ELECTRICITY INFRASTRUCTURE

REPOSITIONING FINANCE WITHIN AFRICA'S SUSTAINABLE ENERGY TRANSITION

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AFRICAN CENTRE FOR CITIES
urbanism from an african perspective

Alfred Herrhausen Gesellschaft

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EXECUTIVE SUMMARY

It is widely acknowledged that clean and safe electricity is critical to sustainable development in sub-Saharan Africa's rapidly evolving cities. Prevailing electricity services across the region are inadequate, expensive and unreliable. Those households that are grid-connected in sub-Saharan African countries pay up to three times more than comparable households on other continents (AfDB, 2018) and almost all electricity grids in Africa experience frequent outages. Expensive and unreliable power in Africa is estimated to cost 2%-4% of GDP and is often cited as the cause of Africa's inability to make industrial progress (APP, 2015; Azolibe & Okonkwo, 2020). In addition, the electricity deficit underpins a horrendous humanitarian and environmental burden. An estimated 400 million people in sub-Saharan African countries continue to rely on energy feedstocks that cause deforestation and indoor pollution. Fisher et al. (2021) reported that 1.1 million Africans, half of them children under the age of five, died from air pollution in 2019.

Less widely documented or acknowledged are the reasons why financing sub-Saharan Africa's electricity has been so difficult and why deficits remain despite numerous programmes and the availability of household budgets ($10 billion per annum by some estimates) for inferior electricity substitutes such as batteries, candles and paraffin. Too easily the technocratic demands of electrification and the default of finance to seek out familiar, low risk, high return opportunities, combine to deliver electricity projects, but not the flow of safe electricity that is able to drive sustained, inclusive progress. The concentration of political and fiscal power in national, as opposed to city governments, and the vested political interests in large vertically integrated electricity utilities, contribute to the unsatisfactory outcomes.

Transcending facile prescripts for sub-Saharan Africa's electricity finance deficit depends on understanding the conflation of interests, incentives and transactions at multiple scales, which makes this nightmare so difficult to dislodge. Despite this perspective, the paper strikes an optimistic note, identifying the confluence of current disruptions at multiple scales as an opportunity to break the deadlock on sub-Saharan Africa's electricity finance and provide the estimated $68 billion per annum over the next two decades required to ensure universal access to safe electricity in sub-Saharan Africa. Applying a socio-technical analysis, the paper identifies shifts at global, regional and local scales that now make it easier to extend sustainable electricity finance (Geels et al., 2016). These include the following.

- Technological progress that enables a shift away from large, long-lived sunk investments that were theexclusive responsibility of national governments, towards smaller scale electricity solutions financed by a variety of actors.
- Innovations in renewable energy that have driven an 85% drop in the price of photovoltaic electricity and a 70% drop in the price of onshore wind between 2010 and 2020, and made these forms of electricity cheaper than alternatives.
- The linking of this electricity to digitalised payment systems that has improved tariff setting, enabled revenue collection and led to the proliferation of mini-grids and smart-grids capable of integrating multiple sources of electricity.
- The urbanisation of sub-Saharan Africa's population that has concentrated demand for household electricity and industrial power in financially viable geographical hubs.

Implicit in the paper is a challenge to financiers to think more systemically about the risks and opportunities associated with universal access to sustainable electricity, and a warning to electricity sector incumbents that fail to appreciate the scale of the technology revolution that is already underway. For those African countries that have historically struggled to raise electricity finance, build the infrastructure, access the feedstocks and collect revenue from electricity users in order to service the costs, the current disruption offers hopeful prospects for multi-nodal, clean power sources, owned cooperatively and distributing reliable, safe and affordable electricity to every household, factory and business on the continent. Taking advantage of the current set of circumstances is not without risks for financiers, electricity utilities, their employees and electricity users, but it is necessary if global finance is to support the sustainable development goals.

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ABBREVIATIONS AND ACRONYMS

AfDB:	African Development Bank
APP:	Africa Progress Panel
BoT:	Bank of Tanzania
CISL:	Cambridge Institute for Sustainability Leadership
CO2:	Carbon dioxide
Covid-19:	Coronavirus disease of 2019
CPI:	Climate Policy Initiative
CSAG:	Climate System Analysis Group
CSIR:	Council for Scientific and Industrial Research
DFI:	Development finance institution
DRC:	Democratic Republic of the Congo
EPP:	Emergency power producers
ESG:	Environmental, social and governance
FDI:	Foreign direct investment
GCF:	Green Climate Fund
GDP:	Gross domestic product
GHG:	Greenhouse gas
GtCO2 :	Gigatonnes of carbon dioxide
GW:	Gigawatt
IEA:	International Energy Agency
IPP:	Independent power producer
IPT:	Independent power transmission
IRENA:	International Renewable Energy Agency
ISMO:	Independent system market operator
kWh:	Kilowatt hour
LEAF:	Leveraging Energy Access Finance (Framework)
LNG:	Liquefied natural gas
MEM:	Ministry of Energy and Minerals (Tanzania)
MW:	Megawatt
MWh:	Megawatt hour
PV:	Photovoltaic
REIPPP:	Renewable Energy Independent Power Procurement Programme
SDG:	Sustainable Development Goal
SEforALL:	Sustainable Energy for All
SSA:	Sub-Saharan Africa
TANESCO:	Tanzania Electric Supply Company Limited
tCO2e:	Tonne of carbon dioxide equivalent
TIPS:	Trade and Industrial Policies Strategies
UK:	United Kingdom
UNECA:	United Nations. Economic Commission for Africa
UNFCCC:	United Nations Framework Convention on Climate Change
UNSD:	United Nations Statistics Division
US:	United States (of America)
WHO:	World Health Organisation
WRI:	World Resources Institute

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1 INTRODUCTION

The 17 SDGs are divided by a mostly unspoken fault line. More than half of them require an advance or expansion of economic activity, “decent work and economic growth”, more food and sanitation (SDGs 1-4, 8 and 9). The others depend on a seeming scaling back, including lowering GHG emissions, “responsible consumption”, restoring fish stocks and ending deforestation (SDGs 12-15). In SDG 7, the unspoken tension between growth and degrowth in the SDGs is reconciled by “ensuring access to affordable, reliable, sustainable and modern energy for all”. Sustainable, non-polluting energy enables economic growth without compromising progress on many of the other SDGs, which is a prerequisite for most of the SDGs (Van den Bergh, 2011; Zenghelis, 2016). Africa’s rapidly evolving cities, covered under SDG 11, aggregate both demand for energy and development challenges, and provide the key site at which this tension and potential reconciliation is playing out.

This paper is focussed on a particular component of the sustainable and modern energy challenge, namely how to finance the electricity that SSA countries require to support sustainable urbanisation[1]. The focus on electricity excludes the analysis of liquid fuels and other forms of energy, except where they are displaced by electricity or form a part of electricity feedstocks. The urban focus situates cities within national and global processes, recognising the interconnected infrastructural scales.

Prevailing electricity services across the continent, especially in SSA, are inadequate, expensive and unreliable. Grid-connected households in SSA countries pay three times more for electricity than households on other continents (AfDB, 2018). Almost all grids in Africa have frequent outages. Expensive and unreliable power in Africa is estimated to cost 2%-4% of GDP and is often cited as the cause of Africa’s inability to make industrial progress (APP, 2015; Azolibe & Okonkwo, 2020). Truncated generation, transmission, distribution and electricity access results in a low-level equilibrium in which investment in electricity does not catalyse the type of sustained economic growth that lifts people out of poverty, and low per-capita incomes, coupled with low levels of tariff collection, undermines the ability to invest in additional electricity.

The lack of finance for sustainable electricity in SSA underpins a horrendous humanitarian burden. An estimated 600 million Africans, two-thirds of whom live in SSA, continue to rely on candles, paraffin and biomass feedstocks for cooking, heating and lighting. Dependence on these energy feedstocks is directly associated with deforestation and indoor pollution. Fisher et al. (2021) reported that 1.1 million people living in Africa, half of them children under the age of five, died from air pollution in 2019. While still a massive problem and responsible for 697 000 deaths in 2019, indoor air pollution has been declining as electricity reaches more households and cookstoves improve. However, the burning of fossil fuels to produce electricity and the growing number of private motor vehicles have seen outdoor air pollution responsible for a growing proportion of premature deaths; 394 000 in 2019 (Fisher et al., 2021). Collectively, such pollution caused by sustainable electricity deficits cost African countries an estimated US$3.02 billion in 2019 (Fisher et al., 2021).

Against this backdrop, financing access to safe and affordable electricity, particularly in cities and urban areas, is fundamental to life and socio-economic ambition in SSA countries (IEA, 2019; World Bank, 2021). There is no shortage of calls or programmes seeking to address the electricity deficit (APP, 2015; AfDB, 2016). The reasons that render the financing of universal access to electricity in SSA so difficult remain underdocumented, poorly understood and fundamental to the lack of progress (Whitfield et al., 2015). In a 2015 report, it was calculated that households in Africa spent US$10 billion annually on inconvenient and polluting candles, paraffin and batteries, suggesting that the inability to pay does not explain all prevailing electricity poverty. Similarly, while limited access to affordable debt restricts the options available to SSA electricity utilities, many African countries experienced rapid economic growth between 2004 and 2014, but were unable to translate that growth into proportionate gains in electricity services.

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[1] The data analysis can be expanded to include the entire African continent, if it is required.

This paper moves beyond normative calls for electrification and bankable electricity projects. Instead, it identifies the co-evolution of centralised political power, the operating assumptions of finance and the technocratic characteristics of electric power systems in producing SSA's prevailing electricity nightmare and in understanding why it has proven so difficult to allocate global capital to a region and sector in which more capital would produce so many benefits (UNECA, 2017). Implicit in the paper is a challenge to financiers to think more systemically about the risks and opportunities associated with universal access to sustainable electricity, and a warning to incumbent electricity sector players that fail to appreciate the scale of the technology revolution that is underway. Nevertheless, the paper strikes an optimistic note with regards to electricity finance, citing the confluence of disruptions at multiple scales as an opportunity to break the deadlock on SSA's electricity finance. More specifically, and applying a socio-technical analysis, the paper identifies a confluence of shifts at global, regional and local scales, which makes it easier to extend sustainable electricity finance (Geels et al., 2016).

These shifts include the following:

- Technological progress that enables a shift away from large, long-lived sunk investments that were the exclusive responsibility of national governments, towards electricity solutions financed by a variety of actors on a smaller scale.
- Innovations in renewable energy that have driven an 85% drop in the price of photovoltaic electricity and a 70% drop in the price of onshore wind between 2010 and 2020, and made these forms of electricity cheaper than alternatives.
- The linking of this electricity to digitalised payment systems that have improved tariff setting, enabled revenue collection and led to the proliferation of mini-grids and smart grids capable of integrating multiple sources of electricity.
- The urbanisation of SSA's population that has concentrated demand for household electricity and industrial power in financially viable geographical hubs.

For the African countries that have historically struggled to raise electricity finance, build the infrastructure, access the electric power feedstocks and collect revenue from electricity users in order to service the costs, the above shifts offer hopeful prospects for multi-nodal, clean power sources, owned cooperatively, and distributing reliable, safe and affordable electricity to every household, factory and business on the continent.

How finance, in its various forms, engages this transformation is not yet clear and realising the potential is not guaranteed. The technological innovations, while creating new opportunities, also open the door to new risks, including clean electricity becoming the preserve of the affluent, job losses, elite capture and cyber attacks (Whitfield et al., 2015). Significantly, a set of enabling conditions identified in this document create a rare alignment of interest between the finance sector and the needs of respective SSA countries. The opportunity is not only to secure the estimated US$68 billion in electricity and transmission investment that is required every year until 2050, but also to ensure that this investment becomes the catalyst for new forms of socio-economic progress and inclusion. Where finance can deliver this electricity, it will generate virtuous cycles of energy security, ambitious and enabled urban youth, environmental and human health, low-carbon manufacturing and increasing local content in energy services, all of which will benefit the finance sector in systemic ways (UNECA, 2017).

The trope of financial, social and ecological sustainability is evoked throughout the paper. There are many definitions for sustainability, but fundamentally activities that are unsustainable will stop. It is this perspective that frames this paper. In the context of anthropogenic climate change, it is assumed that sustainable African economies will either be net-zero by 2050 in terms of GHG emissions or confront an existential crisis (IPCC, 2018). Correspondingly, it is assumed that simply decarbonising prevailing electricity poverty and inequality is not a durable strategy. It is the responsibility of the finance sector to confront the imperative of universal access to electricity and these absolutes, and it is the associated financial opportunity that provides the focus of this paper.

2 PREVAILING ELECTRICITY SYSTEMS

For much of the 20th century, electricity planning involved charting the socio-economic need, raising the required public and private finance based on projected revenue from electricity users, building the required generation and distribution capacity, and managing the environmental consequences of feedstock choices. This was typically the responsibility of national government, comprising large vertically integrated electricity utilities meant to unlock economies of scale and serve the public good. It was a system that co-evolved with financial instruments, such as infrastructure bonds, and technological innovations, such as prepaid metres, but self-evidently it was not a system that served SSA countries well (Balabanyan et al., 2021).

In 2013, the African Union's Agenda 2063 set the 10-year goal of increasing access to electricity by at least 50% compared to the levels in 2013, and increasing household energy efficiency by at least 30% before 2023 (IEA, 2019). Prior to the Covid-19 pandemic, progress against the AU goal was on track. The rate at which people were being connected to the grid doubled between 2000 and 2018, and electricity access rates in Africa rose from 28% to 48% over the same period, while generation capacity rose by 43 GW (World Bank, 2021).[2] Over the same period, the number of people without grid access in Africa hardly changed, peaking at 610 million in 2013, but only dropping to 595 million by 2018 (IEA, 2019a). More than half of those receiving grid connections in this period were in Kenya, Ethiopia and Tanzania, while four of the countries identified as most in need of electricity experienced a decline in investment from 2017 as electricity investment continued to flow to regions of highest financial return, rather than the communities most in need (SEforALL, 2019). Progress in providing electricity has lagged progress in Asian and Latin American countries. The IEA estimates that, after seven consecutive years of improvements, 2% (13 million) fewer African people had access to electricity due to the Covid-19 pandemic.

The average African person consumed a mere 180 kWh of electricity in 2019, which is less than 4% of the global average,[3] but this figure conceals significant regional differences and pockets of recent progress. On average, 70% of the continent's electricity is generated in North African countries and South Africa, with North African countries having enjoyed universal access to electricity since 2010 (IEA, 2019). Rural–urban differences prevail across SSA where only 29% of rural households had access to electricity in 2019, compared with 76% of urban households.

Energy landscapes shape developmental landscapes and pathways of development, and the absolute and relative electricity deficit, as well as the manner in which available electricity is generated and allocated, shape the continent's economic options (Castan-Broto, 2017). The region's energy poverty is the underlying cause of multidimensional poverty across SSA (see Figure 1) (Jennings & Oldiges, 2020). Indoor air pollution, the result of biomass (mostly wood and charcoal) and paraffin use in food preparation kills more than half a million people annually (Fisher et al., 2021). Outdoor air pollution emanating from vehicles, diesel generators and coal-fired power stations killed an additional 285 000 people in 2019, a mortality number that has increased by 60% between 1990 and 2017 (Jennings & Oldiges, 2020; Rees et al., 2019). Deforestation in West, Central and East Africa is underreported, but the loss of approximately 2% per decade of the world's second largest tropical rain forest is destroying habitats and watersheds, contributing to flooding and disrupting regional weather patterns (Damania & Wheeler, 2015). The GHG emissions associated with wood and charcoal burning tend not to feature in national GHG reporting inventories. Ghana began reporting emissions from charcoal manufacturing for the first time in 2016 and added 0.1MtCO2e to the national greenhouse gas inventory, but this is difficult to measure and did not include the loss of forests in charcoal making. Anecdotal evidence suggests the contribution to emissions could be much greater (Ghana EPA, 2019).

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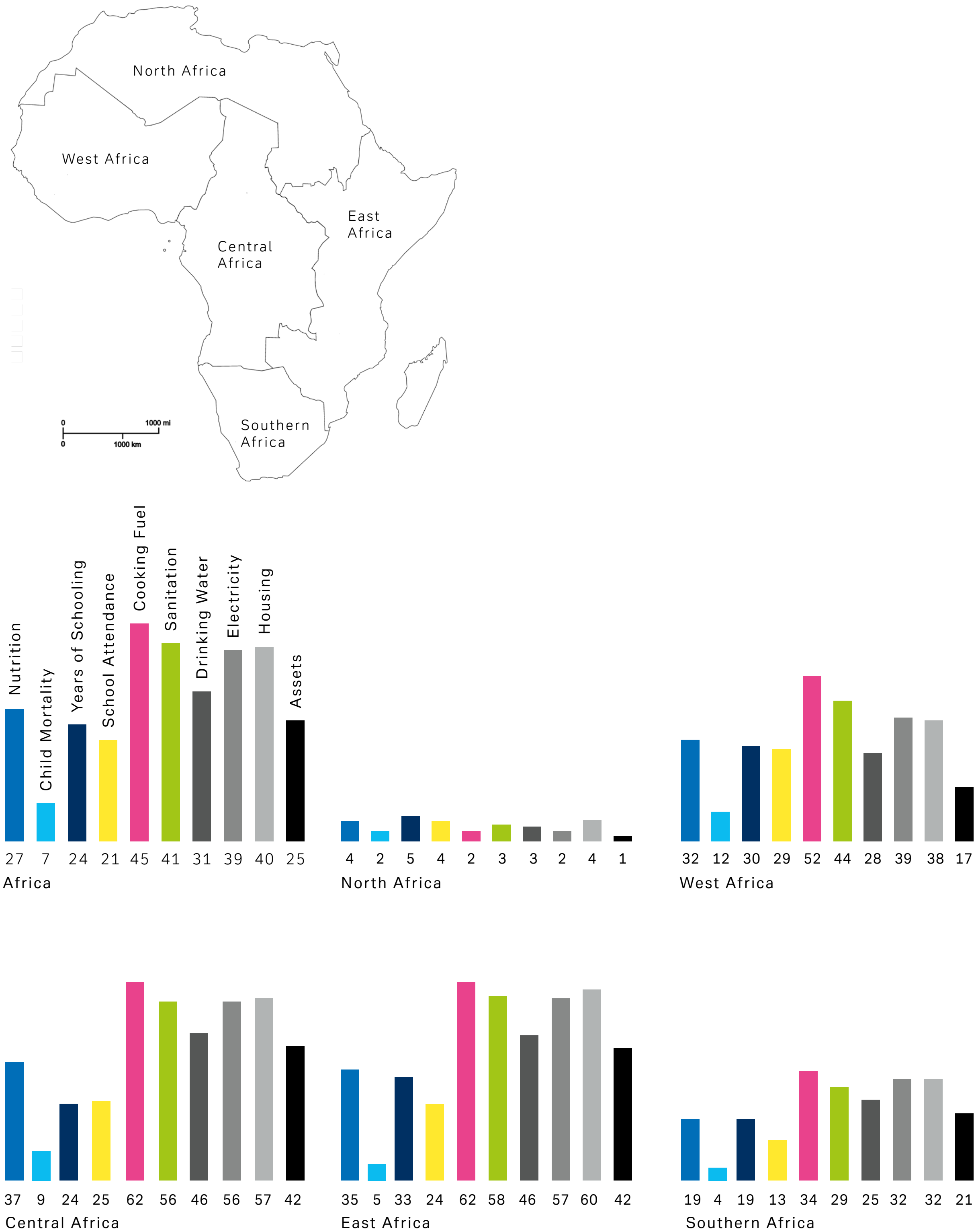
[2] An IEA report put the figure at 37% in 2019.

[3] Average annual electricity consumption in the United States is 13 000 kWh and 6 500 kWh in Europe (AfDB, 2020).

FIGURE 1: COMPONENTS OF MULTIDIMENSIONAL POVERTY ACROSS AFRICAN REGIONS (JENNINGS & OLDIGES, 2020)

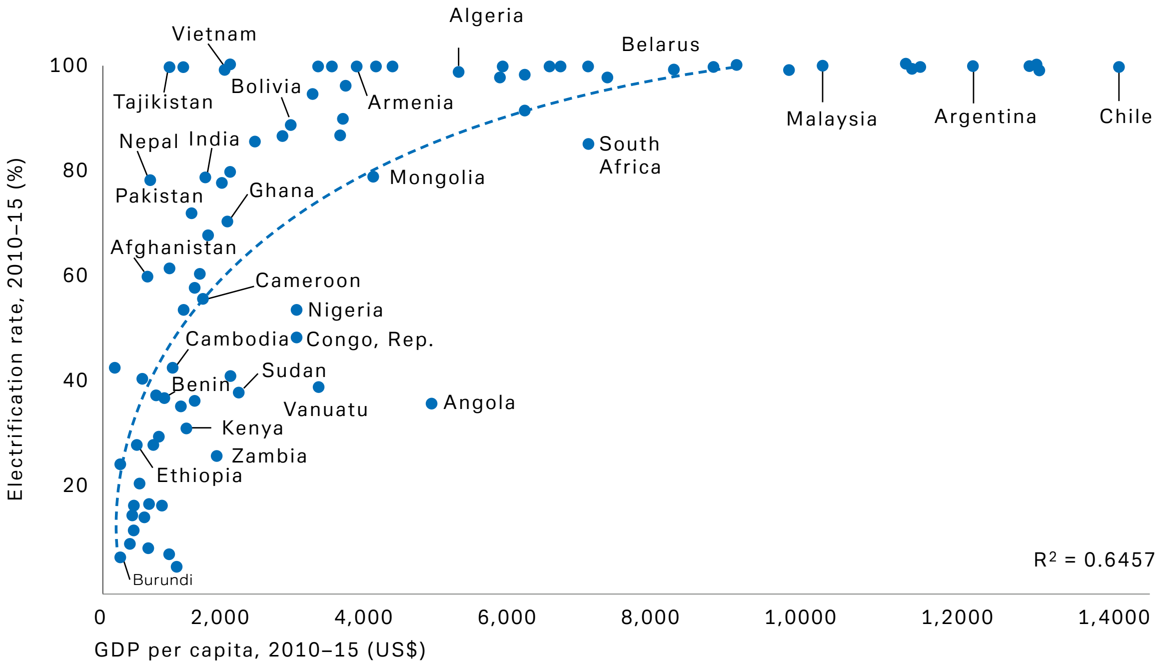


The response to electricity deficits in SSA has included rapid market liberalisation and the introduction of IPPs, the contracting of EPPs and the ring-fencing of energy systems to meet the bespoke needs of mines or factories. However, these solutions did not address the structural conditions giving rise to insufficient and perverse electricity finance, and often splintered governance frameworks creating problems of their own. The procurement of electricity feedstocks from miners, IPPs and EPPs was too often linked to patronage networks and poorly policed by national environmental agencies (Eberhard et al., 2016; Lameck et al., 2019).

The pockets of progress that have emerged are difficult to trace definitively. Inference on the extent of investment flows to Africa's electricity projects still suffers from the gap between inherently bullish project level data and pledges, and the aggregated data that tend to not capture the multiple locations, scale and types of progress that are emerging. The IEA, the World Bank, the UNSD and IRENA track the status of the global energy sector, while REN21 produces an annual assessment of investment in renewable energy, including hydropower below 50 MW. The WHO collaborates with the above organisations to publish updates on SDG 7, while Climate Action Tracker uses the above information and national contribution submissions to the UNFCCC to gauge progress relative to the requirements of the Paris Agreement. The growing body of evidence is useful, but not always concordant. Definitive insights are further complicated by differences in whether or not hydropower and biomass are renewable, distinctions between Africa, SSA and North Africa in data sets and the occasional exclusion of South Africa and Nigeria. Data ambiguity is compounded by the lack of detail on where the money from bilateral commodities for investment deals ends up. These transactions have been a recent feature of investment in Africa, most notably via China's alleged US$1.3 trillion investment programme, which definitely includes US$40 billion in loaned finance and known resource for infrastructure swaps, but rarely discloses their composition in terms of loans, equity and grants (Chen, 2021). Tracking progress is further complicated by the proliferation of mini-grids in East Africa, most of them privately installed (REN21, 2021).

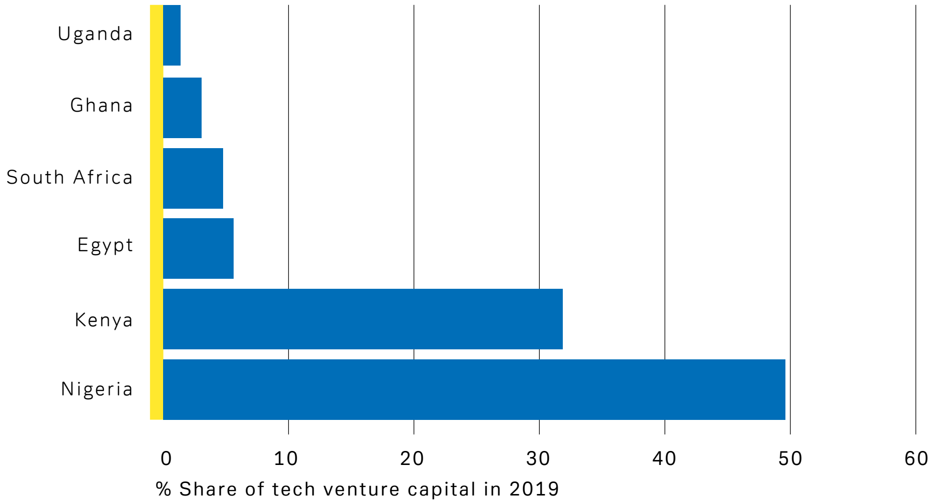
In terms of electricity sector structure, vertically integrated State-owned utilities remain intact in most SSA countries. As a result, most of the electric power capacity that has since been built in SSA countries has been funded and operated publicly, and has been subject to the fiscal capacity of national governments. IPPs have contributed 42% of investment in generation and transmission capacity in low- and middle-income countries, with the Philippines, Georgia, Peru and Cambodia having received more than 80% of the electricity sector investment from IPPs since 1990. In SSA, this proportion was a mere 40%, and small in absolute terms at just more than US$30 billion out of a total of US$600 billion between 1990 and 2016 (Foster & Rana, 2020). In terms of attracting IPP investment, GDP per capita remains more significant than governance structure (see Figure 2) (Foster & Rana, 2020).

FIGURE 2: RELATIONSHIP BETWEEN INVESTMENT IN ELECTRICITY AND GDP PER CAPITA (FOSTER & RANA, 2020)



Venture capital has begun familiarising itself with the risks and opportunities in SSA countries, most notably the opportunity presented by the ambition, consumption and capacity of the growing urban elite. Half of the investment made by venture capitalists went to FinTech in 2019, with CleanTech (mostly electricity) attracting the second highest amount of roughly 12% More than 70% of this investment flowed to Nigeria and Kenya in 2019. Symptomatic of the inherent difficulties, only 20% of the venture capital in Africa's electricity sector and 40% of the IPP investment emanated from Africa itself between 2015 and 2020 (Foster & Rana, 2020; Okonkwo, 2021).

FIGURE 3: ALLOCATION OF TECH VENTURE CAPITAL ACROSS SECTOR IN SSA (2019) (WEETRACKER,2020)

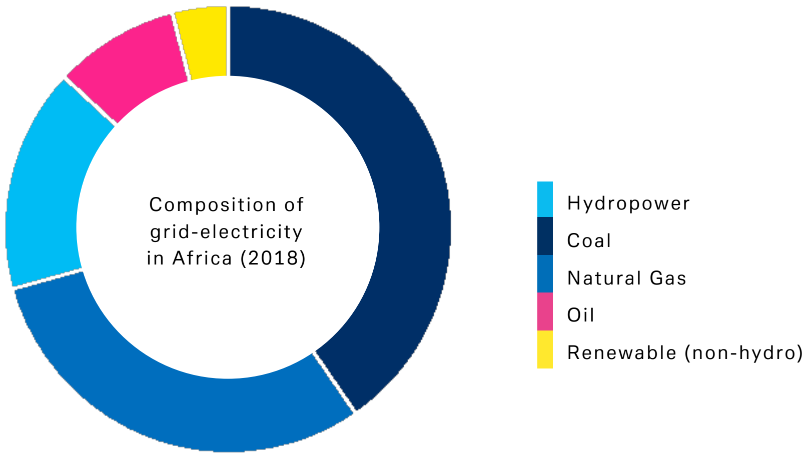


While there is a sense of flux in both the structure of global energy sector and the flow of finance to SSA countries, it remains useful to distinguish between generation, transmission and distribution in order to understand these changes.

2.1 Power generation

The African continent has 180 GW of installed power capacity, roughly the capacity that China has built every two years over the past decade, of which 53.8 GW is renewable power, including hydropower (AfDB, 2017; IRENA, 2021). The historical contribution made by coal ensures that it remains the most common source of installed grid-supplied electric power in Africa (40%), followed by natural gas (30%), and hydropower (16%) and oil (9%). Regional differences prevail, with natural gas providing the dominant feedstock in North Africa and Nigeria, hydropower being prevalent in Central Africa and coal dominating South Africa's grid (IEA, 2019).

FIGURE 4: BREAKDOWN OF FEEDSTOCKS USED IN ELECTRICITY IN AFRICA (IEA, 2019) (AUTHOR'S CALCULATIONS)

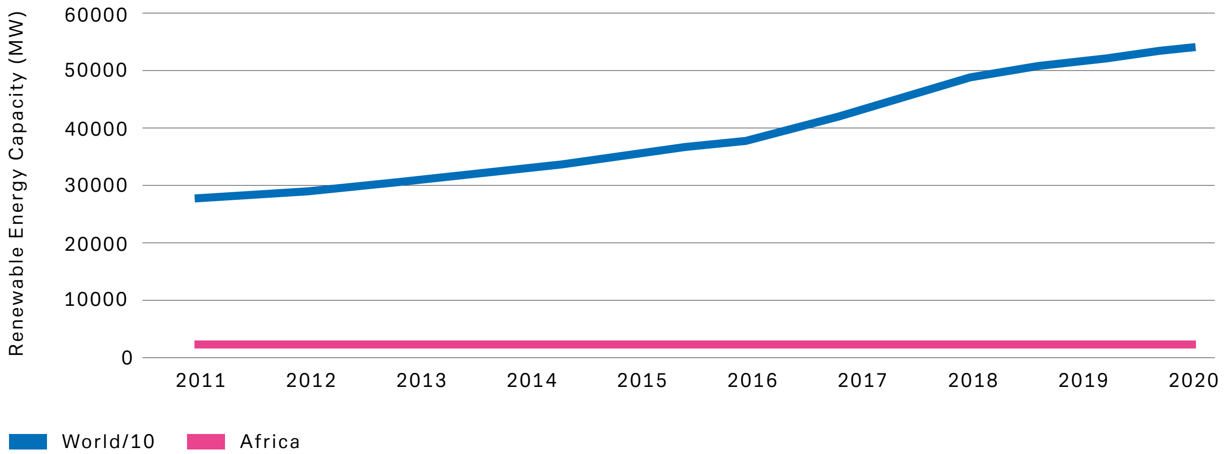


The growing contribution made by private investors tends to track the growth opportunities closely. Between 2010 and 2018, the greatest proportional gains in power generation were made by wind and solar power, with a 250% increase and most of these involved private finance (IEA, 2020). The emergence of renewable power opportunities has been supported by new sources of finance and new financiers. Contrary to what their public relations efforts suggest, none of the major oil and gas companies active in Africa invested more than 10% of their 2020 capital investment in renewable energy (Ren21, 2021). Public finance flows to electricity projects have been slower to switch into wind and solar power, and totalled US$5.6 billion in 2019, with hydropower comprising a 40% contribution. Data from IRENA differ from the data from IEA, but still show that the available renewable energy capacity almost doubled to 53 GW in the decade since 2010, and that photovoltaic solar energy, followed by wind power and hydropower showed the greatest growth rates.

Initial renewable energy investment has been concentrated in Tunisia, Morocco, Egypt and South Africa, but data for 2018/2019 show 20 projects ranging in scale from 14 MW to 250 MW across 11 SSA countries from Cameroon to Zambia (World Bank, 2021). The projects comprise a blend of donor funds, private finance and public funds, with the shortest investment period being 20 years. Data from REN21 differ from those of the World Bank, but it is reported that Egypt (Benban photovoltaic), Ethiopia (wind), Kenya (Turkana wind and Olkaria geothermal), Morocco (Noor concentrated solar power) and South Africa (wind and photovoltaic) are building new utility-scale renewable energy projects (REN21, 2021). In a complementary development, East Africa now leads the global market for off-grid solar appliances with nearly four million units sold a year. Moreover, there were more than 40 000 mini-grids in SSA in 2019, up from a mere 2 000 in 2016 (REN21, 2021).

Despite growth in renewable electricity investment and evidence that African countries have competed more effectively for renewable electricity investment than conventional electricity investment, flows of private finance remain inadequate (see Figure 5) (SEforAll, 2020). Between 2010 and 2018, the continent most in need of electricity constructed a mere 7% of global renewable energy capacity, with total electricity capacity on the continent comprising less than 3% of the global capacity. Evidently, the rules that govern the allocation of renewable energy investment are not yet significantly different to the rules that govern investment in general, and Africa remains a difficult investment proposition.

FIGURE 5: INSTALLATION OF RENEWABLE ENERGY CAPACITY IN THE WORLD (DIVIDED BY 10) AND AFRICA, SHOWING THE GROWTH RATE IN AFRICA NOT KEEPING PACE WITH THE GLOBAL TREND (ADAPTED FROM: SEFORALL, 2020)



There is still insufficient "productive power" in SSA – the high intensity power supplied with sufficient reliability to operate manufacturing equipment. This has seen many African countries pursue a twin-track of embracing renewable energy service providers while still pursuing oil, gas and coal options for industrial power, and as backup. Truncated and unreliable electricity supplies, and the associated need for expensive back-up power, are estimated to cost the continent 2%-4% of GDP and are often cited as the causes of Africa's inability to make industrial progress (APP, 2015; Azolibe & Okonkwo, 2020).

Most African countries use five-year master plans to assess electricity demands and plan expansions of generation capacity. In practice, these plans neither tend to be implemented due to fiscal constraints, nor to be heavily delayed (Foster & Rana, 2020). Deficits have created opportunities for EPPs in significant, but opaque contracts supplying power to bespoke factories, towns and settlements in technology agnostic ways. In Ghana, for example, the uncoordinated procurement of electricity from IPPs prior to 2016, in what was termed 'emergency power procurement', required the government to pay US$450 million in 2019 to private companies for power that the country did not use (Dwazu & Janse van Vuuren, 2019). This took place despite the unbundling of vertically integrated utilities in Ghana in 2005.

TANZANIA'S ELECTRICITY GOVERNANCE

Tanzania is emblematic of SSA's electricity challenges, in many ways. Current electricity capacity is less than 5% of that of South Africa, which has a similar-sized population. The national utility, TANESCO, is unable to extend the grid to all regions for financial reasons (Lameck et al., 2019). Private sector finance has begun complementing fiscal resources, with almost half of the 643 MW capacity installed in Tanzania since 2000 being financed privately. Half of this, however, was procured through opaque emergency power agreements with the private sector at a cost of US$0.30-US$0.43 per kWh and drawing on LNG and diesel to supply electricity to bespoke mines, construction projects, towns and cities (MEM, 2014). Paying for this electricity cost TANESCO undermining the utility's ability to invest in new generation capacity (Eberhard et al., 2016). To redress this situation, central government began investing US$308 million in 2018/2019 to build the Rufiji Hydropower Plant, which would more than double Tanzania's electricity generation capacity once complete. It is not clear how the US$2.9 billion required to complete the project will be raised (BoT, 2018). The finance shortfall at Rufiji Hydropower is mirrored across Tanzania's Power System Master Plan, which, if implemented, would require US$46.2 billion by 2040, which is 80% of the country's 2020 GDP (Cartwright, 2019).

2.2 Power transmission

Ironically not all the electricity that is generated in SSA countries is transmitted. In Nigeria, where there has been active private sector investment in generation capacity, under-investment in transmission has resulted in a three-fold increase in undispatched electricity in the eight years since the grid was privatised in 2013. This "over-supply" co-exists with 43% of the population not having access to the grid and truncated industrial development (Tena, 2021). Ghana has experienced a similar fate following hasty and untransparent procurement of emergency power, which it does not need.

The modalities used to transmit power from generation plants to end users are central to the access and financing challenge in Africa, but are too often overlooked as investment focuses on generation. Where generation companies are unable to transmit their electricity, the financing model, whether public or private, collapses.

In most SSA countries, with Nigeria being one of a few notable exceptions, electricity transmission is viewed as a public good. Accordingly, State-owned companies with varying degrees of autonomy own and finance the transmission system. In some countries, for example, South Africa and Senegal, grid transmission is overseen by the same companies responsible for generation, making for vertically integrated monopoly–monopsony arrangements in which only a State-owned company can supply the grid and only the grid can procure electricity. The intention was for vertical integration to confer stability and economies of scale on electricity systems, in addition to ensuring the coordinated expansion of generation, transmission and distribution capacity. The more common reality, whether public or private, is for investment in transmission and distribution to lag investment in generation. Incumbent entities on generation and transmission have been slow to adopt new technologies that could lower costs, extend electricity access and strengthen the investment case (World Bank, 2021). As a result, most transmission companies ration access as the cost of extending the grid to remote users becomes impossible to recoup from electricity tariffs (Lameck et al., 2019).

Where transmission has been privatised, the outcomes have been varied. In Nigeria, private distribution companies operating under a public sector mandate have done little to improve access, but Uganda has successfully included private sector investment in distribution while enhancing financial viability and governance transparency. Umeme Limited, Uganda's largest distribution utility, is privately owned, but operates under a 20-year contract for distribution and retail. Actis, the private equity partner that owned and operated Umeme's concession for 11 years before a successful listing of the company in 2012, raised prices and insisted on tariff payments through pre-paid meters ("yakas"), but also tripled the share of the population connected to the grid, halved line losses, eliminated network-related fatalities and increased the bill collection rate to 98.4%, setting a benchmark for what is possible through an effective public–private partnership (Eberhard et al., 2016). The transmission stability introduced by the private sector investor, came at a high cost to the fiscus. Crucial to Umeme Limited's success was improved communication with customers that allowed them to alert the company to "livewire incidents" and network problems. Umeme also benefited from its State guarantees, and the private investor was also able to extract US$623 million in payments from the Ugandan Government between 2005 and 2012 (at its peak 7% of the annual national budget) by exercising clauses in its contract relating to the supply of electricity (Eberhard et al., 2016; Fu, undated).

A few countries, namely Ghana, Tanzania and Mozambique, operate two transmission networks, in which separate utilities hold responsibility for rural and urban consumers, respectively. The rationale is that rural users confront higher connection charges owing to their remoteness and, therefore, require higher degrees of subsidisation. In practice, all State-owned utilities rely on national governments, donors and DFIs for finance. In Tanzania, the national government has exchanged access to commodities for investment in the extension of the transmission network and generation capacity through bilateral deals with China Exim. The terms for commodity-for-investment deals are opaque, but rely on government-owned utilities to manage the construction, and operate and maintain the transmission line after it has been constructed (World Bank, 2017).

As sources of power generation become more diffuse, the scope for multiple transmission networks becomes stronger. The smaller scale of these networks provides scope for IPTs or electricity cooperatives, both of which are capable of drawing in private finance. Ideally, public oversight retains the task of integrating respective mini-grids, coordinating generation and transmission over time and space, and allowing for ongoing cross-subsidisation of poorer households and grid safety, but this governance hybrid has not emerged in African countries yet. On the contrary, there is already a risk that renewable energy and mini-grids will see affluent consumers cede from the publicly run system, making it more difficult to finance access for poor households.

2.3 Electricity distribution

In theory, local governments are able to take advantage of proximity to users to nuance distribution, connections and disconnections, and pricing and revenue collection in ways that enhance investment and permit cross-subsidisation to poorer energy users. The systematic undermining of local government authority and budget autonomy by central governments nervous about the political consequences of devolving fiscal authority, means that most local authorities hold "limited information on who should be paying tax, … and low use of online and mobile payments" (Owusu & Shand., 2020:4). The weak fiscal state of local authorities in most African countries impairs their ability to extend the grid or manage electricity distribution, and instead requires national power utilities to distribute electricity directly to end-users (Cartwright et al., 2018). The centralised control of electricity systems has, in turn, undermined revenue collection, making it difficult for utilities to complete new capital projects (Amani et al., 2019).
Against the backdrop of truncated grid-reach, some extractive companies and factories have struck concessionary tariff deals in exchange for investing in the grid extensions required to supply their operations with electricity. Alternatively, industrial development parks or bespoke private distribution grids are created around intensive electricity users.

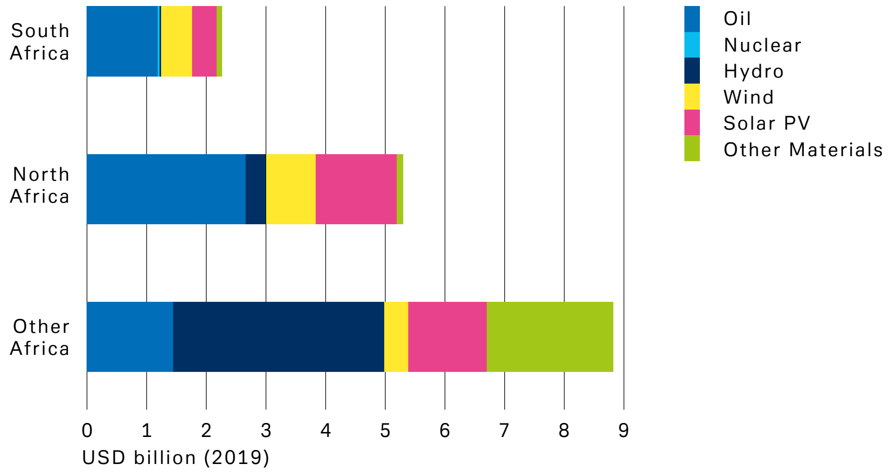
There are exceptions to the above norms, for example, the national utility in Morocco, namely ONEE, increased the rural electrification rate from 18% in 1995 to 97% in 2009 by applying a "fee for service model" in connecting 95% of households to the grid and installing solar-powered systems to remote homes for whom grid connection would have been too expensive (IEA, 2019).

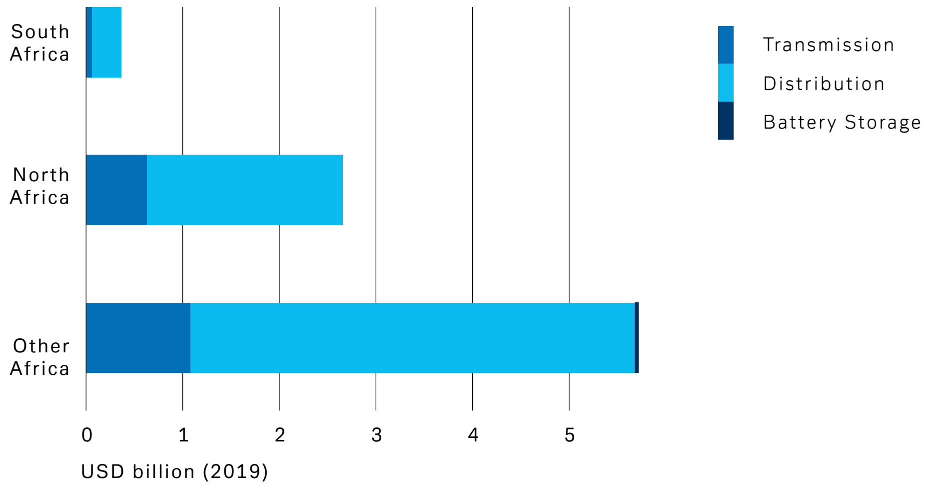
3 PREVAILING ELECTRICITY FINANCE

There are various estimates for the quantum of energy and investment required to address Africa's electricity backlog:

- IRENA pegs the investment need at US$70 billion annually until 2030 in order to create 310 GW of renewable energy (IRENA, 2019).
- The goal of the AfDB of universal access by 2025 involves a doubling of existing capacity, 130 million new on-grid connections, 75 million new off-grid connections and 150 million households with access to clean cooking solutions. This would not provide the quantum of electricity required to drive industrialisation, but would support poverty alleviation. The targets of the AfDB require an estimated US$60 billion - US$90 billion to be invested per year, of which the AfDB is committed to providing US$12 billion over five years.
- Applying a guideline cost of US$1 billion per GW of capacity, which assumes ongoing progress in technological innovation and price declines, roughly US$2 trillion is required to be invested over the next 30 years, which translates to US$68 billion a year, in order to meet Africa's electricity needs.[4]

FIGURE 6: INVESTMENT IN GENERATION AND TRANSMISSION AND STORAGE IN AFRICA (2019 IN US$) (IEA, 2021)





[4] This should be compared to the US$1 trillion that is invested in fossil fuel exploration, extraction and delivery infrastructure (UNU-INRA Stranded Assets).

While estimates vary, historical flows of investment to SSA's electricity capacity have been inadequate, and predominantly to fossil fuel generation in countries that have reasonable capacity (IRENA & CPI, 2020). The disconnect between places where electricity is most acutely needed, namely the high impact countries identified by the UN's High-level Dialogue on Energy, and places where electricity investment can generate financial returns, is at the core of Africa's electricity finance challenge. While investing in universal access to clean and safe electricity in SSA would alleviate humanitarian crises, be good for global security and contribute to climate change mitigation, these returns do not accrue to investors and fail to generate what financiers euphemistically call "effective demand".

In theory, state-owned electricity utilities should be able to internalise the positive externalities generated by sustainable electricity in SSA and finance the required electricity without the need for financial returns. However, indebtedness, the financialisaton of public entities across the world, and the influence of credit rating agencies in pronouncing who should qualify for finance, renders it difficult for public utilities and national treasuries to issue bonds and raise the finance required to invest (ICA, 2017). For these reasons, the countries that need electricity investment most are the last to receive it, and attract investment at prohibitive rates (Ameli et al., 2021; Donaubauer et al., 2020).

Similarly, the multifaceted benefits that arise from sustainable electricity should create a role for DFIs in mobilising investment. In practice, African DFIs have to raise most of their money in capital markets, and have struggled to carve out a segment of risk and reward in the finance market that is distinct from that of either governments, on the one hand, and commercial banks, on the other. In some instances, DFIs have been complicit in a global energy system characterised by a profound lack of transparency on how deals are reached, and void of accountability for its socio-ecological costs and risks, and distributional impacts (Sareen, 2019). The World Bank was a key financier in South Africa's disastrous Kusile and Medupi coal-fired power stations, as an example, and, in general, financing from DFIs has failed to unlock the public good that would be generated if all SSA electricity needs were financed at reasonable rates.

Addressing this situation to meet the needs of rapidly urbanising populations and lift SSA countries out of multidimensional poverty requires a complete overhaul of the demand for, and supply of electricity finance (Hourcade et al., 2021). Replicating the status quo of energy finance will perpetuate oppression and exclusion despite the evolving context of service delivery in African cities (Castan Broto et al., 2018; Geels et al., 2017). In 2020, the AfDB sought to advance a New Deal on Energy for Africa. The programme comprises action on five fronts, namely i) raising aspirations to solve Africa's energy challenges; ii) establishing a Transformative Partnership on Energy for Africa; iii) mobilising domestic and international capital for innovative financing in Africa's energy sector; iv) supporting African governments in strengthening energy policy, regulation and sector governance; and v) increasing AfDB's investments in energy and climate financing. The available budget in the bank is limited, but is intended to leverage support from the GCF, civil society, cities, IPPs and national governments.

The sobering reality is that humanity has never decreased its consumption of a major energy feedstock, with even biomass use continuing to increase despite the advent of oil, coal and renewable energy. The process is made more difficult by the role of incumbents in strongholds of political and financial power. The finance transformation required to drive the required electricity progress is fraught with "transition risk", especially for fossil fuel-dependent developing economies and vulnerable workers and communities that depend on coal or oil value chains (CISL, 2019). While the "just transition" discourse promises a sustainable, democratic, more transparent and more fair electricity system, it also draws attention to the fact that the prevailing system incorporates none of these attributes (McCauley & Heffron, 2018). Co-evolved energy and finance systems make that prevailing system difficult to disrupt. For this reason, it is essential to consider the conditions that enable improved outcomes.

4 EMERGING OPPORTUNITIES FOR FINANCING SSA'S ELECTRICITY SECTOR

If it is assumed, as outlined above, that approximately US$2 trillion is required to be invested over the next 30 years (US$68 billion a year), to meet SSA's electricity need,[5] the question becomes 'what are the prospects of raising this finance and spending it well?' To place the required investment in context, global investment in electricity totalled US$1.9 trillion in 2021, of which less than 20% was for renewable electricity. Across Africa, global energy investment and "deal flows", which is the amount of infrastructure investment secured, decreased between 2014 and 2020 as the commodity cycle slowed (IEA, 2019). The Covid-19 pandemic exposed a combination of development deficits in African countries and deep-seated biases among rich nations, which makes it difficult for SSA countries to raise finance. In the context of global electricity investment, delivering on SSA's need is only possible if the total quantum of renewable energy investment triples to approximately US$1 trillion per annum by 2030 and SSA countries secure 6%-8% of this investment every year (Donaubauer et al., 2020).

To avoid the default and take full advantage of the current set of circumstances, African countries will have to be deliberate in the way that they shape not only the demand for finance from bankable projects, but also the supply of finance into the electricity sector. The section below explores a set of emerging conditions, at different scales, that are destabilising the co-evolved finance and energy systems, changing the nature of electricity demand and supply, creating an unprecedented opportunity to finance much-needed electricity in SSA countries (Geels et al., 2017).

4.1 Climate change and renewable electricity innovation

Africa's negligible (3%) contribution to the atmospheric GHGs causing climate change, is a function of the continent's energy poverty, not clean energy. The electricity that is provided to SSA is still predominantly fuelled by coal and natural gas. While low emissions provide the continent with moral high ground in climate negotiations this does not constitute a reason to pursue fossil-fuel powered electricity and should not blind leaders in the region to the "death knell for coal and fossil fuels" (Guterres, 2021). SSA's good fortune is that the region is seeking sustainable electricity finance at a time when renewable electricity prices are plummeting. The global weighted average levelised cost of electricity (LCOE) from new capacity additions of onshore wind declined by 13% between 2019 and 2020, offshore wind fell by 9%, concentrating solar power (CSP) fell by 16%, and that of utility-scale solar PVs fell by 7% over the same period (IRENA, 2021). The 2019-2020 price drops were on the back of an 85% drop in the price of photovoltaic electricity and an approximate 70% drop in the price of onshore wind between 2010 and 2020. The price declines are expected to continue for another 10-15 years as technology, supply chains, scalability and manufacturing processes continue to improve (IRENA, 2021; Way et al., 2021).

The lead time associated with modularised renewable energy (usually two years) relative to coal (six to eight years), large-scale hydropower (10+ years) and nuclear power (12+ years) makes the adoption of renewable energy particularly attractive in meeting the growing demand in African countries. As the CEO of South Africa's national electricity utility, Eskom, pointed out:

> *If you start to look at the capital cost of building new nuclear and you look at the time associated with that, it will take you 12 to 15 years to bring new nuclear online and it will probably cost you about R1.80/kWh. So, when you compare that to new wind, at about 70c/kWh, and you look at solar photovoltaic electricity, which is about 60c/kWh, and the fact that you can bring wind and solar online in about 18 to 24 months, the decision kind of makes itself, even if you ignore any environmental considerations (De Ruyter, August 2021).*

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[5] This should be compared to the estimated US$1 trillion that is invested in fossil fuel exploration, extraction and delivery infrastructure annually (UNU-INRA Stranded Assets).

The shift towards renewable electricity and the associated price declines make cost recovery across the full electricity system possible within 10 years without increases in electricity prices. This, on its own, has made electrification attractive to multiple types of finance (Foster & Rana, 2020).

The year 2021 added 290 GW of renewable energy globally, which is up from 280 GW (US$303.5 billion) in 2020 despite rising costs and supply-side bottlenecks for rare earth minerals and other materials needed to make new solar panels and wind turbines (IEA, 2021). The IEA anticipates that between 2020 and 2026, 4 800 GW of electricity will be added globally, of which 95% will be powered by renewable technologies (IA, 2021). To meet its needs, African countries will have to compete for 8.5% of the globally installed capacity. Effective leadership will leverage the threat of increasing emissions from SSA countries to attract investment on much-improved terms. The technologies used by African countries to address their future electricity needs will have implications for the global effort to keep temperature increases within the guardrail of 1.5 °C by 2100. The 250 GtCO2 that would be added to the atmosphere by 2050 if Africa's growing population consumed 4 MWh of electricity produced at the same carbon intensity as the average South African, would account for half the available carbon budget required to have a 50% chance of keeping 2100 warming below 1.5 °C. More bluntly, this scenario would remove any chance of preventing globally catastrophic climate change.

4.2 Financial support for just climate transitions

As the world grows more aware and anxious about the impacts of climate change, large parts of the global finance sector have been called to account and, not before time, have begun to relocate their investments (Hourcade et al., 2021). SSA has the chance to harness the decarbonisation of finance to usher in electricity and economic diversification (REN21, 2021; Swilling et al., 2021). All 54 African countries are signatories to the Paris Agreement and, motivated in part by the opportunity to benefit from the reallocation of finance, many African countries have been vocal proponents of ambitious climate responses motivated by the desire to position African countries favourably in order to receive green climate finance (CPI, 2021). The Special Report of the IPCC on 1.5 °C of warming is clear that the pace and scale of decarbonisation needed to limit warming to 1.5 °C, requires the decarbonisation effort to address the SDGs at the same time (Chapter 5, IPCC, 2018). No social or political compact will endure if decarbonisation does not simultaneously address poverty and inequality.

The strategy of making nationally determined contribution pledges contingent upon the release of finance for sustainable electricity in developing and middle-income countries, was successfully applied by India and South Africa at the COP26 in Glasgow in 2021. At COP26, South Africa secured US$8.5 billion in concessionary loans and grants to accelerate the country's decommissioning of coal-fired power stations and to build renewable energy replacements. The deal involving public grants, DFIs and private finance remains to be implemented, but hints at the scope for new approaches, from global capital that acknowledge the shared risk of climate change and the importance of development in SSA countries, to the global effort to transition away from these risks. SSA's centrality to any notion of globally just energy transition should empower the region's leaders to negotiate for more finance on improved terms than has been the case in the past.

In the same negotiations, focus should be on secure investment in the value chains that support renewable energy. Forty-two of the 54 countries in Africa have known deposits of the minerals that are essential for renewable energy, and lithium-ion batteries. South Africa holds 90% of the platinum group minerals. Namibia and Zimbabwe are home to all known cesium and 89% of the known rubidium reserves. The DRC holds 47% of the world's cobalt reserves. The re-emergence of hydrogen as a feedstock for power-intensive, hard-to-abate industrial sectors, such as iron, steel and aeroplanes, creates similar opportunities for SSA countries. Hydrogen is a clean energy feedstock, but requires more energy to make than it can produce. Where electricity from wind turbines or photovoltaic panels – surplus to requirements – can be used in electrolysis to make hydrogen, it is possible to combine investment in clean electricity with hydrogen manufacturing and hydrogen-powered industrial capacity. SSA countries can link their pursuit energy investment to investments that unlock local green economy ecosystems and mobilise regional value chains. In Ethiopia, sustainable electricity investments have been used to unlock investment in industrial parks, new value chains and productivity (Swilling et al., 2021). The potential is further enhanced in arid countries that can link renewable electricity, hydrogen manufacturing and the desalination of sea water for human consumption (CSIR, 2021).

4.3 Urbanisation, digitalisation and reduction in scale

An estimated 20 million people in SSA are gaining access to mobile technology for the first time each year, and by 2025, more than half of the region's population is expected to have access to mobile technology (GSMA, 2021). A similar number of people will be added to African cities annually for the next two decades at least (Cartwright, 2015). Urbanisation is concentrating demand for electricity and making electricity finance easier. The combination of digitalisation and urbanisation, in conjunction with the renewable energy innovations described above, have the potential to transform access to electricity finance, drive regional economic development as the growing number of digitally connected, economically ambitious young people in Africa's cities and reduce the unit cost of linking people to existing distribution networks (Rifkin, 2011; Swilling et al., 2021).

The digitalisation of electricity supply, consumption regulation and tariff payments obviates the need for much of the bureaucracy previously required to collect electricity tariffs, and allows public electricity utilities, IPPs and private distribution companies to be more confident about revenue streams when raising finance. The ability of digitalisation to improve revenue collection and accountability has created the potential to recoup the estimated 17% of electricity that is dispatched without contracts or payments in African countries (IEA, 2019). In Nigeria, where tariff collections have been historically low, the digitalisation of supply and payments resulted in 93% of customers paying their electricity bills, significantly enhancing revenue collection and opening the opportunity for ongoing investment. There are examples, including in Nigeria, in which digitalisation and prepayments for electricity have been used regressively to extract limited cash from poor households (Parnell & Robinson, 2006). However, this need not be the case. Digitalisation can be linked to the cross-subsidisation of poorer and time-of-day tariffs that reduce the quantum of electricity capacity that countries require. In Accra, Ghana, digitalised payments have been used to displace rent-seeking by EPPs who were applying opaque financing mechanisms and extortionist prices to fill the gaps left by inadequate electricity planning and budgeting (Cartwright, 2019).[6]

In concert with the modular nature of solar installations, incinerators and biogas to electricity plants, the ability to track, in real time, the supply and demand of electricity has been behind the explosion of mini-grids (less than 50 MW capacity) in Eastern and Southern Africa. Mini-grids avoid the need for State-funded roll-outs of the national electricity grid over vast, sparsely populated areas. The ability to match local demand and supply in mini-grids mobilises household investment, something that has been historically difficult in SSA countries. Similarly, the modularity of mini-grids suits SSA cities, companies and projects without access to massive fiscal resources. SSA countries attracted 65% of the world's off-grid renewable electricity investments from 2007 to 2019, with investments concentrated especially in East Africa (IRENA, 2021). Ghana's Renewable Energy Master Plan alone seeks to establish 1 000 mini-grids by 2025, many of them linked to local biomass feedstocks and local economic development plans. M-Kopa finances the supply of solar homes, fridges and smartphones in Kenya, Nigeria and Uganda. For customers that prove their ability to make reliable payments on PAYGo, M-Kopa offers clean biomass cookstoves, entertainment packages and even financial services such as loans and hospital plans (REN21, 2021). Pico Solar also uses the PAYGo platform and sold more than 2 million solar home-affiliated appliances in 2020.

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[6] The uncoordinated procurement of energy from IPPs and EPPs prior to 2016 now requires the government to pay US$450 million in 2019 to private companies for power that the country does not use.

4.4 New financial options

The combination of technological and finance sector innovation and SOE reform, has created options for electricity finance beyond the traditional fiscal channels. As of 2020, 10 out of 54 African countries had unbundled their vertically integrated utilities and 29 of the 54 countries allowed some form of private investment in electricity infrastructure IEA, 2021).[7] In 2020, SSA attracted US$11 billion in generation and US$5 billion in transmission networks and storage, which is not nearly enough, but significant relative to historical amounts (IEA, 2021). Changes in finance and financing offer the chance to recalibrate the value and valuation of what financiers previously considered intangible assets or externalities.

The emergence of these options fortuitously coincides with mounting pressure on the mainstream finance industry to account for the ESG impacts of their investments through programmes such as the Taskforce for Climate-Related Financial Disclosure. To respond to climate change, the global finance sector is being urged to conduct a "finance sector triple jump", in which the estimated US$380 trillion in available savings undergoes simultaneous divestment from fossil fuels, investment in low-carbon assets and a 2%-3% increase in energy sector investment (Hourcade et al., 2021; Robbins, 2018). This process has begun as US$100 trillion of global assets under management have signed up to the UN's Principles of Responsible Investing and are implementing ESG metrics. By the start of 2021, 1 300 investors had made firm fossil fuel divestment pledges totalling more than US$15 trillion. This wave of green investments has begun making fossil fuel investments more expensive. In finance terms, the risks associated with fossil fuel investments have made them 10% more expensive than finance for renewable electricity. By some estimates, this is the equivalent of a US$80/tCO2e carbon tax (IEA, 2021). These pressures have seen the UK, China and India terminate the financing of coal-fired electricity beyond their borders. Together with the spurning of fossil fuel investments by companies such as Black Rock, the shift in global finance makes it extremely difficult for SSA countries to attract investment for new fossil fuel-powered electricity plants, even when these are considered viable and necessary.

Electricity finance is already avoiding the risks of stranded fossil fuel assets and tracking the growth opportunities in renewable energy. The growth rate of renewable energy (5% a year between 2009 and 2019) outpaced the growth in fossil fuels (1.7%) off a much larger investment base.

The GCF was established to support developing country-level efforts under the UN's Framework Convention on Climate Change and has become the flagship for multiple new climate finance initiatives. The GCF has the target of allocating US$100 billion in climate finance per annum over the next five years. This global fund has resourced regional efforts, including SSA's LEAF Framework, which is emblematic of a range of new electricity financing initiatives. In 2021, the LEAF Framework secured US$170.9 million in GCF finance through the LEAF Framework programme of the AfDB, aimed at unlocking private sector, local currency financing for decentralised renewable energy projects in Ghana, Guinea, Ethiopia, Kenya, Nigeria and Tunisia. The ability of these initiatives to access climate finance is supported by the broader effort to finance progress against the SDGs. The broad shifts in global finance should, in theory, enhance access to electricity finance for SSA countries, especially given that more than 60% of climate finance was spent on renewable energy in 2018.

[7] https://www.iea.org/reports/electricity-market-report-december-2020/2020-regional-focus-africa

5 MANAGING TRADE-OFFS

The changing nature of global electricity and finance systems is fracturing long-standing and co-evolved approaches, and creating new opportunities to finance electricity in SSA. The same changes are demanding difficult trade-offs for financiers, utilities and regulators. There are no definitive templates on which SSA countries can draw. The capacity to navigate these trade-offs and cohere a credible energy narrative will be a prerequisite for attracting sustainable energy finance, of which examples include the following:

5.1 Oil and gas

Liquid nitrogen gas has been proposed as the ideal interim fuel with which to provide electricity while adding less CO2 per kWh. If SSA tripled its electricity consumption overnight using only natural gas, the additional CO2 would be equivalent to a mere 1% of global emissions. To date, the gas reserves that have been exploited (see Mozambique as an example) have done little to extend electricity access, support economic development or protect the natural environment (Gaventa, 2021), and concerns around all fossil fuels and every additional tonne of GHG emissions seem set to grow.

SSA is estimated to hold 115.34 billion barrels of oil and 21.05 trillion cubic feet of gas (UNU-Inra, 2019). New oil and gas discoveries are being made in Mozambique, South Sudan and Ethiopia, with the Ogaden Basin alone containing 8 trillion cubic feet of natural gas reserves worth a potential US$7 billion annually once at full capacity. Between 2000 and 2012, expansion of the mineral extractive sector increased FDI into Africa from US$10 billion to US$50 billion (Halland et al., 2015). The discovery of new oil, gas and coal deposits places SSA at a crossroads. Integrated assessment models estimate that Africa must forego burning 90% of known reserves of coal, 34% of gas and 26% of oil (McGlade & Ekins, 2015). However, the real question is whether exploiting the oil and gas reserves is the best way of advancing SSA's electricity needs or whether more affordable and more labour-intensive options in the renewable energy sector should be prioritised. Decision-makers should be clear that the notion of "baseload" electricity feedstocks is no longer appropriate for modern electricity grids (Parkinson, 2021).

There is a risk that less scrupulous and less transparent financiers will take over fossil fuel-powered electricity assets, and it is evident that several hydrocarbon companies view Africa as a last-gasp opportunity before fossil fuels are phased out. However, the realisation that all electricity supplied will have to be at least "net zero" in terms of its GHG emissions, by 2050, makes decisions around electricity planning simpler for SSA countries.[8] The task is to cohere the rapidly increasing demand, especially from urban centres, and develop clear plans for clean electricity systems that can displace existing coal, charcoal, paraffin, diesel and biomass systems. These plans should make superior alternatives legible to financiers.

Carbon capture and storage technologies will advance and possibly become commonplace and more affordable. However, avoiding catastrophic climate change requires their deployment and the phasing out of fossil fuels. This was the rationale behind Ghana's resistance to the Aboano Coal-Fired Power Station; a resistance that received international acclaim. A sober account of the contribution of fossil fuels to socio-economic progress will show that they have generated impressive FDI, but seldom supported local value chains or contributed to poverty alleviation (Salinas, 2021; Sovacool, 2020; Whitfield et al., 2015;). It is not yet clear that new gas opportunities will advance the electricity sector transformation, as opposed to allowing incumbent companies and politicians to entrench their positions and frustrate the necessary transition. There are too many examples of gas companies having undermined governance and ecological integrity. Between 1976 and 2010, there were 13 030 oil spills in the Niger Delta and more than 3.2 billion barrels of oil discharged in the marine, forest and coastal ecosystems (UNU-INRA, 2021).

[8] Even if carbon capture and storage technologies become available, the cost and scale of these technologies, combined with the need to remove GHGs from the atmosphere post-2050, will require all future electricity to be renewable.

5.2 How to integrate mini-grids and household-scale generation

The proliferation of household-scale and factory-level electricity, together with mini-grids, has alleviated the deficits left by public sector utilities and distribution grids. The outlawing household-scale electricity seems futile given the technology gains that have been made. However, these technologies are difficult to cohere into a coordinated and balanced electricity system.

To some degree, the future of electricity systems will hinge on whether or not existing electricity utilities can embrace both new technologies and multi-actor contributions in order to remain competitive. There is not yet a reliable hybrid system capable of cohering investment in the myriad of new, highly innovative energy generation, energy efficiency and storage technologies with existing efforts, such as the Grand Inga Hydro Plant, to generate utility-scale power and transport it across borders. Curating new electricity systems will require regulators and ISMOs that can integrate the required investment in national grids and State-owned energy utilities, emergent mini-grids, EPPs, international hydropower projects, newly found gas fields, transmission and distribution networks and storage capacity, behind a vision of universal access to clean, affordable electricity. NUPs can authorise cities to contract IPPs, thereby stimulating investment and addressing the economically damaging urban energy deficit. With a few exceptions, cities in SSA did not attract the investments in renewable energy and fuels globally in 2020 (REN21, 2021).

5.3 Local content and jobs versus price

South Africa has attracted more than R200 billion (US$13 billion in 2021 prices) in its IPP, most of which went towards renewable electricity between 2014 and 2020. At the same time, the programme has capitalised on innovation to drive the price of electricity down from R276.00/kWh in Round 1 to R0.79 in Round 4 for PV, and from R2.02/kWh to R0.70/kWh for wind (Eberhard & Naude, 2017). Bid rounds 5 and 6 elicited further investment and the record low price of R0.37/kWh for a wind project.

The REIPPP signals what is possible through competitive bidding processes, but countries face the tricky decision of whether to continue to pursue the public good of cheap, clean electricity, or pay higher prices in exchange for more connections with local value chains and suppliers, and the associated employment (Swilling et al., 2021). This is a tension that can only be navigated at country scale.

5.4 Job losses

A more general concern confronting the shift to renewable energy is the displacement of jobs. Undoubtedly, workers in coal and oil sectors will have to be redeployed, while existing coal-fired power stations will have to begin a phase-out over the next two decades. Crucially, the act of constructing the new electricity infrastructure on its own will possibly create more jobs, safer jobs and more geographically dispersed jobs than will be lost in the existing fossil fuel industry (CSAG, 2020; TIPS, 2021). The requirement is to locate wind and PV plants on land that is close enough to decommissioned fossil fuel plants in order to allow workers to transition.

5.5 Cyber attacks on electricity systems

While the digitalisation of electricity services offers SSA countries crucial revenue mobilisation and investment benefits, digitalisation and increased automation of electricity also raises cybersecurity risks. The threat of cyber attacks on electricity systems is reported to be growing and responsible for service disruption. While the task of electricity regulators will possibly become more complex and ambiguous in the years ahead, one of their unambiguous responsibilities involves protecting customers and the stability of supply against cyber attacks (IEA, 2021).

The interdisciplinarity of the above trade-offs makes addressing them difficult. Historically, the task of managing industrialisation, urbanisation, job creation and climate change have fallen to distinct departments and strategies within countries. The SSA region has begun producing excellent electricity data and research, but unpicking the historic electricity governance institutions and ushering in a new brand of sociotechnical learning that catalyses progress on multiple fronts simultaneously is more difficult. Creating the institutions and interdisciplinary processes capable of reconciling the respective mandates is a prerequisite for forging a new electricity narrative in SSA, and making the investment needs and opportunities more legible to public and private financiers. It is only once the ecological, social and economic outcomes of sustainable electricity in SSA have been blended, that the finance that delivers these outcomes can be blended. At the moment, competing interests fragment any notion of a compelling and coherent outcome.

6 CONCLUSION

The inability to finance SSA's electricity system is a key cause of the region's humanitarian and economic challenges. Despite much attention and various programmes being aimed at supporting electrification and mobilising finance respectively, the number of people without access to electricity has more or less remained constant over the past decade. In an economic sense, the problems are well documented, with the risks of not financing sustainable electricity and of pursuing fossil fuelled powered electricity being externalities; the narrow interests of finance in pursuing familiar financial returns being difficult to reconcile with the public good of sustainable electricity; SSA countries not having the fiscal capacity or the governance required to embrace the public good of sustainable electricity finance and develop bankable projects; and in SSA, many households operating outside of the fiscal system undermining the tariffs that could be used to finance electricity. What is less clear is why these forms of economic market failure have proven very difficult to resolve despite all the attention.

This paper identifies the desire to place blame on a particular deficit or institution as a diagnostic error. The more complex reality is that unsatisfactory energy, finance and governance systems have co-evolved in SSA to create the prevailing nightmare, replete with opaque contracts, the "silent killer" of indoor air pollution (Fisher et al., 2021), the ongoing destruction of the Central African rainforest, the most sulphur dioxide-intensive power stations in the world and widespread energy poverty. While viewing the problem through a "socio-technical systems" lens is useful, no single actor or technology can change the entire system (Geels et al., 2016; Geels et al. 2017). Rather, transcending facile prescripts for SSA's electricity finance deficit depends on understanding the conflation of interests, incentives and transactions at multiple scales, which makes this nightmare so difficult to dislodge.

Nevertheless, in this paper, features of the current situation are identified, which render this an unprecedented time to mobilise finance in support of sustainable electricity. Radical progress in renewable energy technologies over the past decade, combined with the growing unanimity around climate change, offers a rare opportunity to re-imagine Africa's energy sector. This opportunity coincides with the steep rise in electricity demand to support SSA cities and industrial ambition, a global focus on the SDGs, and growing financial pressures to account for ESG in the allocation of capital. To not harness the moment to invest the estimated US$68 billion per annum required to ensure universal access to safe electricity in SSA, would be a tragedy and would lock SSA countries into their existing laggard status.

Finance, however, remains a means to an end. Too easily, the technocratic demands of electrification and the default of finance to seek out familiar, low risk, high return opportunities combine to deliver electricity projects without ensuring human and environmental safety, and without powering sustained, inclusive growth and human well-being. Taking advantage of the current moment to ensure that electricity finance is not only mobilised, but provides a socio-economic catalyst, requires capacity that does not yet exist in SSA countries. The blending of outcomes proposed in this paper as a perquisite for blending finance, demands a new role for energy procurement agencies and needs to be sensitive to local starting conditions, the role of utilities and the people they employ in the State, private sector and civil society. While the focus on universal electricity access should remain, the drive for universal access will have the greatest impact if both draw on local labour and regional value chains for biomass, copper, PGM and rare earth minerals used in renewable electricity, and anticipates both the quantum and spatial dimensions of future electricity demand from rapidly growing cities and emerging industrial hubs. The same capacity must advance new and compelling narratives of how that electricity is not only essential in saving lives in SSA countries, but central to reconciling the tensions between growth and degrowth, and attaining the SDGs on which global welfare hinge.

The specificity of this narrative must be curated at national and subnational level. Failure to recognise the centrality of rapidly evolving SSA cities to the region's electricity needs will result in fundamental design flaws. Across all scales, the development of a compelling narrative for investment in SSA electricity will probably include the following:

- A clear estimate of electricity demand over time, which factors in the needs of rapidly growing cities, the trend towards working and learning at home, and industrial and manufacturing ambition. This will require a stock take of existing energy services, including those that have evolved in the gaps left behind by the State and through informal networks.
- A commitment to universal electricity access with details of how access will be cross-subsidised from affluent and intensive users to poorer and more remote users.
- A linking of generation capacity to local value chains and industrial ambition. The disruptions caused by Covid-19 have revealed the importance of local value chains for various industries. There are opportunities to create significant stimuli for local value chains and associated employment in what will amont to a 30-year build phase of renewable energy.
- A heightened appreciation for the opportunity to gain competitive advantage where social progress and industrial capacity are supported without increasing GHG emissions. This will require phasing out existing fossil fuels and foregoing opportunities to exploit new-found oil, gas and coal resources. The lobbying by fossil fuel companies to embark on what will almost certainly result in stranded assets must be resisted in favour of renewable electricity that is owned and financed by local communities. Aligning spatial strategies with electricity investments is a key component of the potential competitive advantage and is greatly enhanced when electricity investments are curated locally.
- Align SDGs with industrial strategies. Link the roll-out of renewable energy to industrial policy, including the use of local labour and the 'green economy' minerals found on the continent.
- Recognition that top-down, capital-intensive energy infrastructure has proven difficult to maintain and has yielded very low economic multipliers, thereby forging interest in new and hybrid forms of energy generation, including community-owned electricity cooperative, grid-tied cogeneration from factories, sawmills and sugar refineries.
- Investment in the skills and knowledge to advance continent-wide sustainable electricity. Africa's youthful population is ideally placed to drive innovation and electrification in SSA. The nature and scale of the challenge demands a degree of experimentation and innovation. Investing in the data to make better energy decisions, and the research and development capacity to collaborate, innovate and document experiences is an essential component of the learning by doing process that will underpin sustainable electricity finance on the continent.
- Invest in capacity across the entire system, including generation, transmission and distribution

Drawing on the current trends to disrupt the obdurate status quo in electricity finance and achieve the outcomes listed above, requires a new narrative. It is this narrative that, once adopted by financiers across the world, will render SSA electricity projects bankable and allow a flow of public and private investment from domestic and international sources. In a prescient, but analogous critique of the Obama Administration's Strategy for a Green Economy, Jeremey Rifkin points to the lack of such a narrative, as follows:

> *We are left with a collection of pilot projects and siloed programs, none of which connects with the others to tell a compelling story of a new economic vision for the world. We're strapped with a lot of dead-end initiatives—wasting billions of dollars of taxpayer money with nothing to show for it (Rifkin, 2011).*

The opportunity currently available to SSA countries and cities is to take stock of the global and regional trends, and exploit them in order to reposition the region's electricity needs as part of the solution to global needs. Where this new story is underpinned by a process of learning by doing and combines innovations in the finance and electricity sectors respectively, it will finally break the low-level equilibrium that has defined SSA's electricity deficits for too long.

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