant regulation. However, as discussed in Section 2, national regulators do not seem to have had the necessary bargaining power anticipated by the standard model. In all four countries, regulators have had less power and influence over the implementation of mini grid regulation than institutions that prioritise the continuation of the centralised grid. A key example of this is ERC/EPRA and KPLC in the case of Kenya.

Third, the electricity system in its centralised form is now subject to significant challenge from decentralised technological systems, which if successfully scaled up, have the potential to disrupt the network architecture and structure of a centralised monopoly. However, as we have discussed, the shift towards private participation in mini grids has faced its own challenges, one of which is the absence of a tariff structure that is deemed acceptable at once to investors, developers, the government, and consumers. For instance, as discussed in the case of Senegal, government has been reluctant to allow tariffs that could enable third generation mini grids to be economically sustainable in areas where the national grid is not yet established. A related challenge is that the extension of the centralised grid to areas in which mini grids have recently been installed is generally seen as an investment risk for developers rather than an opportunity (Muchunku et al 2018). A key reason for this, as Kenya, Tanzania and Senegal illustrate, is limited clarity on the status of mini grids which have been installed in areas where the centralised grid may later arrive. Moreover, predictions regarding the assumed future cost competitiveness of mini grids with conventional grid-based generation may need to consider that thus far, rural electrification efforts have for the most part been heavily dependent on some kind of public subsidy.

Finally, this research puts forward two key areas for further research. First, while various parallels and comparisons can be drawn across the case studies, for instance regarding experiences of power sector reform, the introduction of mini grid regulation and the influence of international trends and state priorities, there are also significant differences in national circumstances. For instance, in terms of levels of rural/urban energy access, population size as well as political, economic, and socio-cultural dynamics. There is therefore a danger of assuming that lessons can be transferred from one country to another, and in order to avoid such assumptions, in-depth interrogation of these important geographical specificities is needed.

Second, and to conclude, this study puts forward important theoretical implications regarding how the changing social, political, economic and technological configurations of electricity, its governance and ownership, should be accounted for. Growing contributions from energy geography and development studies provide useful insights into conceptualising the evolving governance of decentralised electricity. Despite assumptions by some that the decentralisation of electricity may also be accompanied by the democratisation of accompanying structures and institutions, technological disruption is not necessarily aligned with political or socio-economic disruption. And decentralisation does not necessarily make electricity more affordable for the poorest users. A deeper political economy and critical governance focus could therefore be brought to bear in order to understand the messy politics of electricity sector reform under rapid technological changes for decentralisation.

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