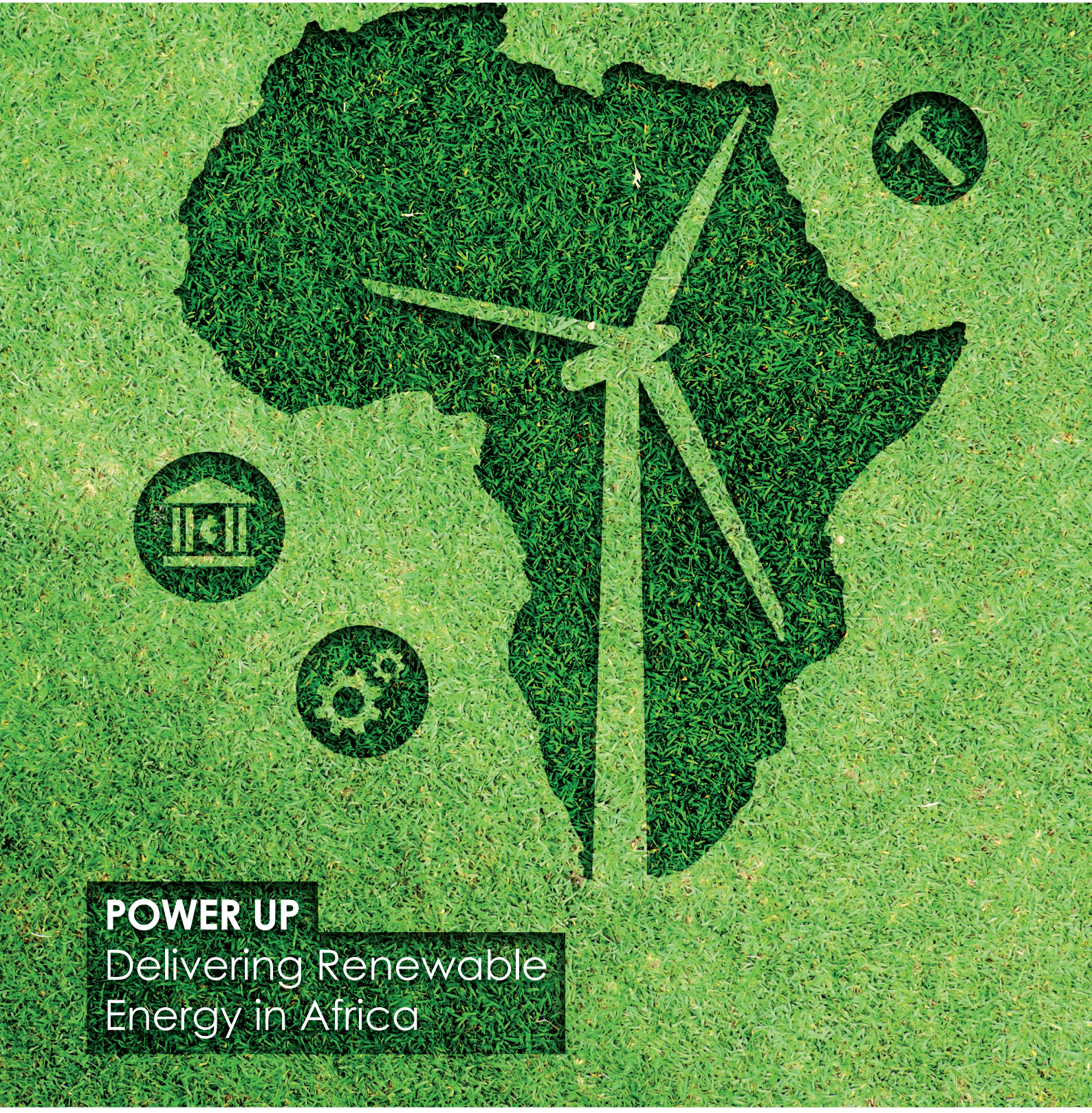
The Economist Intelligence Unit

A report by The Economist Intelligence Unit



POWER UP
Delivering Renewable Energy in Africa

Commissioned by:

IHS
Towers of strength

Contents

Glossary of terms

Off-taker
The buyer of power produced by a given power generation asset.

Power purchase agreement
A contract between a power supplier and the purchaser of power. A PPA typically sets the commercial terms between the two parties, including duration of contract, payment terms, transmission issues, timeline for delivery, penalties for non-compliance, and credit and insurance terms.

Renewable procurement programmes
Policy programmes aimed at securing a given capacity of power production from renewable energy.

Off-grid power
Power produced independently of the power grid. Examples include solar home systems.

Micro-grid
A small-scale power grid that can operate independently of the main electrical grid. It can be used for both on and off-grid purposes.

Feed-in tariffs
A payment made to energy producers generating electricity from renewable energy sources, usually proportional to the amount of electricity generated.

Transmission and distribution system
Transmission systems transport high quantities of power - usually through overhead lines, underground cables - to substations, and connect power generators to the distribution network which delivers power to users.

About this research

"Power Up: Delivering renewable energy in Africa" is an Economist Intelligence Unit report on renewable energy infrastructure in Sub-Saharan Africa, with a focus on solar and wind. Findings are based on desk research and expert interviews and the report includes fieldwork in Nigeria, Zambia and Uganda. The Economist Intelligence Unit would like to thank the following experts for their time and insights:

- Andrew Johnstone, chief executive officer, Climate Fund Managers
- Dr. Tobias Bischof-Niemz, head of energy research at the Council for Scientific and Industrial Research (CSIR), South Africa
- Alastair Campbell, managing director, Vantage GreenX
- Benjamin Warren, global power and utilities corporate finance leader, EY
- Dario Musso, senior transactor, infrastructure finance, Rand Merchant Bank, South Africa
- Rentia R. Van Tonder, head, Power, Corporate and Investment Banking, Standard Bank
- Reda El Chaar, executive chairman, Access Power MEA
- Nico Tyabji, senior associate, Bloomberg New Energy Finance
- Christophe Fleurence, vice-President, business development, Africa, EREN Renewable Energy
- Timon Herzog, chief operating officer, Global Renewable Independent Power Supplier (GRIPS)
- Georgios Pergamalis, head, business development, Africa and Middle East, Enel Green Power
- Phylip Leferink, general manager, Lake Turkana Wind Power Ltd.
- James White, senior manager, business development, SunEdison South Africa
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- Aubin Kalaidjian, founding partner, Greenwish Partners
- Batchi Baldeh, head of power, Africa Finance Corporation
- Abayomi Adebisi, Nigerian Federal Ministry of Power
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- Dolf Gielen, director of the Innovation and Technology Center at IRENA
- Michael Obale, agriculture graduate, Gulu University, Uganda
- Nils de Baar, president for central europe, Vestas
- Peter Nyeko, renewable energy developer, Mandulis Energy
- Jasandra Nyker, CEO, Biothern
- Sipho Phiri, executive chairman, Western Power
- Owen Silavwe, managing director, Copperbelt Energy Corporation
- Charles Mate, executive director of corporate affairs, IDC

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Executive summary

Following high-level declarations at the Sustainable Development Goals and the Paris Climate Conference in late 2015, there is a growing appetite for renewable energy in Africa. This is much-needed; the continent's energy supplies are not meeting the needs and aspirations of its people. A better system will promote economic diversification, raise productivity, and improve the health and wellbeing of citizens.

Africa requires between $60 and $90 billion annually to address its energy shortfall, roughly quadruple 2014 investment levels. While fossil fuels, notably coal, oil and gas, continue to provide a significant quantity of energy - especially in South Africa - renewables need to play a greater role.

Africa has plentiful resources, from geothermal power in Kenya and Ethiopia to hydropower in Zambia and the Democratic Republic of Congo. Solar and wind are especially promising, thanks to falling costs and resource abundance. From solar-powered hospitals in Lagos to wind farms in Lake Turkana, renewable energy is not just a pipe dream - it is a reality. Renewables can increase energy security, reduce energy import bills, and diversify and de-risk the energy mix. Through off-grid technologies, they can provide direct, affordable power to rural regions beyond the reach of the grid system.

But to harness renewables at scale, very significant infrastructure is needed: both core assets like wind and solar farms[1] and transmission grids, as well as connective infrastructures, like roads to and from sites for transporting kit and manpower, or for bringing products, like solar-powered mobile phones, to market. This requires effective regulation, sufficient financing, appropriate technologies and smart business models.

The ambitions are there. The African Renewable Energy Initiative, led by institutions including the African Union and the United Nations Environment Programme, has set a goal of 300 GW of renewable energy capacity by 2030. But this requires a 680% increase in current deployment rates. According to IRENA's latest data, the installed renewable power generation capacity in Sub-Saharan Africa currently stands slightly below 30 GW, roughly 25-30% of the installed power base, but this is dominated by large hydro, with other renewables collectively accounting for just 4-5% of power generation.

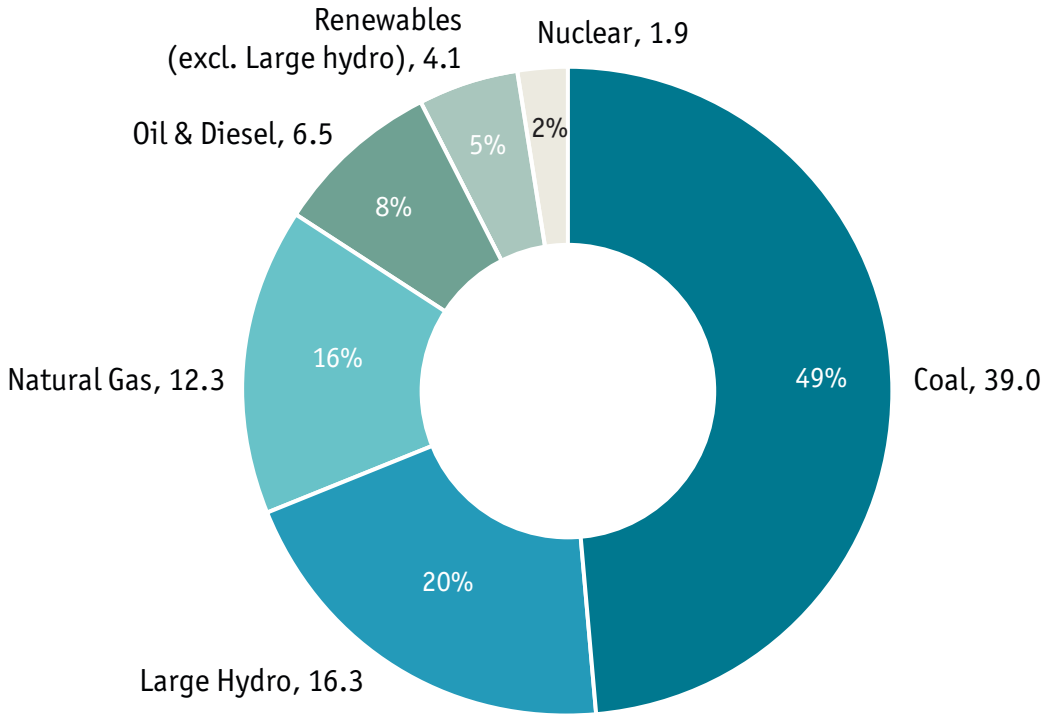
Can the investment be achieved? Who are the current players and how is the market evolving?

[1] This report focuses primarily on solar and wind energy, the resources most widely available and technically feasible from an infrastructure standpoint, given Africa's grid systems. These are also the renewable sources attracting the majority of investment globally and solar, in particular, is set for rapid growth. It excludes large hydroelectric projects, the infrastructure dynamics of which can be idiosyncratic, and not necessarily feasible for most countries.

Which strategies are most successful, and what challenges do developers face? This report, combining expert interviews with country fieldwork, assesses renewable infrastructure dynamics in Africa today, focusing on solar and wind and outlines the strategies employed by developers, corporates, governments and international partners.

Sub-Saharan Africa's power generation

(GW)



Source: Climate Scope 2015. Data for 2014. Tracks 80 GW in Sub-Saharan Africa.

Key findings

The sun is shining on African renewables. Falling technology costs, ambitious targets, resource abundance, a pipeline of high-quality projects, and the support of international donor partners are driving the rollout of renewable power in Africa. Countries can look to positive experiences in lead markets like South Africa and Kenya for strategies and best practices.

Like mobile communications in the late 2000s, Africa's power sector can 'leapfrog' heavy infrastructure. Africa's green power sector resembles mobile communications a decade ago. There is a large pool of African consumers able to buy power but simply lacking appropriately priced and designed options. 'Leapfrog' strategies are emerging in rural regions, where electricity is delivered without heavy, clunky infrastructures. Innovative 'pay as you go' contracts, affordable technologies like pico-solar units, and remote utility management software, are smart alternatives to the conventional grid approach. In rural regions, off-grid power generation could create an entirely new type of 'bottom-up' network as island grids gradually become interconnected. As with mobile in Africa, the key will be smart business models, not just a reliance on cheapening technology.

Governments must implement cost-reflective tariffs based on publicly available 'cost of service' studies. To attract infrastructure investment, power tariffs must reflect costs. Targeted subsidies to protect the poor can help improve access to power without deterring the private sector from investment.

Transparency and harmonisation are essential for investors. Governments should publish key planning documents, like Integrated Resource Plans, and introduce bankable and harmonised legal documentation including PPAs (power purchase agreements), Government Support Agreements, and Connection Agreements. Africa also needs strong, independent energy regulators that enforce competitive procurement.

Improve border customs efficiency. To utilise renewable technologies, landlocked African nations must improve supply chain efficiency so developers can quickly move equipment and replace parts like panels and turbines. Faster customs processes are vital to achieve this.

Countries should design competitive renewable procurement programmes, rather than relying on one-off investments. While investors occasionally pursue one-off projects, government-backed renewable procurement programmes are more likely to attract long-term investment. Following South Africa's lead, Uganda and Zambia are emulating the 'programmatic' approach: other countries could do the same. Transparent, standardised,

and competitive programmes reduce risks for developers, and costs for governments. They signal long-term policy commitment to green energy and build local expertise.

Ambitious targets are not enough: investors are also looking at whether governments have the technical capacity to deliver: The majority of Sub-Saharan African countries have the ingredients to make renewable energy infrastructure viable, and over half have explicit renewables targets. But those moving fastest also have the technical capacity to make it happen. Improving the fiscal conditions of national energy off-takers, and implementing well-designed, standardised power purchasing agreements, are of critical importance here. Developers also pay close attention to a country's infrastructure track record and the relationship between its renewable energy goals and its actual economic needs.

1 Powering African renewables

Last year was bright for the global renewable energy industry. Investments in clean energy reached their highest level yet ($329bn, excluding large hydropower, according to Bloomberg New Energy Finance), and net capacity additions in wind (60GW) and solar photovoltaic (56 GW) surpassed deployments in new coal (42GW) and gas (40 GW) power generation.[2]

This figure is over five times the 2004 investment total, according to BNEF, showing the remarkable distance that renewable power has come in little over a decade. Last year was also the first year developing countries out-invested developed ones, after marked increases in China, Latin America, Africa and India.[3] And with developing countries as a whole expected to drive future energy demand growth and renewable energy costs on the decline, that trend is expected to continue.

Growth was particularly marked in Mexico (114%), Chile (157%), South Africa (329%) and Morocco, which saw $2 billion investment from zero in 2014 according to BNEF data.[4] These investment figures are more remarkable given the historically low oil and gas prices of late, and the sluggish growth in emerging markets. That said, this is also an industry in flux. In mid-April, Solar Impulse 2 broke several world records (including speed, distance, and altitude) as it flew across the Pacific powered by the sun. The same week, SunEdison Inc., a US-based clean energy developer, filed for bankruptcy. Clearly, ramping up renewable energy is as much about business models as technologies.

Africa's place in the sun

Sub-Saharan Africa is yet to fully harness renewables on a continent-wide scale. Its power supply is failing to keep up with people's needs. Hospitals and schools go without lights or equipment, and at home families huddle around polluting, dangerous kerosene lamps. Job-creating services and manufacturing industries cannot emerge due to intermittent power supplies. Each year, the average Sub-Saharan African manufacturing firm loses 5.5% of annual sales due to power outages, over double the global average (2.6%). Nigeria has nearly 33 outages a month; the average duration is 8 hours, according to the World Bank.

Overall, almost 600 million people in Sub-Saharan Africa lack access to electricity. According to McKinsey[5], only seven countries—Cameroon, Côte d'Ivoire, Gabon, Ghana, Namibia, Senegal and South Africa—have access rates above 50%. The rest have an average grid access rate of 20%. Outside of South Africa, average

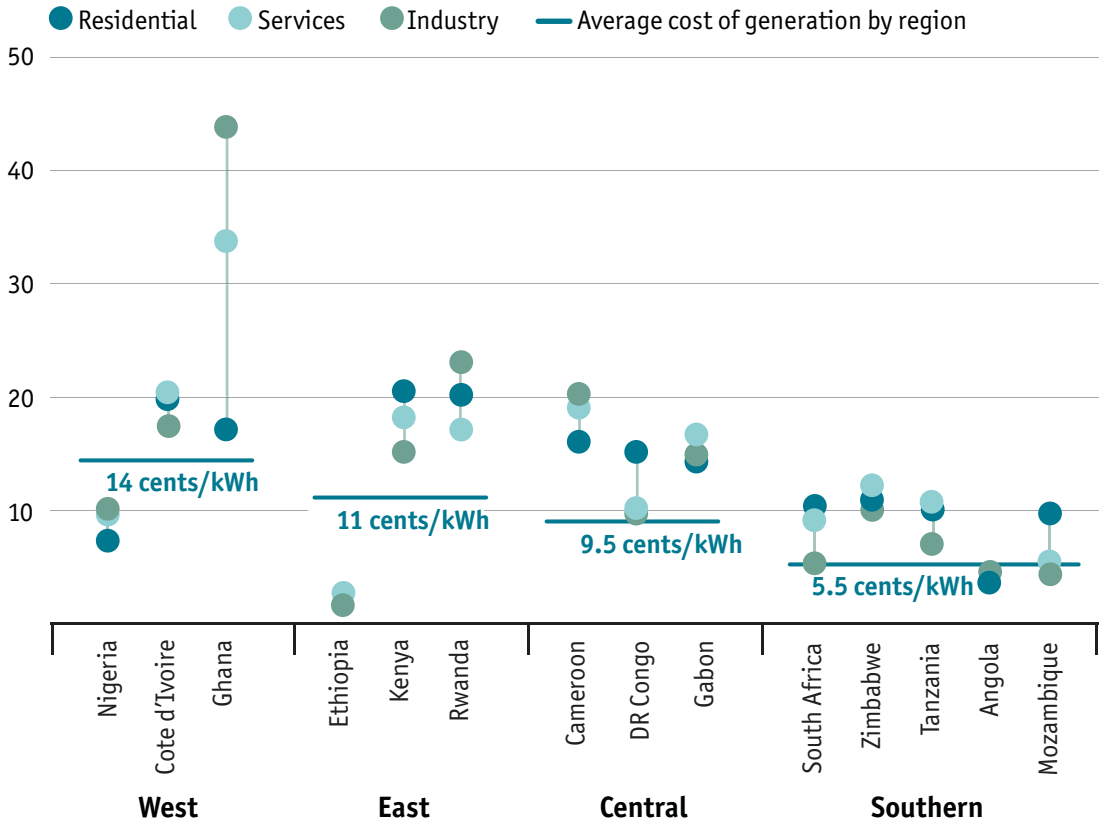
[2] Source: UNEP 2016.

[3] Source: UNEP 2016.

[4] See Bloomberg Visual Data, available on bnef.com

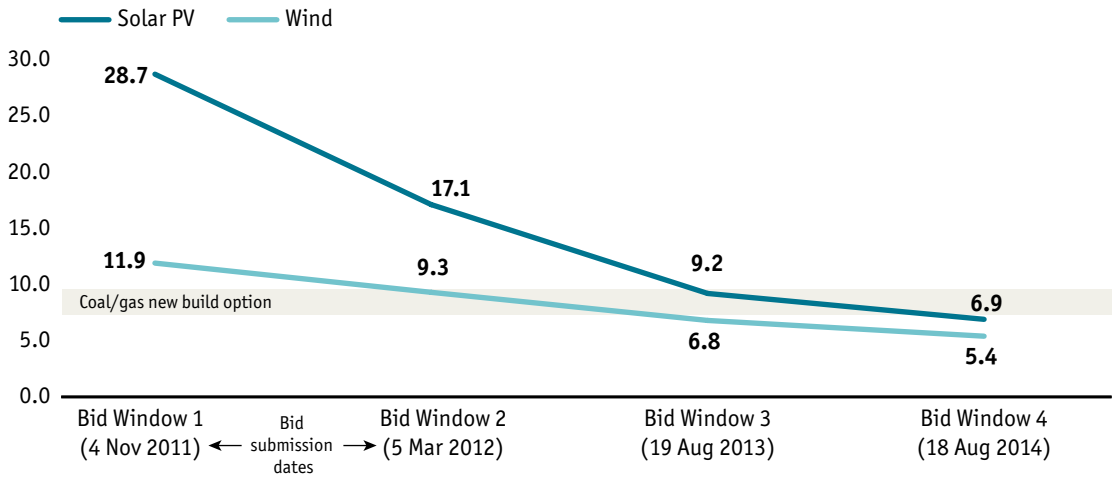
[5] "Brighter Africa: The growth potential of the sub-Saharan electricity sector", McKinsey, February 2016.

Figure 1: Grid electricity prices by end-use sector in selected countries, 2013
(US cents per kWh)



Source: IEA 2014

Figure 2: Average cost of wind and solar in South Africa, according to bids submitted during the first four rounds of the REIPPPP
(Average tariff in US cents)



Source: CSIR, 2015.

electricity consumption is about 150 kilowatt-hours per capita, a fraction of consumption rates in Brazil or India. If such trends continue, in 2030 there will still be 655 million people in Africa (42% of the population) without access to power according to IRENA[6].

Renewable energy can help: Africa has abundant solar, wind, and geothermal resources, to name a few. Solar PV alone could provide more than 8TW, according to McKinsey data. By way of comparison, total capacity installed in the Sub-Saharan African region stood at 97 GW in 2012, including fossil fuel generation.

Governments are engaged, say interviewees in this report, especially if they are energy-importers. "Nearly 40 African countries have introduced renewable energy targets in the last 10 years and there are now more than 100 GW of renewable energy projects in the pipeline" says Dolf Gielen, Director of IRENA's Innovation and Technology Center. There is a "real openness to renewable energy" in Africa, adds Nils de Baar, president for Central Europe at Vestas, a global market leader, with wind farms in Cape Verde (28 MW), Egypt (79 MW), Kenya (12 MW), Morocco (50 MW) and South Africa (350 MW). Vestas is also constructing the 310 MW Lake Turkana Wind Power project in Kenya, which will be the largest wind power plant in Sub-Saharan Africa when completed. "We see significant potential for developing wind power in Sub-Saharan Africa," says de Baar. "Africa can be the continent that achieves the highest contribution of renewable energy".

Yet, while Africa has seen a near 60% increase in renewable energy capacity over the past 15 years[7], its relative share of global installed renewable energy capacity has actually dropped from 2.7% to 1.8% over the same period, according to IRENA. In Sub-Saharan Africa, nearly 60% of the 1.8 GW net capacity additions in last year (large hydro included) was installed in South Africa, as Dario Musso, senior transactor of infrastructure finance at Rand Merchant Bank, explained: "The country has a strong grid, a deep and sophisticated financial market in local currency and a credit worthy off-taker". The rest of the continent is less advanced. But, as this report argues, South Africa provides a beacon for other countries to look to. Some are already following its example.

Renewables: The new 'mobile' revolution?

Global technology cost trends are proving a helpful tailwind. According to BNEF, the 'levelised' cost of wind power generation is now half what it was in 2009, while the cost of Solar PV modules has fallen by 80% since 2008, on average. "On a $/kWh basis, Solar PV and wind power are the cheapest new-build options in South Africa today...even cheaper than new coal," says Dr. Tobias Bischof-Niemz, head of energy research at the Council for Scientific and Industrial Research (CSIR) in South Africa, referring to the average bids under South Africa's Renewable Energy Independent Power Producer Procurement Program (REIPPP). Africa holds the world record of the cheapest bid for electricity from wind power generation, at $3c/kWh[8], and has world leading renewable resources. Lake Turkana wind farm, for instance, has one of the highest load factors in the world due the powerful wind resources on the site.

Falling technology costs reminds some experts of the mobile phone sector in previous years. Benjamin Warren, global power and utilities corporate finance leader at EY, said: "For me the best analogy is the telco market where it seems technology was available and affordable.... there is no reason why that can't be the same with energy. In fact, the technology is probably evolving as quickly, if not quicker, than in the mobile telephone market".

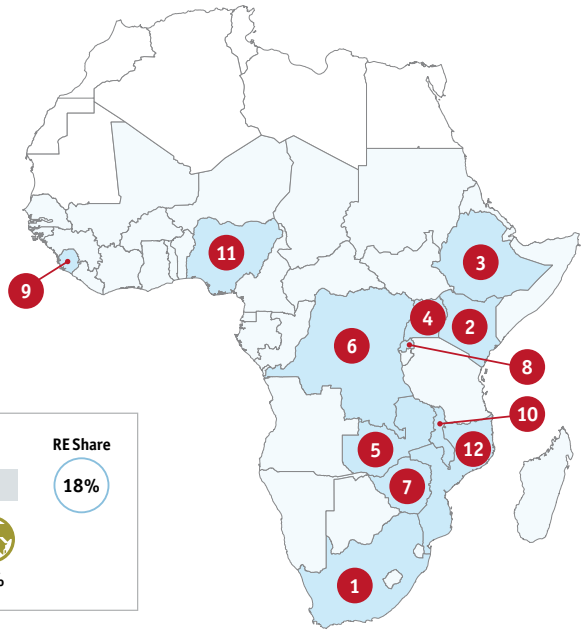
A second helpful tailwind is the significant public support for renewables, from Power Africa (led by USAID) to the African Renewable Energy Initiative (AREI), an African-led initiative that aims to deploy 10 GW of renewable energy by

[6] "Africa's renewable energy future: The path to sustainable growth", International Renewable Energy Agency.

[7] From 23 GW in 2000 to 36.7 GW in 2015 (including large hydro) according to IRENA 2015

[8] This was the lowest bid in Morocco's latest rounds of auctions for 850 MW. A bid does not guarantee the project will get delivered at this cost.

Top renewable energy markets in Sub-Saharan Africa by installed capacity



1. South Africa

RE Installed Capacity MW: 1,989
RE Share: 4%
4% 55% 29% 13%

2. Kenya

RE Installed Capacity MW: 719
RE Share: 33%
14% 3% 7% 75%

3. Ethiopia

RE Installed Capacity MW: 416
RE Share: 18%
30% 41% 27% 2%

4. Uganda

RE Installed Capacity MW: 154
RE Share: 17%
43% 57%

5. Zambia

RE Installed Capacity MW: 131
RE Share: 5%
70% 30%

6. DR Congo

RE Installed Capacity MW: 115
RE Share: 4%
92% 8%

7. Zimbabwe

RE Installed Capacity MW: 96
RE Share: 5%
23% 77%

8. Rwanda

RE Installed Capacity MW: 89
RE Share: 63%
90% 10%

9. Sierra Leone

RE Installed Capacity MW: 89
RE Share: 40%
64% 36%

10. Malawi

RE Installed Capacity MW: 88
RE Share: 24%
78% 1% 21%

11. Nigeria

RE Installed Capacity MW: 62
RE Share: <1%
100%

12. Mozambique

RE Installed Capacity MW: 58
RE Share: 2%
100%

KEY

Hydro (<50MW) Solar Wind Bioenergy Geothermal

Source: Climatescope 2015
RE = renewable energy
Blue bars represent installed capacity, measured relative to South Africa

Renewable energy roadmap to 2030

Breakdown of renewables in total energy mix, by region, and required forecast to 2030 to meet energy goals

WEST

SHARE OF RENEWABLES (excluding hydropower)

2013 **2%** → 2030f **15%**

Cumulative investment in RE required 2015-2030

Breakdown by type 2030f

71%	US$36bn
9%	US$31bn
3%	
3%	
14%	
T&D	US$52bn

CENTRAL

SHARE OF RENEWABLES (excluding hydropower)

2013 **3%** → 2030f **36%**

Cumulative investment in RE required 2015-2030

Breakdown by type 2030f

59%	US$13bn
10%	US$17bn
9%	
23%	
T&D	US$14bn

EAST

SHARE OF RENEWABLES (excluding hydropower)

2013 **14%** → 2030f **28%**

Cumulative investment in RE required 2015-2030

Breakdown by type 2030f

70%	US$36bn
1%	US$21bn
14%	
11%	
3%	
T&D	US$49bn

SOUTHERN

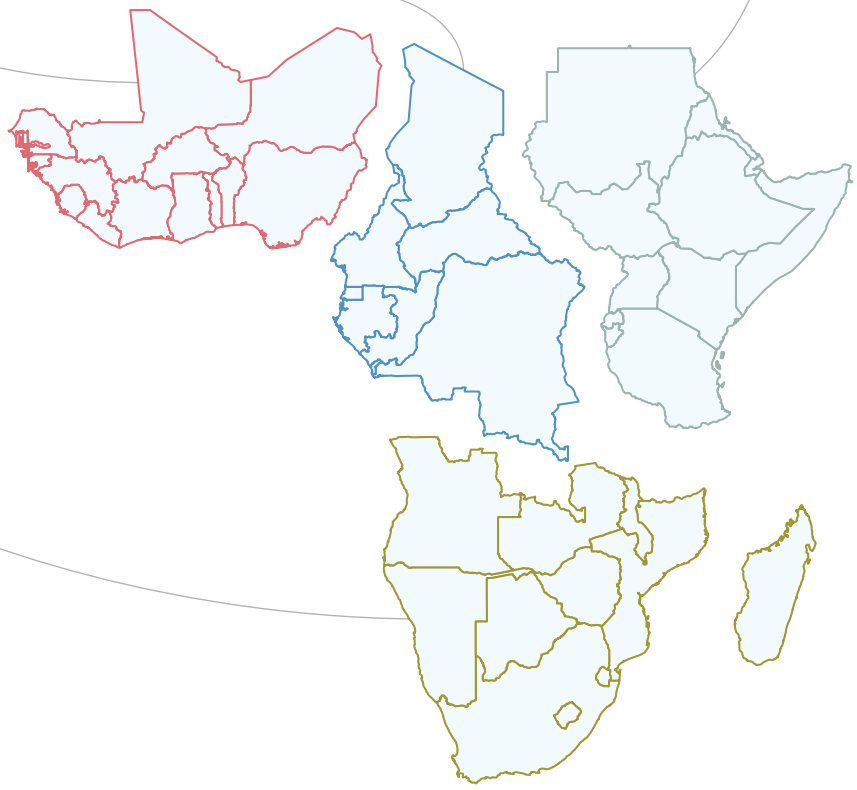
SHARE OF RENEWABLES (excluding hydropower)

2013 **1%** → 2030f **23%**

Cumulative investment in RE required 2015-2030

Breakdown by type 2030f

50%	US$18bn
27%	US$94bn
18%	
5%	
T&D	US$74bn



KEY

Hydro · Solar PV · CSP · Wind · Geothermal · Biomass · Transmission & Distribution

Source: IRENA

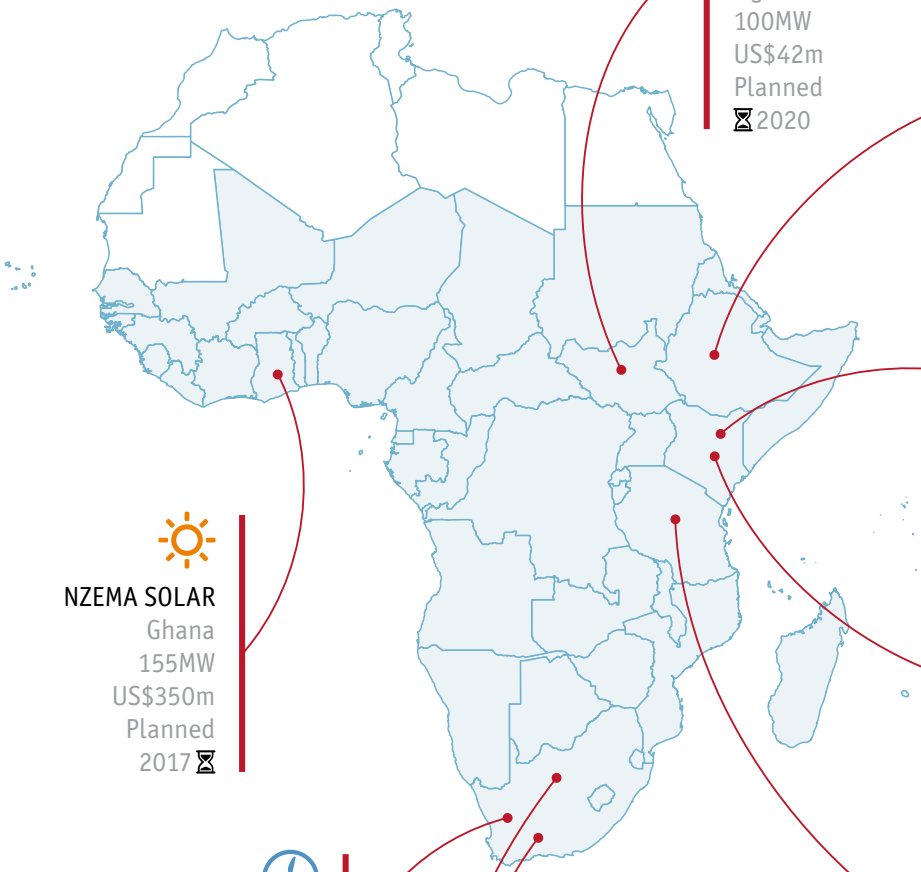
2020, reaching 300 GW by 2030. Against the backdrop of the Sustainable Development Goals (SDGs), which aim to provide universal access to affordable energy by 2030, and the Paris Climate Change Agreement, which aims to achieve a net zero carbon global economy by 2050, there is no shortage of ambition.

But, between ambition and reality, there is a sizeable gap. Delivering 300 GW of renewable energy capacity by 2030 requires a 680% increase in current deployment rates. "The 300 GW is entirely achievable, but it will require more support from governments and institutions across Africa" says Dolf Gielen, Director of IRENA's Innovation and Technology Center.

Meeting these targets requires policy and investment frameworks reflective of the realities of deploying renewable energy infrastructure. Importantly, these will be unique to the markets and contexts, and developers should re-assess their pre-conceived notions of what constitutes a 'necessary environment' for renewable energy. "The development of renewable energy in Africa will not follow the pure textbook that has been forged by the more entrenched markets of the developed world," says James White, senior manager for business development at SunEdison South Africa.

Upcoming renewable energy projects* in Sub-Saharan Africa

*excluding hydropower projects



BURANGA GEOTHERMAL POWER STATION
Uganda
100MW
US$42m
Planned
2020

AYSHA WIND FARM
Ethiopia
300MW
US$502m
Planned
N/A

LAKE TURKANA WIND POWER
Kenya
310MW
US$700m
Under construction
2017

KIPETO WIND FARM
Kenya
100MW
US$300m
Under construction
2017

SINGIDA WIND FARM
Tanzania
100MW
US$285m
Planned
2017

NZEMA SOLAR
Ghana
155MW
US$350m
Planned
2017

KHOBAB WIND FARM
South Africa
140MW
Approx US$230m
Under construction
2017

LOERIESFONTEIN 2 WIND FARM
South Africa
140MW
Approx US$230m
Under construction
2017

REDSTONE SOLAR THERMAL POWER
South Africa
100MW
Approx US$715m
Under construction
2018

KEY

- Wind
- Solar
- Geothermal
- Expected launch date

2 Greening African power: The view from corporates

At its core, a renewable energy infrastructure project is a capital-intensive endeavour where most costs are incurred up-front in the form of capital expenses while operational costs are low, as there is no cost of fuel. Thermal power plants, on the other hand, might have lower capital expenditure but higher operational costs. This changes cash-flow profiles and thus the investment dynamics.

For renewable energy, says Dr. Bischof-Niemz, certainties about the tariff (the price to be paid for the power generated) and about the off-taker (certainty that the buyer of the power will take all of it) are critical. "The market structure doesn't matter; you still need these two certainties. If you don't have them, you might still deploy the project but at higher than necessary costs - that's just inefficient and creates windfall profits during the latter part of the lifetime of the asset."

Both factors are challenging in Sub-Saharan Africa. In many countries, the off-taker (such as an industrial user or utility) risk - the risk faced by the power producer as a result of the buyer not paying or not taking the power - is high. "The practical reality on the African continent is that you can't simply sell the power into the grid or to a third party buyer if there's a default from your original buyer" says Alastair Campbell, Managing Director at Vantage GreenX, a renewable energy fund in South Africa.

The level of electricity tariffs can also be problematic. In a recent survey of African power utilities by PwC, two-thirds of respondents admitted to not being able to recover the cost of new power generation via existing tariffs. Only a handful of countries have moved towards cost-reflective tariffs.

Many utilities also face challenges in bill collection. This results in off-takers having weak balance sheets, as in Nigeria. "Distribution companies are financially distressed at the moment" says Andrew Johnstone, CEO of Climate Fund Managers. "They're not achieving their target loss ratios and you've got shareholders and financiers who are under pressure due to slowing down economies, low oil prices, and no hard currency; the whole market is just in a very difficult place at the moment."

Given this context, "investors and funders want to make sure there is a move towards a cost-reflective tariff-regime" says Rentia Van Tonder, head of Power, Corporate and Investment banking at Standard Bank. The majority will also look to the public sector for guaranteeing Power Purchasing Agreements (PPAs). "It's almost impossible to bank a long-term PPA in Sub-Saharan Africa without a government guarantee" says Musso.

The challenge is that most African countries are unable to provide the required long-term

Key stakeholders in Africa's renewable energy sector

investment certainty on their own. "This is where development financial institutions (DFIs) come in," says Dr. Bischof-Niemz. "They can help de-risk the PPAs" he adds. Recent examples include Uganda's GetFit program, and Zambia's partnership with the IFC's "Scaling Solar program".

Then come financing challenges such as currency risk - a particular problem recently, in the likes of Nigeria - and the costs of debt, as well as logistical challenges affecting imports of products. "Inter-border customs can be prone to extensive delays, which can create additional bottlenecks," says Reda El Chaar, Executive Chairman of Access Power. Many infrastructure projects involve importing equipment such as turbines or panels from overseas.

Investors may need to build infrastructure to transport equipment, more so in Africa than other regions. The Lake Turkana wind project, led by a consortium including Vestas, Aldwych International, KP&P and Standard Bank, required 208 km of road from Laisamis to the site. Construction, which took about a year, also influenced the choice of equipment. "One of the reasons we ended up going for smaller wind turbines is that they are a lot easier to bring into the area than some of the newer - but larger - turbines," says Phylip Leferink, general manager of Lake Turkana Wind Power Ltd, Kenya.

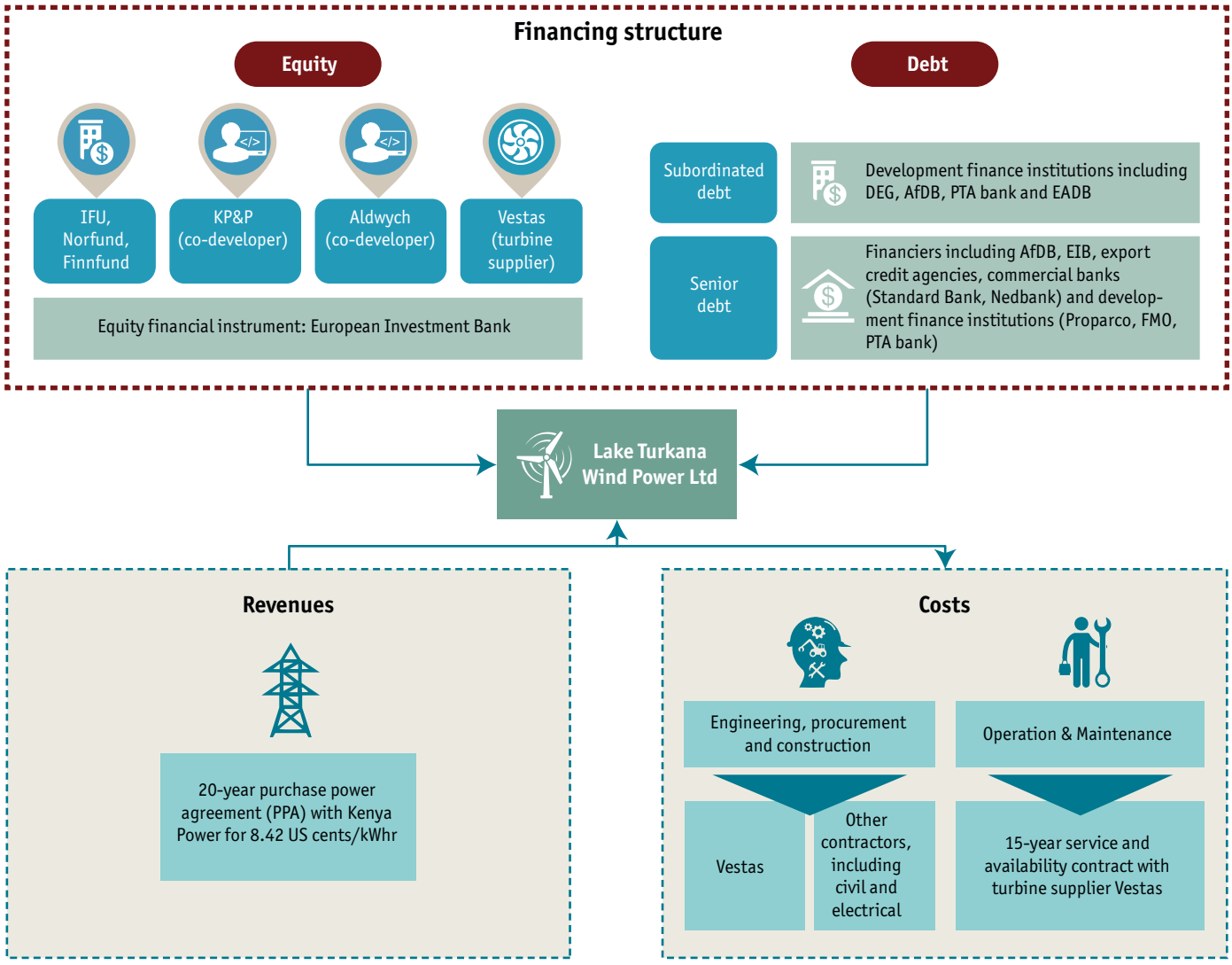
The first turbine to reach the site arrived last March, nearly three years after the PPA was signed, shipped from Tianjin in China. Such challenges impact the connecting up of assets: "the cost and the challenge of getting utility-scale projects connected up is significantly greater in Africa than in other parts of the world," says Nico Tyabji, senior associate at Bloomberg New Energy Finance.

For developers, such challenges mean proper prior planning is key. "You can't go into the middle of Ethiopia and say 'Today I'm going to put a wind farm up here or a solar farm' when there are no roads and there is no access to the grid. These things will kill your project," says James White, of SunEdison South Africa. It also means projects might take longer to deliver.

"Building a 10MW solar project in a landlocked country without a mature local solar supply chain such as Uganda takes about 6 months. In developed markets, the same 10MW could probably be delivered in a matter of few weeks," says Reda El Chaar, executive chairman of Access Power, an investor in the 10 MW Soroti project in Uganda.

Interestingly, having to invest heavily in projects is leading some companies to act both as

Financial components of Lake Turkana wind power project



Source: Lake Turkana wind power project official website.

developers and vendors: Vestas is one example. The Danish turbine maker does not ordinarily invest in energy infrastructure, preferring to be an equipment vendor, but made an exception in Lake Turkana. "Investment is not our core business, so we normally do not invest even in wind parks. But, on certain occasions, and this was a special occasion, 'co-development', is a way forward to make sure the project is established," says Nils de Baar at Vestas.

Taken together, supply chains, borders and logistics challenges can impact construction risk. The way to deal with that is very much the same as any other infrastructure project. "In the majority of our projects," notes El Chaar, "the risk of delay is passed on to the EPC[9] contractor. But passing a risk to another entity does not necessarily mean that risk no longer exists. It just means that a different entity is pricing it, and that means we face a contractor premium in markets that have a challenging execution environment".

The worry is that these costs offset the benefits of falling technology prices. "When you start looking at capex for individual projects, some can be almost double the global benchmark prices. This doesn't seem right, because the whole point is to take advantage of the cost reductions driven by other parts of the world," says Tyabji at BNEF.

Nigeria: Brightening Africa's biggest economy

When the power went out at Ita-Elewa Primary Health Centre in times gone by, workers would occasionally pay to keep the lights on themselves. Nowadays, they do not worry about the dark. Two enormous solar panels tower over the scruffy single-storey clinic in Ikorodu, a far-flung corner of Lagos.

Under the stifling sun, they produce more than enough power to keep fans whirring over patients' heads, and to support nine cooling units, which store vaccines for the hundreds of children who are carried in for check-ups daily. "We used to have to keep two generators running to support those," a doctor says, gesturing to the fridges. "Now we don't have to pay for anything."

Ita-Elewa is one of 11 primary healthcare centres and 172 schools which have been lit up since the Lagos Solar Project launched last year, funded by the Lagos State Government with assistance from the UK Department for International Development. The goal of the project is to provide vital power to a community who are mostly rural and riverine, and not connected to power lines. Some people simply could not keep up with their bills. Today, the project's photovoltaic cells produce a total of almost 5 MW of power, making it the largest off-grid solar programme in West Africa, according to the Lagos State Electricity Board.

This is a luxury. Nigeria is Africa's biggest economy and home to one in five of its people, but power blackouts hamper development. The country's total capacity, including fossil fuel generation, is over 6,000 MW, of which only 3,500 MW is tapped. South Africa has over 11 times that. Consequently, just under half of Nigerians lack access to light.

According to World Bank data, manufacturing firms experienced an average of 32.8 power outages a month, resulting in a loss of 10-15% in annual sales[10]. Big headquarters in Lagos spend enormous amounts on diesel to fuel generators which they rely on for most of their power needs.

Partly, this is because the Nigerian privatisation process was hit with problems, including strikes which prevented several investors from inspecting their assets before purchasing. When they took over, they found infrastructure in disrepair, or poorly mapped customer networks.

Nigeria's power plants mostly generate electricity using gas - which it has plenty of. But low prices set by the government encouraged oil producers to flare it off rather than selling it at a loss, and vandals regularly attack pipelines. Even if plants could produce more, the public grid cannot carry it. Distribution groups have failed to collect adequate revenue, so the sector

[9] Engineering, Procurement and Construction

[10] 2014 World Bank data, World Bank Enterprise Surveys, "Power outages in firms in a typical month". Available at: http://data.worldbank.org/indicator/IC.ELC.OUTG.

has fallen into a quagmire. By March 2016, Egbin, the country's biggest independent power producer, was owed 40 billion Naira by the bulk trader.

Developing alternative sources of power is essential. Yet Nigeria has lagged as other African countries diversify their energy mix. Large hydro projects should contribute about 1,800 MW to the grid, but they underperform. A wind farm in the northern state of Katsina should have been generating 10MW of power by now, but development has stalled. High construction costs make solar projects more expensive than in other African countries.

Some positive signals have come from a new government which swept to power in Nigeria's first democratic transition last year. New regulation, which entered into force in February this year, sets up dollar-denominated Feed-in-Tariffs with 20 year PPAs and a 50% renewable energy procurement goal for electricity distribution companies. Nigeria also has several hydro projects under construction, which are equivalent to nearly 5 GW.

Late last year, a 450 MW greenfield power plant called Azura-Edo raised $876 million, providing a framework for project finance for Independent Power Producers (IPPs) in Nigeria. Leaders say they are now negotiating major PPAs which will allow the country to generate 10% of its energy (a target of 2,000MW) through biomass, small hydro, wind and solar by 2020. "Conventional base-load power plants are required to anchor utility scale renewable power projects," argues Batchi Baldeh, head of power at the Africa Finance Corporation.

Off-grid solutions are also increasingly sought after as the costs of technology fall. Companies tired of paying big diesel bills are increasingly looking to install solar panels, says Charlotte Aubin Kalaidjian, founding partner at GreenWish Partners, a Paris-based group which is launching its first 20 MW solar plant in Senegal and hopes to build a 600 MW portfolio in Sub-Saharan Africa. EU donors are investing in micro-grids, and the Lagos Solar Project hopes to show that the sun's energy is reliable.

However private investors contend with doubtful consumers, cheap electricity tariffs and fuel subsidies which make renewable energy less competitive. On larger projects, industry experts complain of regulatory uncertainty or lack of enforcement. "The challenge is that the government doesn't want to subsidise solar, and would rather develop gas if it's cheaper," one investor argues, on the condition of anonymity. Excluding large hydro, just 0.1% of the country's power currently comes from renewable sources.

Successive administrations have failed to meet power production targets, so lofty ambitions should be treated with caution. "The government has started (but not yet completed) very important and constructive reforms. Their successful implementation is key to provide an enabling environment for private investment" says Henning Wuester, director of knowledge, policy and finance at the International Renewable Energy Agency.

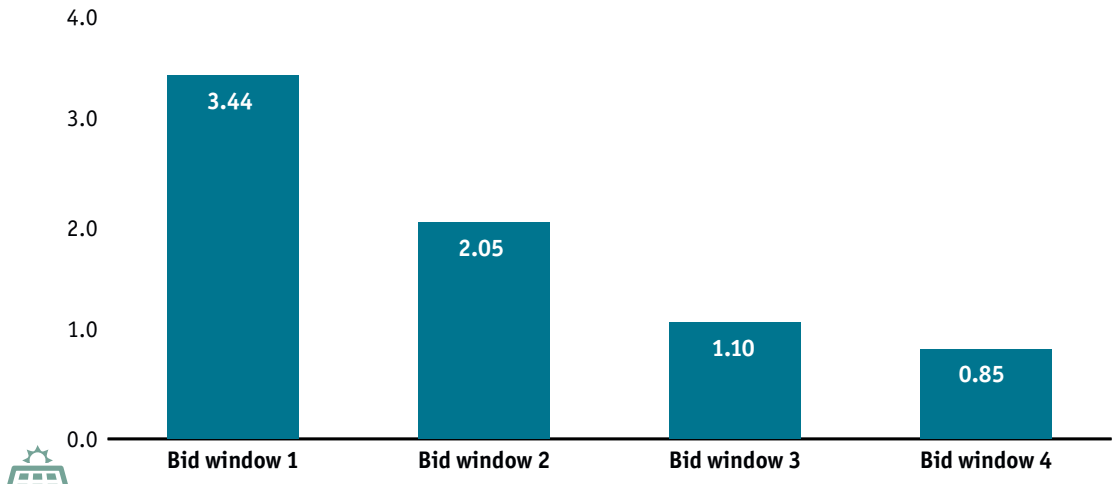
Nigeria needs a stronger roadmap for renewable energy development, along with robust guarantees. While setting tariffs for large solar projects, the government needs to take into account Nigeria's full energy mix, including not just gas, but the expensive fuel that supplies most of its electricity needs, states Ms Aubin Kalaidjian at GreenWish Partners. Controversial fuel subsidies, which dried up earlier this year when oil prices bottomed out, must be abolished to make renewables more competitive. Renewable energy is a "new concept" in oil-rich Nigeria, says Abayomi Adebisi, of the Federal Ministry of Power. But with continued attention, it could provide some light at the end of the tunnel for Africa's biggest economy.

3 Programmes or projects?

High capital costs, execution delays and risk mean most of Africa is not attracting sufficient renewable infrastructure investment, but there are innovative approaches afoot. Most notable are government-led renewable energy procurement programmes which provide structure, investor certainty and a 'policy signal' to the private sector. The landmark was South Africa's Renewable Energy Independent Power Producer Procurement Programme (REIPPP) and other, smaller countries, notably Uganda and Zambia, are following suit.

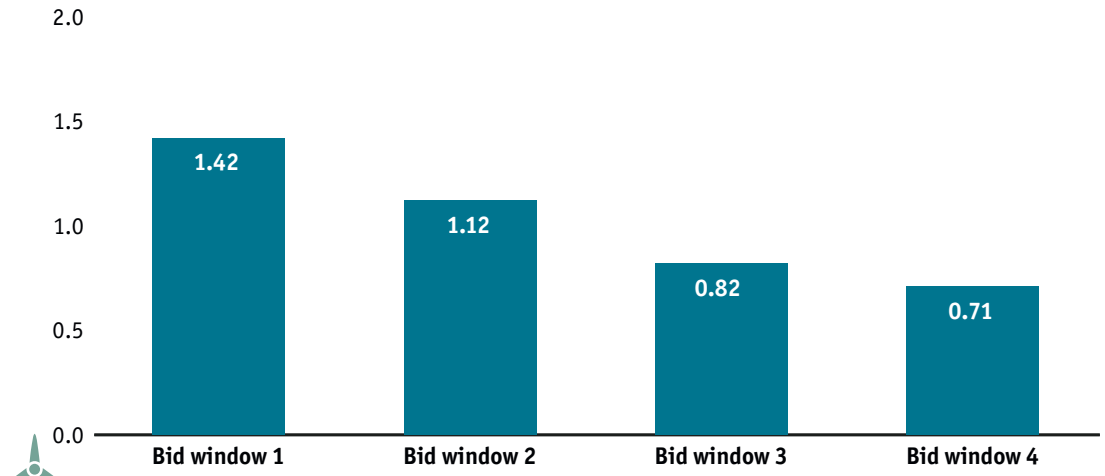
"Greenfield projects are a great way to attract private equity investors looking for opportunistic high returns, but it is not going to give you scale; for that you need a clear enabling environment implemented through transparent procurement programs", says White. "As a large scale IPP renewable energy developer you need to be selective on where you invest your time and money which is especially relevant in Africa due to the added market entry barriers. A once-off project opportunity of fifteen megawatts in Mauritius is 15 MWs in Mauritius, but 50 MW in Zambia, in a stated programme that will consist of 600 MWs backed by the World Bank provides a medium or short term pipeline that is part of a longer term vision, and that's where you can

Average bid price of Solar PV under South Africa's REIPPP program - Rounds 1 to 4
(R/MW)



Source: South Africa's Department of Energy, 2015

Average bid price of onshore wind under South Africa's REIPPP program - Rounds 1 to 4
(R/MW)



Source: South Africa's Department of Energy, 2015

justify the development time and money," he adds.

Dr. Tobias Bischof-Niemz at the Council for Scientific and Industrial Research in South Africa, believes programmes are necessary to give investors the scale they need. "A 50 MW wind farm is a big renewables project in Africa, but compared to other infrastructure investments it's tiny, with less than $100 million investment volume. You don't want to go into a project-by-project approach, with project-specific negotiations, project-specific PPAs, or project-specific connection agreements". When combined with a competitive bidding procedure, a programmatic approach can reduce the costs of procuring renewable energy. In the five years since South Africa's first auction in 2011, for instance, the costs of power from new solar and wind procured through the programme have gone down by 75% and 50% respectively.

Committed governments

To be successful, renewable programmes need a committed government. "When it comes to renewables, the majority of Sub-Saharan African countries have the ingredients. What we're missing are the chefs to put these ingredients together. There needs to be a local champion for renewables," says Reda El Chaar of Access Power, adding that "when you see true political commitment, things move".

Continuous support from the Kenyan government has been key for Lake Turkana, says Phylip Leferink, general manager, Lake Turkana Wind Power Ltd. "There were two governments during the development phase and both governments have been very supportive of the project."

But political willingness is not enough: there must also be technical capacity to deliver. Some tenders have been issued with very short deadlines, says Georgios Pergamalis, head of business development for Africa and the Middle East at Enel Green Power. "If you want to get pricing down, people need the time to do their homework and optimise their bids" he adds. Lack of capacity can lead to projects being delayed, or cancelled. 'Bandwidth' is also an issue. James White recalls a Namibian project that stalled "not because it was not technically feasible" but because the people qualified to validate it "simply didn't have the time to work on it".

South Africa boasts the technical capacity to incite investment. "The PPP Unit of the [South African] National Treasury was a massive stamp of approval and halo effect from day one, because

its head and the department had a strong track record of delivering infrastructure projects" notes Johnstone, about South Africa's REIPPP.

Wide-ranging consultation has also been a hallmark of South Africa's strategy. "South Africa's approach was to consult widely with experienced advisors, developers and financiers to develop a bankable suite of projects and government documents. Other countries seeking to unlock their own renewable energy markets would do well to follow this example" says Musso.

Kenya is also well-positioned, according to El Chaar: "In markets like Kenya that have been doing IPPs successfully, you have a capable counterparty that understands IPPs so you're able to easily discuss risk allocation, and they generally have the capacity. But when you go into trickier markets where they have not concluded IPPs before, the discussion becomes significantly more challenging, just because the institutional capacity is not there".

Thankfully, interviewees see momentum. "I am very positive on the new federal government of Nigeria" says Johnstone. "If you look at Lagos State over the last five years, that's a jurisdiction that has done PPPs and they know how project finance works. Some of these PPPs are good, some are bad, but if they can supersize that at federal level then you've got the same sort of dynamic that the National Treasury did for the Department of Energy in South Africa."

Zambia, Ethiopia and Tanzania are also promising. "Zambia's Scaling Solar programme and Ethiopia's recent expression of interest are demonstrating that African governments are realising the power of well-structured procurement programmes," says White. "Uganda and its Get Fit programme is another good example" he adds.

African developers, global partners

A thriving clean energy sector cannot be achieved without local expertise. As South Africa shows, international developers still play an important role in deploying renewable projects on the ground - but most will partner with local developers and/or have their own local branches.

The challenge is thus not lack of talent. "Africa has well-educated and capable entrepreneurs that can come up with meticulously thought-out concepts" says El Chaar. But "there has not been enough early-stage credible, international technical capabilities followed with financial commitment to really bring those significant concepts to life. This is the biggest issue today in Africa."

'One-stop-shops', such as developed by Climate Fund Managers (Climate Investor One) or Access Power (the Access Co-Development Facility), is one way the private sector is responding. From the developer's point of view, 'one-stop-shops' reduce transaction costs by providing easier access to partners, technical experts and investors[11] while investors benefit from lower risk profiles thanks to the portfolio diversification these facilities provide.[12] Other facilities include the $350m IRENA/ADFD Project Facility and the $10m Project Support Facility of the African Renewable Energy Fund. The result, long term: a rise in the number of African-led bankable projects. "Doing business with people who understand Africa and are using African money is an incredible opportunity for the continent" says White.

[11] As in AccessPower's Co-development Facility, which selects investments through a prize competition in which donors are part of the judging panel. The US$7 million financial support mechanism fund prize, in its second year, is designed to help local power project developers and originators with technical experience, expertise and funding required to bring projects to financial close. The first round saw 55 submissions from 18 countries across Africa, with technologies including solar, wind, hydro, hybrid and bio-mass projects.

[12] ClimateOne offers five different risk/return options across the life of a project, from a $50m development fund (donor invested), to a construction equity fund structured in three tranches ($100m, $200m, $200m) with donor funding taking the more risky tranche while the least risky one is targeted for commercial lenders, and a $500m re-financing fund opened to both public and private investors.

Uganda: Going solar

East Africa's largest solar power plant, led by Access Power and EREN RE, shows the rollout of programme-led approaches in smaller economies. Currently under construction on the outskirts of Soroti, a small town 300 kilometres northeast of the capital, Kampala, it will provide enough electricity for 40,000 homes and businesses.

However, establishing the plant in rural Uganda has been far from easy. 32,680 photovoltaic panels, on one site, are south-facing. To avoid maintenance requirements, they do not contain parts that would allow the panels to track the movement of the sun. "I've worked on renewable energy projects across Europe, USA, Mexico, Brazil, Philippines and Pakistan," says Jorge Lopez Galera, Access Power's Engineer on-site in Soroti "and this is the most difficult yet."

The challenges are social and technical, explains Galera. "We are bringing something completely new.....we have to act sensitively. In some ways we are like an NGO, making suggestions and supporting local people. We don't leave them aside, we make them a part of the project."

The biggest challenge is sourcing materials in this landlocked country. "The machine hire companies we approached in Uganda had never heard of some of the heavy equipment that we wanted. We had to go to Nairobi to buy poles for the medium voltage line. In Brazil and the Philippines, they were easy to find."

Delays affect goods sent from Asia or Europe, adds Galera, "If an inverter [a device that converts direct current to alternating current] breaks in Europe it can be replaced in three days. Here you have to send it to Germany to be repaired. That takes time and pushes up costs. Even in Pakistan it was easier. Parts can be imported from India next door."

To entice the private sector, the Ugandan authorities authorised an innovative bidding and financing program, Global Energy Transfer Feed-in Tariffs (GET FiT). The German international development agency, KfW, and four European donors provided top-up payments that would be added to the feed-in tariffs set by Uganda's Electricity Regulatory Authority and paid for by Ugandan electricity customers. Donors subsidise each kilowatt hour by 5.37¢ while the national electricity distributor pays a feed-in tariff of 11¢/kWh. The project is planned for a 20 year lifetime. Uniquely, the donor-funded top-up payments were front-loaded so that developers receive all the top-ups in the first five years of operation.

Soroti: a helping hand

If successful, this project can make a significant difference to the lives of Ugandans. Sitting in the shade of a tree outside his mud-walled hut in Opolai village, a 10 minute drive from the Ugandan town of Soroti, Michael Obale discusses the difference that grid-connected electricity would make. As his mobile phone charges from the solar panel lying on the hot, red earth, Obale, an agriculture graduate from Gulu University, says the biggest advantage would be safely storing and transporting his produce of sweet potatoes, mung beans and sesame to market.

"We need to develop a 'cold chain' for perishable items once they have been harvested so as to reduce waste. Too much of our food goes bad in the heat before we can sell it. We need regular electricity here." In Opolai village, Obale considers what the solar plant, which he has visited, could mean to him. "It's simple, with electricity I could do agro-processing, grinding millet before I take it to market - making more money. Potentially, I could build a permanent house and have a better life."

For local businessman Emmanuel Okalebo, reliable long-term power supply allows him to plan ahead. Surrounded by busy workers in his packed electrical repair shop in Soroti town centre, Okalebo explains that the electricity supply regularly shuts off. "Last week it was almost every day. My customers travel here by bus - some from as far as Pallisa." Okalebo describes the journey from a town about 100 kilometres from Soroti,

"The roads are very bad, the buses don't run on time and sometimes break down. Customers have to pay to transport their appliances, when

they get here and the power is off I can't test and fix their gadget. There's nowhere they can afford to stay overnight in town so they travel back and return the next day. Only, many of them never come back. They've lost money and I've lost business. It's too uncertain." Okalebo's only concern about the new power plant is that it will not help to reduce prices, which he considers too high.

Peter Nyeko, a renewable energy developer, says the GET FiT program needs to go further to deliver its full potential. The former aerospace engineer says his proposed hybrid biomass-solar combined on- and off-grid project could deliver electricity at 11¢/kWh without any subsidy[13]. "I see what they're doing at Soroti, good on them. But we can deliver similar quantities of energy without subsidies" leaving money to be spent elsewhere or allowing end customer costs to be reduced.

Investors in his Mandulis Energy project hired three World Bank-approved consultancy firms to test the feasibility of the proposal. All three endorsed the plan. Nyeko says that the conservative nature of local bureaucrats stifles development. "The technical capacity in the energy ministry doesn't exist to understand non-hydro or non-combustible biomass. They've gone for the simplest solar solution but it's not the most cost effective."

The Soroti project is straightforward. Complex hybrid energy proposals are riskier but have the potential to reap bigger rewards. As Ugandan expertise in diverse forms of renewables increases, authorities may wish to consider more elaborate systems which push innovative on- and off-grid techniques.

Zambia: Relying on the rains

Zambia is a second African country advancing a 'programmatic' approach, to deal with the country's over-reliance on hydroelectric power. Like Uganda, this is a relatively low income, landlocked economy building a renewable energy industry with little existing experience - especially, in Zambia's case, outside of hydro.

Since independence in 1964, Zambia relied on large hydropower plants in the south of the country to send electricity along a north-south transmission corridor to Lusaka, the capital, and on to large copper mines further north. For decades, electrification remained limited primarily to end users near the grid, leaving most of the eastern and western parts of the country without electricity. But beginning in the 1990s Zambian authorities became aware that new power plants were needed. More recently, the risks of hydropower-based energy have become increasingly apparent.

Zambia is dependent on hydropower for almost all of its supply needs. Last year, Zambia's two largest hydro power plants drastically reduced output due primarily to regional drought. At the same time, major sources of new demand came online, led by First Quantum's giant Sentinel copper mine in North-Western Province which at its peak capacity gobbles up 160 MW of power, or about 7% of total installed capacity in Zambia.

Making matters worse, construction of two new power plants - which were meant to meet this added demand - fell behind schedule. Thankfully, steady rains through the early months of 2016 helped avert a catastrophic escalation of the electricity crisis, replenishing perilously low water levels that threatened to worsen the rolling blackouts that became a daily affliction beginning in summer 2015.

Zambia's power deficit will take years to correct, especially at the 1,080MW Kariba North Bank power plant where power stations on both the Zambian and Zimbabwean side of the Zambezi River consumed far more than their allotted water supply over the course of 2015 and into early 2016. In February 2016, the reservoir at Kariba Dam fell to only 1.5 meters above the level that would necessitate a full shutdown of the plant. Although seasonal rains have slightly replenished the reservoir, it remained only 17% full as of late March, compared to 49% last year. Refilling the lake will require a series of healthy rainy seasons coupled with a moderation of output from the power plant—neither of which are a certainty. In the meantime, Zambia must

[13] The Soroti project subsidy is USc 5.37/kWh.

rely on much more expensive imported power to avoid even worse blackouts.

The power crisis comes at a particularly bad time for a copper-dependent economy reeling from tumbling prices. Amid these electricity and economic challenges, the Zambian government is searching for long-term solutions.

The need for investment in power infrastructure has galvanised interest from international donors and private sector players to not only reduce the deficit but also improve electrification rates in the country—only 25% of the population has access to electricity, a figure that drops to a paltry 5% for rural Zambians, according to the Ministry of Energy.

On top of domestic needs, the most ambitious-minded investors see Zambia, with its links to the Southern and East Africa power pools, as a potential exporter to the region. The long-delayed 300 MW Maamba Collieries coal project should come online in summer 2016 and another coal project is in the works, and several hydropower projects in the wetter north of Zambia are in development.

The need to diversify power has brought solar to the fore. A small number of projects were initiated before the crisis but now have a renewed impetus. BioTherm, a South African Independent Power Producer (IPP), is one beneficiary. The company was a preferred bidder in a 2013 solar tender issued by what was then the Ministry of Mines, Energy and Water Development and is currently negotiating a power purchase agreement (PPA) for four projects in Eastern Province totaling 10MW.

According to Jasandra Nyker, CEO of BioTherm, Zambia should be lauded for "being the first Sub-Saharan African country outside of South Africa to run a solar tender," adding that while "Zambia is taking longer than South Africa, we are accomplishing our objectives and are ready for financial close."

Two other government-sponsored solar initiatives are underway that, if successful, will drastically increase the profile of solar power in Zambia while offering more transparency to the procurement process for building new power plants. Early in 2015, President Edgar Lungu directed the Industrial Development Corporation (IDC), an investment company wholly owned by the Zambian government, to plug the gaping supply deficit with up to 600 MW of solar power. The IDC subsequently partnered with the International Finance Corporation to roll out its 'Scaling Solar' program offering a rapid and transparent tendering process along with bankable project documents backed by the World Bank.

Under Phase 1 of the program, two 50 MW projects will be built on the Lusaka South Multi-Facility Economic Zone. From 48 firms that submitted applications, the IDC invited eleven pre-qualified bidders to submit proposals to build the projects. Among these firms are multinationals like EDF Energie Nouvelle of France, China's Shanghai Electric Power, and Enel Green Power of Italy, and large investment funds including the UK's Globaleq and the Old Mutual-backed Africa Infrastructure Investment Fund 2, based in Mauritius.

Charles Mate, executive director of Corporate Affairs at IDC, noted: "we were obviously pleased and impressed by the interest in 'Scaling Solar'. It was more than we expected, and a revelation of the pent-up demand from the private sector for investing in the Zambian power sector." Scaling Solar will name the winners of round 1 and launch Phase 2 of the program for a planned 200 MW in the coming months.

Also this spring, the Ministry of Energy is expected to introduce Zambia's first Renewable Energy Feed-in Tariff (REFiT) Strategy. The strategy aims to incentivise the construction of 200 MW of renewable energy projects between 1-20 MW, half of which is set aside for hydro and the other half for other resources, including solar. Zambian stakeholders have partnered with donors, with the Energy Regulation Board (ERB) linking with USAID to set the initial REFiT guidelines and the Department of Energy asking KfW, the German Development agency, to help implement the REFiT Strategy using KfW's Global Energy Transfer Feed-in Tariff (GET FiT) program. GET FiT was first deployed in Uganda's inaugural 170 MW REFiT program, where grant funding closed the gap between the price the utility could pay and tariff levels acceptable to private developers. In Zambia, GET FiT will

similarly address the tariff gap as well as offer a grid connection facility, risk mitigation support, and a technical assistance facility that provides standardised legal documentation for the REFiT program. Solar developers have already shown interest in REFiT, with several experienced international companies as well as local firms busy identifying land sites and initiating the regulatory processes in Zambia as the program takes shape.

The exact amount of solar capacity that can be absorbed by Zambia's grid is unknown, but studies are underway to provide clarity. The technical limitations of a grid with only about 2,450 MW of installed capacity is one challenge facing developers, but another more daunting one is Zambia's extremely low power tariffs.

Electricity has historically been extremely cheap in Zambia, due mostly to reliance on large hydro projects that have already been paid for, but also because the government keeps tariffs artificially low. With a weighted tariff of only about $0.04/kWh, there are concerns that ZESCO will struggle to sign off on the solar projects in development that will require over $0.10/kWh (or significantly higher depending on the project size) to be viable.

Sipho Phiri, executive chairman at Western Power, an IPP developing hydro and solar projects in Zambia's Western Province, notes: "ZESCO understands that they must have a viable tariff or else the banks aren't coming and power isn't coming." An initial attempt by the utility to raise rates late last year was reversed by President Lungu in January, and no rate increase is expected until after the August 2016 national elections. It is likely, however, that some level of tariff hike will come before the end of the year.

Another obstacle facing investors is the lack of a publicised planning document that specifies Zambia's power sector strategy and prioritises power projects for development. Zambian officials are deluged with direct proposals for grandiose plans to transform Zambia's energy landscape with massive solar arrays. These approaches appeal to a country in crisis, but the sheer number of firms seeking this route also muddies the investment landscape.

Owen Silavwe, managing director at the Copperbelt Energy Corporation (CEC), a Zambian power company listed on the Lusaka Stock Exchange, said: "From an institutional perspective, we need a central coordinating body" charged with implementing policy and the various programs meant to meet demand. Charles Mate agrees, noting that "the South African renewable energy model is a good one for Zambia, as you get very clear price discovery there through a procurement process that is competitive and transparent."

Given near-term counterparty risk for solar projects with ZESCO as the offtaker, some developers are eyeing off-grid or so-called private-to-private solar power solutions. These captive power plants provide a viable option for companies seeking to lower dependence on grid supply and dirty and expensive backup diesel generators. As seen in several East African countries ahead of Zambia in promoting off-grid solar, this avenue also offers a more rapid solution to electrifying rural areas.

"Solar will play a big role in the electrification of Zambia and in addressing the current supply gap", says Silavwe. CEC is exploring hydro and solar prospects in Zambia and is participating in tenders run by Scaling Solar and the Ministry of Energy, and considering private-to-private projects with some of their mining customers in Copperbelt Province. Silavwe states that "tariffs are the biggest obstacle to investing in solar in Zambia, but if we can get a 20 MW project online, we think we can encourage further projects. Starting small is appropriate in this market."

Donors are also advancing off-grid power, with the US and Swedish governments partnering on an initiative called Beyond the Grid providing funding for a range of off-grid projects. The program is targeting private-sector investors, and aims to assist companies reluctant to deploy capital in non-core activities like building an on-site solar power plant but might instead be interested in becoming an off taker for a project built by a dedicated IPP. The opportunity is vast, extending from the mining, industrial and commercial sectors to clinics and schools in villages. But, noting the various financial, technical and political pitfalls that can slow projects, Mate warns that "there are windows of opportunity, and these windows can shut very quickly."

4 Africa's 'bespoke' grids, and the innovators driving the market

Energy projects do not exist in a vacuum: the African grid will be essential to the smooth functioning of the overall power system. One strategy is to strengthen regional power pools. According to McKinsey, this could cut by $40bn the $490bn of capital investment in new generation capacity needed to meet Africa's energy needs. Increased connectivity between countries could reduce the average cost of grid-connected power by up to 10% in the case of the East African Power Pool.

Grid extension and power pooling takes time, however; and with 645 million people in Sub-Saharan Africa lacking energy access today, decentralised solutions will be required, notably in rural areas where stand-alone and mini-grid solutions are expected to meet 70% of the demand of newly connected customers over the next 25 years, according to the International Energy Agency.

Increasingly, developers are seeing the beauty of smaller developments. Deploying large-scale renewable energy projects in networks with poor transmission and distribution infrastructure is a challenge, and one solution, says Dr Bischof-Niemz, is to deploy smaller capacities across the national grid network. "If you want to connect relatively large renewables projects in the hundreds of MW then you need a transmission grid with a significant size to accommodate that power. But if you implement a more distributed approach and go for 5-10 MW projects instead, you can connect to the existing grid much more easily " he says.

Off-grid: Game on

In 2014, $17bn was spent in Sub-Saharan Africa for off-grid energy services, according to BNEF. While nearly two thirds of that (63%) was spent on kerosene, the broader market is growing quickly. Tanzania, with a 70% rural population, has been active in off-grid, providing standardised tariffs and PPAs and simplified procedures for mini-grids. Kenya and Rwanda have picked up pace, with the latter recently partnering with UK firm Ignite Power to deploy off-grid systems in 250,000 homes by 2018, as part of the country's goal to achieve 70% electrification rate by June 2018.

The off-grid market is large and its value proposition is clear: the cost of a solar lamp can be recouped in a matter of months. Its structure is also very different than what most people imagine. While most off-grid dwellers in the poorest countries live on under $2 a day, in larger economies like Ethiopia or Kenya, more than half live with a disposable income between $2-$10/day. "These are people who would have

the money to pay for the grid if it was there," says Thomas Duveau, head of business development at Mobisol, an off-grid energy service provider of solar home systems active in Tanzania, Rwanda, and soon in Kenya. While the scale of each project is limited, small scale solar off-grid is growing fast.[14] "This year, we're on track deploy 4 MW. Next year we're targeting more than 8 MW. Deploying a large scale project of similar size would take longer than that" says Duveau.

This consumer market is allowing a range of offerings, from 'pico-scale' products of just a few Watts that enable lighting lamps and charging a phone, to more expensive solar home systems of 100-200 Watts that provide electricity for lighting, charging and appliances such as a TV, fan or fridge.

New and innovative business models are emerging based on the "pay as you go" model, in which a customer pays via mobile for the electricity consumed and access to electricity can be cut in case of non-payment. One of the market leaders is M-KOPA, an award-winning company which brought solar power to 330,000 homes in Kenya, Tanzania and Uganda, with its 8W battery-powered systems, which have 3 lights, a mobile phone charger and a solar-powered radio. It operates through 100 services centres and is a proof of concept of a ready and willing market of African energy consumers.

Other Active firms include Germany-based Mobisol, which combines solar power with mobile-based payments, and 'plug and play' solar tech company BBOXX whose products include 50W roof-mounted solar panels with mobile payments. Not only does this create an effective incentive for payments, it also reduces maintenance costs[15] and builds a customer credit profile.

Applied to a large customer base, customer information provides the visibility needed to package contracts together, opening the door to securitisation. The model has been in play for several years - Solar City issued the first solar bond in 2013 - and it has strong potential for the African market. "The next 10,000 customers become a 1MW project with a stream of cash-flows associated with it and collateral; it's standard asset-backed finance," says Duveau. The first securitisation for small scale off-grid solar in Sub-Saharan Africa took place in January this year, by BBOXX, through a $500m issuance corresponding to 2500 contracts in rural Kenya.

Berkeley-based Powerhive is another microgrid innovator. Among their technologies is Asali, a stand-alone distributed metering system which services customer clusters. This creates a microgrid that accommodates communities of different sizes. Powerhive has also developed a remote cut-off system, called Honeycomb, which helps companies offer flexible payment models while ensuring their revenue is reliable. BBOXX has invented the same kind of remote monitoring system to reduce payment plan risks.

Micro-grids can take longer to deploy but have larger capacity per project. It took Powerhive two years and four pilot projects in Kenya before it could acquire the license to sell electricity to the general public, for instance. Now secured, however, the microgrid company is working on deploying 1 MW worth of mini-grids across 100 villages in Kenya, delivering electricity to 20,000 households and businesses. "Kenya's rural electrification rate, combined with the cost of electricity access and average income made it a great case for investment" says Georgios Pergamalis, head of business development in Africa and the Middle East at Enel Green Power, which took an option to acquire a 93% interest in the 1MW project ($12m).

To some extent, these models (off-grid solar and microgrids) are competing for the same market (rural electrification), albeit at different speeds and scale. The growth of one may affect the other. Mini grids, for instance, might not be viable in areas where small scale solar is present, as the residual unmet demand of customers

[14] 4.5 million pico-solar unit were sold in 2014 (from nearly none in 2009). The 'Pay As You Go' model is a small but rising part of the market (it doubled in size in the first nine months of 2015, according to BNEF).

[15] Since maintenance can be done remotely and technicians are only sent when neither remote maintenance nor the user (with whom the company can interact via phone) can fix the issue.

might not justify the investment. Reciprocally, off-grid solar might not penetrate a market which already has a mini-grid, although the focus of off-grid solar on selling services – as opposed to just electricity - might give an entry point.

What shape rural electrification takes in the long term is unclear. "In mini-grids, the business model is still work in progress" says Pergamalis. It is clear, however, that the rise of off-grid power generation could create a new type of network altogether in rural regions, where power networks are built from the bottom-up as opposed to the top-down. "It will happen in a grass-roots way", says Dr. Bischof-Niemz. He envisions supply being provided first in 'island grids' which gradually get interconnected.

While some economies of scale that would emerge from this are similar to those of centralised systems (including the portfolio effect of mixing different supply and demand sources, which leads to lower costs and higher security of supply for each participating island grid), the key difference is that "the interconnection between two island grids is now much smaller in size than the large transmission line that you would have to build in the old days – because you have a lot of generation sitting right next to the load."

While these Africa-centric innovations will be key drivers of the renewables market, it is important not to forget the impact of continued innovations in the rest of the world. One crucial area will be energy storage, a key mechanism for dealing with demand spikes or variable renewable power generation from intermittent sources like solar and wind. According to research by BNEF and UNEP, in 2015 some 250 MW of utility-scale electricity storage (excluding pumped hydro and lead-acid batteries) were installed worldwide, up from 160MW in 2014.

Last year brought notable global developments, including the unveiling of Tesla's rechargeable lithium-ion battery for residential use. Forecasts by Deutsche Bank see the cost of lithium-ion batteries falling by 20 to 30% a year, potentially bringing mass adoption over the next decade[16]. As with the falling costs of solar panels, these innovations take time to filter through to the African market - but they can filter through in time.

[16] Deutsche Bank Markets Research, 27 February 2015. https://www.db.com/cr/en/docs/solar_report_full_length.pdf

Conclusion

The case for renewable energy infrastructure in Africa is strong. The price of wind and solar technologies is falling. Political ambition is there - with nearly 40 countries penning renewables targets. And the continent has abundant resources.

But the continent must 'level up' to meet the ambitious energy access goals it has set itself. South Africa, the most developed market, offers several lessons in procurement programme design. Kenya is a front-runner, with the Lake Turkana wind farm promising a very high load factor and showcasing Africa's considerable natural assets. And others, including Uganda and Zambia, are busily advancing their renewable infrastructure sectors from a low base. As technology costs fall, especially in wind and solar, the case for renewables grows stronger still. And support from development finance institutions is bringing capital, de-risking investment and providing technical support.

However, between the renewables targets and the actual deployment trends, there is a sizeable gap: the African Renewable Energy initiative goal to deploy 300 GW by 2030 requires a 680% increase in current deployment rates[17]. This report, interviewing developers, financiers and energy experts, has identified several enabling factors essential to make that vision a reality. Top measures to support renewable infrastructure in Africa include:

Cost-reflective tariffs based on publicly available 'cost of service' studies: Artificially low tariffs, due to government subsidies, are deterring investors and ultimately reducing power supply. To attract infrastructure investment, power tariffs must better reflect costs. Targeted subsidies to protect the poor can improve access to power without deterring the private sector from investment.

Transparency and harmonisation. Governments should publicly publish key planning documents, like Integrated Resource Plans, and introduce bankable and harmonised legal documentation including PPAs, Government Support Agreements, and Connection Agreements. Africa also needs strong, independent energy regulators that can enforce competitive procurement.

Improve border customs efficiency. To utilise renewable technologies, landlocked African nations must improve supply chain efficiency so that developers can quickly move equipment and replace parts like panels and turbines. Faster customs processes are vital to achieve this. Capital expenditure on some renewable infrastructures in Africa are far higher than the

[17] Defined as the total net capacity of renewables added each year.

rest of the world, and customs bottlenecks are one reason for cost escalation.

Design renewable procurement programmes, rather than relying on one-off investments. While investors occasionally pursue one-off energy infrastructure projects, government-backed renewable procurement programmes are proving more likely to attract greater investments in the long term. Following South Africa's lead, Uganda and Zambia are emulating the programmatic approach: other countries could do the same. Transparent, standardised, and competitive programmes reduce risks for developers, and costs for governments. They signal long-term policy commitment to green energy, and build local expertise.

As these processes play out, developers need resilience and patience, since renewable infrastructure can, outside South Africa, take considerably longer to deliver. "You need to pump a huge amount of effort into making contacts, understanding regulations and understanding local laws, employment....and even so, things will take much longer than you expect before they really kick-off" says James White. But while Africa has its challenges, experts in this report believe it can offer rewards for those willing to navigate imperfect environments, adjust business models based on context, and take the long view.

About IHS Towers

IHS Towers is the largest telecommunications infrastructure provider in Africa, Europe and the Middle East, with over 23,300 towers in its portfolio. IHS currently operates in Nigeria, Cameroon, Côte d'Ivoire, Rwanda and Zambia and is investing in renewable power solutions to both improve energy and operational efficiencies, and reduce the environmental impact of its operations.

IHS has set itself the target of becoming largely diesel-neutral through a combination of on and off-grid solutions. Over the next few years, IHS plans to become almost diesel neutral across its Zambian portfolio and the company is assessing solar farm opportunities in Rwanda that could potentially supply power to the national grid in the first 'energy swap' model to be used in Africa. To date, IHS has invested over US$500 million in new green energy power systems across its portfolio.

IHS is achieving its renewable energy goals whilst integrating newly acquired towers into its network. At the same time, IHS is maintaining network uptime of over 99% in all of its five markets, with all tower sites connected to IHS's Network Operating Centres so that they can be monitored 24/7.

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