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RETHINKING INFRASTRUCTURE

Achieving Clean Energy Access in Sub-Saharan Africa

Jan Corfee-Morlot (3Cs), Paul Parks, James Ogunleye
and Famous Ayeni (Carbon Limits Nigeria)

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Governments recognise that scaling up and shifting financial flows to low-emission and resilient infrastructure investments is critical to deliver on climate and sustainable development goals. Efforts to align financial flows with climate objectives remain incremental and fail to deliver the radical transformation needed. The OECD, UN Environment and the World Bank Group, with the support of the German Ministry of Environment, Nature Conservation and Nuclear Safety, have joined forces under a new initiative that provides a roadmap to help countries make the transformations in their infrastructure, investment and finance systems that are needed to make financial flows consistent with a pathway towards a low-emission, resilient future.

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Achieving Clean Energy Access in Sub-Saharan Africa

A clean energy revolution in sub-Saharan Africa is urgently needed to win the fight against energy poverty, to promote robust development and to make it more sustainable. Clean energy can unlock sustainable economic growth, improve human health and well-being and enable women and children to lead more productive lives. It will also raise human security and build resilience in nation states and communities. This report takes an in-depth look at the challenges and opportunities to provide clean energy access in sub-Saharan Africa. Packages of policies are needed to promote clean energy access, including electricity for productive uses and a full range of technical solutions – notably off-grid and mini-grid renewables, energy efficiency – as well as clean cooking. Innovative financing and improved public sector governance are essential ingredients to make markets work. Delivering on this golden opportunity for development requires not just more money but policy attention and massive political effort from both domestic and international actors

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31 January 2019

by

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Abstract

A clean energy revolution in sub-Saharan Africa is urgently needed to win the fight against energy poverty, to promote robust development and to make it more sustainable. Clean energy can unlock sustainable economic growth, improve human health and well-being and enable women and children to lead more productive lives. It will also raise human security and build resilience in nation states and communities. This report takes an in-depth look at the challenges and opportunities to provide clean energy access in sub-Saharan Africa. Packages of policies are needed to promote clean energy access, including electricity for productive uses and a full range of technical solutions – notably off-grid and mini-grid renewables, energy efficiency – as well as clean cooking. Innovative financing and improved public sector governance are essential ingredients to make markets work. Delivering on this golden opportunity for development requires not just more money but policy attention and massive political effort from both domestic and international actors.

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Executive Summary

A clean energy revolution in sub-Saharan Africa is urgently needed to win the fight against energy poverty. Clean energy provides a golden thread to deliver on the promise of Agenda 2030 Sustainable Development Goals (SDGs) and the Paris Agreement. It can unlock sustainable economic growth, improve human health and well-being and enable women and children to lead more productive lives (UN, 2018; NCE, 2018). Beyond direct economic and social benefits, clean energy access will raise human security and build resilience in states and communities to help limit the risk of large scale migration across the African continent (Rigaud et al., 2018).

What is the nature of the challenge?

Sub-Saharan Africa (SSA) has the lowest energy access rates in the world. Electricity reaches only about half of its people, while clean cooking only one-third; roughly 600 million people lack electricity and 890 million cook with traditional fuels (IEA, 2018a). Thirteen countries in SSA have less than 25% access, compared to only one in developing Asia (World Bank, 2018). Economic growth in the region is also relatively low at an estimated an 2.8% percent in 2018, compared to 7.1% in South Asia (IMF, 2018). This dramatic lack of energy access stifles economic growth and sustainable development (World Bank, 2017).

Despite promising technology and market trends, today's policies and patterns of finance and investment are off-track. They do not recognise the transformative potential of solar off-grid and mini-grid solutions to deliver clean energy access, nor do they incorporate the potentially huge social and economic benefits of electricity access and clean cooking.

What needs to be done?

Solutions exist in the form of decentralised solar (among other renewables) for electricity, and for clean cooking options range from improved biomass to liquefied petroleum gas (LPG.) Yet, to reach the level of implementation needed for universal energy access in SSA, policies and financing requires a major step-up – both in money and domestic capacity.

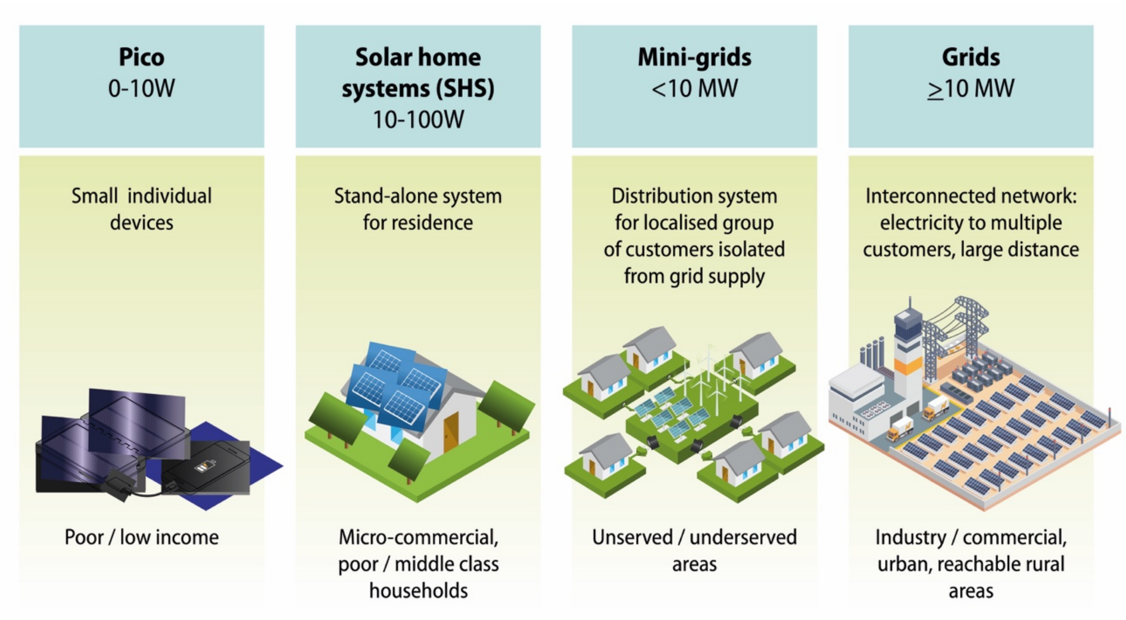
Stepped up policies and financing from the public and the private sectors, and new business models, can work in tandem with official development finance (ODF), which in turn can play a catalytic role. Domestic leadership, policy reforms and capacity must lay the foundation for more effective public investment and to facilitate private investment. Mobilising the needed investment, and scaling the domestic capacity, to manage these changes will require massive political efforts from both domestic actors and the international community. Better planning and collaboration in-country will also be required to shift available public and private resources into new technologies and new markets.

Understanding new clean energy pathways

Access to electricity via national grids will continue to play a key part in energy access solutions, yet technological advances in renewable energy, especially solar, can dramatically expand options for increasing access to those not served or underserved by grids. Recent progress in solar and wind technologies provides the means to leapfrog the traditional fossil-fuel dependent and centralised power system model (World Bank, 2018). The cost-effective development of individual and household solar devices is already providing access to millions. Decentralised solar options, including mini-grids, are expanding rapidly in East Africa, and are now also spreading in West Africa - reaching rural unconnected and urban underserved populations.

An important takeaway from renewable technologies and emerging markets is that an increasing number of new options exist to improve access, and in many cases, can reach people faster and in a more targeted way than grid-expansion alone. While cost per kWh for these options is often higher than grid connections, they can avoid long-range transmission costs and provide access at lower cost than diesel generators for local use. They also benefit from individual and modular designs that allow for rapid implementation, independent of the grid. Other important benefits include improved supply reliability and reduced local pollution from diesel usage. The concept of electricity access being solely grid based is changing to one of a "lego" design, where different and varied options each have a part to play.

Figure ES-1: Renewable Technologies Dramatically Expand Electricity Access Options



Source: Authors based on Figure 5.

Financing electricity access

The level of investment required to achieve universal access in SSA is estimated by the IEA (2018) to be US $27 billion per year (2018-30). which is at least double current levels of financing – highlighting the need for major increases from domestic sources and international sources.

An urgent, near-term priority is to reform subsidies from public and parastatal entities away from fossil fuels (OECD 2018). Direct and indirect subsidies for fossil fuel production and power generation are estimated to be on the order of US $26 billion per year in 2015 (Whitley and van der Berg, 2015).[1] Shifting domestic public finance away from these subsidies towards clean energy access could make a significant contribution to filling the financing gap.

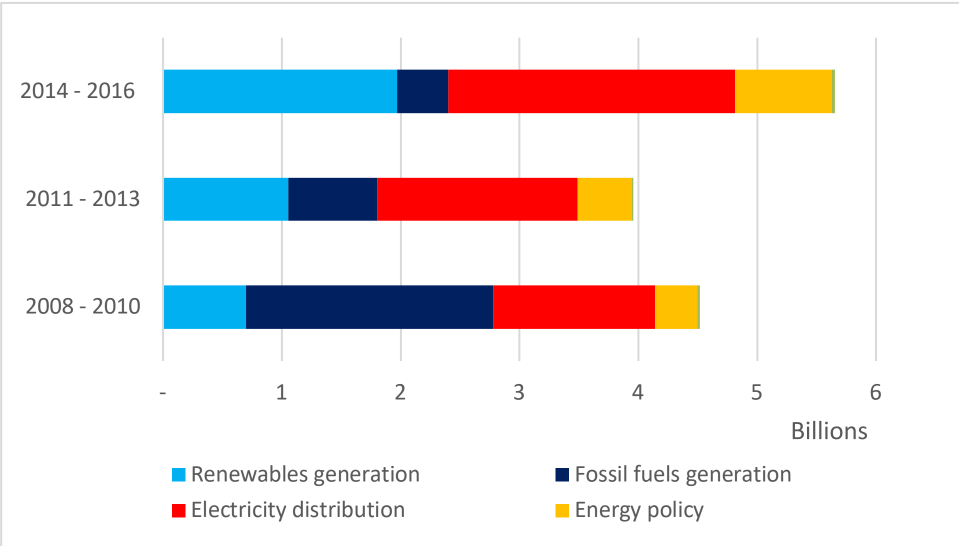
ODF is also a major contributor to financing of electricity access in the sub-Saharan region: recent analysis suggests it is the largest single source of finance today, yet the vast majority of this is going to the grid (SEforAll 2018, 2017a). The report provides

[1] This estimate includes externalities following an approach developed by IMF; see details of the methodology in paper by Whitley and van der Berg, 2015.

an updated estimate of annual commitments of ODF for electricity, identifying about US $5.6 billion per year (2014-16) in SSA; the largest share of this finance supports the grid with transmission and distribution (42%) and a growing share of renewables generation (35%).[2] A closer look at investment needs versus ODF flows in three countries – Ethiopia, Kenya and Nigeria - shows that only Kenya is receiving major flows at about one-third of the estimated need with Ethiopia and Nigeria lagging far behind. Overall, countries in SSA, which have the greatest share of global population without access, do not receive a proportionate share of international ODF for electricity (SEforAll, 2017a, 2018).

Private financing is also crucial to deliver decentralised renewable options. In Pico solar and Solar Home System markets, tailored consumer finance business models (e.g. via pay-as-you-go and mobile money) and private investment are enabling markets to grow rapidly in some countries and importantly, to reach the poor. Impact investment appears to be a small but growing force (OECD, 2019). However domestic investment is the most essential piece; better access to local debt capital could further serve to expand Pico solar and SHS businesses (SEforAll, 2017b, 2018). By contrast to SHS financing needs, renewable mini-grids currently require capital subsidies to be economic, but they will become more commercially viable with declines in technology costs and as supportive policy frameworks emerge to attract investors. Importantly, they do not require the on-going operating cost subsidies common in many grid systems.

Figure ES-2: Official Development Finance, Sub-Saharan Africa, Electricity Sector
3-year annual average, 2014 - 2016, billion USD commitments



Source: Authors based on OECD DAC-CRS statistics, 2018.

Development finance can play a role to attract and blend with private finance for decentralised renewable options. Notably, there is an uptick in the level and number of dedicated funds and facilities supporting blended finance for decentralised renewables in SSA, however available financing remains a fraction of what is needed to support countries to achieve the 2030 SDGs.

[2] It is unknown exactly what share of this targets off-grid or mini-grid supply. However, drawing on SEforAll 2018 suggests that it could be less than a few percent of the total.

The clean cooking imperative: challenges and opportunities

The chronic failure to deal with the widespread lack of clean cooking burdens economies and limits human productivity for the region's population. This welfare cost is born largely by women and children through premature death and sickness. Yet, most countries in SSA lack comprehensive clean-cooking strategies. Even where clean cooking strategies exist, implementation is weak and provided with little finance such that even modest gains are hard to obtain (SEforAll, 2017a and Hosier et al. 2017).

Raising the priority, profile and ambition of clean cooking goals will help governments to attract development financing to support implementation. Policies and financing for clean cooking should be integrated into poverty alleviation and health strategies at the national level. The gender element is crucial, ranging from awareness-raising campaigns to directly engaging women as champions and as entrepreneurs. Engaging women in clean cooking businesses and distribution will boost results and make them more lasting (Shankar et al., 2015; see Box2).

With respect to financing, the absolute gap is much lower than for electricity, with an estimated need of US $1.8 billion (IEA, 2018a). But the required scale up is more challenging than for electricity, partly since it lacks the benefit of institutions and infrastructure that exist in the electricity sector. Significant progress requires both greater financing and perhaps more importantly the building of domestic outreach and capacity.

1. Introduction

1.1. Clean energy access as a key part of the Paris Agreement and Agenda 2030

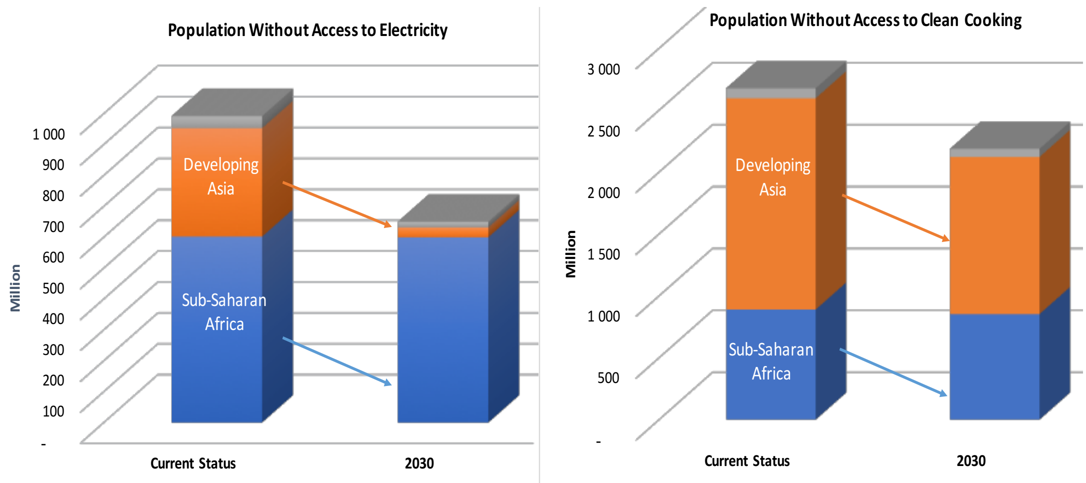
The Paris Agreement and the 2030 Agenda for Sustainable Development (UNFCCC 2015; UN 2015), both signed in 2015, thrust energy access and climate change to the centre of development policy. Taken together, they commit the world's nations to work together to eradicate poverty in all its forms, advance sustainable development and aggressively fight against climate change. Achieving the objectives of both agreements highlights the need for a global clean energy revolution to win the fight against energy poverty and to deliver climate protection.

Electricity reaches only about half of the people in sub-Saharan Africa (SSA) today, the lowest energy access of any major region in the world. Currently while only one country in Asia has less than 25% access, 13 sub-Saharan countries have access below 25% (World Bank, 2018). This dramatic energy access problem is exacerbated by the parallel lack of access to clean cooking, where only one-third of people living in sub-Saharan Africa have access to clean cooking. Economic growth in the region is also relatively low at an estimated an 2.8% percent in 2018, compared for example to 7.1% in South Asia. (IMF, 2018).

Figure 1: Sub-Saharan Africa Electricity and Clean Cooking Challenge in Global Context
Share of global population without access, 2017 – 2030

Electricity: globally, nearly 1 billion people without access today, falling to 650 million in 2030 of which 600 million are in SSA

Clean cooking: globally, 2.7 billion people without access today, falling to 2.2 billion in 2030 of which 853 million are in SSA



Source: Authors based on data from IEA 2018 World Energy Outlook

Energy access is put under even more pressure by rapid population growth. With 1 billion people today, sub-Saharan population is expected to double by 2050 (UN DESA, 2017). Under current and planned policy aiming to tackle energy access, the IEA Outlook (2017) shows that while the share of people in the region lacking access is expected to decline for both electricity and clean cooking to 2030, the absolute numbers of those lacking access will increase. Further, the global energy access problem is increasingly concentrated in sub-Saharan Africa; which by 2030 will account for nearly 90% of the world's population without electricity access and 40% without clean cooking (IEA, 2018a; Figure 1). Sub-Saharan Africa's chronic shortage of electricity carries a high economic cost, with opportunity costs amounting to up to 2% of their GDP (IRENA, 2015; IEA, 2014).

Achieving energy access via clean energy in sub-Saharan Africa is a necessary pillar of economic transformation required to deliver on the promise of the Paris Agreement and Agenda 2030 Sustainable Development Goals (SDGs) (see Box 1). Indeed, clean energy can be a "golden thread" for development, connecting all the SDGs and unlocking sustainable economic growth, while improving gender equality, human health and well-being (UN, 2017). Importantly, clean energy access enables women and children to lead more productive lives and to contribute to the economy (NCE, 2018). Access to clean energy can help to raise millions from poverty and to improve livelihoods of urban and the rural poor. Clean energy access strategies will help countries meet long-term climate objectives as set out in their Nationally-Determined Contributions (NDCs), and beyond, per the objectives of the Paris Agreement. Beyond direct economic and social benefits, clean energy access will raise human security and build resilience in states and communities to help limit the risk of large scale migration across the African continent (Rigaud et al., 2018).

1.2. Structure of the report

This report takes an in-depth look at the challenges and opportunities to provide clean energy access in sub-Saharan Africa. As one of several case studies in the OECD – G20 project, *Financing Climate Futures*, the authors show that successfully tackling energy access needs to be part of an essential package of policies promoting both access and clean energy solutions (renewables, energy efficiency and clean cooking), innovative financing as well as improved public sector governance. Section 2 begins with an overview of trends, considering the state of play for renewables technologies and market developments in the electricity sector and similar developments for the clean cooking sector; it closes with a look at investment needs for energy access. Section 3 considers policies, capacity and finance approaches, providing the means to shape future markets to advance clean energy access. Section 4 outlines the range of financing approaches in play, covering consumer, domestic and ODF; using OECD data, it includes an up-to-date assessment of ODF commitments for electricity in sub-Saharan Africa and considers how ODF is being used for blending. While country examples are featured throughout, Section 5 closes with an in-depth case study on Nigeria, situating off-grid, mini-grid and clean cooking opportunities in the context of a major African economy.

Box 1: The Paris Agreement and Agenda 2030 for Sustainable Development

The aim the *Paris Agreement* (Article 2.1) is to limit global mean temperature to "well below 2ºC" increase above pre-industrial levels, to increase the ability to adapt to climate change and build resilience, and to make "finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development." The goals of the Paris Agreement are anchored in global efforts to achieve sustainable development and eradicate poverty (UNFCCC 2015). Clean energy access will be essential in the mission to eradicate poverty and to achieve sustainable development and this can be a pillar for achieving the *Paris Agreement*.

The *2030 Agenda* for Sustainable Development sets out 17 distinct sustainable development goals (SDGs), with the broad aim to "eradicate poverty in all its forms and dimensions including extreme poverty" as a central part of sustainable development. Governments also agree achieve sustainable development across economic, social and environmental dimensions. The specific goals include clean and affordable, modern energy for all (SDG-7) as well as climate protection (SDG-12). The *2030 Agenda* builds on and extends the Millennial Development Goals (UN, 2018), which did not recognise energy access nor did they address the threat of climate change as part of the development agenda (UN 2015).

2. Current trends: progress and current outlook

The IEA's World Energy Outlook (2018a) uses two main scenarios to assess energy challenges and opportunities to 2030 and beyond; both use a "Current Policy Scenario" as a baseline for comparison. With respect to access:

- the "New Policies Scenario" (NPS), considers the changes resulting from full implementation of planned and announced national policies between 2017 and 2030. For example, the NPS includes new renewable energy policies and targets described in the Nationally Determined Contributions submitted by countries under the Climate Convention.
- the "Sustainable Development Scenario", describes the changes required to meet universal energy access and other SDGs by 2030.

The IEA's New Policy Scenario highlights a number of key challenges and opportunities for access to electricity and clean cooking in sub-Saharan Africa emerge (IEA 2018a, 2017):

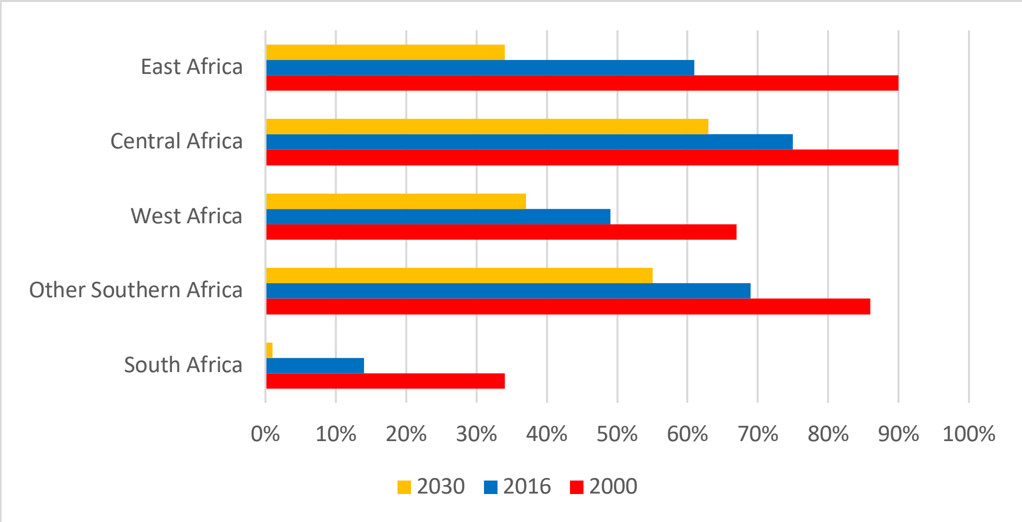
- The number of people with access to electricity is expected to remain at about 600 million by 2030 – essentially unchanged from 2017.
- Overall comparatively good progress is made in achieving electricity access yet the pace of progress is overwhelmed by population growth keeping the absolute numbers of those without access high.
- Some sub-regions and countries achieve electricity access at dramatically different paces (Figure 2).[3] East and West Africa make the most progress, bringing the share of those without access to electricity to under 40% by 2030. Several other countries – Ethiopia, Gabon, Ghana, Kenya and South Africa - are also on track to achieve universal access by 2030.
- For electricity, the primary challenge is in rural areas, where grid connections are more difficult, expensive or financially risky to install. Even in urban or peri-urban areas, where grid-based electricity is accessible, reliability is often a problem leading to expensive and polluting diesel back-up generation, e.g. in the case of Nigeria.
- About 893 million people cook with solid biomass and other highly polluting fuels (e.g. kerosene) today and even with planned new policies, the number of people without access to clean cooking rises slightly to 900 million.
- For clean cooking compared to electricity access, the challenge is more evenly spread across growing urban and rural communities, where there is an urgent need, first, to raise awareness and knowledge of the benefits of clean cooking alternatives and second to make these affordable and accessible.
- Most new power generation to 2030 is provided via the grid (57%) albeit the share of renewable energy provides 73% of the all new generation, thus improving GHG emissions/kWh.
- In addition to enabling grid expansion, new business models are providing solutions to people previously unserved by the grid. Mobile communications and (to a lesser extent) mobile money platforms are firmly embedded in some countries and provide an important foundation for pay-as-you-go (PAYG) consumer finance, which drives rapid uptake of off-grid solar in several African countries.

[3] The full list of countries by region for the Africa breakdown is found in Annex C.

The IEA-NPS shows that demographics are a major challenge to African governments trying to deliver universal electricity. Population growth is the fastest in the countries and sub-regions that have the least access to electricity today, which is a major barrier to decreasing the total numbers without access (IEA, 2017), even if by 2030, current and planned policies are expected to bring down the share of population without access in each sub-region (Figure 2). By 2030, those without access are increasingly concentrated in rural areas (IEA, 2017).

Figure 2: Sub-Saharan Africa by Region, Population Without Access to Electricity (%)[4]

Trends 2000 to 2030s (projected IEA-NPS 2017, with current and planned policies)



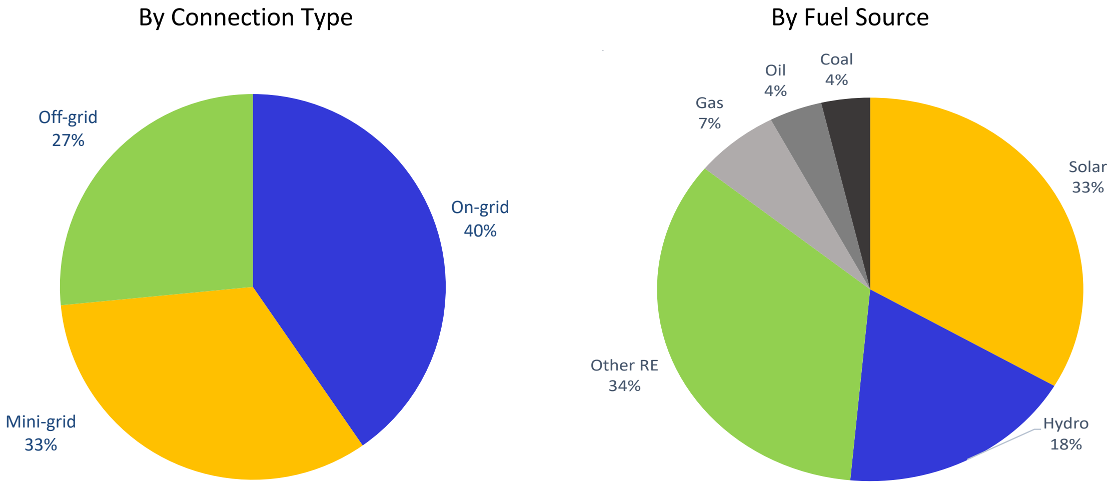
Source: Authors with data from IEA 2017 (historical and outlook under New Policies Scenario)

IEA Sustainable Development Scenario (SDS) illustrates a pathway to achieve universal energy access compared to the current policy scenario (CPS). Each scenario provides an overview of the mix of energy sources, technologies and investment that would be required to meet 2030 universal electricity access along with other sustainability goals (Figure 3). Under IEA-NPS (current and planned policy), fossil fuels are still projected to provide about 20% of the power delivered in 2030. Yet this changes with a stronger policy push as reflected in the SDS, where the share of fossil fuels in power generation drops to 14% by 2030.

In the IEA-SDS, renewables – on-grid and decentralised – are expected to play a more dominant role, in both urban and rural areas (IEA, 2018a). Solar power provides one-third of the additional power between 2017 and 2030 in the region (more than double the share in NPS), and another 51% comes from hydropower and other renewables; a total of 86% of new generation come from renewables (Figure 3). By connection type, mini-grids are estimated to provide 33% of generation, with off-grid solar (Pico and Solar Home Systems) at 27%, such that decentralised connection options provide more than half of the required new generation in this scenario.

[4] See map in Annex C for a guide to the countries in these sub-regional groupings. The IEA WEO 2018 report does not provide specific sub-regional detail thus this graphic is based on the IEA 2017 report which provided a more in-depth look at SSA.

Figure 3. Sub-Saharan Africa New Electricity Generation for Universal Energy Access
IEA Outlook, Sustainable Development Scenario: 2018 – 2030, % share of additional TWh



Source: Based on IEA, 2018 World Energy Outlook

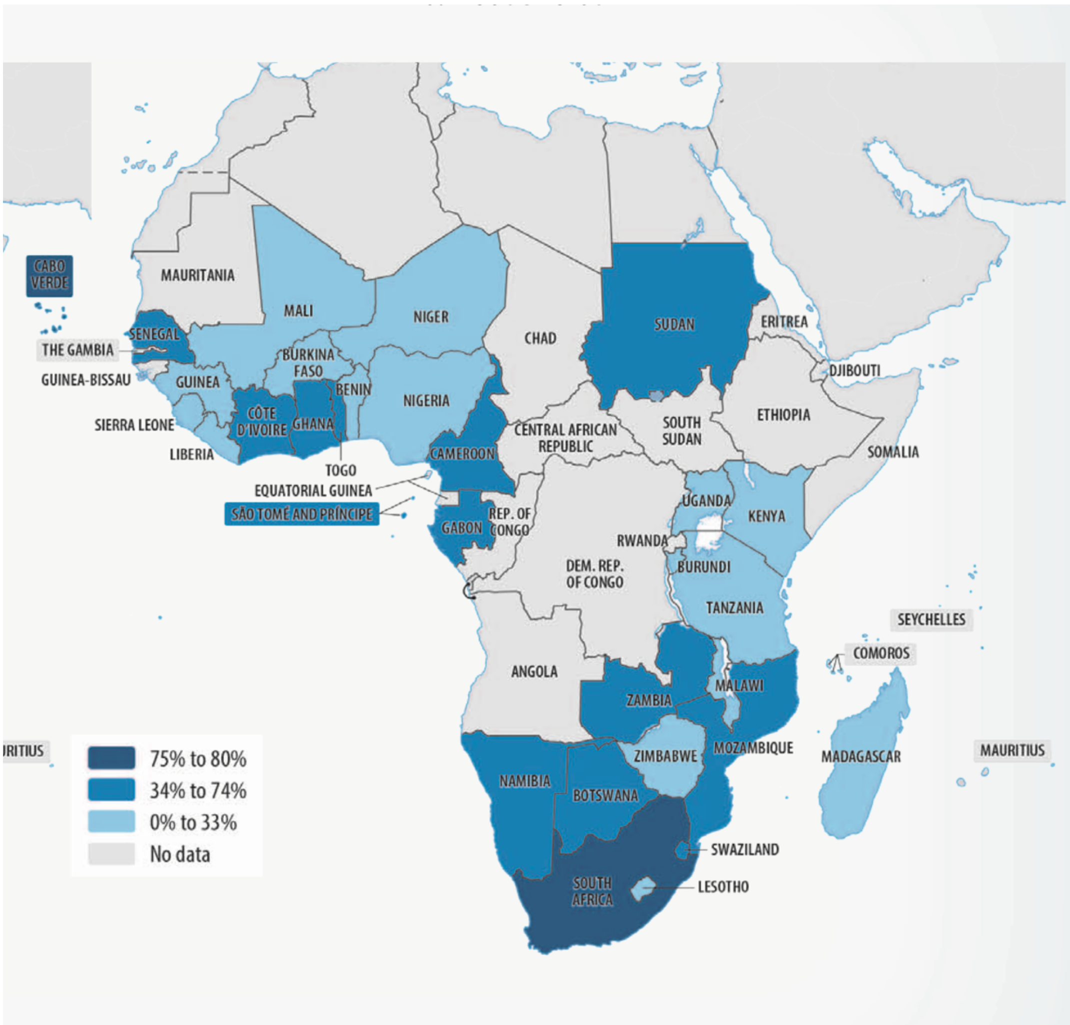
For clean cooking in the IEA-SDS, universal access is achieved by introducing better cooking options, ranging from improved biomass cookstove technologies (ICT) to cookstoves using liquified petroleum gas (LPG) (see discussion Section 2.2).

2.1. Clean electricity access: market developments and technologies

Several countries in sub-Saharan Africa have begun to pave the way to a new energy paradigm for electricity, one that could potentially fill the electricity access gap, have higher reliability, and be cleaner. The resulting clean energy system would be more sustainable than traditional, grid-based power systems. The electricity sector in most countries is designed around a central, national grid, whose primary focus is providing electricity to urban areas and secondarily to rural or other unserved areas. With the important exception of areas with major hydropower resources, the grids are typically supplied with power generated from fossil fuels (coal, oil and natural gas), with the fuel choice often driven by the country's indigenous natural resources. In the past, increasing access to electricity essentially meant expanding the grid. However, grid expansion has increasingly encountered barriers related to both the high cost to reach more distant or hard to connect areas that have relatively low levels of demand, and the endemic problems of reliability and coverage within many existing, grid-served areas. Indeed, many grids have such fundamental problems of reliability, that access alone is not a robust measure of electricity service (Figure 4). The World Bank and others have noted that performance metrics for electricity access include the quantity of electricity used and the reliability of service, and not just whether connections exist; a multi-tier framework for measuring energy access laying out five different "tiers" of access is now widely agreed and used internationally to monitor progress (World Bank, 2018c; Bhatia and Angelou, 2015).[5]

[5] For a quick overview of this framework, see: https://www.seforall.org/sites/default/files/MTFpresentation_SE4ALL_April5.PDF

Figure 4: Indicators of Electricity Reliability for Households in Sub-Saharan Africa



Source: World Bank, "Africa's Pulse", April 2018

In the last few years, rapid advances in renewable technologies, especially solar and wind, have opened major opportunities for both decentralised supply options and the greening of the central grid. While decentralised electricity services at both the household and enterprise level have long existed, these applications have traditionally relied on diesel generators. However, electricity from diesel generators is three to four times the unit cost from grid (McKinsey 2018), thus it is not economical for many, including most of the rural population and the urban poor and relies on a fuel that may not always be available. Local diesel generation represents a major cost for business and has serious local environmental impacts and relatively high emissions of CO_2. Solar technologies are changing the situation for decentralised services. Recent and continuing declines in the manufacturing costs of photovoltaics (PV) and battery storage technologies, and information technology control packages are enhancing the case for decentralised renewables and fundamentally expanding electricity service options beyond the traditional grid system supplemented by diesel generators (World Bank, 2018c). These technologies offer both primary electricity to unserved customers and back-up to households and businesses with unreliable grid connections (Figure 5).

New renewable electricity pathways could herald a fundamental restructuring of the power sector throughout sub-Saharan Africa that can greatly expand electricity access to both unserved and underserved areas in a timely manner, as well as providing a high standard of service reliability. These options create new organizational structures and opportunities for new business models to emerge, to provide services at the individual, household and community(ies) level. (See Nigeria case example, Section 5. for an illustration of this point.) The electricity sector is moving from the traditional binary system of grid-served urban areas surrounded by largely unserved, off-grid areas to a more diverse system that can provide higher accessibility, reliability and greater sustainability based largely on renewable energy technologies (Figure 5).

The availability of electricity services is often viewed as primarily a rural-urban divide, yet a recent World Bank study (World Bank 2018c) estimates that in sub-Sahara Africa the share of unconnected people living under the grid[6] can be double of the number actually connected. The number of unconnected people under the grids varies substantially among countries. A study in Kenya notes an area with "ideal" conditions for grid supply and finds that "electrification rates remain very low, averaging 5% for rural households and 22% for rural businesses" and that this holds across time and for both poor and relatively well-off households and businesses (Lee et al. 2016). The study implies that simply constructing a grid and providing the technical means of an electricity connection does not automatically translate to access and usage. While a portion of those failing to connect is due to the cost of the connection, other barriers include a lack of policy or business model to connect those living in informal housing, organisational failings within the distribution companies, socio-political marginalization and poverty among those without access (Lee et al. 2016).

Important gains in solar technologies have allowed stand-alone solar home systems (SHS) and mini-grid service options to develop rapidly in recent years, however the reliance on grid infrastructure is still important in providing electricity access. A primary issue for policy is to ensure that new capacity and connections exploit the continuum of cost-effective, system options – off-grid, mini-grid and on-grid -- and is not biased towards the existing grid or the dominant energy sources of the past, that is, fossil fuels versus newer, renewable energy technology options. Another key issue for policy is to ensure there is a level playing field and/or targeted, time-bound subsidies to incentivise investment in renewable energy to deliver on the promise of these new technologies and services to capture both the social, health and the environmental benefits of clean electricity access.

Financing and start-up of mini-grid businesses are more complex than that for SHS businesses, requiring setting up operating entities, supplying multiple customers, greater infrastructure costs, compliance with regulations including permitting of facilities, identifying larger-scale financing sources, and managing business risks such as payment risks. As shown in Figure 5, a wide variation in costs exists. While SHS costs are lower per connection compared to other options (apart from Pico), so is the level of electricity provided.

From a climate change policy perspective, renewable energy should be incentivized through-out the electricity sector. Given large public goods benefits associated with the switch from fossil fuel to renewable power generation, there is also a strong policy case not only for levelling the playing field for renewables to compete with fossil fuels, but also for time-bound, technology neutral subsidisation (OECD, 2012). Such policies can provide essential early stage support for renewable energy options, helping to create markets and experience which in turn will help to deliver affordable financing for investment in emerging renewable technology options.

[6] The term "people living under the grid" refers to those people who are in the services areas where grid supply of electricity is available.

Figure 5: Types and Characteristics of Electricity Access Options in Sub-Saharan Africa[7]

	Commercial policy, consumer financing		Energy policy, structured infrastructure financing	
Types of Electrical Systems (Capacity)	**Pico** (1-10W)	**Solar Home Systems (SHS)** (10-100W)	**Mini-Grids** (typically <10 MW)	**Grids** (always ≥10 MW)
Energy Access Tier & Type of System	Tier 1 Small Individual Devices	Tier 2-3 Stand alone system for residences	Tier 3-5 Distribution system for local group of customers, isolated from grid supply	Tier 2-5 Interconnected network, electricity to multiple customers, large distance
Primary Market	Poor, low income	Micro-commercial, poor/middle class households	Rural business, community, households	Urban households, Industry/commercial, Reachable rural areas
Cost (per connection)	USD 5- 200	USD 200-1300	USD 400-1500	Urban - USD 750 Rural - USD 2300
Market barriers	• Commercial policies to support business & markets e.g. high import tariffs, tax policy, foreign currency restrictions, lack of mobile money and no access to local debt capital • Affordability for the poor		• High investment cost • Energy rules weak: non-existent or not enforced • Policy & public finance bias, favouring grid	• Utility companies operating at a loss; chronically poor governance • High investment costs

Sources: Authors based on K4D (2018), McKinsey (2015), USAID (2015).
Notes: Decentralised renewable mini-grids may refer to a range of different technologies such as renewable only (e.g. solar PV or hydro) or hybrid mini-grid (e.g. solar or hydro with diesel back up) and possible configurations. Mini-grids are further defined here to include the smaller micro-grids, which in some contexts (e.g. India) can be up to 10 MW and are always smaller than the much larger grid supply systems. The defining feature of min-grids is both their smaller size and their decentralised design operating in isolation from the main grid. For information on energy access tier definitions, see World Bank (2018c) and Bhatia and Angelou (2015).

2.1.1. Pico solar and solar home systems (SHS)

Pico devices are the smallest of electricity access solutions. They are solar powered and usually provide single light and/or a charging port. Widespread implementation of these devices in sub-Saharan Africa began only in 2010, yet by 2017 an estimated 6 million units had been sold (GOGLA, 2018). Financing Pico solar solutions was originally government, donor or impact investor-led, but now markets operate largely on a commercial basis. Pico is key in providing a minimum level of electricity service to the very poor, including those that lack formal housing (GOGLA, 2018).

Sub-Saharan Africa is the largest regional market for Pico and SHS devices, with annual sales approaching 4 million units a year (GOGLA, 2018). While overall annual growth rates have levelled off to the single digits, SHS sales show impressive growth of over 50% between second half 2016 to second half 2017 (GOGLA, 2018). Again, this represents only a small percentage of non-served households. SHS has evolved to provide meaningful levels for home energy to millions of people – offering a level of electricity sufficient for lighting, small appliances and some cases TV and refrigerator. Importantly, SHS distribution occurs on a commercial basis with systems being sold by private entities at market prices (Lumos, 2018). A major factor contributing to rapid diffusion of SHS are new mobile phone and mobile banking payment systems that have greatly increased the number of people that can access and pay for these relatively low-cost devices (see Section 4.1).

SHS systems incorporate solar panels, batteries and charge controllers (that communicate between the consumer and the provider). While the basic SHS units have limited capacity, sometimes categorised as “two lights and a fan”, larger units may also include lights and appliances (*e.g.* radios, TVs). More advanced SHS with their

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integrated lighting and small appliances, and "plug-and-play" nature, resemble consumer electronic products found in developed countries (IRENA, 2016). Evidence in Kenya indicates that while 57% of customers are in rural areas, 35% are in peri-urban areas, showing that markets exist in both rural and urban areas (Kenya Climate Innovation Center, 2018). Indeed, in Nigeria, the poor quality of the grid has caused many urban residents with grid connections to use diesel generators as backup and thus to be a target market for SHS (Lumos, 2018; see Nigeria case in Section 5.)

The diffusion of new off-grid solutions has allowed millions of people previously without electricity to incorporate lights and basic appliances to their daily lives. Indeed, surveys indicate a desire to use even larger devices over time (e.g. refrigerator, larger TV) (Afrobarometer 2016). Currently larger appliances still require some type of grid connection; however, technology advances make this a very fluid boundary and such services may soon be available through decentralised systems. At the same time, many on-grid customers face reliability issues and see off-grid options as an important backup to grid supplies. As the scope and size of the SHS units expand, the potential customer base moves up the economic ladder, from poorer to wealthier households.

In rural areas, household electricity demand can usually be met by current SHS capacities, which provide several services at greater convenience and at lower cost than diesel. This is true in urban areas as well when household usage is limited to lighting, phone charging, and an electrical fan (Toman, 2017). While SHS provides sufficient power at the household level and technology improvement is ongoing, it is not of sufficient capacity to serve larger commercial and industrial uses, and thus mini-grid, grid and larger power plants remain essential parts of an electricity system to assure economic growth.

2.1.2. Mini-grids

Mini-grids represent an important option to provide electricity access for areas not served by main grids. The IEA (World Energy Outlook, 2017) defines mini-grids as localised power networks, usually without infrastructure to transmit electricity beyond their service areas. Advances in solar technology, coupled with the steep decline in costs of solar photovoltaic panels have allowed solar mini-grid systems to under-price diesel – as well as to provide cleaner, more reliable and quieter operations. In tandem, new payment schemes have developed using mobile payment platforms that have substantially helped with affordability and supported business models to identify viable customers. Other advances that support new business models include sophisticated geographical information systems to more accurately identify viable, unserved customer bases and that have allowed for targeting potential customers (NBER, 2016).

Several countries are now focusing on this option to rapidly and cost-effectively extend electricity access. Tanzania has witnessed a sharp increase in businesses entering the mini-grid space, primarily relying on solar energy and utilising mobile payments to collect revenues from household and business customers – both of which are widespread in the country (Odarno et al. 2017). Kenya also has programmes in place that are implementing mini-grids (World Bank, 2017a). Nigeria has in recent years been developing mini-grids with donor support, and has recently received an important World Bank grant programme to provide major support and leverage in advancing this initiative (World Bank, 2018b; Box 5).

While mini-grids are often associated with rural areas, they can also play a major role for customers in under-served or poor reliability grid areas. In this case, mini-grids act in concert with the grid, either as a back-up or as a primary source of electricity (e.g. see Section 5. Nigeria case).

2.1.3. Grid expansion, reliability and decarbonisation

Grid-based electricity supply is, per kWh, the least-cost option across all alternatives except in rural and hard to reach geographic areas (IEA, 2017). As a result, the centralized power grid is the primary mode for electrification to date in sub-Saharan Africa and will remain a key option for the foreseeable future. Between 2012-2016, grid connections were the primary means for increasing access even if for new connections to 2030 the fuel source for the grid is increasingly based on renewables and also increasingly decentralised (IEA, 2018a).

Several countries have dedicated programmes for grid expansion. For example, Kenya has a programme called the “last mile” that subsidises the connection to households in proximity to the grid (NBER 2016). Tanzania had a programme to build new lines to the electricity grid for unconnected communities. The programme also includes subsidized connection fees and offered low-cost connections to households for certain communities getting new lines. The results of this Tanzanian programme have been mixed with substantially fewer connections than targeted, and of those connected there is no clear impact on the amount of energy used at the household level (Duncan et al., 2017). In another targeted effort, South Africa’s strategy, where there is already high grid connectivity, focuses on improving grid reliability and lowering carbon emissions (South Africa, Department of Energy, 2017).

Decarbonising or greening the grid is key to limiting CO_2 and delivering on the Paris Agreement as well as on the SDGs. A McKinsey (2015) report, which examined power generation options in sub-Saharan Africa excluding solar power, showed that generation in many countries would likely be heavily based on fossil fuel, including coal. Indeed, the study indicates the formidable challenge in bringing into the grid sufficient renewable energy to replace fossil fuels for power generation and to limit emissions.

In a promising market development, grid connected solar power and other renewables are showing market gains in Africa. Between 2012-2015, 18 million people gaining access in sub-Saharan Africa did so from renewable sources – mainly large hydro and geothermal – three times the magnitude from the pre-2000 trend (IEA, 2017). In 2017, a 33 MW grid-connected solar facility began operations in Burkina Faso (Ouba, 2017). While that facility relies on donor assistance, commercial solar is developing in South Africa with ENEL operating five solar facilities for a combined 323 MW capacity. In addition, ENEL has announced financing for 700 MW for wind capacity in South Africa (ENEL, 2018). In June 2018, Zambia announced the tender award for two solar grid facilities totalling 73 MW (Renewables Now, 2018).

The availability and reliability of electricity are an important dimension of access. Research has demonstrated that economic growth and development depends fundamentally on an accessible, well-functioning electricity sector (McKinsey, 2015; IEA, 2014). A 2016 survey of thirty-six African countries revealed that on average, connected households often do not have electricity that works all or even most of the time; in Ghana, the share of those with reliable access is 42%, in Nigeria 18%, and in Guinea 12% (Afrobarameter 2016).[8] Of the thirty-six countries, the survey indicates that only 40% of people with connections are reliably served by electricity.

Grid limitations and supply constraints have led industrial and commercial enterprises to install back-up generators (either diesel or fuel oil) to assure reliability of supply. In Kenya, 57% of businesses own generators, with these numbers reaching 42% for Tanzania and 41% for Ethiopia (McKinsey 2015). Such in-house diesel generation results in per unit electricity prices from three to six times above what grid consumers pay on a global basis. This makes many Africa-based industries and manufacturing sectors uncompetitive on a global basis, slowing job growth, dragging down annual GDP growth; it also leads to greater CO_2 and local air pollution emissions (McKinsey, 2015; IEA, 2014).

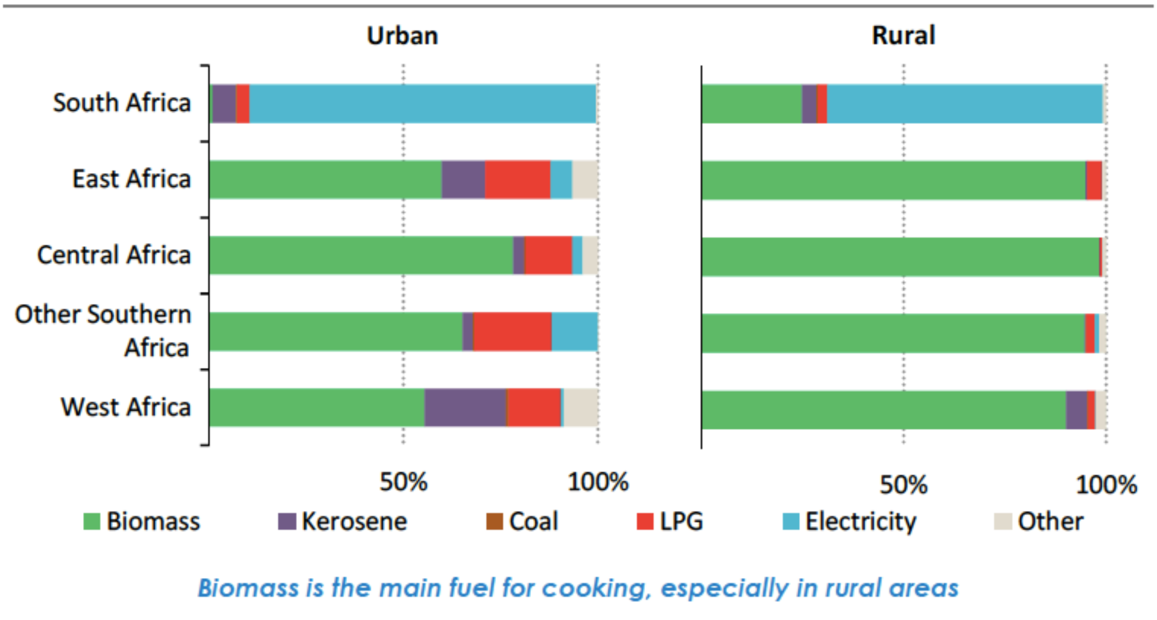
[8] The Afrobarameter survey cited here defines reliable access as those accessing electricity most of the time, i.e. 50% or more of a 24-hour day.

2.2. Clean cooking access: market developments and technologies

Transitioning to clean cooking across Africa could unlock human productivity, cut human health costs, improve well-being and save the lives of hundreds of thousands of people, particularly women and children (WHO 2016; IEA 2017). In sub-Saharan Africa, 17% of the population has access to clean cooking (IEA, 2018), while in the low-income countries this number is even lower (IEA, 2017). Most of those without clean cooking access rely on traditional biomass causing deforestation and smoke and soot pollution, which in turn negatively impacts the local and global environment and human health.

Women and children are the most affected with over half a million pre-mature deaths per year in sub-Saharan Africa alone, and billions of hours spent each year collecting biomass - time that could otherwise be spent more productively (IEA 2017; WHO 2016). Collecting traditional biomass fuels is often a shared task (across men, women and children), and cooking with traditional fuels also increases the time required for cleaning, a task borne primarily by women. The time required to collect, cook and clean soot from traditional fuels limits women and children from using time more productively. Cooking with traditional fuels thus hinders women from earning income outside of the home and children from doing schoolwork or even attending school (for more on women and clean energy, see Box 2).

Figure 6: Primary Fuel Used for Cooking by Urban and Rural Households by Sub-region, 2015[9]



Source: IEA 2017, citing WHO

Cooking with biomass, notably wood and charcoal, is also contributing to net deforestation in sub-Saharan, with a decline in area of about 0.5% per year (The Economist, 2018; Lambe et al. 2015). Heavy dependence on biomass and related deforestation limits natural carbon removal by forests and land; it also increases black carbon and methane emissions (e.g. from charcoal production), which in turn drive

[9] See map in Annex C for a guide to the countries in these sub-regional groupings. The IEA WEO 2018 report does not provide specific sub-regional detail thus this graphic is based on the IEA 2017 report which provided a more in-depth look at SSA.

climate change and contributes to loss of natural habitat and biodiversity (Lambe et al. 2015; Crutzen and Andreae, 1990; Smith et al. 2000).

Overall, traditional biomass remains the dominant source of energy in sub-Saharan Africa, accounting for about 60% of the energy demand today largely due to cooking (IEA, 2017). Related forest area loss is accelerating a decline in ecosystem services with loss of related benefits for people, ranging from flood buffering to water capture and filtering. Continued dependence on biomass in sub-Saharan Africa not only adds to GHG emissions but also raises the vulnerability of people, infrastructure and the economy to more extreme weather events, such as flood and drought due to loss of natural ecosystem services such as flood buffering provided by forests (Lambe et al., 2015; SNV, 2018).

2.2.1. Technology and fuel options

There is no "silver bullet" for clean cooking and compared to electricity access options, the range of alternatives is diverse and even more complex to deliver. A range of clean or cleaner cookstove technologies and fuel sources exist. The IEA Outlook for full energy access suggests that achieving this goal will require the market and support policies to work together to deliver a broad mix of these alternatives. Table 1 shows some of the main alternatives and the trade-offs that exist across performance criteria. Some of the main criteria that influence consumer choices and market developments are affordability or cost of alternatives (including the cost of the initial device and fuel cost over the lifecycle of use); cleanliness measured by emissions levels and types of emissions; energy efficiency and fuel availability (both which in turn interacts with the cost of operation).

Table 1: Trade-offs Between Different Cooking Fuels and Technologies

	Stove cost	Fuel cost	Fuel infrastructure & availability	Human health impact	Gender equality	Environmental impact
ICT – wood	• (Neutral)	• (Advantage)	• (Advantage)	• (Neutral)	• (Advantage)	• (Advantage)
ICT – pellets, liquid ethanol	• (Neutral)	• (Neutral)	• (Disadvantage)	• (Neutral)	• (Advantage)	• (Advantage)
Biogas	• (Disadvantage)	• (Advantage)	• (Neutral)	• (Advantage)	• (Advantage)	• (Advantage)
Solar cookers	• (Disadvantage)	• (Advantage)	• (Advantage)	• (Advantage)	• (Advantage)	• (Advantage)
LPG	• (Disadvantage)	• (Neutral)	• (Disadvantage)	• (Advantage)	• (Advantage)	• (Neutral)
Electricity	• (Neutral)	• (Advantage)	• (Disadvantage)	• (Advantage)	• (Advantage)	• (Neutral)
	Advantage		Neutral		Disadvantage	

Source: Adapted from IEA, 2017 with input from Hosier et al. 2017.

Until recently the cookstove market has suffered from a lack of standards to test performance across key criteria and to assess progress (GACC, 2018). However, the ISO has now approved two parts of a three-part standard. First, is the ISO standard that harmonises laboratory testing protocols for cookstove efficiency and cleanliness (particulate and other air emissions). ISO will also shortly release a voluntary performance standard that manufacturers can follow to demonstrate how their device performs against key performance criteria. This long-awaited set of standards will help to ensure that technologies meet minimum performance criteria to save lives through lower emissions and save money for users through improved energy efficiency and it will also provide a framework for monitoring progress (Naden, 2018).

LPG and improved biomass cookstoves are the two main routes to clean cooking access in sub-Saharan Africa. Electricity use for cooking is widespread in South Africa, however it is largely impractical for most countries because of the lack of reliable electricity supply and the relative high cost of electric cookstove devices (IEA, 2017). The limited scope or lack of LPG markets in some countries and regions also impose constraints on this option. Though North Africa has widespread access to LPG, the IEA (2017) reports that only a small share of the people in SSA currently have access to it, mainly in Sudan, Nigeria, Angola and Ghana. A minimum investment in distribution infrastructure is required to support LPG for clean cooking access (e.g. from roads to storage centres and sales points). Yet where LPG is available, it can be cost-effective, safe and efficient alternative to traditional biomass use.

2.3. Investment needs for universal energy access

Several recent studies consider the question of how much investment is needed to achieve universal energy access both globally and in sub-Saharan Africa. For electricity, the IEA's most recent estimates are US $51 billion per year globally and US $27 billion per year specifically in sub-Saharan Africa (2018-2030) (Table 2).[10] For clean cooking, fewer estimates exist but the IEA (2018a) suggests the numbers are much lower, on the order of US $4 billion per year globally, and for SSA US $1.7 billion per year to 2030 (Table 2).

Key questions are how investment requirements compare to what is flowing today and how to understand the financing gap. In its recent review, Sustainable Energy for All (2018) considered all trackable finance to the electricity and clean cooking sectors for 20 "high impact countries", of which 13 are in sub-Saharan Africa.[11] It identifies $30.2 billion per year (average 2015-16) flowing to electricity in the high impact countries, with these countries representing 80% of the electricity access gap but accounting for just 60% global estimated investment needs of US $51 billion per year (IEA, 2018). International public finance accounted for about 30% of the total flows (US $8.8) and while international private finance accounted for another 10% (US $2.9 billion).[12] The trackable finance heavily favours non-residential customers as well as a strong bias towards the grid with fossil fuels still accounting for 27% of the global total for electricity. While finance commitments for off-grid and mini-grid solutions nearly

[10] Other estimates of investment needs in the power sector in Africa are available (e.g. APP as presented in Table 2; see also Schwerhoff & Sy 2017 for a review). Since the costs of renewables have declined rapidly over the few years, older studies, such as the APP reports cited here, do not account for the current cost competitiveness and lower costs of decentralised renewable solutions in the power sector.

[11] This review covers all trackable finance from the public and private sector, domestic and international finance.

[12] Of these international flows – public and private – amounting to US $11.7 billion per year, about 23% (about US $7 billion) is estimated to be from China (also public and private). See further discussion Section 4.4.

doubled between 2013-14 and 2015-16, they represented only 1.3% of total tracked electricity finance (SEforAll, 2018). For global clean cooking, SEforAll (2018) also find abysmally low levels of financing, with an even larger relative financing gap: flows to the 20 high impact countries are estimated at US $30 million per year compared to needed investment of nearly US $4 billion per year. Almost all flows to clean cooking were from international development finance sources (SEforAll, 2018).

Domestic sources of finance for electricity are much more difficult to track and, due to lack of data, these flows may be largely under-accounted for. The SEforAll (2018) assessment identified about 60% of the tracked flows to be from domestic sources, of which the majority (80%) was from the private sector and the remaining from publicly-owned domestic entities.[13]

For this study, an up-to-date analysis was undertaken of international public finance using OECD statistics to examine flows of Official Development Finance (ODF) to electricity in sub-Saharan Africa. The analysis reveals about US $5.6 billion per year in commitments flowing on average to the electricity sector (2014-2016) (see Section 3 for more details). Assuming ODF accounts for about 50% of total flows to the electricity sector,[14] about US $11 billion per year in total (public and private, international and domestic) could be flowing in the region, compared to an estimated need of US $27 billion per year. If we deduct finance flowing to fossil fuel-fired generation, which is estimated to be on the order of 1 billion per year (SEforAll, 2018; Oil Change International, 2018), then the clean energy access gap is larger.

In the context of sub-Saharan Africa, several key findings emerge from recent assessments. First, Africa is thus not attracting a sufficient share of global electricity financing. While the SEforAll (2018) review covers 13 countries in sub-Saharan Africa, representing about half of the world's electricity access problem, these countries account for less than one-fifth (US $5 billion per year) of the aggregate finance flows for the 20 high-impact countries. Second, the levels of finance flowing today are too low to make meaningful progress towards universal clean energy access by 2030 (SEforAll, 2018; AfDB, 2018; Scwerhoff and Sy, 2017). And finally, international public development finance is dominating current flows to electricity and clean cooking, so how this piece is managed is central to achieving SDG-7.

Table 2 summarises numerical estimates of investment needs and flows. Actual finance flows in sub-Saharan Africa will need to rise significantly to 2030 to meet clean energy access investment needs. For electricity, annual investment across public and private sources needs to more than double what is flowing today. For clean cooking, the financing gap is larger, requiring one hundred times or more than what is flowing today to achieve universal access by 2030.

[13] The majority of the domestic finance tracked by CPI in the SEforAll (2017 and 2018) reports is co-financing from state-owned entities (e.g. SOEs such as public utilities and public banks).

[14] While these numbers will vary widely by region and country, this is based on the findings of SEforAll, 2018, as noted above, which found that 30% of electricity financing globally coming from international public sources, about 20% from Chinese development finance and the remainder from domestic and private investment. For the purposes of this study, we assume international public finance accounts for 50% of the total flowing in sub-Saharan Africa since the review also shows domestic and private capital flows are much lower in SSA than in developing Asia.

Table 2: Global, Africa and SSA Energy Access Investment Needs and Flows (USD)

	Electricity	Cooking
	INVESTMENT NEEDS	
Africa Progress Panel 2015 Update2017[i] 2013 needs and flows	**Africa: US $63 bn/yr** energy infrastructure investment in 2013 **FLOWS Africa: US $8 bn/yr** in 2013, Africa, energy investments	
IEA 2018a[iii] (2018-2030 average annual need)	**Global electricity US $51 bn/year** **SSA electricity: US $ 27 bn/yr** (or 52% of global need and of which **US $7 bn/yr is for grid supply** compared to **US $12 bn/yr for mini-grid** and US **$8 bn/yr for off-grid solar**)	**Global cooking investment**: **US $3.9 bn/yr** **SSA cooking: US $1.8 bn/yr**
	INVESTMENT FLOWS	
SEforAll 2018[ii] (2015-2016 average annual flows) tracking public & private, international and domestic finance, 20 "high impact" countries of which 13 are in SSA	**Global electricity** "20 high impact countries"**: US $30.2 bn/yr**, countries representing nearly 80% of those living without access; tracking public & private, international and domestic flows of which **$8.8 bn/yr international public finance** (about 30%), and about 1.3% of total **(US $380 mn/yr) flowing to decentralised RE**. **SSA, 13 "high impact" countries: US $5 bn/yr,** of which only **US $200 mn/yr** (4%) to **decentralised RE** yet **US $2.6 billion/yr** (just over 50%) is **international public finance (ODF)**.	**Global clean cooking,** 20 "high impact" countries: **US $30 mn/yr** **SSA clean cooking:** 13 "high impact" countries **US $22 mn/yr**
This report [iv] (2014-16 average annual flows) international public finance (also known as **official development finance**, ODF, from OECD DAC-CRS) and estimated total annual investment	**SSA electricity: ODF US $5.6 bn/yr** in international public finance (concessional and non-concessional) **SSA electricity**: **total investment US $11 bn/ yr** estimated, including international, domestic and private investment. [iv]	

Source and notes:

i) Africa -wide electricity (not limited to SSA also including North Africa). Of the $63 bn/yr investment needs in 2013: 1/3 for (new connections) energy access ($20 bn/yr); 1/3 for T&D ($22 bn/yr); 1/3 for power plants ($21 bn/yr). Of $8bn flows in 2013 (APP 2017) about half from domestic financing including from private sector, rest from ODF and Chinese investments.

ii) SEforAll 2018 updates 2017 work to track flows, where data available, for twenty "high impact" countries. Cooking – investment needs, SEforAll (2017) analysis shows that 95% of the costs of clean cooking is in the fuel cost and not the stove costs; the figures presented in this table represent the stove costs alone.

iii) Investment numbers are from the IEA (2018) World Energy Outlook; where not otherwise published, investment numbers were provided through personal communication with the IEA Energy Outlook team. The estimated investment needs for electrification of sub-Saharan Africa declined significantly from estimates of the 2017 Outlook in part due to rapidly declining costs of renewables, while the estimates for clean cooking remained roughly the same.

iv) The source of Official Development Finance (ODF) figures is OECD DAC CRS in 2016 dollars (data extracted July 2018); for more detail see Section 4. Based on SEforAll 2018, it is assumed here that ODF currently accounts for about 50% of all infrastructure financing in SSA, however if this figure of $11 billion is adjusted to deduct flows to fossil fuels it would be lower raising the size of the financing gap.

3. Reforming policies and institutions to raise, shift and scale finance

Stable national policies are needed to raise public finance, incentivise a shift and scale investment to low-carbon, climate resilient alternatives. Elements of an effective policy framework range from cross-cutting policies and strengthened energy sector infrastructure planning to sector-specific policies that create enabling conditions, such as tariff setting for cost-recovery, and that target specific outcomes, e.g. market development for mini-grids. Public finance will need to be raised but will also be limited in the face of the scale of investments required. Private finance will need to drive change. Limited public finance needs to be efficient and to leverage private investment and finance. Innovative green finance platforms, policies and instruments in the blended finance arena (section 4.4) are necessary but, on their own, will not be sufficient; they need to be coupled with national policies establishing enabling conditions for private investment.

3.1. Cross-cutting policies, planning and institutions for clean energy access

Sustainable Development Goal 7 (SDG-7) provides an aspirational goal for energy and clean cooking access that needs to be firmly integrated into macroeconomic, energy and climate policies. At the macroeconomic level, this is about getting the growth strategy right at the country and regional level. Clean energy investment is a way to ensure the sustainability of a key input to economic growth and to boost human productivity, while it will also help to limit and manage the economic risks of climate change.

Policy alignment across sectors will be needed to ensure coherence and to deliver on the full range of SDGs at the same time as clean energy access. For example, this will include reform of fossil fuel subsidies (in accordance with SDG-12) such as those supporting coal and oil production to reform of kerosene subsidies to incentivise clean cooking alternatives (OECD, 2017). Estimates show a potential to save US $21 - 26 billion in annual spending through the reform of fossil fuel subsidies, which could in turn finance up to half of the investment needed to achieve full energy access (APP, 2015; Whitley and van der Berg, 2015). In another example of alignment, compact urban development policies and the use of smart meters can both work to reduce the electricity requirements in buildings, lowering investment costs needed to generate power and deliver better access and economic growth in urban areas (OECD, 2017).

Boosting domestic public investment for clean energy access is a key step for sub-Saharan countries to establish the means to move markets and businesses to scale. Foundational policy actions include domestic anti-corruption reforms as well as improved public financial management, including through state-owned enterprises (SOE) that typically operate national electric utilities (Africa Progress Panel, 2015; World Bank 2018c). The potential for public sector financial gains is large. For example, citing research from Global Financial Integrity, the Africa Progress Panel (2015) reports that five emerging energy powers – Ghana, Kenya, Mozambique, Tanzania and Uganda – collectively lost US $6.3 billion annually between 2002 and 2011 through trade mis-invoicing, amounting to 7 – 13% of total government revenues. More specifically in the electric utility sector, evidence reveals opportunities to restructure tariffs and improve revenue collection to improve the otherwise poor financial performance of the utility sector across the African region (World Bank 2018c).

Investments occurring under state-owned enterprises (SOE) could be shifted away from fossil fuels to clean energy solutions. Recent OECD analysis highlights the role of SOE in the energy sector worldwide, underscoring that these entities either own or are investors in more than half of the world’s existing and planned fossil-fired power facilities (Prag et al. 2018).[15] Given that they are "state-owned", and essentially public entities, aligning SOE spending plans with governmental commitments towards clean energy and climate action could be prioritised to ensure delivery of the Paris Agreement and lead the way for private investment. Beyond this, SOEs benefit from preferential financing, including implicit or explicit grants or credit at below market rates, which means that their investments in fossil fuel generation equate to a form of subsidy. By contrast, procurement of renewable generation by SOEs in an open market manner can help generate transparency and drive prices down through, for example, use of reverse auctions; this provides clarity and a framework for competition to account the latest technology developments, helping to expand markets and deliver clean electricity at lowest cost (IEA, 2018).

Pricing carbon can also be a powerful instrument in a policy framework designed to incentivise private investment in clean energy. Although several sub-Saharan countries have advanced fossil fuel subsidy reforms, only South Africa has specific plans to tax carbon (NCE, 2018). Implementation of this tax measure in South Africa has been delayed several times, and it is now scheduled to come into force in 2019; the planned tax rate is low, at about the equivalent of US $10 per tonne $CO_{2\text{-}e}$ and is to increase by 2% annually through 2022 (World Bank, Ecofys, 2018). In spite the low initial price, this tax measure could send a powerful signal to the market for clean energy in South Africa and could potentially be replicable elsewhere. The Côte d'Ivoire is also reported to be consulting with stakeholders about the possibility of implementing a carbon tax (World Bank, Ecofys, 2018).

The sometimes large and highly valued (at current prices) fossil fuel resources found in many sub-Saharan countries can also be expected to have macro-economic implications when greening the power system. While a discussion on stranded fossil fuel assets has emerged in recent years, it tends to focus on those assets on the books of energy companies. This challenge is equally valid for the macro-economic conditions of those countries in which the assets are located (Mercure et al, 2018). The choice of developing solar or other renewables either for grid or standalone off-grid electricity systems has important implications for these resource rich countries, and these implications present real economy, political barriers to action. Trade-offs need to be identified and managed on both on an energy and an overall macro-economic policy basis, for example, to ensure that displaced workers are compensated and that businesses can manage losses and ideally both can transition into new opportunities.

Commercial or "investment policies" are another essential part of the foundation needed to enable private investment to flow smoothly. For example, investment policies can improve the ease of doing business and help strengthen of local capital markets (OECD, 2017), where relevant policies include those that protect private investments, ensure fair competition and align tax and trade policies to promote a long-term vision for clean energy access, climate action and sustainability. They also include streamlining relevant permitting and licensing requirements, for example for mini-grids. They encompass forward looking education and training policies to position workers and managers with the right skills to support a clean energy economy and policies to enhance transparency in corporate operations (e.g. through disclosure and monitoring of performance on climate change and other ESG objectives) (OECD, 2017). Finally, they require sustained effort to build public institutional capacity at national and sub-national levels to support clean energy investment and market development, e.g. through enhanced planning and project preparation processes, including procurement and public-private partnership administrative units when feasible (OECD, 2017).

Beyond cross-cutting policy reforms is the need to help establish business-friendly markets through energy system design and planning processes. These encompass

[15] This is measured on the basis of installed capacity.

energy infrastructure and investment plans, for example, to identify the potential role and geographies favourable for mini-grids – and regulatory policies, such as tariff design in the electricity sector. These planning exercises should embrace new options for electricity access at the individual, household and community level and include infrastructure planning for clean cooking fuels and their distribution, notably for LPG and biofuels. Decentralised solar and clean cooking developments increasingly open the role for cities and community-level organisations to be pro-active and indeed to help stimulate community-based enterprises as clean energy service providers.

Climate change policies are operating quite separately from energy or electricity policies. A review of the NDCs submitted by African countries indicated that 34 (or about 60%) refer energy access as an enabler of development and thus underpinning their ability to pursue climate change strategies and policy objectives (IEA, 2017). Yet many countries in the region lack energy policies with the detail and the priority setting necessary to set themselves on a pathway to achieve SDG-7 with respect to energy access.

Engaging women and marginalised communities, including urban migrants, is important to ensure clean energy access policies and markets are fully inclusive and beneficial to all constituents. While men provide the largest percent of the workforce in SSA, in the informal sector women are the most engaged. The informal sector includes peddlers, traders in local markets, small service providers and smallholder farmers. For example, women are direct beneficiaries of the expanding clean and cost-effective solar energy access available to traders in local markets and small service providers (Dahir, 2017). A visible sign of this is the number of Pico solar devices that are replacing kerosene lanterns for night lighting among roadside stands and markets.

Gender issues are central to the design of sustainable electricity policies and investments. While clean cooking reduces the risk of illness or death from air pollution and saves time for women, research shows that electricity access also increases the likelihood of female employment and that children – notably girls – will attend and finish school (O'Dell et al., 2014; Dinkelman, 2010; Gorgan, and Sadanand, 2013). Mini-grids have potential to power both households and productive uses for community development and income generation (IEA, 2017), benefiting for example for smallholder farmers, the majority of which are women, and maternal health by powering clinics and hospitals providing essential services. Finally, women as entrepreneurs and policy leaders can be critical to the success of new and innovative clean energy business ventures (see Box 2).

Box 2: Tapping into Women's Leadership and Business Acumen for Clean Energy

While women are a primary beneficiary of clean energy, they have been under-represented in energy policy leadership and in establishing and promoting related businesses. Research shows that women perform as well or better than men as entrepreneurs and agents in furthering renewable energy businesses designing and promoting access, such as in the marketing and provision of technical support for clean cookstoves (Satyam, 2017; Shankar et al., 2015). Yet in terms of employment, female employees are a minority in most rural renewable energy enterprises, particularly in managerial and technical positions (IRENA, 2019). Limited access to capital and limited mobility, as well as socio-cultural restrictions, often preclude a larger role for women in many modern renewable energy enterprises (IRENA, 2019).

Policies and practices targeting these barriers could leverage women as agents of change, creating employment and leadership opportunities for women in the business of clean energy. Some notable success stories stand out in SSA:

- **Solar Sister** is a women-led clean energy enterprise operating in Nigeria, Tanzania and Uganda that recruits, trains and mentors women, and builds women-to-women networks to achieve "last mile" distribution for solar devices and clean cookstoves. Solar Sister has a network of over 2,500 entrepreneurs providing services to over 350,000 people (Solar Sister, 2018).
- **BURN Manufacturing**, a clean cookstove company in Kenya, designs its products based on women's preferences and prioritises employment for women. BURN now serves more than 100,000 Kenyan homes, reducing fuel costs and emissions compared to traditional alternatives by more than 60% (Ashden, 2015).
- **Lady Volta Green Tech Academy** was formally inaugurated in 2018, building upon an earlier initiative that started as a collaboration across two non-profit organisations (Social Ventures Africa, 2018). It now partners with the multinational Schneider Electricity, through its foundation, to train women to work as technicians and managers in clean energy (Mitic, 2017). The training enables women to become certified by the government to work in various clean energy trades and one course is designed to help women pass the Ghana Energy Commission exam to access management positions (Social Ventures Africa, 2018).
- **Economic Community of West African States (ECOWAS)** operates as a regional policy institution for its member states. ECOWAS recently committed its 15-member governments to the goal of mainstreaming women into public and private-sector energy jobs and energy infrastructure decisionmaking (SEforAll and Wallace Global Foundation, 2017). This builds on encouraging patterns showing that women in renewable energy jobs, at about 32%of the workforce, outnumber their representation (22%) in the oil and gas sector, however the numbers are still fall below the 48% level of female employment in the global workforce (IRENA, 2019).

Results for these initiatives show positive social impacts for women, communities and economies. Women in clean energy businesses actively engage their peers and help build trust, and thus increase the chance of successful uptake and maintenance of solutions over time (ARE, 2017; ARE and Energia, 2017; Shankar et al., 2015). Beyond making good business sense, women's engagement raises incomes and the power of women within their communities and society, creating powerful female role models for girls and leaders of the future. Women in clean energy access leads to more productive, healthier, and safer communities (ICRW, 2015) and strengthens women's standing, agency and status.

Source: authors drawing on New Climate Economy, 2018 and IEA, 2017

3.2. Sector policy reforms: electricity

Electricity is a key pillar of energy policy, but it also has major impacts across other sectors. The role of off-grid Pico solar (individual) and Solar Home System electrical devices broadens the policy impact to include issues related to retail and wholesale commercial policies but perhaps more importantly to poverty, health and gender issues especially as it relates to poorer households that are deprived of both electricity and clean cooking. Grid electricity polices need to address how off-grid technologies can strengthen access, and how regulation needs to make a space for these new entrants. On clean cooking, increased emphasis on LPG needs to be reflected in energy policies and the distribution and use of clean cookstoves and fuels, such as LPG or advanced biomass fuels, in social policies.

National electrification strategies and policies need to address both development objectives and prioritize electricity system investments. To date existing policies and tariffs are almost all designed for grid electricity and seldom reflect the specific challenges and financing needs of mini-grids or off-grid solar. Yet to take advantage of recent technology developments electricity policies and financing need to target an integrated power supply system that includes all three connection options – off-grid, mini-grid, and large-scale grid (WB, 2018; SEforAll 2017).

National grids also benefit from pre-existing large-scale operations, technical competence, and some self-financing capacity; by comparison mini-grids lack this under-pinning and will require supportive policies and finance from governments and donors at least at early stages of development. Importantly, grids often benefit directly from subsidies and other government assistance, and these benefits should not be used to undercut the development of the other players in the off-grid sector. Finally, national grids need new and expanded policies to incorporate large-scale solar and wind capacity where it is cost-effective to do so and clear priorities for grid expansion.

In many rural areas, the impacts on economic development of grid extension in the near term may be modest, affirming the reality that more than just electricity is needed for economic development. Components of sound development strategies, such as transport infrastructure, legal land rights, an educated population, and good governance are also fundamental. Off-grid options can be the most cost-effective for meeting the most important basic household needs, particularly for the poor. Conversely, regions with high business potential, developing industrial zones and/or high community service needs (e.g. such as sub-regional medical clinics) could be targeted for grid- or mini-grid connections to encourage and further economic growth (Toman, 2017). This is a dynamic situation, particularly with respect to renewables and related technologies, and policies will need to be flexible to support and adjust to changes in emerging markets for the electricity services they provide.

Policies related to Pico solar and SHS are primarily commercial policies and not electricity policies per se. Nevertheless, the degree of penetration of these devices can be influenced by government policies. For example, direct subsidies can be given to devices targeted for the poorest consumers. Trade or import tariff policies related solar panels and batteries can have important implications on the costs of SHS devices and end-use services can usefully be adjusted to bring costs down.

3.3. Developing mini-grids

While Pico and household solar are to a large degree independent of energy sector policies, the development of mini-grids will largely be determined by energy policies and how well these provide it a secure and profitable regulatory space vis-à-vis the grid. The role that mini-grids can play in sub-Saharan Africa is becoming a major focus of both bilateral and multilateral donors.

As mini-grids serve multiple consumers they typically fall under electrical regulatory authorities. The major variables are cost structure (which often include subsidies), tariff setting, relation to the grid and to grid expansion. Regulation and reporting should act to encourage investment and engage developers and not be burdensome. A major concern for mini-grids is that the grid extensions could encroach on their consumer base or even subsume their operation over time. As the grid can offer lower prices and greater electrical capacity per connection, extension of grid operations into the same territory served by mini-grids could fundamentally disadvantage the mini-grid operators.

Many of the mini-grid operators' policy and regulatory concerns are in initial stages of development and need to be integrated into different national energy policy dialogues, contexts and needs. Mini-grid policies and regulations are developing in different ways as shown by:

- **Kenya,** which is an early entrant in solar mini-grids (especially in rural areas) but also has a clear policy of encouraging grid connections;
- **Ethiopia,** which has a 100% renewable grid and where grid expansion is the primary access strategy; its policy limits mini-grids to isolated areas;
- **Nigeria,** which has a very problematic and unreliable grid, and mini-grids are seen as an important option in both un-served rural areas and under-served urban areas.

In all three countries, a principal factor is that mini-grid development has been driven by the inability of the grid to provide the connections or the cost of those connections. In Kenya, the principal driver for access is grid expansion, and mini-grids are brought in when grid connections are not economically feasible (less than 20% of new connections today are mini-grid based). In Ethiopia, the grid is in an even stronger position and mini-grids are viewed as a transitional stage of access until the grid can be extended. In both countries, the very high percentage of renewables in the grid – 100% in Ethiopia and 70% in Kenya – reduce the economic benefit of decentralised solar operating costs vis-à-vis the grid. Nigeria is a different story. The very poor service from the grid and the grid's reliance on fossil fuels puts solar mini-grids in a stronger position, both for rural and urban areas. More information on the emerging policy frameworks in these three countries are provided in Annex A and an in-depth look at Nigeria is provided in Section 5.

Electricity polices related to decentralised solar technologies and to mini-grids are by default climate positive, but seldom are climate benefits directly referenced in the policies. There are some exceptions however, for example in Ethiopia, where climate change and clean energy are a central pillar of the development strategy (see Annex A). Renewable energy strategies and goals are also typically part of both the climate change and the energy policy landscape in Africa.

3.4. Policy reforms and tailored programmes for clean cooking

While some progress has been made to deliver clean cooking solutions in sub-Saharan Africa, most countries in the region still lack coherent policy frameworks and sufficient finance to deliver clean cooking solutions at the scale required (Hosier et al., 2017; SEforAll2017a). Weak market conditions, a shortage of viable business models and few bankable projects for development finance actors constrain investments and progress (Practical Action, 2017). Some countries are exceptions and have clean cooking action plans or strategies, such as in Ethiopia, Ghana, Malawi, Nigeria, Rwanda, Senegal, and Uganda (Hosier et al., 2017), however progress to date in these countries is uneven.

Ghana, for example, has an action plan for clean cooking with an ambitious goal to have 50% of the population using LPG and at least 50% using improved biomass cookstoves by 2020 (Quinn et al. 2018). Building on the recently approved ISO standard (Naden, 2018), Ghana will soon have labels on all new cookstove devices for sale (Spiak et al., 2018). Ghana has realised some success particularly around promotion of LPG for cooking in urban areas, where it accounts for 36% of household cooking versus 5% in rural areas; yet most households in Ghana still cook with wood fuel (Broni-Bediako and Amani, 2018). Ghana's goals for clean cooking are to shift 50% of its population to LPG and the other 50% to improved biomass cookstoves (IEA, 2017); and its policies include public awareness campaigns as well as subsidy for the uptake of LPG (Broni-Bediako and Amani, 2018).

In Nigeria, biomass and kerosene are currently the main fuels used for cooking with biomass dominant in the rural areas and kerosene dominant in the urban and peri-urban areas (IEA, 2017; see also Section 5. Nigeria case). The IEA (2017) estimates that roughly 40 million people in urban households are cooking mostly with kerosene. This cohort represents a key potential market for LPG since the kerosene fuel savings essentially offset LPG and LPG has better distribution in urban areas. As part of the National Gas Policy (2017)[16], the government aims to replace kerosene with LPG in urban areas, albeit with very little public funding for implementation; however implementation is driven by commercial efforts, notably by private LPG suppliers and distributers. To date, fluctuations in prices and supply have constrained progress as has the economic downturn in Nigeria of recent years (IEA, 2017; Practical Action 2017); this is due in part to exchange rate fluctuations that affect the cost of importing LPG canisters. Meanwhile, the ambitious targets set by the Nigerian government for improved biomass cooking, as a replacement for traditional cooking, are also far from being met (see more on this in Section 5. on Nigeria).

Ethiopia's clean cooking policy focuses on improved biomass cookstove technology (ICT), burning either wood or charcoal (SEforAll, 2017c). As nearly all rural households and 73% of urban households cook with solid fuels (IEA, 2017), the market emphasis on ICT is sensible. Building on previous programmes, the Ethiopian government has set an ambitious goal as part of its growth strategy to distribute an additional 11.45 million improved (fuel-saving) biomass cookstoves during 2016-2020 (SNV 2018); some progress has been made as the baseline is estimated to be 8 to 9 million improved cookstoves in use at the beginning of the period. Further, between 2008 and 2013, the National Biogas Program succeeded in building 8000 biogas plants (IEA, 2017). However, the SEforAll (2017c) outlook to 2030 projected that biogas would account for only 2% of the new connections in the clean cooking market with two-thirds of all new connections being either wood- or charcoal-burning ICT and another 28% from electricity.

Key features of nearly all clean cooking and cookstove programmes today are public subsidies and incentives to decrease the cost and increase ownership amongst users (SEforAll, 2017c). Typically, the financial incentives are designed to promote alternatives that are more durable and affordable while also bringing advantages to the users such as fuel and time savings, ease of use, and reduction of indoor smoke as well as attractive designs for cooking (NCE, 2018). Such financial incentives have proven to be most effective where the targeted family is already paying something for cooking fuels or devices, as is often the case in urban areas. Yet affordability remains a key constraint as roughly 50% of the households in sub-Saharan Africa rely on the free collection of biomass for cooking (Hosier et al. 2017). This is especially true in rural areas, where there is deep poverty. In these contexts, even with the offer of financial incentives, the cost of clean fuels in addition to the costs of the cookstove present a major barrier to their uptake.

[16] Nigerian National Gas Policy, 2017 http://www.petroleumindustrybill.com/wp-content/uploads/2017/06/National-Gas-Policy-Approved-By-FEC-in-June-2017.pdf , see p.74.

Yet in some contexts, affordability may not be the only barrier. World Bank analysis highlights that there is positive willingness-to-pay for improved cookstoves in Ethiopia, while they found a lack of availability of clean cookstoves and fuels to be a key barrier (Dissanayake et al., 2018). A recent review by SNV (2018) on policies and strategies in Ethiopia, notes the lack of governmental capacity, despite the government's ambitious goals and recognition of the potentially huge local and global benefits of action on clean cooking; to deliver progress, they argue a need for "*a strong and capable central government institution with clear mandates, vision and mission to provide guidance and oversight as well as coordinate efforts…*".

In rural areas, evidence shows successful clean cookstove programmes are tailored to local contexts and needs including, preferences for temperature levels, cooking pot size and shape, different types of cooking and usage habits (Hosier et al. 2017; Urmee and Gyamfi, 2014). They also address how to substitute for a range of local amenities from traditional biomass cooking that may include cooking for multiple households and socializing as well as seasonal heating. Livelihoods also need to be considered, for example, where family earnings may be associated with fuelwood or bio-waste gathering for others, or in urban areas, briquette manufacturing and distribution. A livelihood benefit of importance for women is that the time saved from fuelwood collection and avoided cleaning tasks can be put to productive use, for example freeing up time for women to take up community level or income-generating activities, which in turn can improve gender equality.

The financing gap for clean cooking is huge (SEforAll, 2017) in relative terms compared to what is flowing today but not large in absolute terms (see Section 4), but experience suggests it will not be sufficient to throw money at the problem (Urmee and Gyamfi, 2014; Debbi et al. 2014). This conclusion comes from decades of experience and of failed policies as the numbers without clean cooking access continue to rise. Social and cultural factors often drive the poor outcomes. Success will require policies that engage local communities in the design of solutions so as to tailor these to local needs. In parallel, there is also a need to work with these communities to raise awareness of the health risks of air pollution from wood burning and other traditional cooking practices and of the benefits of alternatives. Government sponsored pilots can test innovative approaches, allowing for learning and adjustment prior to scaling up programmes for commercial engagement for full impact. Successful programmes also build monitoring and maintenance capacity at local level from the start, to ensure devices can be maintained and replaced if needed. Finally, successful programmes will put women at the centre as agents of change.

As women often make household cooking decisions, and have intimate understanding of the family cooking needs, their engagement from start to finish in the supply chain of clean cooking programmes and businesses are a key to success. A recent assessment in Kenya showed that women cookstove sellers outsold male counterparts by nearly 3 to 1 and that women were twice as likely as men to be high sellers in urban settings (Shankar et al., 2015). Also, when the sellers were women, consumers were more likely to report consistent and correct cookstove use and to better understand the benefits of the new cookstoves. Engaging women as entrepreneurs in the cookstove sector increases return and results, reflecting the strong role of women's leadership in markets to promote the uptake of clean cooking (see also Box 2).

4. Finance for clean energy access

Current levels of financing are far below what is needed to provide clean energy access by 2030 (see Section 2.3). Increased public finance from both domestic and international sources is an urgent priority. Public finance however will always fall short of what is needed and should serve as a bridge to commercial, market finance rather than the main source for clean energy access investments. Private finance will need to play a strong role in future to deliver clean energy access, building on what is already occurring in the Pico and SHS markets. But even in these markets, debt capital financing is often needed to expand and extend operations in a timely manner to meet demand (SEforAll, Practical Action 2017). By contrast, in large-scale renewables markets and for mini-grids, relatively higher initial costs for renewables compared to business-as-usual fossil fuel options means that (public) development finance, particularly in the form of blended finance, can play an important role to attract higher levels of private capital than would otherwise be possible in today's markets.

4.1. Landscape of first costs, access for the poor and PAYG consumer finance

Financing in the power sector is traditionally thought of as related to major grid and transmission and distribution infrastructure, i.e. large-scale power plants (>500 MW), long-distance transmission lines, and distribution networks that cover millions of customers. Investment costs of large generation facilities run in the hundreds of millions of US dollars if not more. For example, one large, recent, on-grid renewable energy addition is Ethiopia's Grand Renaissance Dam (6.450 MW, with investment costs estimated at US $4.7 billion) (Embassy of Ethiopia, 2018). Such investments require well developed, typically regulated monopoly organisations (often SOEs) with the capacity to carry out substantial and costly planning, investment and operational functions. Financing such investments is equally complex, requiring large scale debt and equity packages.

One major advantage of individual and solar home systems (SHS) is that the investment in absolute terms is very small. This opens retail and commercial financing for customers to self-finance these investments. The costs and affordability of SHS are trending downward due to advances in solar and battery technologies and the existence of competitive markets to provide these. Improved payment options, and sophisticated geographical information systems – in part built on the back of the mobile telephony business – also help businesses to identify and adapt services to rural customers (Bardouille, et.al, 2016). Nevertheless, subsidies and other supportive policies have often been required in early stage development of these new technologies and services (Philips, 2018).

As noted, some countries are early movers in off-grid Pico and SHS markets and this experience appears to be carrying over to support also more ambitious electrification through mini-grid businesses. For example, Tanzania and Kenya have policies and government agencies in place to support mini-grids and they are showing on-the-ground results (IEA, 2017; see also Section 3.3). In Nigeria, recent solar mini-gird developments have been supported by GIZ, and more recently a new World Bank project is another important initiative aiming to grow the scale and market viability of these as part of the overall power system (see Section 5, Nigeria case).

As noted above, financing and start-up of mini-grid businesses are more complex than that for SHS businesses, requiring setting up operating entities, supplying multiple customers, greater infrastructure costs, compliance with regulations including permitting of facilities, obtaining financing, and managing business risks such as payment risks. Currently solar-based mini-grids produce higher cost electricity (on a levelized cost of electricity basis) than provided via SHS or grid-based connections, even though the connection costs remain relatively low compared to the grid.

Financing of the mini-grid sector to date has been primarily via public funding and wide-spread commercial adoption will require some form of public subsidy and public-private cooperation at least at the outset (Philips 2018). The financial risk of these ventures is viewed as high, and policies and targeted financing mechanisms are needed to mitigate this risk, for example, through guarantee funds such as what already exist in the grid electricity and gas sectors (IFC 2016).

Grid connection costs vary substantially. As shown in Figure 5, McKinsey (2015) estimates the cost of adding a single new connection to the urban grid in sub-Saharan Africa at about US $750 while rural grid connections can be much higher at about US $2300 (Tanzania used as benchmark). While small scale and mini-grids may have connection costs below that, only smaller amounts of electricity can be provided to customers, with implications for growth in local economy being served. Generation costs for solar mini-grids are currently somewhat higher than for large scale solar facilities (IRENA, 2016), however the lower transmission and distribution costs for mini-grids provide one economic advantage for this sector.

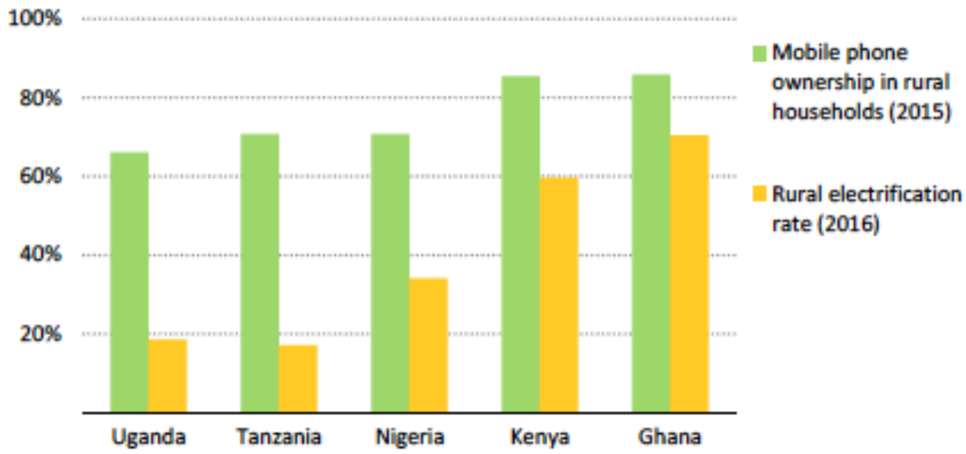
Even with grid expansion, a large percentage of people currently not served by grid-electricity are poor, and the affordability of the options and the ability to pay could well preclude them from benefiting from grid expansions. For this cohort, the large decline in solar prices and the costs of small solar devices offer major benefits. In Kenya, for example, an average small-scale solar home system costs in about US $120. This is roughly equivalent to 5% of a poor family's annual income and can be within the reach of many of these people; for the poorest fifth of the households the amount spent is double this percentage at about 10% of total expenditures (Acumen, 2017). Pico-solar lights are now priced at about US $10 and limited data, from in East Africa, suggests that these may be the only electrical devices reaching the poor in a meaningful way (Acumen 2017).

In some countries the off-grid solar revolution is reaching a significant share of the poor to provide affordable, reliable, and importantly, clean, electricity services. A recent survey shows the success of these markets in reaching the poor with 82% of customers surveyed buying the simplest solar-powered lights (costing around US $10) live below the US $3.10 per person per day poverty line; using this indicator, the equivalent share of this cohort (the poor) in the Pico solar market is 62% in Zambia, 73% in Tanzania, 85% in Kenya, 85% in Uganda, 99% in Malawi (Acumen, 2017). Looking across five SHS and mini- grid companies operating in four East African countries, another survey showed the that 36% of the customers live below the poverty line (Acumen, 2017), yet in the specific case of a solar mini-grid, PAYG service in Tanzania, 82% of the customers live below the US $3.10 per person per day poverty line (Acumen, 2017). While Pico solar lights represent a very important advance and the one most accessible to the poor, it provides a low level of service that constitutes only the first rung of the energy access ladder (Bhatia and Angelou, 2015), so the ability to extent higher levels of affordable service is key, via the grid or mini-grid.

Connectivity of the poor is made increasingly possible by the declining cost of solar devices combined with business models that feature affordable consumer financing tailored to poor communities. Especially for emerging SHS markets, a key feature in market creation is "Pay-as- you-go" (PAYG) payment options managed through mobile phone services. Where PAYG is in use, delivery of off-grid services is rapidly spreading in East Africa and elsewhere (Sanyal et al. 2017), leveraging the high use of mobile phones in Africa, which are estimated to number more than 1 billion today (The Economist, 2016). And the IEA (2017) highlighted that mobile phones are providing an opportunity to accelerate energy access. Indeed, the ubiquity of mobile phone use and well-functioning payment plans have allowed PAYG to build on these to establish payment mechanisms for SHS and in some instances for mini-grid services (Figure 7).

Some mobile phone companies are becoming directly involved with SHS suppliers. For example, the Lumos/MTN partnership in Nigeria, which is now expanding to the Côte d'Ivoire, is taking advantage of MTN's large mobile phone network, customer base and administrative capacity to offer off-grid solar electricity access (Lumos, 2018). PAYG financing has also been supported by policies that encourage and enable movement towards a cashless economy and use of mobile money (e.g. in Kenya) (Sanyal et al., 2017).

Figure 7: Mobile phone ownership and electrification of rural households



Source: IEA, 2017

The use of PAYG, which reaches both rural and urban customers, has allowed markets to reach sustainable sizes in key countries. For example, Kenya is a world leader as is Tanzania, and more recently Uganda and Nigeria also have large and growing markets (GOGLA, 2018). In Tanzania, currently about one-fourth of households with electricity access obtain it from off-grid solar PV (IEA, 2017). Scaling up the pace of growth in these SHS markets is likely to require national efforts to strengthen business environments for information, communication technologies (ICT), mobile money policies and, ideally, stronger local capital markets, which could lower the costs of capital (NCE 2018).

Similar progress has yet to be seen for clean cooking solutions. The costs of clean cookstoves vary with a typical cost in the range of US $ 8 for an advanced biomass cookstove to US $40 for an alcohol cookstove (excluding the fuel cost) (SEforAll, 2017a). These admittedly low first costs of clean cookstoves compete in many cases with free alternatives, i.e. a "three stone cookstove" made from materials readily available with no first cost at all. SEforAll (2017c) points out that the purchase cost of the clean cookstove devices accounts for only 5% of the relevant cost of alternative cooking options with the fuel accounting for 95% of the cost. The investment challenge thus needs to be framed around much higher costs associated with the supply of clean fuels for clean cooking alternatives, including the investment costs of infrastructure to make such fuel available. For LPG, investment in distribution networks and, for advanced biomass fuels, such as biogas or biomass pellets, investment in both production and distribution). It is the cost differential that matters to affordability or the difference between what consumers pay today (i.e. sometimes nothing) and what a clean system costs, where both the upfront costs for the device and fuel costs matter.

While consumer finance is increasingly available for off-grid solar electricity, this is only just emerging in clean cookstove markets in sub-Saharan Africa. Some businesses in East Africa, for example, are offering clean cookstove as part an integrated offering of services to households and commercial customers, thus diversifying their customer base while strengthening cash flows and increasing their ability to adapt to changing market needs (SEforAll, 2017c). But such practices are not yet widespread and clean cooking businesses for clean biomass and other modern fuels remain nascent in sub-Saharan Africa.

Clean cookstove and fuel businesses are typically challenged by the same problems as early stage Pico or SHS, including a lack of access to international finance, a paucity of donor finance, a lack of working capital (e.g. to support local manufacturing), and a lack of viable business models that tailor consumer finance solutions to different segments of the population. For Pico and SHS these issues are being dealt with through commercial finance with innovative financial packages, however this has not been the case with clean cooking. Additionally, policies and financing for clean cooking and existing investment, typically focus narrowly on cookstove devices, ignoring the costs associated with the fuel supply chain (SEforAll, 2017c and Hosier et al., 2017). These challenges are exacerbated by cultural preferences and social influences that guide consumers' (typically women's) decisions about devices and fuels and by a lack of awareness about the risks of traditional cooking compared to the benefits of alternatives.

4.2. Role of private and domestic finance -- public and private

Global assessments suggest that a large share of necessary energy infrastructure investment has and will need to be funded domestically and primarily from the private sector (NCE 2018). Indeed, domestic flows are often expected to support most investment requirements for energy access (Africa Progress Panel, 2017, 2015). Yet in Africa this may not be possible in the near-term since enabling conditions are often weak for both public and private investment. Many African governments are undertaking relevant policy reforms but there are large policy gaps today and reforms will take time to become effective (World Bank 2018c; Schwerhoff & Sy 2017; see also Section 3.1).

The SEforAll (2018) assessment finds that domestic finance accounts for 60% of the trackable financing for energy access in 20 "high impact" countries (of which 13 were in sub-Saharan Africa), and the private sector accounted for the vast majority of this (about 80%). However, in Africa, international public finance is still dominant. In some countries, the share of international finance is estimated to be more than 60 percent (e.g. in Kenya and Ethiopia) of the total flows, dwarfing domestic financing; for example, Ethiopia and Kenya were estimated to have 21-24 percent domestically sourced finance for electricity in the period 2013-14, while in Bangladesh this share was around 44 percent (SEforAll 2017).

Where trackable, private investment exists, the largest share clean energy markets has been external, coming through international investors (Sanyal et al. 2016; SEforAll, 2017b and c). Research shows initial financing for off-grid solar businesses has come from a mixture of donor finance and foreign private investors (Sanyal et al., 2017). High risks from foreign currency exchange is costly and could limit future growth of the off-grid market (The Lab, 2017), despite the high demand for these services. Foreign private investment is largely equity with relatively high expectations for return, while domestically sourced financing for the off-grid sector in sub-Saharan Africa appears to be in short supply. A lack of domestic financing thus raises the costs of capital and the costs of operations for these businesses.

The foundation for domestic private investment will need to come from the domestic policies and public investment, yet infrastructure generally is hugely underinvested by national governments in sub-Saharan Africa (IEA, 2014).

One part of the solution to the need for domestic capital markets could be to make greater use of national development banks (NDBs), working in conjunction with other local financial institutions (OECD, 2018). While their mandates and attention to infrastructure and sustainability vary (OECD, 2017), NDBs have a common thread in their focus on long-term financing to projects that foster development; they also work closely with national government to support development goals (UN, 2005). On clean energy, there is potential for better partnering between national development banks and international financial institutions (i.e. MDBs and bilateral donors), combining the local knowledge and the strong stakeholder relationships of NDBs with technical expertise, higher levels of capitalisation and better credit ratings of MDBs or bilateral donors, to accelerate investment (NCE, 2018). NDBs have long been understood to offer a full range of financing strategies, instruments and approaches to partner with governments, private investors and commercial banks in Africa and elsewhere for better development outcomes (UN, 2005). However, to date, unclear mandates and capacity gaps have limited their influence in clean energy markets (OECD, 2017). Tapping into and fostering their potential to support clean energy access, could help accelerate investment on the ground.

In looking at recent trends in how solar capacity in Africa is being financed, a common thread is that almost all capacity additions rely to some extent on private capital (including foreign) in some type of public-private partnership arrangement. For example, solar based independent power producers (IPPs) in South Africa and in other countries rely on financing and implementation led by private companies, while the government ensures that policies and tariffs are sufficiently strong and stable to generate reliable revenues (Prag et al., 2018). Governance reforms to improve public financial management, procurement and the tariff structures can incentivise renewable electricity supply projects, whether via mini-grids or on-grid generation, by improving the fiscal viability and risk-return profile of projects, thus helping to bring investments to scale (OECD, 2018; NCE, 2016; see also 3.1).

4.3. Official Development Finance (ODF)

Official development finance (ODF) is playing a central role in sub-Saharan Africa to assure timely investment in clean energy access. As outlined in Section 2.3 and above, ODF is currently often the largest single source of finance for the electricity and for clean cooking access at country level (SEforAll, 2018).

This section presents an overview of ODF flows to the electricity sector in sub-Saharan Africa, since 2008 (Figure 8) and in-depth for recent years by donor and country (2014-16). The analysis shows a rise in average annual finance for the sector from 2008-10 at US $4.5 billion per year, compared to about US $5.6 billion on average 2014-16. It also shows a clear majority of electricity finance still going to grid-based solutions, with a dominant share of flows to transmission and distribution (T&D). Finally, the assessment shows only about one-third of the recent electricity flows going to renewables generation directly.[17]

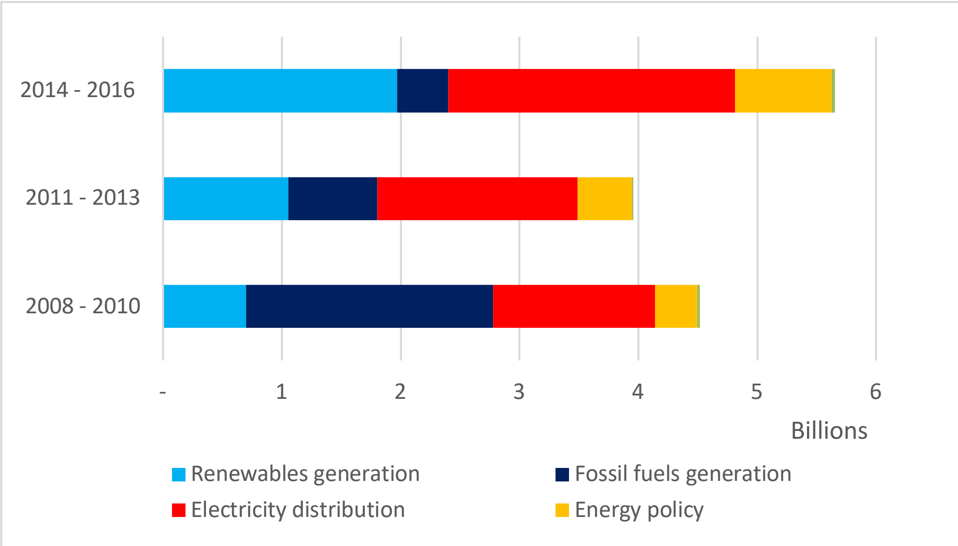
Using a project by project assessment and an overlapping data set for 20 high impact countries, SEforAll (2018) also found that most investments in the electricity sector today were directed to the grid, with only about 1% flowing to decentralised electricity supply solutions. Further it found that only about a third of all flows targeting residential consumers. Finally, SEforAll (2018) highlighted that about two-thirds of trackable finance (public and private) was going to renewables, indicating a shift in the

[17] A conscious choice is made here to look at ODF across policy, transmission and distribution, and generation rather than to isolate generation on its own. So rather than compare the share of funds flowing to RE versus fossil fuels in the generation sub-sector, we try to examine the share of funds supporting electricity system overall including T&D. Flows to "policy" however are energy sector flows and not specific to electricity per se. These may also include a wide range of project types that would require further assessment to understand consistency with sustainability objectives such as climate change.

competitiveness and viability of on-grid renewables compared to fossil fuel investments (SEforAll, 2017, 2018).

This large differences in our results compared to SEforAll (2018), is due to the different focus of our assessments (international public flows in all countries in SSA vs all public and private flows across 13 SSA countries). The private flows included in the SEforAll assessment could be expected to lead investment trends towards renewables as evidence in a global context shows the private sector shifting investments more quickly away from fossil fuels than their public sector counterparts (Prag et al., 2017; SEforAll, 2018). Not surprisingly in the grid-dominant lending context, much ODF for the sector remains tied to the T&D components, which are less commercially viable than other parts of the system (e.g. generation) but still essential to reliability of service. By comparison, grid connected independent power producers (IPPs), both fossil fuel and renewable, are typically able to attract private investment, if the tariff structure is supportive.

Figure 8: Official Development Finance, Sub-Saharan Africa, Electricity Sector
3-year annual average, 2014 - 2016, billion USD commitments



Source: Authors based on OECD DAC-CRS statistics, 2018.
Note: A note on methodology on Figures 8 and 9: the data extracted here are from OECD DAC CRS, represented in 2016 dollars (data extracted July 2018). The DAC statistical data do not allow the granularity to examine off-grid, mini-grid and on-grid electricity finance without a manual search, nor does it permit an isolation of electricity only policy. Hence the analysis here is selective, focusing on RE versus FF generation for example rather than on- vs off-/mini-grid. And the aggregate totals may overstate flows to "electricity" in part because the policy flows have not been examined manually to exclude non-electricity energy projects. As of the end of 2018, the OECD DAC had proposed but not yet agreed a number of useful changes to its system to facilitate monitoring of progress towards energy access goals, for example by creating categories to report off-grid and mini-grid projects separately from on-grid projects. It also proposes to create a separate category for clean cooking projects. While these are potentially powerful changes, the system will require about two years from the time of approval until data are actually available.

Our analysis of ODF commitments also suggests that bilateral and multilateral donors are active in working with governments on the policy agenda, with almost US $1 billion on average per year flowing in the 2014-2016 period, and the share of flows to policy (and otherwise uncategorised energy projects) is up from previous years (Figure 8).[18] From a donor perspective however, financial support for policy reforms

[18] As noted, this "policy" category of the DAC CRS is also used for energy projects that cannot be classified elsewhere in the system so a strong conclusion about what share of this allocation is dedicated to policy cannot be made without manual review of projects reported.

comprises a small share of the commitments accounting for about 15% overall (Figure 9a). AfDB's share is notably higher at 26%.[19]

Development finance in the sub-Saharan Africa region is concentrated in a handful of top donors. Figure 9a shows that the top 20 donors over the period 2014-2016 account for 98% of total commitments. The largest two, the World Bank Group and African Development Bank Group account for about US $2.25 billion per year on average, or 40% of total commitments in the electricity sector across 2014-2016.[20] Together, the eight largest (adding the EU Institutions, US, France, IDB, Japan, Germany in this order of importance) account for 86% of the commitments in this period.

The focus of the ODF lending and grant-making in the electricity sector varies significantly by donor, particularly with respect to renewables, but there is a consistently small share of funding going to fossil fuel generation (overall about 8-9% for both bilateral and multilateral donors) and a relatively high share of transmission and distribution (Figure 9a).[21] Six donors - the World Bank, EU Institutions, the US, Japan, Germany and France - account for 70% of total ODF commitments to renewables,[22] committing from one-third to one-half of their lending to renewables. Though there is an upturn in the African Development Bank (AfDB) Group's commitments for renewable energy in 2017 (AfDB, 2017; Box 3), AfDB is notably absent as a lead donor for renewables in 2014-2016.[23]

Recognition of renewables as a viable investment in grid-based systems is nevertheless well underway in this region. The case of the AfDB illustrates the lag between strategy, operations on the ground and results. As an important development finance institution in the region, the AfDB has aligned its strategy to embrace the continuum of opportunities to use off- and on-grid renewables and clean cooking (AfDB 2017) to address energy access challenges, as can be seen from its *Strategy for the New Deal on Energy* 2016-2025 (AfDB, 2017). The Strategy recognises clean energy access as one of the "*High 5*" priorities guiding project and funding allocation decisions. Yet, data on commitments through the end of 2016 do not reflect significant progress towards specific goals laid out in the strategy (AfDB, 2018a). Further, the AfDB's own internal monitoring of performance against the New Deal goals in 2017 shows no results to date in the off-grid or clean cooking arena. The African Development Effectiveness Report (2018) states: "*We have yet to complete operations that connect people through off-grid systems or provide people with clean cooking.*" This example demonstrates that it takes time to reorient investments being channelled through large institutions, time to realise results and also time for data to catch up to reflect changes in practice.

Beyond statistical analysis and formal monitoring, there is anecdotal evidence from project activities in recent years showing what may be an important shift in AfDB

[19] Indeed, in the period 2014-2016, the AfDB provided around US $2 billion in policy-based operations cumulatively, but this includes large operations in Angola, Nigeria, Egypt); it also includes energy sector as a whole, and not just support for the electricity sector (Naceur, 2018).

[20] The World Bank Group includes IDA, IBRD and the IFC. The African Development Bank Group includes the African Development Fund.

[21] Note the amount of financing for fossil fuels is known to be understated here in part because we did not include data on China's lending in the region but also because we did not do a manual search of the "policy" category.

[22] While there is currently no way to easily isolate off-grid from the OECD statistical data on ODF, the allocation of finance to renewable energy might be considered a proxy.

[23] Though AfDB appears to lag behind other donors on renewable energy, it has nevertheless shifted majority of its funding in power generation to on-grid renewables. According to their own estimates, RE represents 75% of all of its power generation investments, in the 2014-2016 period (Naceur, 2018).

Group practices, with growing attention and resources going to blended financing for investments in off-grid and mini-grid renewables (Box 3). This is potentially promising development will need to continue to grow and move to scale to support countries to exploit the rapidly emerging market opportunities in this sector. With its regional presence, the AfDB also has potential to work with local investors and to be a catalyst for change in local financial institutions.

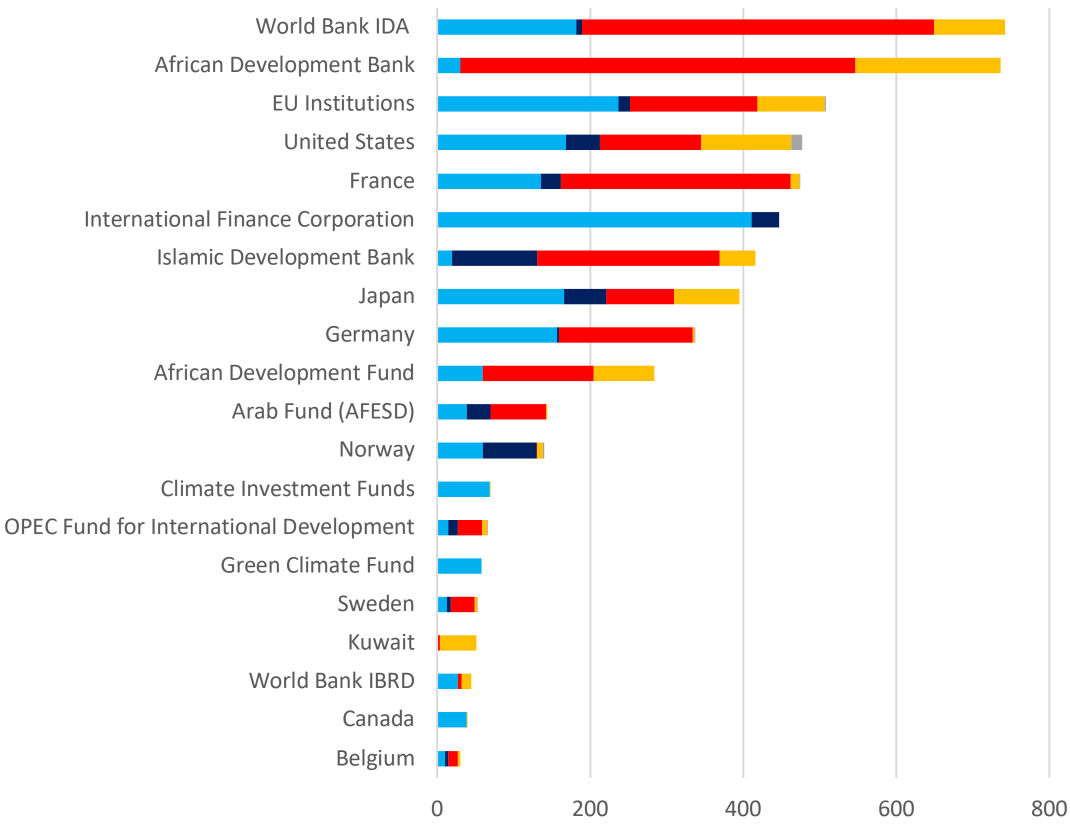
Though difficult to monitor, financing from China, through state and non-state companies, is also broadly engaged in the power sector in Africa and is said to be the "single largest source" of external development finance in sub-Saharan Africa (Gualberti, 2014 and OCI, 2018).[24] Gualberti (2014) reported that over US $16 billion flowed between 2000 and 2012 or over US $1 billion per year from China for the power sector. While China has supported large hydropower developments, its support also extends to fossil fuel generation (and upstream production) facilities (OCI, 2018 and SEforAll, 2018). In 2015-2016 on average, SEforAll (2018) estimates China's energy sector investments in three countries – Ethiopia, Kenya, Uganda -- to be $US 1.1 billion per year, largely in fossil fuel-fired investment. It is less clear to what extent China is supporting off-grid solar investments or businesses, though its solar device manufacturers are clearly benefitting through the commercial supply chains that underpin these businesses.[25]

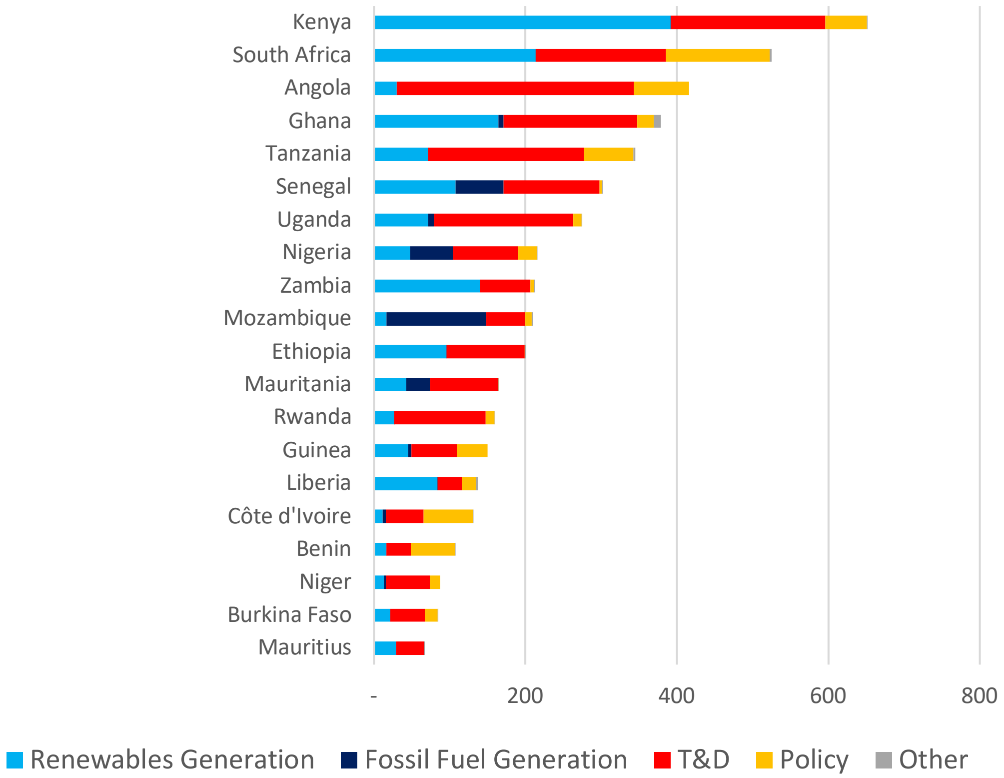
The top twenty recipients of ODF to the electricity sector include all the countries leading in the renewable generation and off-grid solar market (Figure 9.b). A few countries receive a very large share of the ODF commitments to electricity in the region (i.e. more than US $500 million per year). All top recipients are recognised as having relatively strong policy and governance frameworks for the electricity sector. While ODF supporting policy reforms is present in almost all cases, in some countries the share of finance supporting this essential foundation of reform is surprisingly small in the context of the larger portfolio of ODF, e.g. in the case of Nigeria.

[24] The SEforAll (2018) assessment shows 23% (nearly US $7 billion per year) of all international flows in 2015-16 in the 20 "high impact" countries, coming from China in the form of both public (concessional) and commercial (non-concessional) finance.

[25] To note, the DAC CRS does not include data from China so it is not integrated into the ODF assessment presented here. For a recent review of China's finance for energy sector investments in SSA see Oil Change International (2018). AidData also tracks China's development finance in the energy and power sector.

Figure 9: Top 20 SSA Donors (a) and Recipient Countries (b), ODF for Electricity
3-year annual average commitments, 2014-2016, Millions USD





Sources: Authors, OECD DAC-CRS statistics, 2018.

Box 3: AfDB on the Move to Mobilise Blended Finance for Renewable Energy[26]

Over the last half a decade, AfDB's role in renewable energy has been steadily growing and it has potential to be a changemaker in the region as it attempts to expand the impact of its funds through approaches that blend public and private resources. AfDB was, for example, a lead donor for the two landmark, on-grid renewable projects operating today, both garnering large amounts of public and private investment: **Lake Turkana wind power project in Kenya** and for the **Ouarzazate concentrated solar power projects in Morocco**.[27]

In 2016, the AfDB approved another three important RE investments amounting to around USD 135 million in total (Naceur, 2018) and all of which are featuring different types of blended finance:

- The **42 MW Achwa 2 Independent Power Producer (IPP) hydro project in Uganda**,[28] where the AfDB Group provided a senior loan of US $20 million toward the investment cost of US $110 million (working with other investors through the African Renewable Energy Fund, run by Berkeley Energy - see also Table 5).
- The **33 MW Segou Solar IPP project in Mali**,[29] its first utility-scale solar project, where AfDB provided senior loan of US $8.5 million co-financing alongside a senior loan of US $25 million of Climate Investment Funds. The solar facility will generate 52.7 GWh annually, about 10 percent of the country's current capacity.
- An anchor investment of US $100 million in the **Facility for Energy Inclusion– Off-Grid Energy Access Fund (FEI – OGEF)** window,[30] which in turn will provide debt and equity for small scale mini-grid and off-grid. The off-grid window became operational and had its first close in 2018 (see also Table 5).

On decentralized renewables, in 2018 and 2019, AfDB also approved several innovative projects that will establish its presence and expand its direct investments. These include a first-time, asset-backed securitization for pay-as-you-go solar home systems (SHS) that will partially guarantee local commercial financing for **Zola-EDF Cote d'Ivoire**,[31] and in turn support power delivery to 100,000 rural households by 2020. Building on its technical expertise and capacity building efforts for mini-grids,[32] the AfDB also recently approved projects to directly invest in mini-grid programmes:

- in 2018 AfDB approved debt co-financing investment in the **Nigeria Electrification Program** which will work alongside larger amounts of financing from World Bank project (see Box 5);
- in 2019, AfDB partnered with the **Democratic Republic of Congo** to win and match **Green Climate Fund (GCF) funds to co-finance mini-grid investments** (in generation and storage),[33] while the they plan to work with private equity investors to support market development and distribution of the power.

Finally, AfDB also expects its first clean cooking transaction approval to be in 2019 (Naceur, 2018).

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[26] These examples are illustrative of the direction of lending by AfDB in the renewables space and are not intended to provide a comprehensive list of its renewables projects or activities. They were selected largely based on suggestions from Naceur (2018).

[27] For more information on the financing aspects on the blended financing arrangements that underpin these projects, see analysis from CPI: https://climatepolicyinitiative.org/wp-content/uploads/2018/01/BlendedFinanceReport_Annexes.pdf (Lake Turkana) and https://climatepolicyinitiative.org/publication/san-giorgio-group-case-study-ouarzazate-i-csp/ (Ouarzazate).

[28] See: https://www.afdb.org/en/news-and-events/focus-on-afdb-and-africas-top-priority-lighting-up-and-powering-africa-17034/ and https://www.globalelectricity.org/content/uploads/Panel-4a-presentations-case-studies.pdf

At a country level, a key question is: Are the levels of ODF flowing today sufficiently high to be a meaningful catalyst to attract other sources of investment? Combining recent SEforAll (2017c) analysis and our updated review of ODF provides a means to compare what is flowing today with estimates of needed investment in the power sector to achieve universal access (see Table 3). This comparison shows that ODF levels are relatively high in Kenya and it is likely to be on track to fill the financing gap. By comparison, ODF for Ethiopia and Nigeria is far below what is likely to be required to catalyse necessary investment.

Table 3: Investment Needs to Meet Universal Access Compared to ODF Flows, Selected Countries, Electricity Sector

Electricity				
	Investment Needs, Cumulative 2017-2030 Tier 1-3 billion USD	Investment Needs, Average annual 2017-2030 Tier 1-3, billion USD	ODF flows Average annual, 2014-16, billion USD	Ratio Investment needs to ODF
Ethiopia	13.78	0.98	0.1	10
Kenya	14.99	1.07	0.4	3
Nigeria	18.44	1.31	0.05	27
3-country total	47	3.37	0.55	6

Source: Author's calculations based on SEforAll, 2017c (investment requirements) and OECD DAC CRS data (ODF flows)

For clean cooking, the levels of finance are abysmally low, at less than 1% of what is needed to be successful to tackle the problem (SEforAll, 2017, 2018). SEforAll (2018) estimates about US $22 million in commitments per year in 13 high impact SSA countries, largely from development finance providers. By comparison the required level of investment for all SSA countries is estimated to be US $1.7 billion. Funds flowing are from sufficient to have impact in this sector which is so vital to the development of Africa. In some sub-Saharan countries, investments required for clean cooking will also need to fund the full supply of clean fuels such as for LPG or biogas -- amounts that will far exceed what is needed for clean cookstoves and could even exceed what is needed for electricity access (SEforAll, 2017c). And donor finance for clean cooking appears to be on the decline rather than rising in recent years (SEforAll, 2018). Given the extremely low starting point today, a radical scaling up of policy and finance, and a consistent multi-year set of political and financial commitments at

[29] See: https://www.afdb.org/en/news-and-events/focus-on-afdb-and-africas-top-priority-lighting-up-and-powering-africa-17034/

[30] See: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/AEMP/FEI_2_-Pager.pdf

[31] See: https://www.afdb.org/en/news-and-events/cote-divoire-african-development-bank-to-help-mobilize-over-cfaf-15-billion-to-finance-pay-as-you-go-solar-home-systems-18244/

[32] Through its Green Mini-Grids Help Desk and Market Development Program, the AfDB offers technical assistance to mini-grid developers and mini-grid policy makers (http://greenminigrid.se4all-africa.org). The AfDB reported in 2018 to GCF that it is currently providing support to more than 60 green mini-grid developers in 30 countries, as well as to several Ministries of Energy (GCF, 2018).

[33] See: https://www.greenclimate.fund/projects/fp096

national and international level, will be required to meet the goal of universal access to clean cooking.

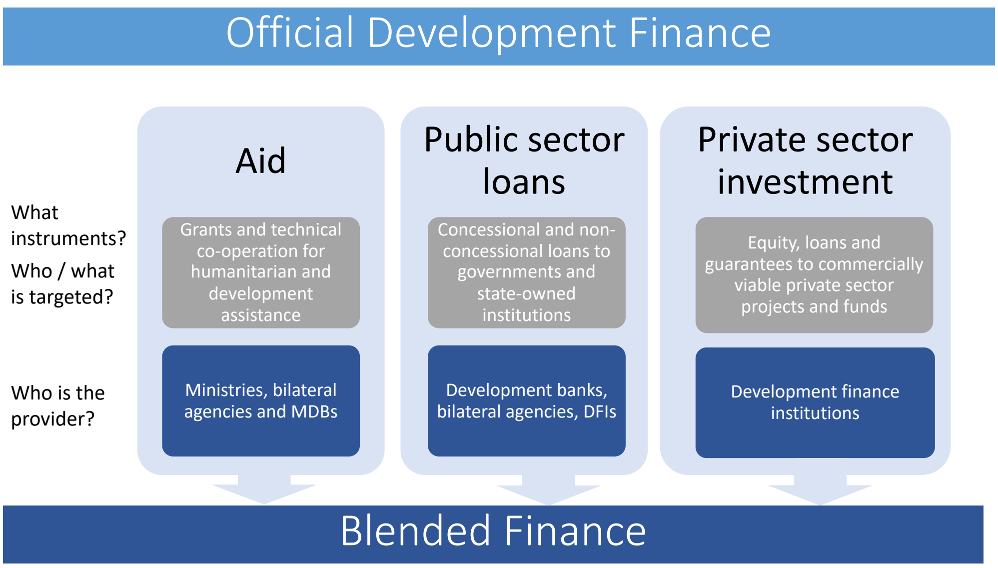
4.4. Blended finance and public private initiatives

Development finance can be used in innovative ways to de-risk private investment as part of blended finance initiatives. The key actors in blended finance are the multilateral and bilateral development finance institutions (DFIs) that allocate ODF. This includes bilateral agencies and development banks, and the multilateral development banks (e.g. the African Development Bank and the World Bank). National development banks, such as the Development Bank of South Africa, can also be key players particularly for infrastructure investment.

Growing the use of blended finance combined with impact investment is now recognised as a key way forward to scale up financing for the SDGs and achievement of the Paris Agreement (OECD, 2019 and 2018). In 2018, the OECD Development Assistance Committee approved the OECD principles for blended finance (OECD, 2018). In parallel, the MDBs and the multi-stakeholder international process – the Task Force on Blended Finance – adopted similar principles, recommendations and guidance to steer good practice in the use of blended finance for development purposes (BFTF, 2018). While important details vary across these different initiatives, they all recognise a key leveraging role for international official (public) development finance (ODF) in de-risking investments for private investors, helping to create viable markets and businesses.

A range of instruments, pathways, target actors and outcomes exist in the use of ODF for blending and these are increasingly in play in dedicated donor programmes and activities in sub-Saharan Africa to support off-grid or mini-grid renewables (see Figure 10).

Figure 10: Different Forms of Official Development Finance and Blended Finance



Source: adapted from OECD, 2018. Making Blended Finance Work for Sustainable Development Goals

ODF financing can be concessional or non-concessional (operating at market rates), with each type of financing typically playing a specific role vis-à-vis commercial and other public sector counter-parts to mobilise additional investment (OECD, 2018). Concessional finance can be used to provide loan guarantees or insurance for projects or portfolios, again with the aim to de-risk commercial investment for private sector partners, or technical assistance to support early stage project or portfolio preparation, or to build capacity or undertake policy reforms at local or national levels, thus making government one target audience of blended finance. Local financial institutions, including national development banks – building their capacity and engagement in financing of sustainable infrastructure – are another target and increasingly a source of concessional and non-concessional blended finance from development finance institutions.

Relevant instruments on the non-concessional spectrum include equity financing, debt financing and mezzanine financing, all of which assume some of the financial risks associated with a project and associated private co-financing thus helping to attract private investment.

Mechanisms or pathways to intermediate and combine use of these instruments also vary. Relevant mechanisms include funds, facilities or platforms that are designed to facilitate collaboration, blending and investment as well as loan syndication that typically operates through special purpose vehicles (SPV) and structuring finance to attract and de-risk commercial investment and debt, where ODF provides subordinated debt or junior equity which takes first losses. In these mechanisms, private sector partners also benefit from the expertise and due diligence capacity embedded in the DFIs, who are typically the lead arrangers for the SPV (OECD, 2018).

Several recent facilities, funds and platforms[34] have emerged to target investment in off-grid and mini-grid commercial opportunities in sub-Saharan Africa. One recent example of a donor sponsored private equity fund is the Africa Renewable Energy Fund (AREF), which is blending donor and private investor capital. In the AREF, non-concessional development finance is used as equity to co-invest with the private investors. This is at one of end of the blended finance continuum demonstrating how development finance can be used to directly engage with and co-finance projects with the private sector. Beyond the contribution of equity capital, the participation of large, AAA-rated DFIs in an investment project, for example through first loss capital, can often lower debt financing costs and help to attract debt financing from the private sector. At the other end of the continuum is more traditional use of concessional finance or grant-based technical assistance, which can fund project preparation costs, support governments entities to reform policies and/or establish platforms to plan and engage with potential project partners from the public and private sectors. (See more on illustrative projects in Boxes 3 and 4, and more on AREF in Table 5, Annex B.)

Public-private partnerships (PPPs), which establish contractual relationships between the government and private sector partners for provision of infrastructure or related services, are a viable pathway to advance blended finance for sustainable infrastructure. PPP are starting to function in some national contexts for the delivery of large-scale renewable energy (grid-based). Their use is less apparent in the mini-grid sector which is just emerging in sub-Saharan Africa.

While the scale of blended finance funds and facilities targeting the off-grid renewable market remains small relative to the size of the financing gap, many draw on the latest market developments, and where successful they could accelerate breakthroughs to bring impacts to deliver on SDG-7 (see Table 5, Annex B for information on a selection of these). A key to scaling and replicating market success will be standardising data collection and information sharing to demonstrate the financial performance of the investments being made in these innovative finance transactions (BFTF, 2018). Sharing information on the performance of the investments can help to build confidence in financial markets and will help to standardise approaches and instruments to swing engagement of local financial institutions and actors, e.g. for commercial banks, institutional and corporate investors.

[34] In the DAC statistical system, these are referred to as "Collective Investment Vehicles".

Box 4: Blended Finance Projects in Sub-Saharan Africa – Selected Examples

Aside from the examples highlighted for AfDB above, a number of other innovative platforms for blended financing to support clean energy access are emerging (see also Annex B for more information on off-grid platforms and funds).

ElectriFI invests US $1.5 million in Azuri Technologies to kickstart its off-balance sheet debt financing programme (2018). Azuri Technologies is a leading commercial provider of PAYG solar home systems to rural off-grid communities. With the widest reach of any provider in sub Saharan Africa, Azuri is leveraging solar and mobile technology to allow users in 12 different countries to access renewable, distributed power on a pay-as-you-go basis. Azuri has launched an innovative US $20 million **off-balance-sheet debt financing programme** to provide working capital for the expansion of off-grid energy and service provision in East Africa, including its satellite-TV solution, to tens of thousands more households across the its target countries. Azuri is rolling this phased programme out in 2018 (Azuri, 2018). ElectriFI is investing US $1.5 million in the first phase of the financing program that is worth more than US $4 million, alongside Azuri and its other investment partners, including impact investment platform TRINE (EDFI ElectricFi, 2018). The first phase will be deployed in Kenya. Subsequent phases of the programme will expand to Azuri's other key territories in East Africa including Tanzania, Uganda, and Zambia.

ClimateOne Initiative supports Rwanda PV investment (2016). In December 2016, Climate Fund Managers of the ClimateOne Initiative Climate Fund Managers (CFM), signed a **Development and Cooperation Agreement (DCA)** with French developers Compagnie des Energies Nouvelles (CDEN) to invest in solar PV which will eventually lead to provision of grid-connected electricity (FMO 2016). The partnership between CIO and CDEN and the government of Rwanda is initially developing of a combined 15MW Solar PV and 2 MW Pumped Storage Hydro (PSH) facility in Rwanda, with a Stage 2 expansion ramping the facility up to 45 MW PV and 6 MW PSH approximately 24 months after Stage1. The project is set to provide grid-connected electricity to approximately 950,000 Rwandans.

The **US Power Africa initiative**, in partnership with General Electric, the U.S. African Development Foundation (USADF) and others, has awarded nine US $100,000 **grants to entrepreneurs** for innovative, off-grid energy projects in Nigeria (USAID, 2018c). In another example of how the Power Africa Initiative is partnering with countries and the private sector in Africa, it also supported the Kenyan Ministry of Energy and Petroleum to lead **a high-level Financing Steering Committee** with Kenya's parastatal companies and leading private sector partners to address the US $14-18 billion funding gap in achieving the government's targets for generation, transmission and distribution and off-grid electrification (USAID, 2018b). This Committee provided a unique forum for dialogue and problem-solving, laying out recommendations that became the roadmap for Power Africa programming in the power sector in Kenya.

In the allocation of development finance, it is important to avoid over-subsidising and crowding out private investment in this dynamic market sector. Where early stage grants are offered to mini-grid market participants by bilateral or multilateral development banks, making them time bound and/or performance-based can send a clear signal to other investors. Further, structured (concessional) debt, working in tandem with local financial institutions, may be more viable than grant financing once companies begin to mature with greater commercial business capacity to support growth. Finally, patient long-term engagement, extending beyond the typical 3 to 5-year project window of DFIs, is required to kick-start markets and fully tap into the opportunity of new technologies, such as mini-grid solar electricity (NCE, 2018).

Green bonds are another major new development initiative that can direct capital to sustainable infrastructure. Green bonds are fixed income securities, an example of financial securitisation, which is another blended finance pathway for governments (or corporates) to tap into local and international capital markets to raise financing. Green bonds are opening a new channel of domestic finance in South Africa, and more recently in Nigeria, and could attract international investors if successful at the national level. In January 2018, the Nigerian government issued the first sovereign governmental green bonds targeted at the domestic market in Africa. The bonds are five-year, sovereign guarantee, denominated in Naira for approximately US $30 million (Debt Management Office Nigeria, 2017). The bonds are focused on renewable energy, mini-grids in multiple communities and small IPPs for universities and teaching hospitals. The World Bank, UKAID, and UNEP supported the development of these bonds, but placement of the government issued bond was to private parties.

Some analysts are critical of the green bond market, suggesting they simply re-package existing investments that may have proceeded without green bond issuance. However, the Nigeria case shows that investor interest in green bonds worked internally within the government to change the priority of associated projects; despite many competing priorities, the green bonds helped to secure priority for funding and allocation in the budget for the mini-grid projects, raising the chance they will be carried to implementation, a step that was less-assured prior to the bonds' issuance (Leigh-Bell, 2018). The green bond market is nascent in sub-Saharan Africa, but it is positioned to grow and could be an effective mechanism to attract institutional investors over time, e.g. sovereign wealth funds or pension funds, which represent large and growing pools of investible capital in search of safe and steady returns.

Social impact investing is also growing as a movement with a focus on investing to achieve impact towards the SDGs, including through a growing level of private sector investments.[35] A recent review of social impact investing trends highlights rapid growth in the sector and notes that sub-Saharan Africa ranks highly as a destination. A 2018 survey of repeat respondents (81 investors), showed sub-Saharan Africa in 2017 with more than US $ 8 billion in assets under management (across public and private investors), up more than 70% from US $4.5 billion in 2013 (GIIN, 2018; OECD, 2019). Evidence for social impact investing in SSA suggests that development finance institutions[36] are by far the dominant source of capital and the key sectors targeted being energy and financial services being the two main targets of activity (thus overlapping with accounting for blended finance to clean energy sources). This OECD (2019) assessment suggests there is high potential for social impact investing to provide impetus to grow to a larger scale and to support an ever-larger number of blended finance activities in support of clean energy in sub-Saharan Africa.

[35] OECD (2019) defines social impact investment as providing "finance to organisations addressing social and/or environmental needs with the expectation of measurable social and financial returns. It is a way of channelling new resources towards Sustainable Development Goals (SDGs)."

[36] In their assessment of SII, the OECD (2019) further defines DFIs as government-backed entities that invest in the private sector for the purpose of economic development, where non-DFIs include fund managers, foundations, angel investors, banks and pension funds.

5. Nigeria: an example from the field

5.1. Overview of the current situation

With one-fifth of sub-Saharan Africa's population and one-fourth of its GDP, Nigeria provides an important example of both the potential and the barriers to dramatically increase electricity access and reliability. An estimated 45% of the population have access to grid electricity, meaning that 20 million households do not (USAID Power Africa, 2018). The national population is evenly split between urban and rural, with 55% of urban and 36% of rural population having electricity access (USAID, 2018). Even for those connected to the grid, electricity service has fundamental problems related to extremely limited supply capacity compared to demand as well as poor reliability. The country's average electricity consumption per capita per year is low even for Africa at 144 kWh compared to 167 for Kenya, 355 for Ghana and 4,200 for South Africa (World Bank 2014). With 5,500MW of available grid capacity, albeit this is not fully utilised, supply availability is a far cry from the electricity demand, which is conservatively estimated to be about 40,000MW (Nigeria Electricity Hub, 2017a). Hence electricity supplied to consumers varies by location and on average is limited to about 6 – 12 hours per day on a nationwide basis.

The dismal reliability of the grid has led industries, businesses, and households to use fossil fuel generators (overwhelmingly diesel) for either primary or supplemental power supplies. The reliability problem so large that the country is estimated to have as much capacity in individual diesel/gasoline generators as for the entire national grid (Nigeria Electricity Hub, 2017b). Poor grid reliability and the general lack of sufficient electricity supply comes at a great cost to GDP growth and productivity, exacerbates local environmental pollution, increases CO_2 emissions, and deteriorates the overall quality of life.

Nigeria illustrates the potential for new renewable technologies, primarily solar, and new organisational structures, to deliver electricity to specific communities and targeted markets. These new technologies and organisational approaches are beginning to provide new avenues for accelerating electricity access and improving reliability of electricity supply in the country, notably through:

- Pico devices [1W – 10W] are widespread in Nigeria and are often the sole option to provide electricity access for the poor.
- Solar home systems (SHS) [10W – 200W] are increasingly utilized, especially by un-served and under-served urban and peri-urban populations.
- Mini-grids [1kW – 1MW] – largely solar hybrid systems -- have become a major government priority and, with the help of donors, several are now in operation, based on public-private partnerships. A new, major World Bank programme is now underway in this area (see Box 3).
- New business and financing models most specifically pay-as-you-go (PAYG) are increasing the affordability of access, especially for SHS applications.

As the time and cost for fixing and expanding the grid is long and expensive, off-grid and mini-grid renewable energy solutions offer a way to provide energy access with reasonable lead time and cost to millions of Nigerians.

Less than 10% of cooking in Nigeria qualifies as clean cooking – with biomass and kerosene the dominant fuels. Attempts to introduce clean cooking biomass stoves have been limited and poorly funded. Recently however, clean cooking via LPG has been making significant inroads, especially in urban and peri-urban areas and is becoming a focus for rural areas as well.

5.2. Technology options and organisational structures

Given the Nigerian situation, increased accessibility will require utilising various technological and organisational approaches. Notably, the specific access challenge can be described today:

- Urban areas (49% of the population of which 14% is without access), where Pico, SHS, grid expansion, including embedded generation, and targeted mini-grids are the most applied options
- Rural areas (51% of the population of which 59% is without access) – Pico, SHS, mini-grids and, to a lesser extent, grid expansion, are most applied options

Figure 11 compares various technology options in Nigeria across several variables: levelized cost of electricity; loads; and time of deployment. Although, grid extension can offer the least-cost option, power supply from mini-grids are starting to approach grid rates. Further SHS and mini-grids offer much faster implementation and more individual and community control over the type of electricity services supplied.

Figure 11: Available Options to Achieve Electricity Access in Nigeria

Minigrids can serve productive-use loads underpinning economic development

	Solar home system (tier 1)	Minigrid	Grid extension	Alternative energy or no energy
Cost per customer	$6 to $12/month for basic services	$6-$10/month for basic service	$0.74 to $12/month for basic service	Typically, costs are $25/ month for customers with a petrol generator or $35/month for diesel. Costs are $11/month per customer using energy substitutes (including torches, kerosene, candles, or cell phone charging)
LCOE*	$2/kWh or higher	$0.50-$1.00/kWh	$0.15-$1.00/kWh, if including cost of grid extension	
Can it serve productive loads?	Currently only small and medium enterprises	Yes	Yes	
Time to deploy	Fast	Fast	Slow	
Least-cost role	Providing energy access to isolated residential customers	**Providing energy access to remote or underserved villages with significant load**	Either for those near existing grid, or very high loads that are farther from the grid	None

*Levelized cost of electricity

Source: RMI industry interviews and analysis, field visits to un-electrified villages

Note: Pico is not included due to the range of devices and levels of usage.
Source: Rocky Mountain Institute/Nigerian REA. Presentation by REA "Mini-grid Funding and Investment Roundtable: Accelerating Deployment of Mini-grids for Timely and Low-Cost Electrification" London, April 19, 2018

5.2.1. Pico

Pico remains the most accessible and affordable option for electricity for individuals and households in both rural and urban areas. While it serves as a source of lighting in poor rural communities, people in urban areas use Pico solar as emergency sources of lighting due to outages from the grid. The distribution of Pico solar devices is mostly through the open market and retailers of electricity appliances. The key providers in the country are d. Light, Total, Green Light Planet, Solar Sister and Barefoot Power.

While the level of electricity supplied with Pico is limited, the potential market is substantial. An estimated 87 million Nigerians -- 45% of the population -- live in extreme poverty (Brookings Institute 2018). The Government estimates that in 2015 the housing shortage was 18 million housing units or approximately one-third of need

(Abah, 2017). For a large section of the poor and those living with housing instability, Pico represents the primary option for electricity access.

5.2.2. Solar Home Systems

In rural communities, SHS is adopted where the grid cannot be readily accessed or is not available. Households in urban areas employ the use of SHS as alternative to grid unreliability or as a replacement for high cost diesel/gasoline backup generators. To a degree, Pico and SHS represent a continuum of service options, where a household or small business may start with Pico and eventually move up to SHS.

In urban areas, middle and upper-class households increasingly own SHS to offset the grid deficiencies. Culturally there is a push to move to larger, more powerful SHS devices in what could be regarded as the '*I better pass my neighbour'*, which shows how Nigerians wish to have better electricity access than their neighbours. The use of larger off-grid solar solutions has also been adopted in some schools especially in the Southwest of the country. For example, Lagos state government took 172 schools off the grid by providing each of them with individual off-grid solar power systems (The Economist, 2016). However typically, SHS technology is used to replace diesel-fired generators (which are also off-grid) and kerosene torches. Currently fourteen SHS distribution companies are active in country, with three dominant providers: Lumos, Azuri and Arnergy accounting for more than 90 percent of the 350,000-unit sales over the past two years (World Bank 2018).

5.2.3. Mini-grids

The Nigeria Rural Electrification Agency (REA) was set up in 2006 under the Electric Power Sector Reform Act of 2005. Its initial goal was to extend the grid to rural areas difficult to reach by grid, with a focus on use of renewable energy technologies. As the electricity sector in the country has evolved, the Federal Government developed the Rural Electrification Strategy and Implementation Plan, which has broadened the scope of REA to include deployment of mini-grid systems not only in rural communities but also in underserved and unserved urban and peri-urban areas. REA works closely with other local and national government stakeholders, private project developers, communities, donor agencies, and financial entities. A specific fund, Rural Electrification Fund (REF), managed by REA, provides funding for electricity access, specifically through the implementation of SHS, mini-grids and grid extension.

Recently REA's focus is on solar mini-grids, due to the increasingly cost-effective solar capacity of panels and batteries and increasing evidence of their widespread and cost-effective applicability. A recent study carried out by the Federal Ministry of Power, Works and Housing (FMPWH) using geo-referenced data of population clusters and load centres, concluded that an estimated 8,000 potential load centres are suitable for mini-grids, which could power about 14 percent of Nigeria's population. As of now, 250 sites have been identified and a preliminary feasibility assessment suggests 97 of these sites are viable for mini-grid development today (REA, 2018).

Over the last two years, REA was involved in implementing pilot scale mini-grid projects in five states spread across different geo-political zones, resulting in 14 operational solar mini-grids being developed by seven different private operators. Financial support for the mini-grid pilot programme was provided by GIZ (GIZ, 2018). The first solar mini-grid began operations in 2013, in the southern part of the country (ESMAP 2017). The smallest mini-grid capacity thus far is 6kW and the biggest is 100kW. These installations are solar based with battery capacity and diesel backup, albeit diesel backup is currently used less than 5% of the time (GIZ, 2018).

5.2.4. Grid /power sector

In assessing the options for expanding electricity utilization in Nigeria, one must first consider the major failings and barriers of the national grid. While some generation capacity has been added in recent years, the sector is still faced with challenges of poor financial viability; weak governance and efficiency, poor performance of electricity distribution companies, transmission constraints, generation and gas supply constraints (World Bank 2018). The distribution companies are faced with fundamental issues of financial solvency; for example, chronic under-collection of revenue means the companies struggle to meet payments on scheduled local bank loans (United Capital 2017). This situation has been a primary stimulus in the search for other options to increase electricity access and reliability.

Until recently, Nigerian Electrical Regulatory Commission (NERC) rules required all power plants above 10MW to be connected to the grid (with certain exceptions for captive facilities), which effectively prevented power plants to be developed for local or regional use; but this is now changing. Given the major deficiencies in the grid, rules have been amended to allow local power plants to be constructed and to direct the added power generation to selected users through the existing distribution system (known as embedded generation). This organisational approach is an important tool in Nigeria electricity system today, that could be used to improve electricity access in major urban areas. For example, states like Lagos and Kaduna have taken this opportunity to develop new facilities to meet industrial, community service and domestic electricity needs. Lagos state government took a bold step to implement six Independent Power Projects (IPPs). These IPPs are currently powering government owned services such as water pumps of water supply companies, state government offices, hospitals, courts, police command and lighting for public spaces and streets.

The transmission network in Nigeria is particularly weak and continues to experience system collapse. Projects currently underway include the Nigeria Electricity Transmission Access Project (NETAP), under the Nigerian Transmission Rehabilitation and Expansion Program (TREP), with intent to support the rehabilitation and upgrade of Nigeria's electricity transmission substations and lines. It aims to ensure an ongoing increase in the power transmission network to enable electricity distribution companies to supply consumers with additional power.

Currently, there is growing interest in the potential for grid connected solar. At the federal level, Nigeria has signed power purchase agreements with 14 large-scale solar developers with each project having an average capacity of 80 – 100MW (combined about 1.2GW). They are expected to be built mostly in the northern part of the country which is the region with the best solar irradiation (Adaju, 2017). Similarly, two major hydro facilities are being implemented through such agreements (Federal Ministry of Power, 2018).

5.3. Energy regulations

NERC regulations and tariffs in Nigeria are based on the Electric Power Sector Reform Act of 2005. To enhance mini-grid operations, NERC has been pro-active in establishing specific mini-grid regulations. In setting tariffs for mini grids, principal issues relate to: establishing the tariff structure; allowing proper treatment of grants in the rate base; assuring that tariffs are acceptable to users; and providing the necessary return to private investors. A major investor concern is the situation if a low-cost grid service reaches the mini-grid service area, what terms protect the investor in the mini-grid. NERC rules provide that the operator may: 1) continue to operate within the grid service area operating on a license to provide energy to the grid; or 2) sell the assets to the distribution company under specific terms (ESMAP 2017).

Currently the regulation allows for mini-grid project developers to operate under two distinct categories between 0 to 100 kW and between 100kw to 1MWcapacity; it also provides rules for tariff-setting and what happens when the grid arrives. Notably, NERC regulations provide the following framework:

- Below 100kW of distribution capacity: registration is required with NERC. Should the grid arrive, the registered Mini-Grid Operator must de-commission and remove all its assets and equipment (with no compensation for its investment) within 2 months after the distribution licensee has started supplying electricity to the area;
- Above 100kW of distribution capacity, but below 1MW of generation capacity: the Mini-Grid Operator must obtain a permit. Should the grid arrive the operator is entitled to compensation.

5.4. Developing markets and finance

For Nigeria to achieve universal access to electricity by 2030, it would need to connect more than1,000,000 households per year (Power Africa, 2017). Grid, mini-grid and SHS options will all be required to both to meet this goal and to provide quality services to unserved and underserved households as well as businesses in a timely manner (World Bank 2018). Such options will require major investments and access to flexible financing.

5.4.1. Financing of small to mid-size connections

Pico and SHS connections can largely be domestically financed, albeit grants both foreign and domestic can be important, particularly to reach the poorest, most vulnerable populations. Pico products are readily available in the market and are usually sold on a cash basis, however in some areas, some micro-financing is available. For example, when micro-finance is used, customers may purchase Pico solar devices (solar lantern) for about N6,000 (US $20) each and arrange payments to be made over 3 months (LAPO Microfinance Bank, 2018).

To date, what financial support exists for Pico devices has been through public grants and private investment. The World Bank, as part of its support to the REA, recently committed funding to support the distribution of 1 million Pico solar lanterns (World Bank 2018). Also, the UK Department for International Development is supporting the Solar Nigeria Programme in the form of grants to companies that manufacture, install, and finance solar energy systems, inclusive of Pico devices. (DFID, 2018).

Sales of SHS are largely commercially driven, with many solar PV companies now operating. Sales of SHS are either cash based or using PAYG business models (World Bank 2018). The Nigerian Central Bank rules prevent an open mobile money platform, thus partnering with mobile phone companies is necessary. For example, Lumos partnered with MTN, to allow a secure payment method via cell phones. This partnership also allows Lumos to utilize MTN's existing technology distribution and customer base (i.e. MTN retail outlets also sell the SHS service to clients). Lumos/MTN had seen its customer base more than double in just one year, rising from 22,000 units sold in 2016 to 47,000 units in 2017; and this rate of growth is continuing (Lumos, 2018).

The capital cost of mini-grids is such that outside financing is needed, and indeed a large portion of this financing needs to be on a grant basis. Most rural customers would not be able to afford full-cost tariffs -- meaning a public subsidy is required to offset the capital costs (World Bank 2018). The WB and GIZ programmes working through REA address this by providing a partial subsidy (see Box 3). Currently, subsidies in Nigeria range from 50-75% of the initial capital costs. As an example, one mini-grid operator observed that initial CAPEX subsidies enabled it to reduce tariffs by a third, and consequently to increase its customer base to a third of the target village's population (ESMAP 2017).

The private finance component, which is usually domestic, is secured either through power purchase agreement with local governments or directly with contracts to end users, particularly in locations with organized community development associations. In some cases, sales agents are identified who will purchase bulk electricity and sell directly to end-user consumers.

Box 5: Mini-Grid and Off-Grid Development Financing in Nigeria

In 2018, the World Bank (WB) in partnership with the Nigerian government and other co-financiers such as GIZ and the AfDB, launched a five-year major, five-year, solar energy project focused on off-grid and mini-grid alternatives. In this programme, the WB seeks to encourage large-scale investments with one-off support through a minimum subsidy tender for mini-grid developers and deployment of funds for individual solar system companies. This WB financing objective is focused on solar hybrid mini-grids, stand-alone Solar Home System (SHS) and Pico, which is based on a programme pioneered by the Nigerian Rural Electrification Agency (REA). The total investment cost of the solar hybrid mini-grid component is about US $330 million, of which US $150 million will be provided by IDA (US $70 million in form of subsidy tender and US $80 million as grant) and the remaining from private sector funding. The programme envisages approximately 110,000 new connections through the subsidy tender, while the performance grant is expected to benefit an estimated 580 mini-grid sites, about eight companies, and 230,000 new connections. It is also providing support to foster stand-alone solar systems for homes (equivalent to SHS) and for micro, small and medium sized enterprises (MSMEs) to displace the use of high cost diesel generators. The total for stand-alone solar home investment is estimated at US $305 million equivalent, of which IDA is providing US $75 million equivalent and US $230 million will come from private sector investment (World Bank 2018).

In Phase 1 (2015-18) GIZ, through the Nigeria Energy Support Programme (NESP), funded by European Union and German Federal Ministry for Economic Cooperation and Development (BMZ), has supported increasing energy access in various geographic areas, particularly through rural electrification. GIZ, for example, was involved in developing the mini-grid regulations and supported the drafting of the Nigerian rural electrification strategy and plan. NESP currently supports five mini-grid projects in the five partner states (Sokoto, Ogun, Cross River, Plateau and Niger); providing 10,000 people with access to sustainable electricity. GIZ has extended the NESP to 2020 and the scope of this mini-grid project to support 20 projects reaching 100,000 customers by 2020. To 2020, planned investment is to be provided through 50% of GIZ financing and 50% private funding, however the GIZ financial assistance will be results-based and scaled related to access.

The US African Development Foundation (USADF) also supports public-private partnership investments with a US $3 million initiative focused on the Niger Delta region. It aims to improve energy access through off-grid solutions over 2018-2020 (Glin, 2018).

5.4.2. Large scale investments

Larger systems, including large solar mini-grids and grid-connected renewables, require substantially more financing and thus more external financing. Such investments have traditionally relied on external financing, usually led by the multilaterals and bilateral donors, and other large international institutions.

Upgrading and expanding the grid is key to energy access – both in terms of expansion and in reliability. However, enhancing grid expansion post-2020 through 2025 will require a total of about US $2 billion over this period (Fichtner, 2017). The financial solvency problems of the grid are a major constraint in financing new investments.

5.4.3. New financing initiatives

As noted, green bonds are a major new development initiative, which is increasingly a component in the international market and opening a new channel of financing domestically. In Nigeria, the bonds are five-year, sovereign guarantee, denominated in Naira for approximately US $30 million (Debt Management Office Nigeria, 2017).

They are focused on renewable energy, micro-grids in multiple communities and small IPPs for universities and teaching hospitals.

Other public-private initiatives are currently being harnessed in the Nigeria. For example, the Lagos State government is working through public private partnerships (PPP) to improve electricity access throughout the state by procuring generation capacity additions (embedded generation), with the aim to directly improve the capacity and the reliability of the grid. Typically, the government provides the land, and ensures smooth regulatory approvals, and agrees to a purchasing power agreement (PPA). This allows the private developers to arrange the financing and implementation and to become the equity owners and the operators of this generation capacity.

5.5. Access to clean cooking

In Nigeria, the choice of cooking fuel is impacted by location, behavioural patterns, cultural belief, safety issues and the affordability of improved clean cooking technology. Biomass is the main cooking fuel used by two-thirds of households, followed by kerosene as the next one in use by about one-fourth of households. There is clear division between urban and rural, with kerosene being the preferred fuel in urban areas, and biomass the overwhelming choice in rural areas (Table 4).

Table 4: Fuel Used for Cooking in Nigeria, 2013 (Percentage of Households)

	Urban	Rural	Total
Wood and other Biomass	43.4	88.0	68.8
Kerosene	47.6	8.7	25.5
LPG	4.6	0.5	2.3
Others	4.3	2.6	3.3

Source: Nigeria DHS 2013

Nigeria has made some progress towards clean cooking, with the proportion of households using solid fuels decreasing from 78% in 2008 to 69 % in 2013 (DHS 2013). However, rather than being policy-driven, a major factor in the reduction of solid fuel cooking is likely due to the migration of rural population to urban areas, and thus the shift away from the use of solid fuels for cooking.

Biomass for cooking is sourced more than 90% from wood, which has contributed to both deforestation and desertification, especially in the northern part of the country. While charcoal is an important biomass cooking fuel in many African countries (IRENA 2015) this is not the case in Nigeria where it accounts for only 5% of the biomass used (DHS 2013). The time spent collecting fuel wood is estimated at about 26.6 hours per week (or nearly 4 hours per day). While the prevailing view is that the firewood collection is done by the same women who cook, this does not appear to be the case in Nigeria. An estimated 90% is not directly collected but purchased, representing an average household monthly expense of about US $10.

An estimated 25.5 hours a week are spent cooking (Kabir, 2018). In rural areas about half of the people cook in the home itself, with about a quarter cooking either in a separate building, or outside (DHS 2013.) The traditional biomass cookstove in Nigeria, as in many other parts of sub-Saharan Africa, is called "three-stone cookstove." The name is very descriptive as it consists of three stones of equivalent height with a pot on top and the firewood below. When the stove is indoors, this leads to significant indoor air pollution and is estimated to contribute of 79,000 premature deaths per year in Nigeria (Gujba, 2018).

In 2013, to address this problem, the Nigerian Ministry of Environment launched the Rural Women Energy Security (RUWES). The RUWES was targeted at under-served rural women, usually off-grid, energy poor and with highest incidence of health-related issues from harmful energy practices (Nigeria Ministry of Environments 2018). The major activity of RUWES was to provide improved cookstoves, primarily those using biomass more efficiently, with the goal of providing 20 million clean cook stoves by 2020 (Global Alliance for Clean Cook Stoves, 2018). Despite strong efforts by its organizers, significant funding did not materialize, and few stoves were distributed. Indeed, in 2017 only about 5,000 biomass stoves were distributed (Ministry of Environment, 2018).

LPG cookstoves have potential to penetrate urban and peri-urban markets replace kerosene and biomass cookstoves. Yet despite being a major producer and exporter of LPG, the domestic per capita consumption of LPG in Nigeria is among the lowest in the world, (World LPG Association, 2015). Recently LPG consumption has increased dramatically, with consumption rising from 5,000 metric tonnes in 2007 to about 600,000 in 2017 (Banner Energy Lagos, 2018). LPG has for a long time been available for retail purchases in cylinders at gasoline stations but until recently, there had not been a major initiative to develop LPG for cooking. This began to change in 2010 when Oando, a private Nigerian downstream marketer began an ambitious initiative to develop and supply LPG for the cooking market. The initiative encompassed selling the integrated stove/cylinder fuel device and also providing finance for the initial purchase of the stove via a microfinance fund (Practitioners Hub for Inclusive Business 2018). Over time, other companies such as Banner Energy have become involved in supplying both LPG, cylinders and cook stoves, and have developed modular LPG supply units that can be established at the community level to refill the canisters. Despite this major effort to promote LPG for cooking, especially in urban areas, a recent study on Lagos, suggests that kerosene continues to have the major market share at 70%, followed by biomass at 31%; and LPG at only 17% (Ozoh, 2018).

To date, almost all LPG related activities have been distributed on a commercial basis, and regulation of the market is negligible. In 2016, the government phased out the subsidy for kerosene, which has improved the fuel cost comparison and the cost-effectiveness of LPG cooking over kerosene. There is also currently discussion on removing the VAT on locally produced LPG, but this is not yet implemented as policy. Nevertheless, the LPG market continues to face barriers, for example, all cylinders are imported (Banner Energy Lagos, 2018) and the major devaluation of the Nigerian naira in 2015 raised the cost of cylinders; additionally, restrictions on foreign exchange have been problematic for the sector.

Federal policy on promoting LPG cooking is still at an early stage. Based on newspaper reports, elimination of the kerosene subsidy was apparently tied to its budget cost rather than a conscious policy to decrease its use for cooking. While the Government is reported to be developing an LPG policy to support its utilization for cooking as well as potential grants (Banner Energy, 2018), no official announcement has appeared. In the Nigerian policy on natural gas, an LPG Availability Intervention Fund of about US $160 million is foreseen, but the fund has not yet been created (Nigeria Gas Policy, 2017). While LPG has developed on a commercial basis in urban areas as a cooking option, the capital costs of an LPG stove and cylinder present serious barriers in entering lower income urban and rural households to displace kerosene and biomass use.

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Annex A. Mini-grid policies in brief: Kenya, Ethiopia and Nigeria

This Annex provides a brief up-to-date review of mini-grid policies in three leading countries – Kenya, Ethiopia and Nigeria -- to illustrate the differences and similarities of these essential frameworks to lay the groundwork for investment to flow.

Kenya is considered one of the most proactive countries in Africa on electricity access and access has increased from 16% of the population 2000 to 56% in 2016 (World Bank, 2016) with current accessibility at 75% in urban areas and 39% in rural. The government objective is to reach 100% by 2020 (ESMAP 2017). The National Electrification Strategy (NES) is based on least cost model with two central pillars:

- Grid extension using medium voltage lines
- Off-gird, primarily mini-grids, in areas distant for the grid.

Grid extension is the primary driver and is expected to provide access to 90% of the population with the remaining 10% by off-grid, primarily mini-grids. The principal actor is the government-controlled Kenya Power and Lighting Company (KPLC) with operates almost all the grid and all government owned mini-grids.

Development of mini-grids is led by Rural Electrification Authority (REA) that was established under the Energy Act No. 12 of 2006 to support rural electrification in the country. The draft 2015 Energy Bill will convert the REA to the Rural Electrification and Renewable Energy Corporation (REREC) and increase its authority including planning, implementing, and promoting electrification and renewable energy.[37] REA has stopped building diesel-powered mini-grids and will only use renewables for new activities.

Regulation and tariff structure are handled by Kenyan Electricity Regulatory Commission (ERC), which has worked to clarify the regulatory structure for mini-grids. The ERC website lists and explains the ten clearances relative to mini-grids. Kenyan has uniform national tariffs, which can be problematic for mini-grids that have a substantially different cost structure than the national grid. Some exceptions for small mini-grids exist, but this is considered problematic for private developers along who could have different cost structures with grid expansion offering lower cost tariffs. In 2016, two privately-owned, mini-grids were decommissioned when the arrival of the national grid made them unsustainable due to their high operation costs . No compensation was paid for their generation assets. (ESMAT 2017)

Despite significant activity related to mini-grids, to date their actual impact is still low. As of 2015, 19 mini-grids are operated by REA/KPLC and 21 by private companies for a total of 40 mini-grids in operation. They serve and estimated 4200 customers -- about 0.03% of those with electricity access. DFID, KfW, and GIZ have been activity in supporting mini-grid development (German Cooperation, GIZ 2016). In July 2017, the World Bank approved a five year, US $150 million “Kenya: Off-grid Solar Access Project for Underserved Counties” of which US $40 million is ear-marked for mini-grids (World Bank, 2018d).

In **Ethiopia** in 2016, 46% of people had access to electricity, with urban areas at 85% and rural areas 26% (World Bank, 2016). Electricity supply is essentially 100 percent renewable and the hydro, geothermal, and wind resources are such that the country has considerably more leeway as to how to maintain a carbon-neutral, electricity supply (Power Africa 2015). Thus solar appears to have a more specialized role, primarily related to off-grid uses – albeit interest is shown for grid-connected solar (Multiconsult Group, n.d.). It should be noted however, that the expansion of hydro, specifically the Grand Renaissance Dam, and a focus on electricity for large industrial projects or export has been criticized for being given priority over domestic access.

[37] As of August 2018 no change in status was posted on the REA website.

Three major policy documents shape Ethiopia's approach to energy access. The 2011 'Climate Resilience Green Economy Strategy' targets a renewable-based energy supply of which 15–20% comes from non-hydropower-based renewable resources and an increasing electricity capacity to 9000 MW (Ethiopia Green Economy Strategy) in 2030, essentially doubling from 2017 levels. The 2016 "Growth and Transformation Plan, Phase II (GTP-2)" for 2015-2020 sets the overall economic targets and investment plans, of which the electricity sector is a key component (Ethiopia Growth Plan 2018). The 2016, 'National Electrification Strategy' (NES) targets universal access by 2025 principally via expansion of the grid but does include an important role for off-grid (World Bank, 2018e).

Due to its hydro-base, the Ethiopian gird-sector has relatively low costs compared to other African grids: the average domestic tariff rate at US $0.03 per kWh is one of the lowest in sub-Saharan Africa; technical and commercial losses are reasonably low at 23%; and the bill collection rate is reasonably high (85–90 percent). Still the grid has challenges and last-mile connections (the core of the accessibility efforts) have not kept up with demand; indeed, of the 14.4 million unconnected households, 5 million are in areas in or near the grid network (World Bank, 2017). Thus the major thrust in both GPT-2 and the NES is on expanding the grid.

While accessibility focuses on grid expansion, GTP 2 has ambitious off-grid targets as well. These focus on: 1) stand-alone, solar systems facilitated by Regional Energy Bureaus, and 2) credit facilities administered by the Development Bank of Ethiopia. More than 1 million households have benefited from these programs and they are being expanded (WB, 2018e). Pillar 2 of the NEC targets communities where the grid would not reach in the next 5–10 years as well as communities for which the grid is not the least-cost solution (primarily small-scale or mini-hydro). The plan responds to Ethiopia's specific country situation and foresees that after 2025 all new connections will be grid-based; until then, stand-alone solar (Pico and SHS) on a household basis is equally as important as mini-grids (WB, 2018e).

To-date, mini-grids in Ethiopia have focused on small-scale hydro and six micro-hydro grids have been implemented in the southwest of the country (GIZ, Ethiopia). Importantly in the 2018 World Bank Ethiopia Electrification Program (ELEAP), a US $375 million loan facility (2018-2023) has a specific pillar to develop micro/mini-grids that are solar or renewable-hybrid based. This will be part of a planned off-grid strategy to bring mini-grids to remote areas. The results of this program could well determine the roll that mini-grids will have in the country.

Nigeria has a number of policies and regulations targeting energy access. The Electric power sector reform (EPSR) act in 2005 led to the formation of Nigerian Electricity Regulatory Commission (NERC) responsible for electricity regulations. A key challenge in the country has been that of implementation of the policies and regulations, as well as providing the right public awareness.

One of the principal outputs of the electricity sector reforms is the roadmap document put together prior to privatization that guides the power sector reforms (Roadmap for Power Sector Reform 2010 & 2013) and the transmission expansion plan under the Nigeria Electricity and Gas Improvement Project of the World Bank (Fichtner, 2017). The transmission expansion plan focuses on network development as one of the key instruments needed by Transmission Company of Nigeria (TCN) to support the large, grid-based electricity supply expansion program.

The power system plan is outlined in a study that presents the development of a Power System Master Plan for the Transmission Company of Nigeria covering the period 2020 to 2037. The study addressed a wide range of topics, including demand forecast, the projection of existing generation capacities availability, future generation candidates to be considered in the transmission and generation optimization studies, power system analysis (load flow, fault analysis and dynamics simulations), least cost generation and transmission analysis, cost estimations, financial analysis and environmental impact scoping. An overview of the main topics is indicated in the followings.

The Federal Ministry of Power developed the Nigerian Renewable Energy and Energy Efficiency Policy (NREEEP) which was approved in April 2015 by the Federal Executive Council for electricity sector nationwide. The policy commits Nigeria to achieving 16% of its national electricity supplies from renewable energies by 2030. Similarly, National Renewable Energy Action Plan (NREAP) states the strategy on how the targets will be achieved. The most current strategy document by government is the Nationally Determined Contributions (Nigeria’s low carbon development strategy) which suggests that solar PV alone would add 13,000 MW to the power pool by 2030. This is however in contrast with NREEEP which falls short of this by about half, as it commits Nigeria to generating 6,830 MW of solar power by 2030. (Please see the Nigeria Country example, Section 5, for additional detail related to tariffs and regulation.) This can be addressed by assuring that should grid connections become available that the investors in the mini-gird would be protected via fair buy-out terms to be established by the regulator.

Annex B. Financing funds, facilities and programmes: renewable energy access in Africa

Table 5: Selected Financing Funds and Facilities Targeting Renewables in Africa

Blended Finance Funds or Facilities Targeting Off-Grid and Mini-Grid Renewables[38]		
Fund or Facility	**Type – Brief Description**	**Example, further references / source links**
Africa Renewable Energy Fund[39] (multi-donor, private equity fund sponsored by SEFA, operated by Berkeley Energy)	**AREF** was launched in 2014; it is a pan-African private equity fund, funded by AfDB, CDC, GEEREF, EIB, GEF, SEFA, West African Development Bank (BOAD), Ecowas Bank for Investment and Development (EBID), FMO, Calvert Investments, CDC Group, BIO, OeEB (development bank of Austria). **Size**: US $200 million, multi-donor, closed fund. **Scope**: Sub-Saharan Africa, excluding S. Africa, small (5-50 MW) IPP renewable energy investments; target US $10-30 million per project; equity capital, combined with technical assistance	The Africa Renewable Energy Fund (AREF) aims to increase renewable energy generation in Africa. It invests into small (5-50 MW) hydro, wind, geothermal, solar, stranded gas and biomass projects. Equity Project Finance, for 30-50% of project; no more than 50% of fund in one technology. The targeted return on investment is 20%. Mezzanine debt finance & technical assistance grants available to cover early stage project preparation.
Climate Investor One (CIO) Initiative[40] (operated by Climate Fund Managers, created by FMO, the Dutch Development Bank, and Sanlam Infraworks of South Africa)	**Climate Investor One was launched in 2015**, born out of The Global Innovation Lab for Climate Finance (the Lab) - a global partnership initiative that identifies and pilots of cutting-edge climate finance instruments. **Size:** as of its third closure (June 2018), it is a US $535 million blended finance, capital-recycling facility. **Scope:** Renewable energy infrastructure in emerging markets : - private sector focus: non-concessional development finance, equity and guarantees - developing countries in Africa, Asia and Latin America.	**Climate Investor One's mission** to deliver in excess of 1,100 (MW) of new additional capacity, producing 3,200 (GWh/year) of affordable clean electricity to approximately 7 million people. CIO is designed to contribute 'end-to-end' or to each phase of a projects' lifecycle, providing funding for projects in the wind, solar and run-of-river hydro sectors. Three distinct, interlinked funds are backed by different donors and private investors: **Development Fund (US $30 million)** to finance and provide technical assistance in the planning and development stage of a project; the **Construction Equity Fund (US $500 million)** to provide all equity financing for the construction phase; the **Refinancing Fund (US $500 million)** to provide long-term senior debt instruments to reduce operational projects cost of capital and optimize its funding structure.
ElectriFI Program[41] (European Union initiative, operated by the European	**ElectriFi was launched in 2015**; it is funded by the European Commission and Power Africa **Size**: US $133 million (EUR 115 million)	**ElectriFI's mission** is to grow viable businesses and projects that create new connections to reliable and sustainable energy in developing countries. Its design tackles a major barrier to investments in access to energy in developing countries by providing access to seed, mid- and long-term capital. ElectriFI was created to bridge the gaps in structuring and financing, stimulate the private sector, and

[38] This selection of funds and facilities is based on those i) targeting decentralised renewable project development; ii) already capitalised or partially capitalised and functioning today (rather than planned); and iii) have a track record or the intention to commit and disburse funding to off-grid and mini-grid renewable projects at any stage of the project life-cycle from project preparation to project construction and refinancing

[39] https://www.africa-eu-renewables.org/_funds/berkeley-energy-african-renewable-energy-fund-aref/

[40] See: https://www.climateinvestorone.com/nl/

[41] See: http://electrifi.org/

Development Finance Initiative (EDFI))	**Scope**: scalable and replicable businesses focused on decentralised renewable energy solutions and targeting populations in rural, underserved areas and areas affected by unreliable power supply - bridge financing for early stage business development; maximum project size is small, at Euros 10 million; types of financing include non-concessional development finance, equity and guarantees -developing countries in Africa, Asia and Latin America	mobilise financiers. It tailors financial structure and repayment schedules to fit the cash flows of the particular project, providing interim financing solutions to help projects overcome obstacles or otherwise reach a sufficiently mature stage that could attract private financiers.
Facility for Energy Inclusion - Off-Grid Energy Access Fund[42] (AfDB managed, SEFA sponsored)	**FEI - OGEF was launched in 2018** as a pan-African renewable energy blended finance debt fund created through collaboration of the [African Development] Bank, SEFA and the Nordic Development Fund, and with co-investment by the GEF and CIC. **Size:** US $100-million blended finance debt fund **Scope:** - Off-grid energy companies to provide energy access and targeting LFIs engagement. - Pan-African off-grid renewable energy, blended finance	**Off-Grid Energy Access Fund (OGEF) mission** is the of scaling up access to clean electricity for off-grid households and crowding in of local financial institutions as co-lenders. It is a window of the Facility for Energy Inclusion (FEI) Fund. It provides loans in local and hard currencies to off-grid energy companies working initially in East Africa as well as Côte d'Ivoire, Ghana and Nigeria East Africa, looking to build a strong pipeline of transactions throughout the region.
Sustainable Energy Fund for Africa[43] (SEFA) (multi-donor fund managed by AfDB)	**SEFA was launched in 2012**; it Is funded by the governments of Denmark, Italy, the UK, the US **Size:** US $95-million multi-donor facility, open fund **Scope:** - sustainable energy project preparation, - technical assistance for capacity building and - early-stage, business and private sector focus	**SEFA mission** is to supports the sustainable energy agenda in Africa through: i) grants to facilitate the project preparation for medium-scale renewable energy generation and energy efficiency; ii) equity investments to bridge the financing gap for small- and medium-scale renewable energy generation projects; this component is implemented through the SEFA-sponsored, Africa Renewable Energy Fund (AREF) and iii) support to the public sector to improve the enabling environment for private investments in sustainable energy.
Multilateral funds targeting renewables in Africa		
Africa Renewable Energy Initiative[44] (AfDB is the trustee, reporting to the Board of AREI)	A climate initiative targeting RE in Africa, the AREI was launched at COP21 in 2015 and operates under the mandate of the African Union and endorsed by African Heads of State and Government on Climate Change (CAHOSCC). In December 2016, as reported by the Climate Initiatives Platform, AREI received €7 million in support from France and Germany **Size**: unclear **Scope**: Africa, renewable energy and energy access	**Africa Renewable Energy Initiative mission** is to: -help achieve sustainable development, enhanced well-being, and sound economic development by ensuring universal access to sufficient amounts of clean, appropriate and affordable energy. -help African countries leapfrog to renewable energy systems that support their low-carbon development strategies while enhancing economic and energy security. **Specific targets** of AREI are to achieve at least 10 GW of new and additional renewable energy generation capacity by 2020, and mobilize the African potential to generate at least 300 GW by 2030.

[42] https://www.afdb.org/en/news-and-events/african-development-bank-nordic-development-fund-global-environment-facility-and-calvert-impact-capital-partner-in-us-55-million-investment-into-off-grid-energy-access-fund-17743/

[43] https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/sustainable-energy-fund-for-africa/

[44] http://www.arei.org/ ; https://www.theguardian.com/global-development/2015/dec/07/africa-plans-renewable-energy-initiative-solar-hydro-cut-emissions?CMP=share_btn_link and http://climateinitiativesplatform.org/index.php/Africa_Renewable_Energy_Initiative

Table 6: Selected Multilateral and Bilateral Development Banks Policies and Programmes

Financing initiative	Type – Brief Description	Examples, Progress to date
AfDB - New Deal for Energy & Desert to Power Initiative[45]	**Policy**: Launched in 2016, this is an organisation-wide policy and embedded in AfDB's operating strategy and financing. On energy access, 4 targets, by 2025: • Increase on-grid generation to add 160 gigawatts of new capacity • Increase on-grid transmission and grid connections by 160 percent to create 130 million new connections by 2025. • Connecting 75 million households through off-grid energy access solutions; • Increase access to clean cooking energy for 130 million households	• The goals set out in the **New Deal for Energy**, include electricity access and cooking; it sets out one of the "**High 5**" priorities of AfDB to light up and power the continent, with aspirational targets by 2025: • **AfDB's Desert to Power initiative** in the Sahel and Sahara regions of Africa envisages 10 GW of solar power generation and providing clean energy to 90 million people. • **Fund for Energy Inclusion (FEI)** was launched in parallel to guide implementation with AfDB 2017 approval of US $100 million of seed funding for a US $500 million debt-fund • **Annual monitoring** of progress occurs in the AfDB's Africa Development Effectiveness Report (see ADER 2018)
World Bank: country programs targeting 'last mile' energy access[46]		Several major sub-Saharan country projects targeting mini-grid and off-grid solar were approved or in planning stages in 2018. This includes an approved US $150 million credit in Kenya for off-grid access to marginalized communities, a US $118 million energy access project in the Congo, DR and projects in Ethiopia and Nigeria (now approved) of US $375 million and US $350 million respectively (see more information, Annex A).
US – Power Africa Initiative (led by USAID)[47]	**Power Africa** initiative Launched in 2013, Power Africa brings together technical and legal experts, the private sector, and governments to work in partnership to increase the number of people with access to power. Power Africa's goal is to achieve 30,000 MW of new generated power and 60 million new connections by 2030 to reach 300 million Africans.	US pledged US $7 billion over five years; the initiative has acted as a focal point for a range of US agencies and the private sector. Partners with other donors and government entities as well as private sector.
Japan-Africa Energy Initiative[48]	The Initiative, launched in July 2017, seeks to support the small and medium players who want to join the regional energy sector under Japan's Light up and Power Africa initiative which aims to enable countries to achieve universal access to energy by 2025, using available energy sources and the most advanced technologies	Japan agreed to provide US $6 billion in both concessional and non- concessional finance for a variety of energy operations for the support of electricity for homes, schools, hospitals, industries, and clean cooking. The initiative will support a full range of activities associated with public and private sector energy projects, ranging from preparation to construction and operations, through a mix of financing and technical assistance. In the power sector, aside from nuclear, all energy sources will be considered including clean coal.

[45] https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Brochure_New_Deal_2-En.pdf
[46] https://www.worldbank.org/en/news/feature/2018/04/18/access-energy-sustainable-development-goal-7 and Annex A; for a critical look at how World Bank efforts performed through 2017, see: https://www.naturskyddsforeningen.se/sites/default/files/dokument-media/energy_access_report_1.24.pdf .
[47] https://www.usaid.gov/powerafrica/aboutus
[48] From New Deal for Energy brochure (May 2018) https://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/Brochure_New_Deal_2-En.pdf ; ESI-Africa https://www.esi-africa.com/gabriel-negatu-japan-africa-energy-initiative/

Africa-EU Renewable Energy Co-operation programme (RECP)[49]	The RECP is a multi-donor programme that supports the development of markets for renewable energy in Africa. It was launched by more than 35 African and European Ministers and Commissioners under the Africa-EU Energy Partnership (AEEP). With the aim of catalysing the development of African renewable energy markets, energy access is one of the main goals, as is promotion of value chains to promote employment and business opportunities for African and European businesses.	The RECP programme partners with countries and relevant stakeholders to develop favourable policies, to build capacity and prepare renewable energy projects, and to develop relevant technical capacities and business skills and to create African-European networks including research, education and private entities. It works in four different areas: • Policy advisory • Private sector co-operation • Access to finance • Innovation and skills development

[49] https://www.africa-eu-renewables.org/about-recp/

Annex C: Africa regional breakdown

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Notes: Africa sub-regions are derived from those used by the United Nations (UN) and the existing regional power pools (bodies set up to strengthen regional power sector integration across Africa). For countries that are members of more than one power pool, such as Tanzania, a decision has been taken to assign it to just one sub-region. This is driven primarily by analytical considerations specific to this study, and so may not be consistent with other groupings (such as Africa's regional economic communities).

Source: IEA

Annex D: List of interviewees and COP24 panellists

List of interviewees
Nigeria

Mr. Suleiman Babamanu
Federal Rural Electrification Agency (REA)
Acting Head, Department of Renewable Projects

Engr Mrs. Bahhjiatu Abubakar
Ministry of Environment/Clean Cooking Alliance
Programme Coordinator

Mr. Chinedu Ukabiala
Nigeria Electricity Regulatory Commission (Renewable Energy Division, Transmission Network, Grid & Tariff, Rate and Metering)
Manager, Regulations for Renewables

Engr Prof. Lukman
Lagos State Electricity Board
Project Manager

Ms. Damilola Ogunbiyi
Federal Rural Electrification Agency (REA)
Managing Director

Mr. Eitan Hochster
Lumos Global
Director of Business Development

Ms. Ina Hommers
GIZ
Head of Programme, Nigerian Energy Support Programme (NESP)

Mr. Nuhu Yakubu
Banner Energy Limited
Managing Director/CEO

African Development Bank

Mr. Ihcen Naceur
African Development Bank

COP24 OECD side event, 10 December 2018
List of Panellists

Mr. Olympus Manthata
Development Bank of Southern Africa
Head of Climate Finance

Ms. Rana Adib
Renewable Energy Policy Network for the 21st Century (REN21)
Executive Secretary

Dr. Han Huang
GEIDCO
Vice Dean of Economic and Technical Research Institute

Dr. Daniel-Alexander Schroth
African Development Bank
Adviser to the Vice President Power, Energy, Climate and Green Growth Complex

Dr. Linus Mofor
African Climate Policy Centre, United Nations Economic Commission for Africa
Senior Environmental Affairs Officer (Energy, Infrastructure and Climate Change)

Dr. Youba Sokona
The South Centre
Special Advisor on Sustainable Development

Financing Climate Futures

RETHINKING INFRASTRUCTURE

Governments recognise that scaling up and shifting financial flows to low-emission and resilient infrastructure investments is critical to deliver on climate and sustainable development goals. Efforts to align financial flows with climate objectives remain incremental and fail to deliver the radical transformation needed. The OECD, UN Environment and the World Bank Group, with the support of the German Ministry of Environment, Nature Conservation and Nuclear Safety, have joined forces under a new initiative – *Financing Climate Futures: Rethinking Infrastructure* – that provides a roadmap to help countries make the transformations in their infrastructure, investment and finance systems that are needed to make financial flows consistent with a pathway towards a low-emission, resilient future.

For more information on *Financing Climate Futures: Rethinking Infrastructure* visit: oe.cd/climate-futures

ACHIEVING CLEAN ENERGY ACCESS IN SUB-SAHARAN AFRICA

A clean energy revolution in sub-Saharan Africa is urgently needed to win the fight against energy poverty, to promote robust development and to make it more sustainable. Clean energy can unlock sustainable economic growth, improve human health and well-being and enable women and children to lead more productive lives. It will also raise human security and build resilience in nation states and communities. This report takes an in-depth look at the challenges and opportunities to provide clean energy access in sub-Saharan Africa. Packages of policies are needed to promote clean energy access, including electricity for productive uses and a full range of technical solutions – notably off-grid and mini-grid renewables, energy efficiency – as well as clean cooking. Innovative financing and improved public sector governance are essential ingredients to make markets work. Delivering on this golden opportunity for development requires not just more money but policy attention and massive political effort from both domestic and international actors.

Bisanti villagers in Nigeria appreciating first time access to reliable, affordable and sustainable electricity through the solar mini grid system. *Photo credit: Simi Vijay Photography©/for the World Bank*